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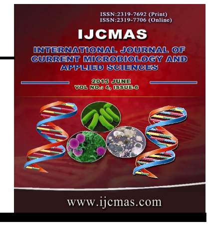

Original Research Article

Height Estimation of the Igbos Using Cephalo-Facial Anthropometry

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A B S T R A C T

Estimation of stature is one of the biological profiles used in the identification of individuals in cases of mass disasters, plane crash, fatal auto crash, bombing, homicides, and in crime investigations. It is an important tool in Medico legal practice. In the present study an attempt has been made to derive regression formulae to determine stature from cephalo-facial dimensions. Informed consent was obtained and measurements were taken following standard protocols. The prediction function was derived through linear regression and multiple regressions for each of the measurement with stature, for the general population and for males and females separately. Cephalo-facial dimensions of 211 subjects females n= 123 and males n= 88 with mean age 23.58± 4.95 belonging to the Igbo population of Nigeria were studied. Eleven cephalo-facial measurements including stature were taken. The mean stature of both genders put together was 167.55±9.10cm while that of females and males were 163.17±7.64cm and 173.66±7.30cm respectively. Males were significantly taller than the females ($p < 0.0001$). Accuracy of determination 'R' of stature from Cephalo-facial dimensions was highest for IOB and EBB in both genders put together; it was also highest using IOB in the females while MFH and MHB yielded that of the males.

Introduction

Cephalo-facial anthropometry has been employed by many authors to estimate stature of the human body (Patil and Mody, 2005; Krishan, 2008; Ryan and Bidmos, 2007), Sahni *et al.* (2010), Chiba and Terazawa (1998), because forensic investigators may be confronted with highly decomposed and mutilated dead bodies with fragmentary remains involving the head (cephalo-facial region). Ilayperuma (2010), investigated the relationship between stature and cranial dimensions in Sri Lanka, and proposed a gender and age specific linear regression model between the cranial dimensions and the height of an individual. There are also reports that odontery and anthropometric data of the skull provide reliable method of estimation of height from skeletal remains in the forensic setup (Kalia *et al.*, 2008).

With the emergence of the importance of stature estimation from body parts as a pointer to determine, the age, sex, stature and race (the "Big Four" of Forensic Anthropology) to which a person belong, and in the dictation of criminals, the present study is designed to estimate stature of the Igbos using cephalo-facial anthropometry.

The Igbo, Pronounced **ee-bo,** are a group of distinguished people who live in the Southeastern Nigeria.

They live in villages, towns and cities scattered over the Eastern part of Nigeria, South of the River Benue and East of River Niger, which is in the rain forest belt of the country (Buchanan and Pugh, 1955).

The Igbos has an area of about 15,800 square mile (about 41,000 square kilometers) between latitude 5º and 7º north and between 6º and 8º east of the Greenwich Meridian. They are bounded to the east by the lands of the Ibibio and the Cross River, to the south by the Ijo speaking people, to the west by the Edo ethnic group and to the north by the Igala and the Idoma speaking people (Nzimiro, 1972; Onwuka, 2002).

Estimation of stature from cephalo-facial measurements (Figure 1-4)

Nine cephalo-facial measurements (serial numbers 1-9 below) of each subject along with their stature (Y) were measured following the conventional methods of Weiner and Lourie (1981), Lohman *et al.* (1988), Hall *et al.* (2003) Krishan and Kumar (2007) plus three other cephalo-facial measurements taken from the ear and mouth.

Cephalo-facial measurements were taken with the help of a sliding caliper and measuring tape to the nearest 0.1cm. Only subjects without any physical body abnormality were included in the study.

