Prediction of Stature from Somatometry of the Left Hand in Igbos, Nigeria

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Abstract

The identification of a person is based on some biological profiles. Stature is one of such; its prediction plays important role in forensic investigation. An attempt was made to establish the stature of the Igbo using left fingers lengths, hand length and hand breadth. The correlation between stature and hand dimensions was studied. Which of the hand segments is the best to predict the stature of the Igbo? 88 males and 123 females were included in this study after obtaining informed consent. Measurements of hand segments were taken using Sliding Caliper and the height was recorded using Anthropometer. The data were subjected for statistical analysis. Significant correlation between stature and the entire hand dimensions was established except hand breadth (HB) in the females. Independent linear regression equations to calculate the stature were obtained for hand segments in both genders put together, in males and females separately. Hand length had the best prediction power in both genders put together as well as in the females. In males, the best prediction power was observed in fourth digit length followed by hand length. The multiple linear regression model generated for both genders put together performed better than the simple linear regression models for the males or females.

Keywords: Stature; Hand length; Digit length; Anthropometer; Sliding caliper

Introduction

Stature is a composite of linear dimensions of the skull, vertebral column (spine), pelvis, thigh, legs [1] and some parts of the foot [2]. It has been estimated in many populations using regression formulas derived from hand dimensions [3-17] and also from other body segments [11,18-31]. It is one of the most important anthropometric parameter for identification of an individual [1,21,29,32,33]. Estimated stature from hand length, phalangeal length as well as from inked print of the aforementioned variables has been performed [5]. Result from such study indicated no significant difference between the hand variables and the hand prints variables but revealed significant correlations between stature and the all variables.

Among the Igbo of Nigeria, much work has not been done in forensic/physical anthropology. We therefore undertake this study to generate reference data for the consumption of the scientist and the general populace using somatometry of the left hands (palmar surface).

Materials and Method

The study was based on a random sampling of 211 Subjects (females n=123, and males n=88) aged 16-45 years of the Igbo ethnic group of Nigeria, and attention was paid to stature estimation using left hand somatometry after obtaining an informed consent.

Study location and duration

The study was conducted in Imo State, Nigeria; it covered a period of ten (10) months.

Demographics

Information on age, sex, and state of origin were documented.

Exclusion criteria

Subjects who were not of Igbo origin were excluded from the study. Also subjects who were pregnant or subjects having any deformity affecting the musculoskeletal system were not allowed to participate in the study. Also hand dimension which were not significantly correlated with stature was not used to regress stature.

Anthropometrics

Stature was measured following standard protocols [34] and the following hand measurements were taken in centimeters using a sliding caliper following the procedure of [3,6,7] but on the left hand.

Stature (Y): The height was measured to the nearest 0.1cm using an Anthropometer with subjects standing without shoes with the heels held together, toes apart, and the head held in the Frankfort plane [29,34].

Hand length (HL): is the linear distance (cm) between the distal wrist crease and the distal end of the longest finger [5,29] (Figure 1).

Hand breadth (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 [12,15] (Figure 2).

- 1st digit length (1st DL) is the linear distance (cm) between the proximal digital crease and the distal end of the first finger.
- 2nd digit length (2nd DL) is the linear distance (cm) between the proximal digital crease and the distal end of the second finger.
- 3rd digit length (3rd DL) is the linear distance (cm) between

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Received February 27, 2015; Accepted June 03, 2015

Citation: Ekezie J, Anibeze CIP, Anyanwu GE, Uloneme GC (2015) Prediction of Stature from Somatometry of the Left Hand in Igbos, Nigeria. J Forensic Res S1: 005 doi:10.4172/2157-7145.S3-005

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J Forensic Res Analytical Applications in Forensic Sciences ISSN: 2157-7145 JFR, an open access journal
the proximal digital crease and the distal end of the third finger see Figure 1.

- 4th digit length (4th DL) is the linear distance (cm) between the proximal digital crease and the distal end of the fourth finger.
- 5th digit length (5th DL) is the linear distance (cm) between the proximal digital crease and the distal end of the fifth finger.

