***Original Research Article***

## Stature Estimation Using Arm Span, Arm Length, Forearm Length, and Foot Length of Hausa Ethnic Group of Nigeria

**Abstract**

**Background:** Stature estimation has been useful in identifying body remains, especially during earthquakes, accidents, fire disasters, and other disasters.

**Aim:** To predict stature estimation using arm span, arm length, forearm length and foot length among the Hausa ethnic group of Nigeria.

**Method:** The study adopted a descriptive cross-sectional study design with a total of 300 subjects, (150 males and 150 females) between the ages of 18-35 years recruited for the study. The mega-size calliper was used to measure the anthropometric variables. Data analysis was done using a statistical package for social sciences version 23. Multivariate regression was 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.

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**Result:** The multivariate regression among the sexes to estimate stature using arm span, arm length, forearm length, and foot length shows (R=0.81, SEE= 4.23). The stature predictive power of females was (R= 0.77, SEE=3.67) and males’ stature (R= 0.69, SEE=4.70). The highest correlation was found in females between arm span and stature (r=0.71) and males between foot length and stature (r=0.75).

**Conclusion:** The study observed that arm span and foot length show a positive correlation between stature in both sexes. However, arm and forearm lengths show a moderate positive correlation. This research will be useful in forensics, anthropology and bioarchaeology.

**Keywords:** Forensics; Stature; Sex; Hausa;

# INTRODUCTION

Stature estimation is vital to physical anthropology, forensic science, and bioarchaeology. It provides significant insights into individual identification, population studies, and the assessment

of health and nutritional status [1]. The relationship between body proportions and stature has been extensively studied, with anthropometric parameters such as arm span [2], arm length [3], hand length [5], horizontal fingertip reach [4], shoulder breadth [5], sitting knee height [6] and forearm length [7] emerging as reliable predictors of stature. These measurements are instrumental in cases where complete skeletal remains or full body measurements are unavailable which is essential in criminal investigations, mass disasters, accidents and missing person cases. Stature estimation helps assess growth patterns, diagnose genetic disorders, and determine appropriate medical treatments, including drug dosages [8].

Asiwe et al., [3] conducted a study on stature estimation using upper arm and forearm-hand length among the Mgbidi Population of Imo State indicating that upper arm and forearm-hand length are good predictors of sex. Another study investigated the stature estimation from forearm length in Iranian medical students, it found a correlation between forearm length and stature which suggested that forearm measurements can be used as a reliable indicator for estimating stature in the Iranian population [7]. In India, Supare et al., [9] researched the estimation of stature from arm span in medical students of Maharashtra, which indicated a strong correlation between stature and arm span.

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Stature estimation holds special importance among the Hausa ethnic group of Nigeria, one of the largest ethnic groups in West Africa, due to their unique genetic, environmental, and cultural influences on body morphology [10]. Understanding the specific anthropometric relationships within this population can enhance the accuracy of stature prediction models and provide valuable data for comparative studies.

# MATERIALS AND METHODS

## Study Design

The anthropometric value of Hausa in Nigeria was measured using a cross-sectional descriptive research method. A total number of three hundred subjects (150 males) and (150 females) between the age of 18-35 years made up the population. The study frame was at NorthWest University at Kano State, where the subjects were selected using a multi-stage random proportionate sampling approach.

## Selection Criteria

**Inclusion Criteria**

This study included individuals whose parents and grandparents belonged to the Hausa ethnic group of Nigeria. Additionally, only those aged between 18 and 37 years, with no history of body surgery, were selected.

## Exclusion Criteria

Subjects who did not meet all these inclusion criteria were omitted from the study, and those with damage or abnormalities in hand morphology or stature were excluded.

## Anthropometric landmarks

The study used some anthropometric variable measures (stature, arm span, arm length, forearm-hand length and foot length), and these variables are defined as follows;

## Stature

The Goodcare ZT-160 stadiometer was used to measure this. On the level platform of the stadiometer, the subject stood upright and barefoot, contacting the bar with their heels, buttocks, shoulder blades, and back of their heads. The subjects were instructed to keep their arms by their sides and relax. To prevent sagging, care was taken.

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## Arm Span

This is measured from a distance between the tips of the middle finger of both hands in a participant’s perpendicular upright with both arms outstretched laterally at 900 shoulder height perpendicular to the body and parallel to the floor.

## Arm length

This is measured from the lateral tip acromion down to the distal part of the arm (lateral and medial epicondyle).

