Asian Journal of Medical Principles and Clinical Practice

Volume 7, Issue 2, Page 482-489, 2024; Article no.AJMPCP.126306

Stature and Sex Estimation Using Some Linear Anthropometric Parameters: A Cross-Sectional Study of the Igbo Ethnic Group of Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/126306

Original Research Article

Received: 04/09/2024
Accepted: 06/11/2024
Published: 25/11/2024

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Cite as: *H. B, Fawehinmi, Oghenemavwe L. E, Okoh P. D, David L. K, Amadi M. A, Chile A. Oparaocha C. A, Ebieto C. E, Irozulike F.C, and Asiwe N. 2024. "Stature and Sex Estimation Using Some Linear Anthropometric Parameters: A Cross-Sectional Study of the Igbo Ethnic Group of Nigeria". Asian Journal of Medical Principles and Clinical Practice 7 (2):482-89. https://journalajmpcp.com/index.php/AJMPCP/article/view/257.*

ABSTRACT

Background: Forensic anthropology's core focus is identifying biological traits like sex, age, and height. This expertise is useful in several fields, including forensic science, anthropology, archaeology, and medical research. The study aims to formulate stature predictive models using shoulder breadth, sitting shoulder height, and knee height amongst the Igbo ethnic group of Nigeria.
Method: A total of 400 subjects, (200 females and 200 males) between the ages of 18-40 years were recruited for the study. Standardized anthropometric techniques were used to measure the shoulder breadth, sitting shoulder height, and sitting knee height. Data analysis used an International Business Machine Statistical Package for Social Sciences (IBM SPSS) version 23. Discriminant and multivariate regression were used to estimate sex and stature. A probability less than 0.05 ($p<0.05$) was considered statistically significant and 95% was denoted as confidence level.
Result: The study shows that males have significantly higher anthropometric values than females. The multivariate regression among the sexes to estimate stature using shoulder breadth, sitting shoulder height, and sitting knee height shows ($R=0.59$, $SEE= 6.81$), the stature predictive power of male was ($R= 0.44$, $SEE=6.27$) and the female stature ($R= 0.27$, $SEE=5 .75$). The estimation for sex shows overall significance ($X^2=261.15$, $ƛ= 0.51$, $p<0.05$).
Conclusion: The study evaluated the sexual dimorphism of shoulder breadth, sitting shoulder height, and sitting knee height, which shows that males are significantly higher in anthropometric values than females and also the anthropometric parameters were good predictors of the sexes.

Keywords: Forensic anthropology; igbo; medical research; stature prediction; sex.

1. INTRODUCTION

Anthropometry is the scientific study of the measurements and proportions of the human body. It has been a fundamental tool in various disciplines, including physical anthropology, forensic science, ergonomics, and human biology [1]. Among its many applications, estimating stature and sex from specific body measurements holds significant importance, especially in identifying individuals from skeletal remains. However, dead bodies might be unidentified, particularly in a mass calamity such as mass accidents, terror attacks, earthquakes, building collapses, plane crashes, and wars [2].

Stature is an important anthropological parameter, as it provides valuable insights into the physical characteristics of a population [3]. However, it plays a big role in an individual's identification in medico-legal scenarios, industrial design of fittings for the human body, furniture manufacturing, etc. Some conditions may hinder the direct measurement of stature like spinal and limb deformities, amputations, fractures, scoliosis, paralysis, and pain; in these cases, body segments are used for estimating the standing of an individual [4]. Consequently, several studies have studied a range of body components to predict an individual's stature, including arm span, foot length, hand length, sitting height, and tibia length.

Yeasmin et al., [5] found out that in their study on the stature and sex estimation from shoulder breadth, shoulder height, popliteal height, and knee height measurements in a Bangladeshi population there is a good correlation between the stature and shoulder height, popliteal height, and knee height and which examined a good body dimension leading to higher accuracy in stature estimation. Özer et al., [6] studied the estimation of stature in Turkish adults using knee height, indicating that knee height showed a high accuracy with stature. A good correlation was observed by Bhatnagar et al., [7] in estimating stature among healthcare workers using arm span, bi-acromial breadth, and forearm length dimensions in Himachal Pradesh.

The Igbo people are one of the largest and most influential ethnic groups in Nigeria, predominantly inhabiting the southeastern part of the country. They are known for their rich cultural heritage, entrepreneurial spirit, and significant contributions to Nigeria's socio-economic landscape [8]. Although, previous anthropometric studies have primarily focused on Western populations, with limited data available for African ethnic groups, including the Igbo. Although several researches have been conducted on Nigerian populations on arm span [9], arm length [10], foot length [11], and tibial length [12] there is a need for more comprehensive studies that include diverse

measurements and larger sample sizes. Moreover, some existing literature often overlooks the importance of alternative measurements like shoulder breadth, sitting hip breadth, sitting shoulder height, and knee height, therefore this research will focus on stature and sex estimation from shoulder breadth, sitting shoulder height and sitting knee height of Igbo ethnic group.