Data Presentation and Analysis

The data analysis was carried out using statistical package for social sciences (SPSS 17.0 software). In summarizing the data, the Minimum, Maximum, Mean and Standard deviations were estimated and presented. A comparison of difference of variable in females and males left hand dimensions was performed. Pearson correlation was then applied to test the relationship between stature and hand dimensions and the results are presented for 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 (R²) and Significance of regression coefficient. The multiple linear regression models [26] with the explanatory variables or repressors- left hand dimensions were proposed as a statistical model to explain the total variation. The generated regression formula from a stepwise analysis is such that stature (y) = a (constant) + b₁ (regression coefficient for the first variable) x₁ (first variable) + b₂ (regression coefficient for the second variable) x₂ (second variable) + … + bₙ (regression coefficient for the nth variable) xₙ (nth variable), with this we can estimate stature from hand dimensions. In the results that follow, R indicates the multiple correlation coefficient value [28]. It is one of the measures used for model adequacy. It is the correlation between the observed values and the fitted values for the dependent variable. R₂ explains the percentage that a dimension contributes to the variation in the dependent variable (stature). R₂ adjusted is used to compare the regression models containing different number of explanatory variables (hand segments). The standard error of estimate (SEE) is the error that may arise from estimating stature. It predicts the deviation of estimated stature from the actual stature [27]. A low value of SEE is indicative of the greater reliability of prediction from a particular measurement while a higher value denotes less reliability.

Result

We can see the standard deviation, the mean, and minimum values of the anthropometric variables in both genders put together (Table 1). Overall, males are more varied with higher mean values than females. All the anthropometric dimensions measured directly showed statistically significant differences between females and males: HL, HB and 1st DL (p<0.0001), 2nd DL and 5th DL (p<0.002), 3rd DL (p<0.001), with males having a higher mean value than females (Table 2).

The correlation coefficient between stature and the left hand dimensions in both genders put together, females and males respectively was found to be statistically significant and positive, indicating a strong relationship between stature and left hand dimensions, except for hand breadth (HB) in females. The highest positive correlation was observed in hand length (HL), r=0.727 while the least was observe in 5th digit length (5th DL) r=0.504 in both genders put together (Table 3). For the females, the least significant correlation was observed in 5th DL, r=0.397 while the highest value was obtained in HL, r=0.638. In the male population, the least significant correlation was observed in HB, r=0.431 while the highest was observed in 4th DL, r=0.633. The Constant, Regression coefficient and Variation explained (R²) derived for each of the left hand measurements with stature are shown in Table 4 for both genders put together, and in Table 5 for females and males respectively. The regression coefficients were significant indicating that they are contributing for the prediction of stature. The variation explained (R² x 100) showed that it ranges from 25.4% to 52.8% in both genders. For the females the variation explained ranged from 15.8% to 40.7%. In the males, the variation explained ranged from 18.6% to 40.1%.

Table 6 shows the values for R, R², Adjusted R², and SEE of the left hand variables in both genders put together, females and males respectively. In both genders together, one multiple linear regression models was constructed using 1st DL and 2nd DL and this has the highest values for the coefficient of determination R² as 0.505. R² Adjusted as 0.495 and multiple correlation coefficient R as 0.711 with a lower SEE as 6.158. Seven simple linear regression models were also constructed. The best simple linear regression model was developed using HL and this
Table 1: Descriptive statistics of age (years), left hand dimensions (CM) of both genders, females and males.

