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Research article - Basic and applied anatomy

Stature estimation from cephalometric parameters of young adults in five Nigerian ethnic groups

Dennis E. Eboh*, Patrick S. Igbigbi

Department of Human Anatomy and Cell Biology, Faculty of Basic Medical Sciences, College of Health Sciences, Delta State University, Abraka, Nigeria

Abstract

Various studies across the globe have documented population-specific data on stature estimation from dimensions of the head. This is important in forensic identification. This study was undertaken to formulate regression equations from circumference, length and width of the head, with a view to determining stature. A total of 888 undergraduates from six South-South Nigerian universities, who are of the tribes Ukwuani, Bini, Annang, Izon and Ikwere, were sampled for the study. Body height and three dimensions of the head were measured using standard methods. Results show that the parameters measured were higher in males with significant values than females in most ethnic groups studied ($p<0.05$). There were significant relationship between height and dimensions of the head ($p<0.05$) in most cases. Application of cephalometric parameters as tools in forensic examination is hereby highlighted.

Key words

Anthropology, human identification, stature, head dimensions, ethnic groups.

Introduction

Human variation is an important component of human populations (Ashok, 2006). This may be attributable to mutation, natural selection, hybridization, and geographic, environmental or genetic factors (Ashok, 2006). Human identification becomes necessary because of this variation since everyone possesses distinct features unique to the individual. Identification can be by gender, age, ethnicity or ancestry, and stature. It can also be by fingerprints, lip prints, and some other factors (Mutalik et al., 2013).

Estimation of stature or height in standing position is carried out as one of the processes in building the biological profile to reduce the number of missing individuals and increase the chances of individual identification. It used to be the practice in stature estimation, to articulate the entire skeleton and make direct measurements (Stewart, 1979). Nowadays, the regression analysis methods, 'based on a mathematical relationship between bone dimensions and stature' are commonest (Iscan, 2005). A forensic anthropological problem may exist if no data native to a people is available for human identification. When isolated head alone is found, and stature is the most sought data, the population-specific equations derived from this study will serve as useful tools to obviate the problem.

* Corresponding author. E-mail: deeboh@delsu.edu.ng; drebohdennis@gmail.com

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A handful of studies utilizing cephalometric dimensions for stature estimation in adults exist in Nigeria (Ukoha et al., 2015, Ekezie et al., 2015;) and other parts of the globe (Jadav and Shah, 2004; Agnihotri et al., 2011; Singh, 2013; Mansur et al., 2014; Chourasia et al., 2014).

This study is aimed at documenting gender and ethnic specific model formulae from dimensions of the head, for stature prediction in adults of five South-South Nigerian ethnic groups. This will provide the forensic, anthropological and archeological clues where the total height of a subject needs to be calculated from known cranial dimensions.

Materials and methods

The study population of this descriptive anthropometric study comprised undergraduate students, aged between 18 and 30 years inclusive, belonging to the Ukwuani, Bini, Annang, Izon and Ikwere ethnic groups, in six Nigerian universities. The ethnicity of subjects was confirmed from the registers of the five ethnic groups sampled for the study in the respective Universities.

The five ethnic groups were sampled through balloting from the sampling frame. Six Universities, evenly spread across the six states of the zone, were sampled. Eight hundred and eighty-eight (888) subjects completed the study, using the stratified type of sampling. Family pedigree study was ascertained to authenticate ethnic origin. Subjects with features suggestive of developmental, traumatic or metabolic disease were excluded from the study.

This study used primary data that were collected at the respective sampled Universities. Method of measurements of the cephalometric parameters and body height, were in line with institutional research guidelines, and international best practices (WMA, 2008).

