Stature estimation using right digits and palm length in IGBO population, Nigeria

ABSTRACT

Introduction: Estimation of stature is an important anthropometric tool which helps in the identification of an individual. The dimensions of the hand have been used for the determination of age, sex, and stature of an individual. **Materials and Methods:** The present study examines the relationship between stature and hand dimensions of a unique ethnic group in Nigeria, the Igbos. Stature (Y), Palm length (PL), hand breath (HB), first digit length (1st DL), second digit length (2nd DL), third digit length (3rd DL), fourth digit lengths (4th DL) and fifth digit length (5th DL) of 211 subjects comprising 123 females and 88 males (age range 16-45 years) were measured after obtaining an informed consent. The data obtained were analyzed using SPSS 17.0. **Results:** Sex differences were found to be highly significant ($P < 0.0001$) for all the measurements. Linear and multiple regression equations for stature estimation were constructed using the aforementioned variables and multiplication factors were computed. The highest correlation coefficient between stature and PL provides the highest reliability and accuracy in estimating stature of unknown gender, while that of 2nd DL provides that of the males specifically. **Conclusion:** Prediction of stature was found to be most accurate by using linear regression in both gender put together as well as in the females while multiple regression was most accurate for estimate of stature in the males.

Key words: Anthropometer, digit length, palm length, sliding caliper, stature

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INTRODUCTION

Body stature (height) has been reported as one of the most important and useful anthropometric parameters which determines the physical identity of an individual. Because of this, the reliability of stature estimation from upper extremity measurements[1-7] as well as lower extremity[8-12] has been documented. The usefulness of this, is continually been applied in Forensic Medicine, Clinical practice, Anthropology, and other Medical Sciences.[13,14]

Anatomically, stature which is a composite of linear dimensions of skull, vertebral column, pelvis and legs[14] and some parts of the foot, has been estimated in many populations using regression formulas derived from hand dimensions;[15,16] also sex has been determined from hand dimensions[3] such derived formula are population specific.

Most of the time, upper and lower extremity segments (hands and feet) are recovered from the site of natural as well as man-made disasters.

In Nigeria, forensic anthropological data are scarce and there have been cases of manmade disasters (bombing, auto crash, and killings by unknown gun-men) and even flood in recent times. Because of this, there is need for anthropological research in each of the three major ethnic groups (Hausas, Igbos and Yorubas) in order to generate reference data that will help in the identification of individuals. In this present study, attention was paid to one of the major ethnic group (the Igbos) for the estimation of stature using hand dimensions.

MATERIALS AND METHODS

The study was based on a random sampling of 211 subjects (females, $n = 123$, and males, $n = 88$) aged 16-45 years of

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the Igbo ethnic group of Nigeria, and attention was paid to stature estimation using right digits lengths and PL, after obtaining an informed consent.

STUDY LOCATION AND DURATION

The study was conducted in Imo State, Nigeria. The study covered a period of ten 10 months as follows: (i) Eight months for the field work. (ii) Two month for data analysis and interpretations.

Demographics: Information on age, sex, and state of origin was documented.

Exclusion criteria: Subjects who were not of Igbo origin were excluded from the study. Also subjects having any deformity or disease were not allowed to participate in the study.

Anthropometrics: Stature was measured and the following hand measurements were taken in centimeters using a sliding caliper:

Stature (Y) is the height measured to the nearest 0.1 cm using an Anthropometer with subjects standing without shoes with the heels held together, toes apart, and the head held in the Frankfort plane.

Palm length (PL) is the linear distance (cm) between the distal wrist crease and the distal end of the longest finger.

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.

First digit length (1st DL) is the linear distance (cm) between the proximal digital crease and the distal end of the first finger.

Second digit length (2nd DL) is the linear distance (cm) between the proximal digital crease and the distal end of the second finger.

Third digit length (3rd DL) is the linear distance (cm) between the proximal digital crease and the distal end of the third finger.

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

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

RESULTS

The anthropometric characteristics for both genders put together, females and males are shown in Table 1. We can see the standard deviation (SD), the mean, the maximum and minimum values of the anthropometric variables.

All the anthropometric dimensions measured directly showed statistically significant differences between females and males, $P < 0.0001$ with females having a lower mean value than males [Table 2].