| Variables | Both gender | Females | Males |
|-----------|-------------|---------|-------|
| N         | Min | Max | Mean | SD  | N  | Min | Max | Mean | SD  |
| AGE       | 211 | 16  | 45   | 23.58| 4.95| 123 | 16.00| 45   | 23.74| 5.36| 88  | 18  | 43  | 23.35| 4.34|
| STATURE   | 211 | 149 | 190  | 167.55| 9.1 | 123 | 149.00| 190  | 163.17| 7.64| 88  | 156 | 190 | 173.66| 7.3 |
| HL        | 92  | 16.4| 22   | 19.24| 1.18| 55  | 17.4 | 21   | 18.77| 0.85| 37  | 16.4| 22  | 19.92| 1.27|
| HB        | 93  | 6.1 | 11.2 | 9.43 | 0.82| 56  | 6.10 | 10.8 | 9.03 | 0.71| 37  | 8.3 | 11.2 | 10.04| 0.6 |
| 1ST DL    | 96  | 5.1 | 8.4  | 6.49 | 0.62| 56  | 5.10 | 8.4  | 6.27 | 0.52| 40  | 5.2 | 7.8 | 6.81 | 0.61|
| 2ND DL    | 96  | 5.7 | 9.2  | 7.18 | 0.57| 56  | 5.80 | 8.15 | 6.98 | 0.43| 40  | 5.7 | 9.2 | 7.46 | 0.63|
| 3RD DL    | 95  | 6.1 | 9.9  | 7.97 | 0.64| 56  | 6.60 | 9.2  | 7.77 | 0.49| 39  | 6.1 | 9.9 | 8.25 | 0.73|
| 4TH DL    | 96  | 5.2 | 9.3  | 7.39 | 0.59| 56  | 6.40 | 8.45 | 7.2  | 0.43| 40  | 5.2 | 9.3 | 7.65 | 0.69|
| 5TH DL    | 96  | 3.7 | 5.9  | 4.71 | 0.59| 56  | 4.60 | 5.77 | 5.04 | 0.48| 40  | 3.7 | 7.5 | 6.08 | 0.69|

HL: Hand Length; HB: Hand Breath; DL: Digit Length

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

| Variables | Both gender | Females | Males |
|-----------|-------------|---------|-------|
| N         | Min | Max | N | Pearson Correlation | Sig. (2-tailed) | N | Pearson Correlation | Sig. (2-tailed) |
| HL        | 211 | 16  | 45 | 0.638* | 0 | 37 | 0.610* | 0 |
| HB        | 211 | 149 | 190 | 0.166 | 0.223 | 37 | 0.431** | 0.008 |
| 1ST DL    | 92  | 16.4| 22 | 0.409* | 0.002 | 40 | 0.528* | 0 |
| 2ND DL    | 93  | 6.1 | 11.2 | 0.465* | 0 | 40 | 0.594* | 0 |
| 3RD DL    | 96  | 5.1 | 8.4  | 0.482* | 0 | 39 | 0.570* | 0 |
| 4TH DL    | 96  | 5.7 | 9.2  | 0.472* | 0 | 40 | 0.633* | 0 |
| 5TH DL    | 95  | 6.1 | 9.9  | 0.397* | 0.002 | 40 | 0.511** | 0.001 |

HL: Hand Length; HB: Hand Breath; DL: Digit Length

Table 3: Pearson correlation between stature with left hand dimensions in both genders put together, females and males. Correlation is significant at the 0.01 level (2-tailed)

| Variables | Constant | Regression Coefficient | $R^2$ | p value |
|-----------|----------|------------------------|-------|---------|
| HL        | 66.603   | 5.161                  | 0.528 | 0.000   |
| HB        | 111.841  | 5.733                  | 0.324 | 0.000   |
| 1ST DL    | 110.952  | 8.530                  | 0.370 | 0.000   |
| 2ND DL    | 96.304   | 9.761                  | 0.414 | 0.000   |
| 3RD DL    | 99.744   | 8.353                  | 0.374 | 0.000   |
| 4TH DL    | 97.296   | 9.347                  | 0.409 | 0.000   |
| 5TH DL    | 122.590  | 7.414                  | 0.254 | 0.000   |
| 1ST DL    | 85.207   | 5.089                  | 0.505 | 0.000   |
| 2ND DL    | 6.702    |                        | 0.000 |         |

HL: Hand Length; HB: Hand Breath; DL: Digit Length

Table 4: Constant, Regression coefficient and Variation explained ($R^2$) of left hand variables with Stature (dependent) variables in both genders.
has the highest values for the coefficient of determination $R^2$ as 0.528, $R^2$ Adjusted as 0.523 and multiple correlation coefficient $R$ as 0.727 with 5.782 as the SEE.