1. Stature (S): It measures the greatest distance from the plane where the subjects sands to the vertex (V) on the head using Anthropometer.
2. Morphological Facial Height (MFH): it measures the straight distance from the nasion (N) to the gnathion (Gn).
3. Physiogonomic Facial Height (PFH): it measures the straight distance between trichion (Tr) and gnathion (Gn).
4. Maximum head circumference (MHC): This measures the maximum circumference of the head from the glabella area (usually horizontal just above the eyebrow ridges) to the area near the top of the occipital bone (opisthocranion).
5. Maximum Head length (MHL): measures the straight distance between glabella (the most prominent point on the frontal bone above the root of the nose, between the eyebrows) and the opisthocranion (the most prominent portion of the occiput, close to the midline on the posterior rim of the foramen magnum).
6. Maximum Head breath (MHB): measures the distance between the most lateral points of the parietal bone. It is also called maximum biparietal diameter.
7. Bigonial diameter (BD): it is the maximum breadth of the lower jaw between two gonion points of the mandible. It represents the most posterior, inferior and laterally situated point on the external angles of the mandible.
8. External Biocular Breadth (EBB): it measures the straight distance between

ectocathion (Ec) i.e., outer corners of the eye. It would be measured by using sliding caliper.

9. Inter- Ocular Breadth (IOB): it measures the straight distance between endo-canthion (En).
10. Ear height (EH): The straight distance between the most superior part of the auricle and the most inferior part of the lobule (ear lobe).
11. Ear width (EW): The straight distance between the middle part of the helix and the middle attachment of the tragus to the skin of the face.
12. Distance between the ear and the angle of the mouth (DBE&AM): This measures the distance between the inferior attachment of the ear and the angle of the mouth in cm.

Data presentation and analysis

The data analysis in this present study was carried out using statistical package for social sciences (SPSS 17.0 software).

The Minimum, Maximum, Mean and Standard deviations of the variables are presented.

Paired samples test was performed to check for statistical significant difference between the male's and female's cephalo-facial variables.

Pearson correlation was then applied to test the relationship between stature and cephalo-facial dimensions and the results are presented for the general population (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 with the explanatory variables or repressors'- cephalo-facial dimensions were proposed as a statistical model to explain the total variation (Dawnson and Trapp, 2004). The generated regression formulais 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) x_n($_n$th variable), with this one can calculate stature from cephalo-facial dimensions.

Results and Discussion

The total sample (N=211) for cephalo-facial anthropometry had a mean age of 23.58 ± 4.95 years, a mean height of 167.55 ± 9.10cm. The mean, standard deviation, minimum and maximum value of age, height (Y), and cephalo-facial variables of both genders put together, females and males are shown in table 1; males had higher values than the females.

In the paired samples test between females and males for the cephalo-facial variables, only bigonal diameter (BD) and morphological facial height (MFH) had significant values (p= 0.028, and p= 0.046) at 95% CI respectively, (Table 2). This shows that the mean BD and MFH for the males were significantly larger than that of the females.

The Pearson Correlation coefficients between stature and cephalo-facial variables for both genders put together, females and males is shown in table 3. In both genders put together the External Biocular Breadth (EBB) and Inter- Ocular Breadth (IOB) were positively correlated with height ($P<0.05$;r = 0.150 and r=0.181, respectively).

The linear regression equations derived for the cephalo-facial measurement with stature for both gender indicated that the constant for EBB and IOB was 162.26 and 159.63 respectively. The regression coefficients (0.57 and 2.32) were significant indicating that they are contributing for the prediction of stature. The variation explained (R^2 x 100) showed that EBB contributes 2.2% to stature while IOB contributes 3.3%. The multiple regression equations derived for the cephalo-facial measurement with stature for both gender indicated that the constant for EBB and IBB was 154.828 (Table 4). The regression coefficients were also significant indicating that they are contributing for the prediction of stature. The variation explained (R^2 x 100) showed that multiple regressions for both EBB and IOB contributed 5.3% to stature. The best prediction power was observed in EBB and IOB combined.