## Forearm-hand length

This is measured from the radius's proximal head to the third finger's most distal limit.

## 2.2.6 Foot

This is measured from the distance of the most prominent part of the heel to the most distal part of the longest toe (great or second toe).

## 2.3. Method of Data Collection

A semi-constructive descriptive questionnaire and a personal interview were used to gather the sociodemographic data for the Hausa indigen in Nigeria. This ensured that the subjects met the inclusion criteria and were fit to participate in the study. The arm span, arm length, forearm-hand lengths and foot length were measured using a mega-size calliper, adopting the appropriate anatomical landmarks. Data readings were recorded and preserved by the authors.

## 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). Results obtained were presented in the table as mean ± standard deviation. T-test was used as an inferential statistic to evaluate sexual. Pearson’s coefficients of correlation and regression analysis were used to formulate a model based on the stature of the measured variables.

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## Result

In this study, the mean of arm span, arm length, forearm length and foot length of all subjects were 175.04±9.73, 34.06±2.61, 47.74±3.03, 24.37±1.81 respectively (Table 1). Table 2 shows the sexual difference in stature, arm span, arm length, forearm length and foot length. Table 3 shows the results of Pearson’s coefficients Regression Analysis, where the arm span, arm length, forearm length, and foot length predict stature, and all the anthropometric parameters show a better predictor of stature in females than males. Multivariate regression of stature estimation among all subjects shows the correlation coefficient (R= 0.81, SEE= 4.23) with a standard error of estimate which shows a positive significant correlation among the subjects. Comparison between the males and the females has demonstrated that the female has a better prediction of stature (R=0.77, SEE=3.67) than the males (R= 0.69, SEE=4.70) which shows a strong correlation among the sex (Table 4).

# DISCUSSION

The present study evaluates sexual dimorphism using arm span, arm length, forearm length and foot length among the Hausa ethnic group of Nigeria. The findings present that male had a stature of 171.75±6.47, am span of 181.84±7.26, arm length of 32.73±2.60, forearm length of 49.62±2.52, and foot length of 25.73±1.16, while females had 163.65±5.72 of stature, 168.25±6.65 of arm span, 35.39±1.84 of arm length,45.87±2.52 of forearm length, and foot length of 23.02±1.25. Our findings have shown that males have higher mean values than females, which directly showed gender-based variation in stature, arm span, arm length, forearm length, and foot length. The study's findings were consistent with males having higher anthropometry values than females [11,12,13,] due to factors associated with gender differences like hormonal, genetic, and lifestyle factors.

Our study found a significant positive correlation between arm span, foot length and stature in genders. It also shows a moderate positive correlation between arm and forearm lengths with stature. Where the arm span shows a strong significant correlation in females (r=0.71) compared to males (r=0.66) and this is in line with Mulu and Sisay [14]. In foot length, there’s a strong significant correlation in males (r= 0.75) compared to females (r=0.65), and this is consistent with Oghenemavwe and Egwede, [15], Uhrová et al., [16] and Ibeabuchi et al [17]. However, arm length in females shows a significant correlation compared to males (r= 0.52, r=0.28) respectively. In contrast, the forearm length in females (r=0.62) shows the most significant correlation compared to males (r=0.55), and this is in line with Jouzdani et al [18] and Akhlaghi et al., [19].

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Stature from the upper limb extremity (arm span, arm length, forearm length) and foot length have been discovered greatly in this study presenting that all subjects of the Hausa ethnic group have a correlation coefficient (r=0.81, SEE= 4.23). The findings showed that they have predictive power for stature with no statistical differences. However, when compared with sexes, the findings show that females' stature is better predicted using the arm span, arm length, forearm length and foot length (r=0.77, SEE= 3.67) compared to the males (r=0.69, SEE= 4.70) and this could be attributed to some factors influencing estimation such as bone length, muscle mass and fat distribution. Still, since females typically have more adipose tissue less dense than muscle

tissue, their upper arm and forearm-hand lengths may be slightly longer relative to their overall stature compared to males. This can result in a more accurate prediction of stature in females as the SEE is smaller in females than in males. The findings of this study agree with the conclusions from Navid et al. [20] among medical students at Tehran University of Medical Sciences, Tehran, Iran that using arm length, females had more predictive power when compared to males. In 2008, Kanchan et al. [21] also reported that females have a higher power of prediction of stature compared to males using upper arm length and our findings are also consistent with Akhlaghi et al., [19]. On the contrary, our findings disagreed with Shakya et al. [22], whose report was that the upper arm and forearm in males have a better predictor of stature when compared to females. Ilayperuma et al. [23] findings were consistent with ours.