In the females, no multiple linear regression model was developed but the best simple linear regression model was developed using HL and this has highest values for the coefficient of determination as $R^2$ 0.407, $R^2$ Adjusted as 0.396 and multiple correlation coefficient $R$ as 0.638 with 4.072 SEE. In the males, it was not possible to develop multiple linear regression models. The best simple linear regression model was developed using HL in both genders together and this has highest values for the coefficient of determination $R^2$ as 0.528, $R^2$ Adjusted as 0.523 and multiple correlation coefficient $R$ as 0.727 with 5.782 as the SEE.

The findings of this investigation also indicate that all the hand dimensions are positively and significantly correlated with stature except HB in females. This observation has the implication that HB cannot be used to estimate stature in Igbo females except when both sexes are put together. HL shows stronger correlation with stature than those of other hand dimensions. This observation is confirmed by lower SEE as well as high value of $R$, $R^2$, and Adjusted $R^2$ for HL. It means that the regression equation generated using HL in both genders together and females give high degree of reliability and accuracy than those of other hand dimensions. In males reliability and accuracy was highest using 4th DL.

The present study also shows that the multiple linear regression equation obtained using 1st DL and 2nd DL in both genders performed better than the simple linear regressions generated for the male or females. This statement is also proved by the values of $R$, $R^2$, and Adjusted $R^2$ for HL, HB, and other hand dimensions. This observation has the implication that HB cannot be used to estimate stature in Igbo females except when both sexes are put together. HL shows stronger correlation with stature than those of other hand dimensions. This observation is confirmed by lower SEE as well as high value of $R$, $R^2$, and Adjusted $R^2$ for HL. It means that the regression equation generated using HL in both genders together and females give high degree of reliability and accuracy than those of other hand dimensions. In males reliability and accuracy was highest using 4th DL.

## Table 5: Constant, regression coefficient and variation explained (R2) of left hand variables with stature (dependent) variable in 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 |
| HL        | 0.727 | 0.528 | 0.523 | 5.782 | 0.638 | 0.407 | 0.396 | 4.072 | 0.610 | 0.372 | 0.354 | 5.794 |
| HB        | 0.569 | 0.324 | 0.317 | 6.895 | 0.431 | 0.186 | 0.162 | 6.623 | 0.528 | 0.279 | 0.260 | 6.416 |
| 1st DL    | 0.608 | 0.370 | 0.364 | 6.911 | 0.409 | 0.167 | 0.152 | 4.845 | 0.594 | 0.353 | 0.336 | 6.076 |
| 2nd DL    | 0.644 | 0.414 | 0.408 | 6.666 | 0.465 | 0.216 | 0.201 | 4.702 | 0.570 | 0.325 | 0.307 | 6.288 |
| 3rd DL    | 0.617 | 0.380 | 0.374 | 6.876 | 0.482 | 0.232 | 0.218 | 4.654 | 0.633 | 0.401 | 0.385 | 5.848 |
| 4th DL    | 0.639 | 0.409 | 0.402 | 6.697 | 0.472 | 0.223 | 0.208 | 4.682 | 0.511 | 0.261 | 0.242 | 6.492 |
| 5th DL    | 0.504 | 0.254 | 0.246 | 7.523 | 0.397 | 0.158 | 0.142 | 4.873 | 0.711 | 0.505 | 0.495 | 6.158 |