2. MATERIALS AND METHODS

2.1 Study Design

The anthropometry of the Igbo people in Nigeria, including shoulder breadth, sitting shoulder height, and knee height, was measured using a cross-sectional descriptive research approach. For the six-month study period (January 2024 to June 2024), four hundred people between the ages of 18 and 40 years made up the study population (200 males and 200 females). Owerri town in Imo State, Nigeria was used as a study frame and the subjects were selected impartially using a multi-stage random proportionate sampling approach. The Taro Yamane formula was used to determine the minimal sample size.

2.2 Selection Criteria

2.2.1 Inclusion criteria

Only participants whose parents and grandparents are of Igbo descent were selected for the study, and they had no medical history or trauma that may have affected the studied human morphology or stature. The study also recruited subjects who consented to participate and whose ages ranged from 18 to 40 years to ensure that there were no hard tissue changes or development observed.

2.2.2 Exclusion criteria

Subjects who were not of Igbo descent did not fit the study's age criteria, underwent surgery, or had abnormalities that would have affected their studied human morphology or standing height were excluded from the study.

2.3 Method of Data Collection

A semi-constructive descriptive questionnaire and a personal interview were used to gather the sociodemographic data for the Igbo of Nigeria. This ensured that the subjects met the inclusion criteria and were fit to participate in the study. The shoulder breadth, sitting shoulder height, and knee height were measured using a mega-size calliper, adopting the appropriate anatomical landmarks. The standing height was measured from the vertex of the head to the sole in an upright position using a ZT-160 Goodcare stadiometer. Data readings were recorded and preserved by the authors.

2.3.1 Anthropometric landmarks

The study employed some anthropometric variable measures (stature, shoulder breadth, sitting shoulder height, and knee height), and the method of measurement of these variables is defined as follows.

2.3.2 Stature

This was measured with a ZT-160 Goodcare stadiometer. The participants stood erect and barefoot on the stadiometer's level platform, with the back of their heads, shoulder blades, buttocks, and heels touching the bar. Participants were advised to relax with their arms by their sides. Care was taken to avoid sagging.

2.3.3 Shoulder breadth

This was measured using a mega-size calliper. Shoulder breadth was measured as the horizontal length from the left to the right acromial process of the shoulders.

2.3.4 Sitting shoulder height

Sitting shoulder height was measured as the vertical distance from the top of the shoulder's acromion process to the participant's sitting surface and it was measured with a mega-size calliper

2.3.5 Sitting knee height

Sitting knee height was measured in the sitting posture as the vertical distance from the top of the knee-cap to the foot resting surface while the knee flexed at 90◦ angles and it was measured with a mega-size calliper.

2.4 Method of Data Analysis

Data obtained were subjected to statistical analysis using the International Business Machine of Statistical Package for Social Science (IBM version 25). The results obtained were presented in the table as mean ± standard deviation. T-test was used as an inferential statistic to evaluate sexual and asymmetry differences. Discriminant and linear regression were used to estimate sex and stature. A

probability less than 0.05 ($p<0.05$) was considered statistically significant and 95% was denoted as confidence level.

3. RESULTS

The present study comprised four hundred subjects of Igbo origin who were 18-40 years of age. The descriptive comparison between the subjects showed that all participants had an average stature of 171.05±8.41cm, shoulder breadth of 39.47±5.05cm, sitting shoulder height of 54.13±3.77cm, and sitting knee height of 57.36±4.88cm respectively (Table 1), The inference has shown that there were sexual differences in stature, shoulder breadth, sitting shoulder height, sitting knee height (Table 2). Table 3, shows the multivariate regression analysis for all subjects on stature estimation using stature, shoulder breadth sitting shoulder height, and sitting knee height in Igbos was statistically significant across the parameters, from the Collinearity Statistics Variance Inflation Factor (VIF) have shown that the parameters Stature, Shoulder Breadth, Sitting Shoulder Height and Sitting Knee Height (S, SB, SSH and SKH) are good predictors for stature (VIF<2). The standard error of estimation has shown the accuracy of the prediction (SEE< 1). Table 4 displays multivariate regression analysis for males which shows that it has a strong significant value ($p<0.05$) to stature estimation in males and its accuracy of the prediction across the parameters was observed to be high (SEE<1) and it equally shows that the collinearity of the parameters further indicated that the parameters are good predictors of stature (VIF<2). Table 5, among the females, our results present a similar finding to the males showing that the overall prediction was significant ($p<0.05$) with a high level of accuracy (SEE<1) of the parameters to stature estimation. However, the collinearity of the parameters to stature estimation has shown that the parameters are good predictors for stature (VIF<2). Table 6, a summary of multivariate regression of stature estimation among all subjects shows the correlation coefficient (R=0.59, SEE= 6.81) with a standard error of estimate. Comparison between the males and the females has shown that the male has a better prediction of stature (R= 0.44, SEE=6.27) than the female's stature (R= 0.27, SEE=5 .75).