The correlation coefficient between Y and the right hand dimensions (PL, HB, 1st DL, 2nd DL, 3rd DL, 4th DL, and 5th DL) in both genders was found to be statistically significant and positive, indicating a strong relationship between Y and right hand dimensions. The highest positive correlation was observed in palm length (PL), r = 0.610 while the least was observe in 1st DL, r = 0.328 in both genders put together [Table 3]. For the females, the least significant correlation was observed in the hand breath r = 0.244 while the highest value was obtained in PL, r = 0.561. In the male population, significant and positive correlation was recorded between Y and right hand dimensions. The least significant correlation was observed in HB, r = 0.293 while the highest was observed in 2nd DL, r = 0.561 [Table 3].

Table 1: Descriptive statistics of right hand dimensions in both genders put together females and males

Variables	Both gender					Females					Males				
	N	Min	Max	Mean	SD	*N*	Min	Max	Mean	SD	*N*	Min	Max	Mean	SD
Age	211	16.00	45.00	23.58	4.951	123	16.00	45.00	23.74	5.36	88	18.00	43.00	23.35	4.34
Height	211	149.00	190.00	167.55	9.10	123	149.00	190.00	163.17	7.64	88	156.00	190.00	173.66	7.30
PL	202	13.50	23.00	19.31	1.46	119	15.30	22.00	18.77	1.12	83	13.50	23.00	20.07	1.54
HB	204	6.60	11.30	9.44	0.86	120	6.60	10.70	9.06	0.64	84	7.70	11.30	9.98	0.86
1st DL	209	3.20	9.10	6.45	0.84	122	3.20	9.10	6.21	0.81	87	5.10	8.40	6.79	0.75
2nd DL	208	5.60	9.00	7.11	0.61	122	5.80	8.50	6.91	0.49	86	5.60	9.00	7.41	0.63
3rd DL	209	5.80	9.80	7.92	0.67	122	6.20	9.30	7.71	0.56	87	5.80	9.80	8.21	0.71
4th DL	209	5.30	9.00	7.32	0.65	122	5.30	8.60	7.11	0.57	87	5.70	9.00	7.61	0.66
5th DL	209	3.80	8.30	5.86	0.66	122	4.50	8.30	5.68	0.63	87	3.80	8.00	6.10	0.62

SD=Standard deviation; DL=Digit length; PL=Palm length; HB=Hand breath

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

Variables	Paired differences					T	Df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error mean	95% confidence interval of the difference				
				Lower	Upper			
Height (F)-height (M)	−14.00682	3.77036	0.40192	−14.80568	−13.20796	−34.850	87	0.000
PL (F)-PL (M)	−1.66062	1.63157	0.18241	−2.02371	−1.29754	−9.104	79	0.000
HB (F)-HB (M)	−1.05305	1.07193	0.11837	−1.28858	−0.81752	−8.896	81	0.000
1st DL (F)-1st DL (M)	−0.64126	1.13835	0.12204	−0.88388	−0.39865	−5.254	86	0.000
2nd DL (F)-2nd DL (M)	−0.57337	0.73536	0.07930	−0.73103	−0.41571	−7.231	85	0.000
3rd DL (F)-3rd DL (M)	−0.60747	0.85190	0.09133	−0.78904	−0.42591	−6.651	86	0.000
4th DL (F)-4th DL (M)	−0.62517	0.82012	0.08793	−0.79996	−0.45038	−7.110	86	0.000
5th DL (F)-5th DL (M)	−0.53057	0.83251	0.08925	−0.70801	−0.35314	−5.945	86	0.000

PL=Palm length; HB=Hand breath; DL=Digit length; (F)=Female; (M)=Male

Table 3: Pearson correlation between Y with right hand dimensions in both genders, females and males

Variables	Both genders			Females			Males		
	N	Pearson correlation	Sig. (2-tailed)	*N*	Pearson correlation	Sig. (2-tailed)	*N*	Pearson correlation	Sig. (2-tailed)
PL	202	0.610**	0.000	119	0.561**	0.000	83	0.429**	0.000
HB	204	0.479**	0.000	120	0.244**	0.007	84	0.293**	0.007
1st DL	209	0.328**	0.000	122	0.069	0.450	87	0.331**	0.002
2nd DL	208	0.540**	0.000	122	0.290**	0.001	86	0.561**	0.000
3rd DL	209	0.559**	0.000	122	0.421**	0.000	87	0.516**	0.000
4th DL	209	0.554**	0.000	122	0.437**	0.000	87	0.462**	0.000
5th DL	209	0.453**	0.000	122	0.374**	0.000	87	0.317**	0.003

**Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed). PL=Palm length; HB=Hand breath; DL=Digit length; Y=Stature

Table 4: Constant, regression coefficient and Variation explained (R^2) of right hand variables with Y (dependent) variable in both genders

	Constant	Regression coefficient	R^2	*P* value
PL	94.681	3.767	0.372	0.000
HB	119.860	5.045	0.230	0.000
1st DL	144.470	3.571	0.107	0.000
2nd DL	109.659	8.122	0.291	0.000
3rd DL	107.355	7.596	0.313	0.000
4th DL	110.995	7.722	0.306	0.000
5th DL	130.559	6.308	0.205	0.000
2nd DL	98.804	4.250	0.354	0.001
3rd DL		4.850		0.000

PL=Palm length; HB=Hand breath; DL=Digit length; Y=Stature

The Constant, Regression coefficient and Variation explained (R^2) derived for each of the right hand measurements with Y are shown in Table 4, for both genders put together and in Table 5 for females and males respectively. The variation explained ($R^2 \times 100$) showed that it ranges from 10.7% - 37.2% in both genders. For the females, the variation explained ranged from 5.9% - 31.5%. In the males, the variation explained ranged from 8.6% - 36.1%. The variations explained are highly significant.

Table 6 represent the values for R^2, Adjusted R^2, and SEE of the right hand dimensions in both genders together, females and males respectively.

The linear regression model for PL in both genders together was found to be the best model with the highest values for the coefficient of determination R^2 as 0.372, $R^2_{Adjusted}$ as 0.368 and multiple correlation coefficient R as 0.610 with a 7.152 Standard error of estimate (SEE) and this is better than the value gotten for the combination of 2nd DL and 3rd DL using multiple regression.

In the females, no multiple linear regression model was developed but the best simple linear regression model was developed using PL and this has the highest values for the coefficient of determination R^2 as 0.315, $R^2_{Adjusted}$ as 0.309 and multiple correlation coefficient R as 0.561 with a 6.402 SEE.

In the males, a multiple linear regression model was developed which was better than the ones developed using simple linear regression. This very model has the coefficient of determination R^2 as 0.361, $R^2_{Adjusted}$ as 0.346 and multiple correlation coefficient R as 0.610 with 5.9318 SEE; but the best simple linear regression model

Table 5: Constant, regression coefficient and variation explained (R^2) of right hand variables with Y (dependent) variable in females and males

Variables	Females				Males			
	Constant	Regression coefficient	R^2	*P* value	Constant	Regression coefficient	R^2	*P* value
PL	90.970	3.851	0.315	0.000	132.838	2.018	0.184	0.000
HB	136.861	2.912	0.059	0.007	148.198	2.538	0.086	0.007
1st DL					151.765	3.221	0.109	0.002
2nd DL	131.840	4.529	0.084	0.001	125.425	6.498	0.314	0.000
3rd DL	118.704	5.760	0.178	0.000	130.017	5.316	0.266	0.000
4th DL	121.115	5.908	0.191	0.000	134.672	5.121	0.213	0.000
5th DL	137.166	4.569	0.140	0.000	150.752	3.751	0.100	0.003
2nd DL					117.154	4.441	0.361	0.001
3rd DL						2.864		0.016

PL=Palm length; HB=Hand breath; DL=Digit length; Y=Stature

Table 6: R^2, adjusted R^2, and SEE of right upper extremities variables in both genders, 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
PL	0.610	0.372	0.368	7.152	0.561	0.315	0.309	6.402	0.429	0.184	0.174	6.596
HB	0.479	0.230	0.226	8.004	0.244	0.059	0.051	7.474	0.293	0.086	0.075	7.132
1st DL	0.328	0.107	0.103	8.645					0.331	0.109	0.099	6.961
2nd DL	0.540	0.291	0.288	7.680	0.290	0.084	0.077	7.359	0.561	0.314	0.306	6.108
3rd DL	0.559	0.313	0.309	7.585	0.421	0.178	0.171	6.975	0.516	0.266	0.258	6.318
4th DL	0.554	0.306	0.303	7.620	0.437	0.191	0.184	6.917	0.462	0.213	0.204	6.542
5th DL	0.453	0.205	0.201	8.157	0.374	0.140	0.133	7.133	0.317	0.100	0.090	6.996
2nd DL	0.595	0.354	0.348	7.351					0.601	0.361	0.346	5.932
3rd DL												

PL=Palm length; HB=Hand breath; DL=Digit length; SEE=Standard error of estimate

was developed using 2nd DL and this has highest values for the coefficient of determination R^2 as 0.314, $R^2_{Adjusted}$ as 0.306 and multiple correlation coefficient R as 0.561 with a 6.108 SEE.