The linear regression equations derived for the cephalo-facial measurement with stature for the females indicated that the constant for MFH and IBB was 181.845 and 148.186 respectively. The regression coefficients (-1.327 and 4.541) were significant indicating that they are contributing for the prediction of stature. The variation explained (R^2 x 100) showed that MFH contributes 5.3% to stature while IOB contributes 5.8% (Table 5)

The linear regression equations derived for the cephalo-facial measurement with stature for the males indicated that the constant for MHB and MFH was 152.93 and 158.53 respectively. The regression coefficients (0.93 and 1.02) were significant indicating that they are contributing for the prediction of stature. The variation explained (R^2 x 100) showed that MHB contributes 8.1% to stature while MFH contributes 4.7%. The multiple regression equations derived for the cephalo-facial measurement with stature for males indicated that the constant for MHB and MFH was 137.947. The regression coefficients (0.948 and 1.017) were highly significant indicating that they are contributing for the prediction of stature. The variation explained (R^2 x 100) showed that the multiple regression for both MHB and MFH contribute 12.8% to stature (Table 5).

The mean predicted (estimated) value of stature through the regression function was similar to the mean observed (actual) value (tables 6 and 7). This is because the regression equations were calculated from measures of central tendency; however the minimum and maximum value indicated that there were differences in the predicted and observed value.

Table 8 shows regression equation, for estimation of stature from cephalo-facial measurements in both genders put together, females and males. There are separate equations for positively correlated cephalo-facial measurement which can help in estimation of stature from individual part of the head or face. The regression equations have been calculated by regression analysis, the value of constants ‘a’ and ‘b’ are calculated. ‘a’ is the regression coefficient of the dependant variable, i.e. stature, and ‘b’ is the regression coefficient of the independent variable, i.e. any of the cephalo-facial dimensions. The regression formulae were constructed from cephalo-facial measurement by substituting the appropriate values of constants ‘a’ and ‘b’ in the standard equation of regression line. A multiple regression analysis was also performed with two cephalo-facial parameters (i.e. EBB and IOB) put together for both genders put together.A multiple regression analysis was also performed with two cephalo-facial parameters (i.e. MHB and MFH) put together for the males. Also presented in the table is the standard error of estimate (SEE) and multiple regression coefficients (R). SEE tends to predict the deviation of estimated stature from the actual stature i.e. refers the error that may arise from estimating statureOzaslan et al (2003). A low value denotes greater reliability of prediction from a particular measurement while a higher value shows less reliability of prediction. R (the multiple correlation coefficient value) is one of the measures used for model adequacy. R is defined as the correlation between the observed values and the fitted values for the dependent variable (Dawnson and Trapp 2004).

Eleven cephalo-facial measurements including stature of the subjects were taken. The prediction function was derived through linear regression and multiple regressions for each of the cephalo-facial measurement with stature, for the general population and for males and females separately.

In this study, the mean stature and age for the general population is167.55 ± 9.00cm and 23.58 ± 4.95yrs respectively. While the minimum and maximum stature is 149.00 cm and 190.00 cm respectively. The mean stature and age for the female and male subjects are 163.17 ± 7.64cm, 23.74 ± 5.36 yrs. and 173.66 ± 7.30cm and 23.35 ± 4.34yrs respectively.

In sexing the cephalo-facial parameters, only the bigonal diameter and morphological facial height showed significant difference ($P= 0.028$, $P = 0.046$) respectively. These values were higher in the males than the females.

The findings of the present study indicate that not all the cephalo-facial dimensions are positively and significantly correlated with stature. In this study only EBB and IOB were significantly correlated with stature ($P< 0.05$) in the general population. In the females MFH and IOB were significantly correlated with stature while in the males only MHB and MFH indicated significant correlated with stature ($P<0.05$). The linear regression analysis showed that IOB contributed 3.3% with 8.98 Standard error of estimate (SEE) much to stature than EBB and would be more appropriate to be used in stature estimation for the population. However the multiple regressions constructed had a SEE of 8.91 and contributes 5.3% to stature and would be more ideal to be use in the general population than the linear regression generated. For both the female and male subjects the multiple regressions constructed contributed 9.1% and 12.8% respectively to the variation in stature than the linear regressions.