Table 1. Descriptive statistics of the stature, sitting shoulder height, sitting knee height, and shoulder breadth in igbo subjects

Parameters	N	Minimum	Maximum	Mean	Std. Deviation
S (cm)	400	150.50	202.00	171.0585	8.41659
SB (cm)	400	6.40	82.90	39.4770	5.05064
SSH (cm)	400	42.00	84.00	54.1335	3.77041
SKH (cm)	400	17.60	88.40	57.3675	4.88387

S= Stature, SSH= Sitting Shoulder height, SKH=Sitting Knee Height, SB= Shoulder Breadth

Table 2. Sexual differences of stature, sitting shoulder height, sitting knee height, and shoulder breadth in igbo subjects

Parameters	Male	Female	T-test	P-value	Inference
Stature (cm)	176.46±6.94	165.65±5.92	-16.733	0.00	S
SB (cm)	40.75±3.41	38.19±6.01	-5.229	0.00	S
SSH (cm)	56.26±3.67	52.00±2.43	-13.684	0.00	S
SKH (cm)	59.15±4.36	55.57±4.72	-7.868	0.00	S

S= Stature, SSH= Sitting Shoulder height, SKH=Sitting Knee Height, SB= Shoulder Breadth, S=Significant

Table 3. Multivariate regression of stature estimation in all subjects

Model	Unstandardized Coefficients		Standardized Coefficient	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(constant)	88.56	5.76		15.38	0.000*		
SSH (cm)	0.276	0.074	0.160	3.708	0.000*	.882	1.134
SKH (cm)	1.003	0.097	0.449	10.289	0.000*	.862	1.160
SB (cm)	0.312	0.081	0.164	3.863	0.00*	.915	1.092

*S= Stature, SSH= Sitting Shoulder height, SKH=Sitting Knee Height, SB= Shoulder Breadth, *= Significant*

Table 4. Multivariate regression of stature estimation in male subjects

Model	Unstandardized Coefficients		Standardized Coefficient	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	108.607	9.821		11.059	.000*		
SB (cm)	.404	.133	.199	3.050	.003*	.965	1.036
SSH (cm)	.506	.123	.267	4.104	.000*	.966	1.035
SKH (cm)	.387	.102	.244	3.804	.000*	.998	1.002

*S= Stature, SSH= Sitting Shoulder height, SKH=Sitting Knee Height, SB= Shoulder Breadth, *= Significant*

Table 5. Multivariate regression of stature estimation in female subjects

Model	Unstandardized Coefficients		Standardized Coefficient	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	134.199	9.195		14.594	.000*		
SB (cm)	.105	.068	.106	1.535	.126*	.991	1.009
SSH (cm)	.623	.177	.255	3.520	.001*	.899	1.113
SKH (cm)	-.089	.091	-.071	-.973	.332*	.896	1.116

*S= Stature, SSH= Sitting Shoulder height, SKH=Sitting Knee Height, SB= Shoulder Breadth, *= Significant*

Table 6. Summary of multivariate regression model of stature estimation using shoulder breadth, sitting shoulder height, sitting knee height

Subjects	Multivariate model	R	R Square	Std. Error of the Estimate	Sig. F Change
All	S=88.56+(SB)0.31+(SSH)0.27+(SKH)1.00	0.59	0.34	6.81	0.00*
Male	S=108.60+(SB)0.40+(SSH)0.50+(SKH)0.38	0.44	0.19	6.27	0.00*
female	S=134.19+(SB)0.10+(SSH)0.62-(SKH)0.08	0.27	0.07	5.75	0.00*

*S= Stature, SSH= Sitting Shoulder height, SKH=Sitting Knee Height, SB= Shoulder Breadth, *= Significant*

Table 7. Sex discriminant function of shoulder breadth, sitting shoulder height, sitting knee height in igbo ethnic group

Eigenvalue	Canonical Correlation	Wilks' Lambda	Chi-Square	df	Sig.
0.93	0.69	0.51	261.15	3	0.000*
Sex centroid Male = 0.50 Female = 0.50		Canonical Discriminant Coefficient 28.34+(SB)0.11+(SSH)0.02+(SKH)0.16			
Classification Coefficient		Predicted Group Membership			
Male=-383.13+(SB)3.66+(SSH)0.67+(SKH)3.54		Male	Female		
Female=-383.13+(SB)3.45+(SSH)0.63+(SKH)3.23	Male	27	173		
	Female	166	34		
		13.5%	86.5%		
		83%	17%		