The circumference of the head was measured as 'maximal fronto-occipital circumference, with the non-stretchable plastic tape' (Eboh, 2016, Kalia et al., 2008). The length of the head was measured as the glabella-opisthocranion linear distance (Eboh, 2016). The width of the head was measured as the maximum linear biparietal diameter (Eboh, 2016). Length and width of the head were measured with a spreading caliper (ORION, Japan). Stature was measured with an anthropometer, with the subject standing upright barefooted, and head positioned in the Frankfurt's plane

The data obtained were analyzed using the IBM SPSS software 20. Comparisons were made between the measurements recorded with respect to gender using statistical means, standard deviations, ranges and independent sample t-test. Linear regression analysis between standing height and the head parameters recorded was carried out. P value < 0.05 was considered statistically significant.

Results

The contributions of the ethnic groups to the sample size in descending order are: the Annang, Bini, Ikwere, Izon and Ukwuani.

Tables 1-5 show the results for the parameters measured in males and females. Table 1 shows males had higher standing height, head circumference and length than females among the Annang. Also, the mean head width was higher in females than males, but the difference was statistically not significant. Tables 2, 3, 4 and 5 showed

Table 1 – Comparison of the parameters measured between gender in the Annang (N=107 males and 100 females).

Dimension	Sex	Range	Mean	SD [a]	t	Df	p-value
SH (cm)	Male	156.00 - 180.00	168.62	5.51	6.65	205	0.001
	Female	155.00 - 174.00	163.82	4.82			
	Total	155.00 - 180.00	166.30	5.71	-	-	-
HC(cm)	Male	53.00 - 57.80	55.12	1.02	3.29		0.001
	Female	52.90 - 56.30	54.72	0.67			
	Total	52.90 - 57.80	54.93	0.89	-	-	-
HL (cm)	Male	18.10 - 20.60	19.04	0.61	2.75	205	0.006
	Female	17.80 - 19.80	18.83	0.50			
	Total	17.80 - 20.60	18.94	0.57	-	-	-
HW(cm)	Male	13.10 - 15.90	14.65	0.63	-1.56	205	0.121
	Female	13.90 - 15.80	14.78	0.52			
	Total	13.10 - 15.90	14.72	0.58	-	-	-

SH = height; HC = head circumference; HL = head length; HW = head width; [a] Standard deviation.

Table 2 – Comparison of the parameters measured between gender in the Bini (N=93 males and 112 females).

Dimension	Sex	Range	Mean	SD [a]	t	Df	p-value
SH (cm)	Male	157.20 - 188.00	172.03	7.69	11.23	203	0.001
	Female	151.40 - 177.40	161.64	5.52			
	Total	151.40 - 188.00	166.35	8.37	-	-	-
HC(cm)	Male	51.40 - 59.70	55.56	1.79	8.06	203	0.001
	Female	49.50 - 57.50	53.55	1.75			
	Total	49.50 - 59.70	54.46	2.03	-	-	-
HL (cm)	Male	16.00 - 20.80	18.79	0.86	6.36	203	0.001
	Female	16.10 - 19.70	18.08	0.76			
	Total	16.00 - 20.80	18.40	0.88	-	-	-
HW(cm)	Male	13.20 - 18.90	14.94	1.10	6.39	203	0.001
	Female	13.00 - 15.60	14.18	0.55			
	Total	13.00 - 18.90	14.53	0.93	-	-	-

SH = height; HC = head circumference; HL = head length; HW = head width; [a] Standard deviation.

males had significant higher mean (SD) height and all head dimensions measured than females among the Bini, Ikwere, Izon and Ukwuani respectively.

Table 6 shows results of regression analysis between body height and head circumference in the five ethnic groups. Correlation between head circumference and height was significant in all groups, except the Ukwuani males. Female and the total

Table 3 – Comparison of the parameters measured between gender in the Ikwere (N=89 males and 88 females).

