

# Anthropometric Determination of Body Height from Foot Length of Adults in Abeokuta Southwest Nigeria

\*Adekunle I. Musa<sup>1</sup>, Temitayo S. Ogedengbe<sup>2</sup>, Grace M. Amusan<sup>3</sup>, Solomon O. Giwa<sup>4</sup>

<sup>1&4</sup>Department of Mechanical Engineering, Olabisi Onabanjo University, Ago Iwoye, Nigeria

<sup>2</sup>Department of Mechanical Engineering, Elizade University, Ilara Mokin, Ondo State, Nigeria

<sup>3</sup>Department of Civil Engineering, Olabisi Onabanjo University, Ago Iwoye, Nigeria

\*Email: musa-olokuta.adekunle@oouagoiwoye.edu.ng

**Abstract:** Forensic identification of an individual in this time of unrest in some parts of the world cannot be overemphasized. The study was conducted to investigate and determine the body height (Bh) from foot length (Fl). Two hundred and sixty (260) adults (male and female) of ages ranged between 24years and 55years in Abeokuta Southwest Nigeria participated. The Bh and Fl of participants were measured using a stadiometer with a venier caliper and subsequently analysed. Descriptive statistics and simple linear regression model was determined. The result shows that the participants have an average of  $168.36 \pm 8.99\text{cm}$  and  $26.06 \pm 1.99\text{cm}$  as Bh and Fl respectively. The result also revealed that a statistical coefficient existed between Bh and Fl ( $P < 0.001$ ) with  $R^2$  of 0.598 and standard error estimate (S.E.E) of 5.710. With the analysed result, a linear regression model was established to determine the Bh from Fl. The study concluded that Fl has been identified as a predictor of Bh estimation and it is therefore recommended the use of anthropologist, forensic examination and medico-legal experts in demonstrating the identity of an individual and to determine Bh of adult Nigerian based on Fl.

**Keywords:** Body height, Foot length, Anthropometric, Forensic, Skeletal, Adult

## 1. INTRODUCTION

The insecurity presently ravaging the entire world has revealed that the identification of individuals is critical in forensic consideration. The identification may be obvious in instances of war, accidents, cultism, bomb blasts, kidnapping and crime [1]. The constant killings by armed bandits and cults in Nigeria have created a lot of panic in residents of the country. Many families could not identify the remains of their loved ones eventually resulting in mass burial by the Federal government. Whenever the human remains are discovered, a forensic investigator is employed to identify the corpse [2].

The Bh measurement plays a vital role in medico-legal empathy which has become indispensable assistance in the research of anthropometry. Cholamreza *et al.*, [3] reported that despite the gradual development in

the field of forensics, little has been done to the finding of Bh from the skeletal remains. Tanko *et al.*, [4] described the estimation of Bh as very important in establishing the individuality of people and their bodies when it is found mutilated or fragmented. Bh is also described as useful anthropometric parameters that determine the physical identification of an individual (Ebeya *et al.*, [5] and very important in medico-legal issues [6].

Reference to various parameters used for the identification of an individual, Bh played a vital characteristic. The determination of which is accepted to be vital in the case where the remains are mutilated or amputated limbs of an unknown person are only recovered with no obvious sign of individual identification in the event of natural disasters, accidents and murders [7]. Hairunnisa *et al* [8] reported that foot anthropometry is very useful in the determination of Bh, sex and age due to their strong correlation. Tanko *et al.*, [4] also stated that estimation of Bh is a veritable tool to establish the identity of an individual. Okafor *et al.*, [9] stated that there is a definite correlation between Fl and height of an individual, thus adjudging the study as very useful for anatomy and forensic experts.

Many scientists in the field of ergonomics and human factors studied different aspects of the foot [10] because in road accidents, often times feet remain intact due to the shoe. So it is very possible to find the persons' Bh on the basis of Fl. In view of this, it is essential to establish a close connection between Bh and Fl of an adult in Ogun State Southwest Nigeria, which has yet to be done to curb the spate of unidentified remains killed by the cultist. The study also designed and developed a model for the determination of the close connection between Bh and Fl for adults within the scope of the study.

## 2. MATERIALS AND METHOD

*Sample selection and measurement procedure*

A total of two hundred and sixty (260) individual adults both male and female were randomly selected. The purposive and judgment sampling methods were use because it is the best when studying a particular set of groups. The selected population was examined to determine their Fl, Bh and age. The age span of the participants was 24 – 55 years old.

- The Fl was measured as distance from the point of the back of the heel to the tip of the hallux or to the tip of the second toe using sliding venier caliper and recorded to the nearest centimetres.
- The Bh was measured using a stadiometer in a standing position bear footed with head in Frankfort plane and recorded to the nearest centimetres.

It is worth mentioning that subjects having malformed limb(s) were exempted from participating in the study.

**Data Analysis:** Obtained data were analyzed using statistical package for social sciences (SPSS) version 21.0 to determine the average mean values, standard deviation (SD), correlation of coefficient (R) and simple linear regression. The linear regression analysis determines the prediction of Bh from the Fl at a significance level of  $P < 0.05$  and their relationships is presented in the scatter plot.

**3. RESULTS AND DISCUSSION**

The result of the anthropometrical measurement (Table 1) shows that the mean Bh and Fl of the respondents are  $168.36 \pm 8.99$  cm and  $26.06 \pm 1.99$  cm respectively.