*S= Stature, SSH= Sitting Shoulder height, SKH=Sitting Knee Height, SB= Shoulder Breadth, *= Significant, 84.8% of original group cases correctly classified*

Table 7, shows the discriminant analysis using the stature to classify sex with shoulder breadth sitting shoulder height, and sitting knee height. The overall chi-square test shows a significant value (X^2=261.15, ƛ= 0.51), canonical correlation = 0.69, df= 3, and p<0.05). The sexual centroid displayed that the male was 0.50 while the female was 0.50. The Canonical Discriminant Coefficient shows *28.34+(SB)0.11+(SSH)0.02+(SKH)0.16* across the sex while for specificity and validity, the discriminant classification coefficient model for;

males=-383.13+(SB)3.66+(SSH)0.67+(SKH)3.54 while

female = -383.13+(SB)3.45+(SSH)0.63+(SKH)3.23

4. DISCUSSION

The present study evaluates the stature and sex estimation from shoulder breadth, sitting shoulder height, and sitting knee height among the Igbo ethnic group of Nigeria. The findings of this study found the larger anthropometric dimensions of stature, shoulder breadth, sitting shoulder height, and sitting knee height in males than females. The study findings are consistent with the biological and genetic factors that play a major role in the average height difference between males and females. Testosterone plays a significant role in promoting bone growth during puberty. Males tend to have higher levels of growth hormones, which contribute to increased bone density and muscle mass than females. Genetics also plays a crucial role, as height is influenced by multiple genes, with males generally inheriting traits that predispose them to greater stature. The sexual variance shown in this study is in line with other research across many populations, which found that males and females differ significantly (p<0.05) from one another Chuau et al., [13], and Sageghi et al., [14].

Our present study exhibited a significant positive correlation coefficient of sex between stature, shoulder breadth, sitting shoulder height, and sitting knee height (R= 0.59, SEE= 6.81) and this would be reliable for predicting human stature. However, when comparing the sex using anthropometric parameters, the finding shows that males (R= 0.44, SEE= 6.27) are better precited using shoulder breadth, sitting shoulder height, and sitting knee height than females (R= 0.27, SEE= 5.75), this could be attituded to them during puberty, males typically experience a significant increase in testosterone production, which promotes growth spurts and contributes to the development of longer bones and larger body size compared to females. The findings of this study agree with the findings of Yeasmin et al., [5], Asadujjaman [15], and Asadujjaman [16]. Our study showed the stature model for males,

S=108.60+(SB)0.40+(SSH)0.50+(SKH)0.38,

females,S=134.19+(SB)0.10+(SSH)0.62-(SKH) 0.08.

Sexual discrimination was also explored to classify sex (male and female) using shoulder breadth, sitting shoulder height, and sitting knee height. The findings of this study present that the stature estimation using shoulder breadth, sitting shoulder height, and sitting knee height is significant (X^2=261.15, ƛ= 0.51, p<0.05). Where the sex centroid shows that applying the discriminant model Sex= *28.34+(SB)0.11+(SSH)0.02+(SKH)0.16*, with the study parameters, a positive resultant value from 0-0.50 predicts males and from 0 - 0.50 predicts females. The findings have shown that group membership of the males was 83% and females was 86.5% were correctly predicted which account for 84.8% of the total sexes were correctly classified. Our findings agree with the work of Yeasmin et al., [5] in the Bangladeshi population showing that the sex estimation accuracy varied from 78.000% to 97.000%.

The study has shown some similarities and differences in sex and stature estimation using shoulder breadth, sitting shoulder height, and sitting knee height among various populations. The limitation differences could be attributed to various factors, like environmental factors, genetic diversity, and body composition.

5. CONCLUSION

The study evaluated the sexual dimorphism of shoulder breadth, sitting shoulder height, and sitting knee height. The findings show that males differ in the anthropometric value of their shoulder breadth, sitting shoulder height, and sitting knee height than females. Using shoulder breadth, sitting shoulder height, and sitting knee height to estimate stature among sexes, the anthropometric parameters were good predictors of sexes. This data will be useful

to forensic anatomists, ergonomics, and anthropologists.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of manuscripts.

CONSENT

A written consent was distributed to all the subjects explaining the nature of the research and only those who consented were allowed to participate in the study. The consents were retrieved and preserved by the authors.

ETHICAL APPROVAL

The study was approved by the research and ethics committee of the University of Port Harcourt, Port Harcourt Nigeria.

ACKNOWLEDGEMENTS

This study is part of the Anatomical Modeling Research Group (AMRG), the University of Port-Harcourt sponsored by TET Fund 2020 NRF.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/126306