Using all possible simple and multiple regression analysis, the best multiple linear regression equation for both gender together is Y = 98.804 + 4.250 (2nd DL) +4.850 (3rd DL). For the females the best linear regression equation is Y = 90.970 + 3.851(PL) while the best multiple linear regression equation for the male is Y = 117.154 + 4.441 (2nd DL) +2.864 (3rd DL). Y could as well be estimated using other dimension of the right hand; the regression equations generated are also in Tables 7 and 8.

The mean predicted value of Y through the regression function was similar to the mean observed (actual) value; however the minimum and maximum value indicate that there were differences in the predicted and observed value; the minimum predicted value overestimates the minimum observed value in both genders together, females and males while the maximum predicted value underestimates the maximum observed value in both genders together, females as well as in the males [Tables 9 and 10].

Table 7: Regression equations for estimation of Y in both genders using right hand measurements

Regression equation	±SEE
Y=94.681+3.767 (PL)	7.15215
Y=119.860+5.045 (HB)	8.00361
Y=109.659+8.122 (2nd DL)	7.68038
Y=107.355+7.596 (3rd DL)	7.58488
Y=110.995+7.722 (4th DL)	7.61960
Y=130.559+6.308 (5th DL)	8.15658
Y=98.804+4.250 (2nd DL)+4.850 (3rd DL)	7.35097

PL=Palm length; HB=Hand breath; DL=Digit length; SEE=Standard error of estimate; Y=Stature

DISCUSSION

Seven right hand dimensions including Y of the subjects were taken. The prediction function was derived through linear regression and multiple regressions for each of the measurement with Y, for the general population and for males and females separately.

In this study, the mean Y and age for the population under study is 167.55 ± 9.00 cm and 23.58 ± 4.95 yr respectively. While the minimum and maximum Y

Table 8: Regression equations for estimation of Y in females and males using right hand measurements

Females		Males	
Regression equation	**±SEE**	**Regression equation**	**±SEE**
Y=90.970+3.851 (PL)	6.40202	Y=132.838+2.018(PL)	6.59632
Y=136.861+2.912 (HB)	7.47442	Y=148.198+2.538(HB)	7.13206
Y=131.840+4.529 (2nd DL)	7.35920	Y=15+1.7653.221 (1st DL)	6.96119
Y=118.704+5.760 (3rd DL)	6.97445	Y=125.425+6.498 (2nd DL)	6.10782
Y=121.115+5.908 (4th DL)	6.91690	Y=130.017+5.316 (3rd DL)	6.31839
Y=137.166+4.569 (5th DL)	7.13344	Y=134.672+5.121 (4th DL)	6.54235
		Y=150.752+3.751 (5th DL)	6.99642
		Y=117.154+4.441 (2nd DL)+2.864 (3rd DL)	5.93181

PL=Palm length; HB=Hand breath; DL=Digit length; SEE=Standard error of estimate; Y=Stature

Table 9: Minimum, maximum, mean and standard deviations of the predicted values of Y by regression functions with right hand measurements in both genders

	Minimum	Maximum	Mean	Std. Deviation	N
Observed value	149.00	190.00	167.55	9.10	211
PL	145.53	181.31	167.41	5.49	202
HB	153.16	176.87	167.47	4.36	204
1st DL	155.90	176.97	167.50	2.99	209
2nd DL	155.14	182.75	167.44	4.91	208
3rd DL	151.41	181.80	167.50	5.10	209
4th DL	151.92	180.50	167.50	5.05	209
5th DL	154.53	182.92	167.50	4.14	209
2nd DL	150.73	184.16	167.44	5.41	208
3rd DL					

Y=Stature; PL=Palm length; HB=Hand breath; DL=Digit length

is 149.00 cm and 190.00 cm respectively. The mean Y and age for the female and male subjects are 163.17 ± 7.64 cm, 23.74 ± 5.36 years, and 173.66 ± 7.30 cm and 23.35 ± 4.34 years respectively.