Dimension	Sex	Range	Mean	SD [a]	t	Df	p-value
SH (cm)	Male	148.40 - 188.00	169.02	7.19	5.82	175	0.001
	Female	147.00 - 175.00	163.45	5.41			
	Total	147.00 - 188.00	166.25	6.94	-	-	-
HC(cm)	Male	51.90 - 59.50	55.73	1.45	5.52	175	0.001
	Female	49.90 - 64.58	54.02	2.55			
	Total	49.90 - 64.58	54.88	2.24	-	-	-
HL (cm)	Male	17.00 - 19.98	18.86	0.69	5.56	175	0.001
	Female	17.20 - 19.50	18.31	0.61			
	Total	17.00 - 19.98	18.59	0.71	-	-	-
HW(cm)	Male	13.40 - 18.50	15.21	0.65	6.19	175	0.001
	Female	13.60 - 15.80	14.64	0.57			
	Total	13.40 - 18.50	14.93	0.67	-	-	-

SH = height; HC = head circumference; HL = head length; HW = head width; [a] Standard deviation.

Table 4 – Comparison of the parameters measured between gender in the Izon (N=84 males and 83 females).

Dimension	Sex	Range	Mean	SD [a]	t	Df	p-value
SH (cm)	Male	160.00 -178.00	169.86	4.96	6.83	165	0.001
	Female	160.00 -175.00	164.84	4.51			
	Total	160.00 - 178.00	167.37	5.35	-	-	-
HC(cm)	Male	52.93 - 57.08	55.72	1.07	3.47	165	0.001
	Female	50.93 - 64.58	54.56	2.87			
	Total	50.93 - 64.58	55.14	2.23	-	-	-
HL (cm)	Male	17.43 - 19.98	18.99	0.68	6.06	165	0.001
	Female	17.43 - 19.48	18.39	0.61			
	Total	17.43 - 19.98	18.69	0.71	-	-	-
HW(cm)	Male	14.43 - 16.08	15.18	0.36	6.18	165	0.001
	Female	13.93 - 15.58	14.77	0.49			
	Total	13.93 - 16. 08	14.98	0.47	-	-	-

SH = height; HC = head circumference; HL = head length; HW = head width; [a] Standard deviation.

Table 5 – Comparison of the parameters measured between gender in the Ukwuani (N=69 males and 63 females).

Dimension	Sex	Range	Mean	SD [a]	t	Df	p-value
SH (cm)	Male	157.00 - 186.20	173.09	7.29	8.51	130	0.001
	Female	149.00 - 173.40	162.33	7.24			
	Total	149.00 - 186.20	167.95	9.03	-	-	-
HC(cm)	Male	51.00 - 62.00	55.98	1.99	8.89	130	0.001
	Female	50.30 - 55.50	53.19	1.57			
	Total	50.30 - 62.00	54.65	2.27	-	-	-
HL (cm)	Male	17.80 - 21.40	19.28	0.77	8.92	130	0.001
	Female	16.80 - 19.60	18.14	0.70			
	Total	16.80 - 21.40	18.73	0.93	-	-	-
HW(cm)	Male	14.20 - 16.70	15.22	0.55	2.88	130	0.001
	Female	13.10 - 18.00	14.69	1.41			
	Total	13.10 - 18.00	14.96	1.08	-	-	-

SH = height; HC = head circumference; HL = head length; HW = head width; [a] Standard deviation.

Table 6 – Correlation between stature and head circumference in males, females and the total population in all the ethnic groups.

Ethnic group	Sex	Correlation coefficient	R-Square	SEE[b]	Constant	Slope	p-value
Annang	Total	0.47**	0.22	5.06	2.59	2.98	0.001
	Male	0.39**	0.15	5.10	52.20	2.11	0.001
	Female	0.49**	0.24	4.24	-25.83	3.47	0.001
Bini	Total	0.47**	0.22	7.40	60.04	1.95	0.001
	Male	0.29**	0.08	7.41	104.24	1.22	0.006
	Female	0.21**	0.04	5.43	126.54	0.66	0.028
Ikwere	Total	0.48**	0.23	6.11	85.18	1.48	0.001
	Male	0.31**	0.10	6.88	83.60	1.53	0.003
	Female	0.50**	0.25	4.72	106.56	1.05	0.001
Izon	Total	0.43**	0.18	4.85	110.65	1.03	0.001
	Male	0.34**	0.12	4.69	81.99	1.58	0.002
	Female	0.43**	0.19	4.09	127.84	0.68	0.001
Ukwuani	Total	0.51**	0.26	7.79	56.98	2.02	0.001
	Male	0.21	0.04	5.18	129.89	0.77	0.083
	Female	0.26**	0.07	7.06	99.88	1.17	0.044

** Significant; [b] Standard error of estimates.

Table 7 – Formulae for stature (S; cm) estimation using head circumference (C; cm) in all the ethnic groups.