## Table 6: R, R2, Adjusted R2, and SEE of left variables in both genders, females and males.

| Variables | Both genders | Females | Males |
|-----------|--------------|---------|-------|
|           | $R$ | $R^2$ | Adjusted $R^2$ | SEE | $R$ | $R^2$ | Adjusted $R2$ | SEE | $R$ | $R^2$ | Adjusted $R^2$ | SEE |
| HL        | 0.727 | 0.528 | 0.523 | 5.782 | 0.638 | 0.407 | 0.396 | 4.072 | 0.610 | 0.372 | 0.354 | 5.794 |
| HB        | 0.569 | 0.324 | 0.317 | 6.895 | 0.431 | 0.186 | 0.162 | 6.623 | 0.528 | 0.279 | 0.260 | 6.416 |
| 1st DL    | 0.608 | 0.370 | 0.364 | 6.911 | 0.409 | 0.167 | 0.152 | 4.845 | 0.594 | 0.353 | 0.336 | 6.076 |
| 2nd DL    | 0.644 | 0.414 | 0.408 | 6.666 | 0.465 | 0.216 | 0.201 | 4.702 | 0.570 | 0.325 | 0.307 | 6.288 |
| 3rd DL    | 0.617 | 0.380 | 0.374 | 6.876 | 0.482 | 0.232 | 0.218 | 4.654 | 0.633 | 0.401 | 0.385 | 5.848 |
| 4th DL    | 0.639 | 0.409 | 0.402 | 6.697 | 0.472 | 0.223 | 0.208 | 4.682 | 0.511 | 0.261 | 0.242 | 6.492 |
| 5th DL    | 0.504 | 0.254 | 0.246 | 7.523 | 0.397 | 0.158 | 0.142 | 4.873 | 0.711 | 0.505 | 0.495 | 6.158 |

Discussion

The results of the present study clearly indicate that stature can successfully be estimated from the somatometry of the left hand in condition where forensic experts are confronted with mutilated upper extremity segments or body part. Such information gotten can supplement the three (age, sex and race) of the “Big Four” of Forensic Anthropology.

The findings of this investigation also indicate that all the hand dimensions are positively and significantly correlated with stature except HB in females. This observation has the implication that HB cannot be used to estimate stature in Igbo females except when both sexes are put together. HL shows stronger correlation with stature than those of other hand dimensions. This observation is confirmed by lower SEE as well as high value of $R$, $R^2$, and Adjusted $R^2$ for HL. It means that the regression equation generated using HL in both genders together and females give high degree of reliability and accuracy than those of other hand dimensions. In males reliability and accuracy was highest using 4th DL.

Over the decade, close relationships between stature and dimensions of various body segments have been reported and the results are frequently applied in anthropometric studies and medicolegal investigations [1,2,4,7,19,33] the application of such result must be population specific since genetics, environment and even nutrition influences stature [12,35,36], and this is in agreement with the present study [3]. Studied subjects in Delhi and found accurate or near accurate correlation between stature and length of fingers. They used independent linear regression equations and suggested that results are statistically significant. From their data it is evident that the index finger is best for the prediction of stature. In this present study, the 2nd digit length was the best to estimate stature in both gender together while the 3rd and 4th digit lengths was the best to predict stature respectively.
Regression equations for estimation of stature in both genders using left dimensions:

Regression equation
Both Genders ±SEE
Stature=66.603+5.161(HL) 5.78192
Stature=111.841+5.733(HB) 6.69491
Stature=110.952+6.530(1ST DL) 6.91076
Stature=96.304+9.761(2ND DL) 6.65652
Stature=99.744+8.353(3RD DL) 6.87608
Stature=97.296+8.347(4TH DL) 6.69735
Stature=122.590+7.414(5TH DL) 7.52301
Stature=85.207+5.089(1ST DL) 6.702(2ND DL) 6.15842

HL: Hand Length, HB: Hand Breath, DL: Digit Length

Table 7: Regression Equations for estimation of Stature in both genders using left dimensions.

| Regression Equation | Females ±SEE | Males ±SEE |
|---------------------|--------------|------------|
| Stature=87.312+3.935(HL) 4.072 | Stature=103.922+3.460(HL) 5.794 |
| Stature=135.252+4.154(1ST DL) 4.845 | Stature=120.681+5.201(HB) 6.623 |
| Stature=121.164+5.752(2ND DL) 4.702 | Stature=129.577+6.438(1ST DL) 6.416 |
| Stature=121.149+5.168(3RD DL) 4.654 | Stature=121.355+6.985(2ND DL) 6.077 |
| Stature=119.815+5.759(4TH DL) 4.682 | Stature=124.544+5.927(3RD DL) 6.288 |
| Stature=135.865+4.404(5TH DL) 4.873 | Stature=133.546+3.801(5TH DL) 6.542 |