The SEE for the cephalo-facial measurement ranges between ± 6.95 and ±9.03cm. The highest value of SEE is exhibited by EBB (± 9.03) in the general population using linear regression analysis. The least value of SEE is exhibited by MHB and MFH, (± 6.95cm) of the females by multiple regressions analysis.

The result of this work can be compared with some available studies on different populations. Patil and Mody (2005), in their lateral cephalometric study showed somewhat higher standard errors for most of the parameters except head length that displayed high degree of reliability (SE =3.71).

Table.1 Descriptive statistics of age (years) and various cephalo-facial dimensions (cm) of both genders put together, females and males

VARIABLES	GENDERS PUT TOGETHER					FEMALES					MALES				
	N	**Min**	**Max**	**Mean**	**SD**	**N**	**Min**	**Max**	**Mean**	**SD**	**N**	**Min**	**Max**	**Mean**	**SD**
AGE	211	16	45	23.58	4.95	123	16	45	23.74	5.36	88	18	43	23.35	4.34
STATURE	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
MHC	202	49.00	65.00	56.59	2.75	118	49.00	65.00	56.53	2.93	84	50.00	64.00	56.69	2.48
MHL	201	20.00	59.00	32.07	4.82	117	20.00	59.00	32.07	5.46	84	22.00	38.00	32.07	3.79
MHB	200	15.50	174.00	23.17	11.05	116	15.50	174.00	24.25	14.32	84	16.00	29.00	21.69	2.21
BD	202	5.10	17.30	10.64	1.34	118	5.10	17.30	10.44	1.39	84	5.10	12.90	10.92	1.21
PFH	195	15.00	25.50	19.70	1.97	115	15.00	25.00	19.44	2.12	80	16.00	25.50	20.07	1.69
MFH	203	11.00	22.00	14.34	1.47	119	11.00	22.00	14.08	1.35	84	12.00	20.00	14.71	1.57
EBB	184	3.10	12.80	9.40	2.38	108	3.10	12.00	9.14	2.52	76	3.30	12.80	9.76	2.12
IOB	184	2.20	11.20	3.45	.71	108	2.20	4.80	3.40	.42	76	2.30	11.20	3.52	.99
EH	95	2.85	9.90	5.16	1.26	56	2.85	6.50	5.06	1.17	39	3.20	9.90	5.31	1.39
EW	95	2.80	10.70	5.36	3.00	56	2.80	10.50	5.17	3.02	39	2.90	10.70	5.63	3.00
DB/W E&AM	205	3.40	11.80	8.75	1.68	121	4.50	10.70	8.64	1.48	84	3.40	11.80	8.91	1.92

MHC= maximum head circumference, MHL= maximum head length, MHB= maximum head breadth, BD= bigonal diameter, PFH= physiogonomic facial height, MFH= morphological facial height, EBB= external biocular breadth, IOB=Inter- ocular breadth, EH= ear height, EW= ear width, DB/W E&AM= distance between the ear and the angle of the mouth.

Table.2 Paired Samples test between Males and Females for the Cephalo-facial variables

	Paired Differences							
				95% Confidence Interval of the Difference				
VARIABLES (CM)	**Mean**	**Std. Deviation**	**Std. Error Mean**	**Lower**	**Upper**	**T**	**Df**	**Sig. (2-tailed)**
MHC (F) - MHC (M)	-.22346	4.06190	.45132	-1.12162	.67470	-.495	80	.622
MHL (F) -M H L (M)	.06875	5.98931	.66962	-1.26410	1.40160	.103	79	.918
MHB (F) -M H B (M)	.81538	3.75064	.42468	-.03025	1.66102	1.920	77	.059
BD (F) - B D (M)	-.46160	1.85409	.20601	-.87158	-.05163	-2.241	80	.028
PFH(F) - P F H(M)	-.45867	2.63942	.30477	-1.06594	.14861	-1.505	74	.137
MFH (F) - M FH (M)	-.50000	2.23270	.24656	-.99058	-.00942	-2.028	81	.046
EBB (F) - E BB (M)	-.69106	3.57908	.44055	-1.57091	.18879	-1.569	65	.122
IOB (F) - IO B (M)	-.20682	1.17869	.14509	-.49658	.08294	-1.425	65	.159
EH (F) - EH (M)	-.33611	1.96415	.46295	-1.31286	.64064	-.726	17	.478
EW (F) – EW (M)	-.77222	4.87129	1.14817	-3.19466	1.65021	-.673	17	.510
DB/W E&AM (F) – DB/W E&AM (M)	-.26386	2.51173	.27570	-.81231	.28460	-.957	82	.341