Ethnicity	Sex	Equation
Annang	Total	S = 2.59 + 2.98C
	Male	S = 52.20 + 2.11 C
	Female	S = -25.83 +3.47 C
Bini	Total	S = 60.04 + 1.95 C
	Male	S = 104.24 + 1.22 C
	Female	S = 126.54 + 0.66 C
Ikwere	Total	S = 85.18 +1.48 C
	Male	S = 83.60 + 1.53 C
	Female	S = 106.56 +1.05 C
Izon	Total	S = 110.65 + 1.03 C
	Male	S = 81.99 + 1.58 C
	Female	S = 127.83 + 0.68 C
Ukwuani	Total	S = 56.98 + 2.02 C
	Male	S = 129.89 + 0.77 C
	Female	S= 99.88 + 1.17 C

Table 8 – Correlation between stature and head length (L; cm) in males, females and the total population in all the ethnic groups.

Ethnic group	Sex	Correlation coefficient	R Square	SEE [b]	Constant	Slope	p-value
Annang	Total	0.40**	0.16	5.24	89.70	4.04	0.001
	Male	0.36**	0.13	5.17	106.42	3.27	0.001
	Female	0.36**	0.13	4.52	97.54	3.52	0.001
Bini	Total	0.41**	0.17	7.65	94.16	3.93	0.001
	Male	0.10	0.10	7.69	155.49	0.88	0.349
	Female	0.38**	0.15	5.12	110.79	2.81	0.001
Ikwere	Total	0.46**	0.21	6.18	82.71	4.50	0.001
	Male	0.33**	0.11	6.87	104.52	3.42	0.002
	Female	0.40**	0.16	4.97	97.87	3.58	0.001
Izon	Total	0.54**	0.29	4.53	91.63	4.05	0.001
	Male	0.50**	0.25	4.32	100.26	3.66	0.001
	Female	0.32**	0.11	4.29	120.68	2.40	0.003
Ukwuani	Total	0.32**	0.10	8.60	110.34	3.08	0.001
	Male	0.29**	0.08	7.04	121.04	2.70	0.017
	Female	0.53**	0.28	6.19	262.21	-5.51	0.001

** Significant; [b] Standard error of the estimate.

Table 9 – Regression formulae for stature (S; cm) estimation using head length (L; cm) in all the ethnic groups.

Ethnic group	Sex	Equation
Annang	Total	S = 89.70 + 4.04 L
	Male	S =106.42 + 3.27L
	Female	S = 97.54 + 3.52L
Bini	Total	S = 94.16 + 3.92 L
	Male	S = 155.49 + 0.88L
	Female	S = 110.79 + 2.81 L
Ikwere	Total	S = 82.71+ 4.50 L
	Male	S = 104.52 + 3.42L
	Female	S = 97.87 + 3.58 L
Izon	Total	S = 91.63 + 4.05 L
	Male	S = 100.26 + 3.66 L
	Female	S = 120.68 + 2.40 L
Ukwuani	Total	S = 110.34 + 3.08 L
	Male	S = 121.04 + 2.70 L
	Female	S = 262.21 + -5.51 L

Table 10 – Correlation between stature and head width (W; cm) in males, females and the total population in all the ethnic groups.