HL: Hand Length, HB: Hand Breath, DL: Digit Length

Table 8: Regression Equations for estimation of Stature in females and males using left hand dimensions.

| Observed Value | Minimum | Maximum | Mean | Std. Deviation | N |
|----------------|---------|---------|------|----------------|---|
| Value          |         |         |      |                |   |
| HL             | 149.00  | 190.00  | 167.55| 9.10           | 211|
| HB             | 151.25  | 180.15  | 165.88| 6.10           | 92 |}

Predicted Value for:

| Distance       | Minimum | Maximum | Mean | Std. Deviation | N |
|----------------|---------|---------|------|----------------|---|
| 1st DL         | 146.82  | 176.06  | 165.90| 4.75           | 93 |
| 2nd DL         | 154.46  | 182.61  | 166.35| 5.27           | 96 |
| 3rd DL         | 151.94  | 186.11  | 166.35| 5.58           | 96 |
| 4th DL         | 150.69  | 182.43  | 166.29| 5.36           | 95 |
| 5th DL         | 145.90  | 184.23  | 166.35| 5.54           | 96 |

HL: Hand Length, HB: Hand Breath, DL: Digit Length

Table 9: Minimum, Maximum, Mean and standard deviations of the predicted Values of stature by regression functions with left hand variables in both genders.

| Observed Value | Females | Males |
|----------------|---------|-------|
| Value          | Mean    | SD    | N    | Min     | Max     | Mean   | SD    | N    |
| HL             | 149.00  | 163.17| 7.64 | 123     | 156.00  | 190.00 | 7.30  | 88   |
| HB             | 169.94  | 161.17| 3.34 | 55      | 160.67  | 180.05 | 4.39  | 37   |
| 1st DL         | 163.85  | 178.93| 7.93 | 123     | 163.05  | 179.79 | 7.43  | 39   |
| 2nd DL         | 155.44  | 161.29| 2.15 | 56      | 163.17  | 185.61 | 4.63  | 40   |
| 3rd DL         | 154.52  | 168.04| 2.45 | 56      | 160.70  | 183.22 | 4.30  | 39   |
| 4th DL         | 155.26  | 168.69| 2.53 | 56      | 156.66  | 184.76 | 4.72  | 40   |
| 5th DL         | 156.12  | 169.07| 2.09 | 56      | 156.16  | 181.32 | 3.81  | 40   |

HL: Hand Length, HB: Hand Breath, DL: Digit Length

Table 10: Minimum, Maximum, Mean and standard deviations of the predicted Values of stature by regression functions with left hand variables in females and males.

in females and males because of the values of R and SEE [37-40].
Reported for Japanese women a correlation (r) of proximal phalange and stature ranging from 0.521 to 0.696. The regression formulae possessed standard errors ranging from 3.59 to 4.27cm. In this study, the correlation of the female's digit lengths with stature ranged from 0.397 to 0.638 while the regression formula possessed SEE ranging from 4.702 to 4.873cm. Although our dimensions for digit lengths incorporated both the distal, middle and part of the proximal phalanx; the upper limits of these values (r, and SEE) are comparable with the study above.

Studies [4,5,7,8,37] have estimated stature from hand length and phalange length and also reported sexual dimorphism in mean hand length. Regression equations were generated. The mean stature in the males was higher as compared to that of the females in such studies.
These findings are congruent with that of this study. Comparing this study with the same isolated genetic population in our previous study using right hand dimensions [2], we observed that the values of R for the various left hand dimensions used to test model adequacy were higher in this present study. Also this study indicated lower SEE than that of our previous study. This means that left hand dimensions are more adequate to estimate stature in the same population than the right hand dimensions.

**Conclusion**

The best dimension to predict stature from the left hand somatometry of the study population is hand length followed by 1st and 2nd digit lengths. Also hand length provides the precise means of estimating stature in the females, this is followed by 3rd digit length. In males, 4th digit length is the best followed by hand length. The regression formula generated in this study will be of utmost help to Anatomists, Anthropologist, Archaeologist and Forensic experts.

**Acknowledgements**

The authors are grateful to all the subjects for their cooperation and patience since without such cooperation this study would not have seen the light of the day.

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