In sexing the right hand parameters, all the variables were highly significant ($P < 0.0001$). These values were higher in the males than in the females.

The estimation of a living Y could be made using the various dimensions of the right hand but differences between populations must be considered before the application of these findings.

The findings of the present study indicate that the correlation r between Y and right hand measurements were significant for PL, HB, 1st DL, 2nd DL, 3rd DL, 4th DL, and 5th DL in both genders put together; the highest correlation r between the dependent variable (Y) and the independent variable, (PL), in both gender was 0.610 ($P < 0.0001$). In the females' right hand, the correlation r between the dependent variable (Y) and the explanatory variables was significant for PL, HB, 1st DL, 2nd DL, 3rd DL, 4th DL, and DL 5th DL. The highest correlation was observed between the dependent variable and (PL), r = 0.561 ($P < 0.0001$) while the least correlation was indicated by (HB), r = 0.244.

In the males, the study revealed that the correlation r between the dependent variable and the explanatory variable of the right hand dimensions (PL, HB, 1st DL, 2nd DL, 3rd DL, 4th DL, and 5th DL) was significant. The highest correlation between the dependent variable and the explanatory variable of right hand was seen in 2nd DL, r = 0.561 ($P < 0.0001$) while the least was 0.293 ($P = 0.07$) as seen in HB.

The correlation obtained in this study for PL has the same significant value ($P < 0.0001$) for hand length in a study conducted by,[17] in which stature estimation was based on hand length and foot length of adults 155 Turks.

This present study shows that the PL either obtained from both gender put together or from the female, is a veritable dimension in estimation of Y of the Igbos because the Pearson's correlation coefficient 'r' obtained was the heights amongst that obtained for the other hand segments (HB, 1st DL, 2nd DL, 3rd DL, 4th, and DL 5th DL).

In support of this finding is the estimation of Y carried out by.[6] The purpose of their study was to analyze the anthropometric relationships between dimensions of the upper extremity and body height. In their study of Turks residing in Istanbul, Turkey, 202 middle class males and 108 middle class females were sampled and variables such as HL, forearm length and upper arm length were measured for analyses. They suggested that the estimation of a living Y could be made using the various dimensions of the upper limb while also stipulating that differences between populations must be considered before the application of their findings.[18] Investigated the relationship between personal Y and HL among a group of male and female of

Table 10: Minimum, maximum, mean and standard deviations of the predicted values of Y by regression functions using right hand measurements in females and males

Observed value	Females					Males				
	Min	Max	Mean	SD	*N*	Min	Max	Mean	SD	*N*
Predicted value	149.00	190.00	163.17	7.64	123	156.00	190.00	173.66	7.30	88
Variables										
PL	149.89	175.69	163.27	4.32	119	160.08	179.25	173.34	3.11	83
HB	156.08	168.02	163.24	1.87	120	167.74	176.88	173.52	2.17	84
1st DL						168.19	178.82	173.63	2.43	87
2nd DL	158.11	170.34	163.13	2.23	122	161.81	183.91	173.55	4.11	86
3rd DL	154.42	172.27	163.13	3.23	122	160.85	182.11	173.63	3.79	87
4th DL	152.43	171.93	163.13	3.35	122	163.86	180.76	173.63	3.39	87
5th DL	157.73	175.10	163.13	2.86	122	165.01	180.76	173.64	2.32	87
2nd DL						158.63	184.74	173.55	4.41	86
3rd DL										

SD=Standard deviation; DL=Digit length; PL=Palm length; HB=Hand breath; Y=Stature

Sri Lankan adults and to derive a linear regression formula between the HL and height of the subjects. The result of the study showed positive correlation between height and HL in both sexes with significant difference. In conclusion, they suggested that HL provides a precise means of estimating the Y of an unknown individual.[16] Studied 200 subjects (150 males and 50 females) aged between 20-30 years from Delhi city. They found that Y could be estimated better with the index finger in both males and females. When we compare our result with their findings, we observed that Y could be estimated better with PL in both gender put together as well as in the females. The 2nd digit was the best to estimate Y in the males but the multiple regression analysis gave a better result when the second and third digits were combined. For the females, the SEE gotten was comparable for all the digits in this study.

The multiplication factor was calculated and the accuracy of the estimated height was checked by comparison with the actual (observed) Y. Similarity of the results indicates that the PL and digit length provides an accurate and reliable means for estimation of Y of mutilated body of an unknown individual.

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