

## Original Research Article

### **Multivariate Regression Model for Stature Estimation from Arm Span, Horizontal Fingertip Reach and Foot Length of Igbo Ethnic Group of Nigeria**

#### **Abstract**

**Background:** Stature estimation is a major factor in biological profiling for identification of persons

**Aim:** To formulate stature estimation models from arm Span, horizontal fingertip reach, and foot length amongst the Igbo ethnic group of Nigeria.

**Method:** A total of 399 subjects, (200 females and 199 males) between the ages of 18-40 years were recruited for the study. Standardized anthropometric techniques were used to measure the standing height, arm span, and foot length. Data analysis was carried out using a statistical package for social sciences version 23 used to calculate Pearson's coefficients of correlation and regression equation to formulate stature model variables.

**Result:** The correlation coefficients (R) for height against arm span, horizontal fingertip and foot length were 0.84 for all sampled subjects, 0.79 for male subjects, and 0.90 for female subjects. Multivariate regression models for stature estimation were  $\text{Stature} = 56.62 + \text{AS}(0.48) - \text{HFTR}(0.006) + \text{FL}(1.15)$  for all subjects;  $\text{Stature} = 62.92 + \text{AS}(0.42) + \text{HFTR}(0.15) + \text{FL}(0.88)$  for male subjects;  $\text{Stature} = 47.73 + \text{AS}(0.50) - \text{HFT}(0.01) + \text{FL}(1.32)$  for female subjects.

**Conclusion:** This data will be useful to forensic anatomists and anthropologists.

**Keywords:** Regression, Models, forensics, stature, arm span, horizontal fingertip reach, foot length, Igbo.

#### **Introduction**

Anthropometry is the science that defines physical measures of a person's size, form, and functional capacities [1]. These physical characteristics include stature, weight, body mass index, hip circumference, waist circumference, foot length, arm span finger reach tip, etc. Standing height also referred to as stature is an important anthropological parameter, as it provides valuable

insights into the physical characteristics of a population [2]. Stature 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 standing height like spinal and limb deformities, amputations, fractures, scoliosis, paralysis, and pain; in these cases, segments of the body are used for estimating the standing of an individual [3].

Stature estimation from arm span, horizontal fingertip reach, and foot length is a common practice in anthropometry and human biology. These measurements are often used as proxies for estimating an individual's height or stature when direct height measurements are not feasible or available. Udo and co [7] suggested arm span is a very reliable anthropometric parameter that predicts the body height of an individual and also plays an important role in assessing growth and development in children and adolescents. This position was supported by some population ethnic-based studies where sex differences in the arm span have also been established [7,8,9,10 & 11]. Horizontal fingertip reaches which is the distance between the fingertips of an individual's outstretched arms when they are extended laterally is an important parameter in furniture design. This measurement is considered to correlate with stature, as it reflects the width or breadth of an individual's skeletal structure [5]. Foot length, on the other hand, is the measurement from the heel to the tip of the longest toe, it may not provide a direct estimation of stature but it can be used in conjunction with other measurements to improve the accuracy of the estimation [6]. Malina [12] posited that foot length and horizontal fingertip reach measurement are the most reliable predictors during adolescent age since ossification and maturation occur earlier in the foot than the long bones, and standing height could be more accurately predicted from foot measurement as compared to long bones during adolescent age [12].

Some studies have examined the relationship between stature and arm span Oguon et al., [21] and Anibor et [22], some have even established bivariate models for the estimation of height from either foot length or arm span in some ethnic groups [6,7]. Nonetheless, studies using multiple variables such as the foot length arm span, and finger reach tip to estimate stature are very rare among the Igbo ethnic group of Nigeria. The use of many variables to estimate a parameter improves accuracy. Thus, the object of this study is to formulate a multivariate regression model for the estimation of height from arm span, foot length, and finger reach tip and foot length amongst the Igbo ethnic group of Nigeria.

## **Material and Method**

The study was conducted at Owerri a major Igbo city in the Eastern Part of Nigeria. A total of 399 subjects, (200 females and 199 males) between the ages of 18 to 40 years participated in the study. The inclusion criteria included that both parents and grandparents of participants must be from Igbo ethnic groups and individuals with physical deformities that affected body height were excluded from the study. The minimum sample size for the study was determined using the Taro-Yamane formula. Ethical approval for the study was given by the Research Ethics Committee of the University of Port Harcourt. All subjects were adequately informed about the procedure for the study and they gave their consent in writing. Demographic data were collected through a structured, pretested interviewer-administered questionnaire to ascertain ethnicity and anthropometric parameters were taken by direct measurements. The following parameters were measured;

### **A. Standing Height**

This was taken using a ZT-160 Goodcare stadiometer. The participants stood erect, and barefooted on the level platform of the stadiometer such that the back of their head, shoulder blade, buttocks, and heels touched the bar of the stadiometer. Participants were asked to relax with arms hanging by the side. Care was taken to avoid a sagging position.

### **B. Arm Span**

The is a distance between the tips of the middle finger of both hands in a participant's perpendicular upright with both arms outstretched laterally at  $90^{\circ}$  shoulder height perpendicular to the body and parallel to the floor. It was measured using a mega-size calliper. It is best obtained when the participant is standing facing a vertical wall to ensure the arms are accurately placed laterally.