MHC= maximum head circumference, MHL= maximum head length, MHB= maximum head breadth, BD= bigonal diameter, PFH= physiogonomic facial height, MFH= morphological facial height, EBB= external biocular breadth, IOB=Inter- ocular breadth, EH= ear height, EW= ear width, DB/W E&AM= distance between the ear and the angle of the mouth, F= female, M= male.

Variables are significant at $P < 0.05$

Table.3 Pearson Correlation coefficients between stature and cephalo-facial variables for 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)
MHC	202	.035	.623	118	- .087	.351	84	.209	.056
MHL	201	.033	.645	117	- .113	.226	84	.114	.301
MHB	200	.058	.413	116	- .023	.807	84	.285**	.009
BD	202	.028	.696	118	- .411	.127	84	.000	1.000
PFH	195	.083	.249	115	- .122	.194	80	.219	.051
MFH	203	.090	.203	119	- .231*	.012	84	.216*	.048
EBB	184	.150*	.043	108	.141	.144	76	.020	.862
IOB	184	.181*	.014	108	.241*	.012	76	.136	.240
EH	95	.055	.599	56	.069	.615	39	-.085	.605
EW	95	.080	.438	56	- .033	.810	39	.121	.464
DB/W E&AM	205	.054	.439	121	- 0.12	.895	84	.041	.711

MHC= maximum head circumference, MHL= maximum head length, MHB= maximum head breadth, BD= bigonal diameter, PFH= physiogonomic facial height, MFH= morphological facial height, EBB= external biocular breadth, IOB=Inter- ocular breadth, EH= ear height, EW= ear width, DB/W E&AM= distance between the ear and the angle of the mouth.

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table.4 Constant, Regression coefficient and Variation explained (R2) of External Biocular Breath and Inter-Ocular Breath with Stature in both genders

	Constant	Regression Coefficient	R^2	p value
EBB	162.26	0.573	.022	.043
IOB	159.630	2.324	.033	.014
EBB IOB	154.828	.542 2.240	.053	0.052 0.017

EBB= external biocular breadth,IOB=Inter- ocular breadth

Table.5 Constant, regression coefficient and variation explained (R2) of cephalo-facial variables with stature (dependent) variable in females and males

Variables	Females				Males			
	Constant	Regression Coefficient	R^2	p value	Constant	Regression Coefficient	R^2	p value
MFH	181.845	-1.327	.053	.012	158.525	1.015	.047	.048
IOB	148.186	4.541	.058	.012				
MHB					152.927	.947	.081	.009
MHB MFH					137.947	.948 1.017	.128	.007 .040

MFH= morphological facial height, IOB=Inter- ocular breadth, MHB= maximum head breadth

The mean predicted (estimated) value of stature through the regression function was similar to the mean observed (actual) value (tables 6 and 7). This is because the regression equations were calculated from measures of central tendency; however the minimum and maximum value indicated that there were differences in the predicted and observed value.

Table.6 Minimum, Maximum, Mean and standard deviations of the predicted Values of stature by regression functions with the cephalo-facial parameters in both genders

		Minimum	Maximum	Mean	Std. Deviation	N
Observed value		149.00	190.00	167.5460	9.10270	211
Predicted value for:	Variables					
	EBB	164.0324	169.5903	167.6397	1.36250	184
	IOB	164.7437	185.6631	167.6397	1.65187	184
	EBB IOB	161.4365	185.8266	167.6397	2.09424	184

EBB= external biocular breadth, IOB=Inter- ocular breadth.