# 5. CONCLUSION

This study evaluates the stature estimation of arm span, arm length, forearm length and foot length of the Hausa ethnic group of Nigeria, which shows a good correlation between the anthropometric parameters. It equally observed that arm span and foot length show a positive correlation between stature in both sexes. However, arm and forearm lengths show a moderate positive correlation. The findings will contribute to the growing body of knowledge in anthropometric research and have practical implications for forensic and clinical applications.

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# ETHICAL APPROVAL AND CONSENT

Ethical approval was obtained from the Research Ethics Committee at the University of Port Harcourt, Port Harcourt, Nigeria. (UPHCEREMAD/REC/MM/91/046). All subjects were adequately informed about the study procedures and they gave their consent to participate.

## Table 1. Descriptive Statistics of the Hausa Subjects

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Parameter | N | Minimum | Maximum | Mean | Std. Deviation |
| S (cm) | 300 | 150.00 | 189.50 | 167.7047 | 7.32768 |
| AS (cm) | 300 | 152.00 | 197.00 | 175.0480 | 9.73248 |
| AL (cm) | 300 | 24.00 | 41.00 | 34.0627 | 2.61515 |
| FAL (cm) | 300 | 40.50 | 58.00 | 47.7460 | 3.03283 |

FL (cm) 300 20.00 29.00 24.3793 1.81886

*S=Stature, AS= Arm Span, AL= Arm length, FAL= Forearm-length, FL= Foot Length*

## Table 2. Sexual Differences of the Hausa Subjects

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Parameters | Male | Female | T-test | P-value | Inference |
| S (cm) | 171.75±6.47 | 163.65±5.72 | 11.484 | 0.00 | S |
| AS (cm) | 181.84±7.26 | 168.25±6.65 | 16.90 | 0.00 | S |
| AL (cm) | 32.73±2.60 | 35.39±1.84 | -10.213 | 0.00 | S |
| FAL (cm) | 49.62±2.52 | 45.87±2.52 | 13.611 | 0.00 | S |
| FL (cm) | 25.73±1.16 | 23.02±1.25 | 19.491 | 0.00 | S |

*S=Stature, AS= Arm Span, AL= Arm length, FAL= Forearm-length, FL= Foot Length S= Significant*

## Table 3. Results of Pearson’s Coefficients Regression Analysis where the Arm Span, Arm Length, Forearm Length and Foot Length Predict the Stature

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|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameters | R | R-square | Std. Error  of the  Estimate | Sig. F  Change |
| **Arm Span** |  |  |  |  |
| Males | 0.66 | 0.435 | 5.4.75 | 0.000\* |
| Females | 0.71 | 0.507 | 4.676 | 0.000\* |
| **Arm Length** |  |  |  |  |
| Males | 0.28 | 0.072 | 2.516 | 0.001\* |
| Females | 0.52 | 0.269 | 1.579 | 0.000\* |
| **Forearm Length** |  |  |  |  |
| Males | 0.55 | 0.304 | 2.116 | 0.000\* |
| Females | 0.62 | 0.385 | 1.757 | 0.000\* |
| **Foot Length** |  |  |  |  |
| Males | 0.75 | 0.254 | 1.004 | 0.00\* |
| Females | 0.65 | 0.420 | 0.955 | 0.000\* |

**Table 4. Multivariate Regression Model for Stature of All Subjects**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Subjects | Multivariate regression | R | R-Square | Std. Error of  the Estimate | Sig. F  Change |
| All | S=57.59+(AS)0.346+(AL)0.153+(FAL)0.418+(FL)0.996 | 0.81 | 0.67 | 4.235 | 0.00\* |
| Males | S=51.61+(AS)0.419+(AL)0.109+(FAL)0.466+(FL)0.949 | 0.67 | 0.48 | 4.707 | 0.00\* |
| Females | S=50.79+(AS)0.343+(AL)0.234+(FAL)0.466+(FL)1.426 | 0.77 | 0.60 | 3.672 | 0.00\* |

*S=Stature, AS= Arm Span, AL= Arm length, FAL= Forearm-length, FL= Foot Length*

*\*= Significant*

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## Disclaimer (Artificial intelligence)

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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 this manuscript.

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