### **C. Horizontal Fingertip Reach or Upper Limb Length**

This is the distance from the acromion to the fingertip with the elbow and wrist stretched. It was measured using mega mega-size caliper.

### **D. Foot Length**

This is the distance from the most prominent part of the heel to the most distal part of the longest toe (great or second toe). It was measured on the AMRG Anthropometric footrest.

### Data analysis and processing:

Data analysis was done using Statistical Package for Social Sciences Version 23. Pearson's coefficients of correlation and Regression analysis were used to formulate a model from the stature of the measured variables.

### Result

The mean value of standing height is  $169.41 \pm 7.91$  cm, arm span is  $176.30 \pm 10.95$  cm, horizontal fingertip reach is  $79.42 \pm 36.01$  cm and foot length is  $25.29 \pm 1.73$  cm as shown in Table 1 and they were not statistically significant. The multivariate model for the estimation of stature, Pearson correlation coefficient, coefficient of determination, and standard error of estimate are presented in Table 2.).

**Table 1, Descriptive Statistics for Standing Height, Arm span, Horizontal fingertip Reach, and Foot Length**

Parameters	Mean $\pm$ Std. Deviation		
	ALL	MALE	FEMALE
S (cm)	$169.41 \pm 7.92$	$169.78 \pm 7.84$	$169.05 \pm 8.00\#$
AS (cm)	$176.31 \pm 10.95$	$176.43 \pm 11.13$	$176.18 \pm 10.80\#$
HFTR (cm)	$79.42 \pm 36.02$	$77.60 \pm 7.15$	$81.23 \pm 50.37\#$
FL (cm)	$25.30 \pm 1.73$	$25.28 \pm 1.74$	$25.31 \pm 1.73\#$

**S= Stature, AS= Arm span, HFTR = horizontal finger reach tip, FL = foot length, # = not Significant**

**Table 2, Correlation, Coefficient of determination and Test for Fitness of Data for Formulation of Regression Model for Stature for all subjects**

<b>Subjects</b>	<b>Multivariate Model</b>	<b>R</b>	<b>R SQUARE</b>	<b>Std. Error of the Estimate</b>	<b>Sig F Change</b>
All	Stature = 56.62 + AS(0.48) – HFTR(0.006) + FL(1.15)	0.84	0.707	4.30	0.00
Males	Stature = 62.92+AS(0.42)+HFT(0.15)+FL(0.88)	0.79	0.63	4.84	0.00
Females	Stature = 47.73 + AS(0.50) - HFTR(0.01) + FL(1.32)	0.90	0.81	3.49	0.00

**S= Stature, AS= Arm span, HFTR = horizontal finger reach tip, FL = foot length**

### **Discussion**

This study has investigated the relationship between stature, arm span, horizontal fingertip reach, and foot length among the Igbo ethnic group of Nigeria. It revealed there is a significant correlation between stature and arm span, foot length, and horizontal fingertip reach when combined. This indicates that stature could be predicted from these parameters and vice versa. This finding is important because of the application of stature in the evaluation of well-being and monitoring of the growth of a person but also for establishing the identity of persons in forensic investigation and used in industrial designs.

Our study revealed that among the Igbo ethnic group of Nigeria between the ages of 20 to 40 years, stature, arm span, foot length, and horizontal fingertip reach showed no gender difference within the study population and this agrees with studies by Sharma et al., [14] and Dorjee and Sen, [15]. However, some studies reported sexual dimorphism existed in these parameters. [13, 21]. The factors responsible for the lack of sexual difference in the measured parameters in the study were

not evaluated, nevertheless, changing environmental factors such as nutrition, health, and lifestyle in recent times appear to have altered the growth pattern in most populations. Furthermore, some studies have shown that environmental factors also influence the expression of genetic traits. While there was no significant difference in stature and arm span between males and females in the studied population, males had a higher mean value for stature and arm span than females. Some studies have shown that the onset of growth is faster in females but the duration of growth is limited because the fusion of the epiphyses of bones occurs earlier in females. [4, 7, 8, 13, 16, 23].

The arm span, horizontal finger-tip reach, and foot length were better predictors of human stature (males  $R=0.79$ , females  $R=0.90$ ), this is important in forensic investigation. Some studies have explored the predictive power of these anthropometric parameters to stature. Mulu and Sisay [13] reported that Arm span showed the highest correlation value than any other anthropometric parameters for both sexes ( $R=0.843$  for males and  $R=0.708$  for females). Studies by Jakhar et al., [19] in Haryana and Patel et al., [20] in Gujarat also showed a significant correlation which was consistent with our study. On the contrary, Udoh et al., [7] reported that males and females had moderate prediction using the studied anthropometric parameters.

### **Conclusion**

In conclusion, the study has shown that the combination of arm span, horizontal fingertip reach, and foot length can be adequately used to estimate stature. There is no sexual dimorphism in these parameters. The findings of this research will be of importance in forensic science and industrial anthropometry

### **Ethical Approval:**

Approved by the University of Port Harcourt Ethics Research Committee; UPH/ERC/2021/046

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