Table.7 Minimum, Maximum, Mean and standard deviations of the predicted Values of stature by regression functions with the cephalo-facial parameters in females and males

Observed value		**Females**					**Males**				
		Min	Max	Mean	SD	N	Min	Max	Mean	SD	N
		149.00	190.00	163.17	7.64	123	156.00	190.00	173.66	7.30	88
Predicted value for:	Variables										
	MFH	152.65	167.25	163.16	1.79	119	170.71	178.83	173.46	1.59	84
	IOB	158.18	169.98		1.89	108					
	MHB						168.07	180.38	173.46	2.10	84
	MHB MFH						166.33	180.68	173.46	2.63	84

MFH= morphological facial height, IOB=Inter- ocular breadth, MHB= maximum head breadth

Table.8 Regression Equations, R and SEE for estimation of Stature in both genders put together, females and males using cephalo-facial measurement

Regression equation	**R**	**±SEE**
Both Genders		
Stature = 162.256 + .573(EBB)	0.150	±9.03
Stature = 159.630 + 2.324(IOB)	0.181	±8.98
Stature = 154.828 +.542(EBB) +2.240(IOB)	0.230	±8.91
Females		
Stature = 181.845 - 1.327(MFH)	0.231	±7.569
Stature = 148.186 + 4.541(IOB)	0.241	±7.644
Males		
Stature = 152.927 + 0.947(MHB)	0.285	±7.09
Stature = 158.525 + 1.015(MFH)	0.216	±7.23
Stature =137.947 + 0.948(MHB) +1.017(MFH)	0.358	±6.95

R= regression co-efficient, SEE= standard error of estimate, EBB= external biocular breadth, IOB=Inter- ocular breadth, MFH= morphological facial height, MHB= maximum head breadth

Krishan (2008) estimated stature from five cephalofacial measurements and noted a SEE of ± 5.820 for MFH. In our study the SEE for MFH was ± 7.34cm in males but BD did not yield any positive correlation with stature and could not be used to estimate stature in the population under study (Igbo). Krishan and Kumar (2007) were able to estimate stature from sixteen cephalo-facial measurements in a sample of Koli male adolescent of North India and reported a SEE of 4.41-7.21. In our own study eleven cephalo-facial measurements were taken but we were able to regress stature on EBB **(**SEE= ± 9.03), IOB **(**SEE= ± 8.98), in the general population; in the females, stature was regress on MFH (SEE = ± 7.60), IOB (SEE = ± 7.64) while in males stature was estimated using MHB

(SEE = ± 7.09) and MFH (SEE = ± 7.23) only.

Maximum head circumference did not yield any positive correlation with stature in this study and could not be used to estimate stature in the Igbos. However, Krishan (2008) estimated stature using horizontal circumference of the head which he indicated to be the best parameter to estimate stature when compared with other cephalo-facial parameters.

Many of these studies (Patil and Mody 2005), (Krishan and Kumar 2007), (Ryan and Bidmos 2007), Krishan (2008), estimated the stature using linear regression. Our study made attempt to estimate stature from cephalo-facial variables using multiple regressions. The multiple regressions analysis presented lower value of SEE as 8.91 when EBB and IOB is combined in the general population; MFH + IOB = 7.58 in the females, HB + MFH = 6.95 in the males when compared with the values obtained using linear regressions in the present study.

Although some of the SEE obtained (6.95 - 7.58) in this study is in line with the values gotten in the other studies state above but the slight high value of SEE in some of our parameters may be due to genetic, environmental and nutritional factors. However this study has proved that stature could be estimate in the Igbos using some cephalo-facial measurements (MHB, EBB, IOB and MFH). The multiple regressions generated performed better than the simple regressions due to the value of R and SEE obtained.

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