Ethnic group	Sex	Correlation coefficient	R Square	SEE [b]	Constant	Slope	p-value
Annang	Total	0.08	0.01	5.71	154.84	0.78	0.254
	Male	0.16	0.03	5.47	147.74	1.43	0.093
	Female	0.10	0.01	4.82	149.83	0.95	0.309
Bini	Total	0.26**	0.07	8.11	132.57	2.33	0.001
	Male	0.12	0.01	7.68	183.99	-0.80	0.273
	Female	0.28**	0.08	5.32	121.18	-2.85	0.002
Ikwere	Total	0.45**	0.20	6.22	97.47	4.61	0.001
	Male	0.18	0.03	7.12	139.30	1.95	0.097
	Female	0.58**	0.33	4.44	82.76	5.51	0.001
Izon	Total	0.48**	0.23	4.70	85.18	5.49	0.001
	Male	0.14	0.02	4.94	140.67	1.92	0.211
	Female	0.54**	0.29	3.82	91.28	4.98	0.001
Ukwuani	Total	0.11	0.01	9.01	154.69	0.89	0.227
	Male	0.06	0.00	7.33	185.59	-0.82	0.614
	Female	0.06	0.00	7.29	166.52	-0.29	0.666

** Significant

Table 11 – Formulae for stature estimation (S; cm) using head width (W; cm) in all the ethnic groups.

Ethnicity	Sex	Equation
Annang	Total	S = 154.84 + 0.78 W
	Male	S = 147.74 + 1.43 W
	Female	S = 149.83 + 0.95 W
Bini	Total	S = 132.57 + 2.33W
	Male	S = 183.99 - 0.80W
	Female	S = 121.18 - 2.85W
Ikwere	Total	S = 97.47 + 4.61 W
	Male	S = 139.30 + 1.95 W
	Female	S = 82.76 + 5.51W
Izon	Total	S = 85.18 + 5.49 W
	Male	S = 140.67 + 1.92 W
	Female	S = 91.28 + 4.98 W
Ukwuani	Total	S = 154.69 + 0.89 W
	Male	S = 185.59 - 0.82 W
	Female	S = 166.52 - 0.29 W

data of the Ikwere and Ukwuani had the strongest relationship. Stature estimation equations from head circumference in the five ethnic groups are shown in table 7.

Table 8 shows results of regression analysis between body height and head length in all the five ethnic groups. Except for Bini males, correlation between body height and head length was statistically significant. The strongest relationship was observed in males among the Izon. Table 9 shows stature estimation formulae from head length in the five ethnic groups.

Table 10 shows results of regression analysis between body height and head width in the five ethnic groups. The strongest relationship was observed in female data in the Ikwere. Table 11 shows stature estimation formulae using head width.

Discussion

A notable feature in the present study was that the mean values of stature were very close to one another across the five ethnic groups. This may be due to their closeness in the same geographic and environmental locations. This was in tandem with previous reports which state that if peoples are in the same geographic and environmental area they share genetic background, and average heights may be characteristic of the area (Preece, 1996; Silventoinen et al., 2000).

The mean height in males was higher than females and the difference was statistically significant. The association of Y chromosome with stature and the age of puberty being two years later in males, giving extra time for growth (Yamada et al., 1981), may explain the reason why males were taller than females. Similar results were

reported by Didia et al. (2009), Adefolaju et al. (2006), Danborno et al. (2009, Egwu et al. (2012), Ebite et al. (2008), Ilayperuma et al. (2009).

The significantly larger head circumference in males compared with females was similar to the results of Oladipo et al., (2010), Maina et al. (2011) and Esomonu et al.(2012). The length of the head in the present study was similar to that of Maina et al. (2011) and Ilayperuma (2010), but higher than values reported for Bangladeshi by Akhter et al. (2012).

On head width, our results were similar to a previous study which reported wider head in males than in females (Maina et al., 2011). However, the results of the present study were slightly higher than in a similar study by Ilayperuma (2010) in Sri Lanka. Discrepancies observed in the dimensions of the head in the present study with other comparable studies may be attributed to environmental, nutritional, geographic and genetic factors.

In this study, head circumference showed positive and significant correlation with stature except among males of Ukwuani ethnic group. Chiba et al. (1998) found correlation between head circumference and stature as not statistically significant. Krishan (2008) however found that head circumference correlated significantly with stature. Furthermore, Kalia et al. (2008) observed that only the combined data showed statistically significant correlation with stature. Ukoha et al. (2015) and Mansur et al. (2014) observed significant positive correlation in both genders; in addition Mansur et al. (2014) observed combined data gave a correlation of 0.40 which was also positive. Nemade et al. (2015) reported significant positive correlation in male, female and total data. Ekezie et al. (2015) observed a correlation between head circumference and body height that was not significant, while Kumar and Gopichand (2013) observed significant correlation.

Considering head length, Krishan (2008) observed that head length measurement correlated significantly with stature. Krishan et al. (2007) also reported similar results. Kalia et al. (2008) observed that females showed no correlation, while males showed poor correlation and only the total data showed correlation between length of the head and stature which were statistically significant. Chiba et al. (1998) observed that females had a lower correlation coefficient between length of the head and stature compared to males. Introna et al. (1993) showed correlation coefficients were low. In a similar study, Chiba et al. (1998) found no significant correlation between length of the head and stature, while Singh (2013) and Jadav and Shah (2014) reported significant positive correlation. Ukoha et al. (2015) observed positive correlation which was also significant in both gender. Agnihotri et al. (2011) observed that males had correlation that was significant when compared with females. Kumar and Gopichand (2013) observed that correlation between height and length of the head was significant. Nemade et al. (2015) reported significant positive correlation in males, females and the total data. Wankhede et al.(2015) observed correlation between height and head length in both males and females which was also significant. Ekezie et al. (2015) observed that correlations between length of the head and body height were not significant among all data. Chourasia et al. (2014) reported that correlation between the body heights and lengths of the head were significant in both gender. The variable results between the present and some of the previous studies may be due to genetic, geographic or environmental factors that affect humans.

Across the five ethnic groups, head width showed positive and statistically significant correlation with stature except those of Annang, Ukwuani and males of Bini,

Ikwere and Izon ethnic groups. This may be as result of genetic and nutritional factors in the respective ethnic groups. In a similar study, Sarangi et al. (1981) found that correlation between the width of the head and stature was not statistically significant. In a similar study, Krishan (2008) found that head width correlated significantly with stature, while Ukoha et al. (2015) observed that there was statistical significant correlation in females, but not in males. However, Agnihotri et al. (2011) showed that both gender did not show significant correlation. Kumar and Gopichand (2013) also observed that correlation between body height and width of the head was not significant, while Nemade et al. (2015) reported significant positive correlation in males, females and all subjects together. In a similar study, Wankhede et al. (2015) observed that there was no significant correlation between body height and head width in males but there was a significant one in females. Ekezie et al. (2015) on the other hand, reported significant correlations in males.

The total variation in the dependent variable explained by the respective independent variables (R square) is in general, very low. The highest was observed in females among the Ikwere. Surprisingly, most similar studies did not report R Square. Ekezie et al (2015) also reported very low R square value between stature and width of the head in females.

Prediction of the deviation of the estimated stature from the actual stature (standard error of estimate, i.e. SEE) in the present research can be compared with similar available studies on different populations across the globe. Ukoha et al. (2015) reported higher values for the head dimensions. Krishan (2008) reported similar values for these parameters. Krishan et al. (2007), Richards (2011) and Ryan and Bidmos (2007) reported variable values for all cranial measurements. It has been opined that homogeneous sample may give rise to high reliability of estimate against exogamous or mixed population (Krishan, 2008).

The present study has shown that the linear regression equations for combined, male and female data are ethnic group or population specific, and therefore cannot be used on other populations. Attempt to combine the data for compound regression models did not improve the outcome.

In conclusion, the study showed that males have significant higher values of parameters measured than females in the majority of ethnic groups studied. Hence cephalometric parameters, to a reasonable extent, show an acceptable reliability in estimating stature, except in situations where relationships were not statistically significant. This study has therefore provided regression formulae for estimation of stature from some cephalometric parameters in five ethnic groups sampled in south-south Nigeria, hence cephalometric parameters can be used as important tools in forensic examination as they provide elements of accuracy in the field of forensic anthropology.

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