**TABLE 1: ANTHROPOMETRIC MEASUREMENT OF THE STUDY (N = 260)**

| Variable         | Mean (cm) | Standard Deviation (SD) |
|------------------|-----------|-------------------------|
| Body height (Bh) | 168.36    | 8.99                    |
| Foot length (Fl) | 26.06     | 1.99                    |

Table 2 shows the regression model analysis, and the correlation coefficient (R) of the obtained data. A Statistical correlation was observed between the Bh and Fl.

**TABLE 2: REGRESSION ANALYSIS (n = 260)**

| Model  | Coeff Beta (R) | R <sup>2</sup> | Adjusted R | S.E.E | T-value | Sig (P-value) | 95% CI for Beta |       | Parameter Estimate |                |
|--------|----------------|----------------|------------|-------|---------|---------------|-----------------|-------|--------------------|----------------|
|        |                |                |            |       |         |               | Lower           | Upper | Constant           | b <sub>1</sub> |
| linear | 0.774          | 0.598          | 0.597      | 5.710 | 19.604  | 0.000         | 3.137           | 3.838 | 77.457             | 3.488          |

a. Predictor: Fl (cm)

b. Dependant: Bh (cm)

S.E.E: Standard Error of Estimate; CI: Coefficient Interval

Linear regression model was determined for the estimation of Bh as follow:

$$Y = \text{constant} + b_1X \tag{1}$$

Where,

Y = body height (Bh)

X = foot length (Fl) (variable)

Reference to Table 2, the linear regression model can be deduced as:

$$Bh = 77.457 + 3.488Fl \tag{2}$$

Furthermore, for the estimation of predictive accuracy of the model for the prediction of Bh from Fl, the

coefficient of determination (R<sup>2</sup>) and S.E.E were also very important and determined as 0.598 and 5.71 respectively (Table 2)

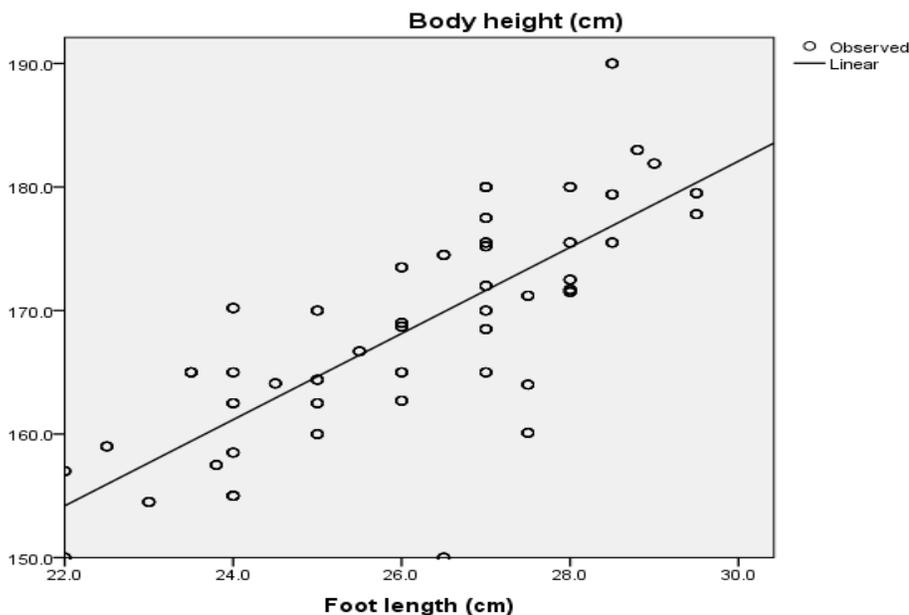
**TABLE 3: T-TEST AND PEARSON COEFFICIENT (n = 260)**

| Variable | T      | R     | 95% CI of Difference |        | P-Value (P<0.01) |
|----------|--------|-------|----------------------|--------|------------------|
|          |        |       | Lower                | Upper  |                  |
| Bh       | 301.90 | 1.000 | 167.26               | 169.46 | 0.000            |
| Fl       | 201.79 | 0.774 | 25.82                | 26.31  | 0.000            |

Table 3 shows the t-test (T) as 301.9, 201.79 and R (1.000 and 0.774) for Bh and Fl respectively. Coefficient R between Bh and Fl was found to be statistically significant and Bh showed a high degree

of correlation (R = 1.000) and foot length has a moderate correlation (R = 0.774).

The relationship between the Bh and Fl is shown in the scatter diagram (Figure 1)



**Fig 1:** Correlation between body height (cm) and foot length (cm)

**TABLE 4: COMPARISON OF THE AVERAGE MEAN Bh AND Fl AND THEIR R**

| Study                         | Country  | Bh (cm) | Fl (cm) | R     |
|-------------------------------|----------|---------|---------|-------|
| Present study                 | Nigeria  | 177.35  | 28.05   | 0.774 |
| Cholemeza <i>et al.</i> , [3] | Iran     | 174.64  | 26.22   | 0.780 |
| Mansur <i>et al.</i> , [11]   | Nepal    | 165.66  | 21.85   | 0.688 |
| Ozaslan <i>et al.</i> , [12]  | Turkey   | 171.97  | 24.90   | 0.700 |
| Jakhar <i>et al.</i> , [13]   | India    | 173.48  | 25.44   | 0.525 |
| Hairunisam and Moorthy [14]   | Malaysia | 164.80  | 23.20   | 0.789 |

Several methods existed to determine the Bh from anthropometric parameters before now but the earlier

and more reliable method is linear regression analysis [15]. Bh estimation is adjudged the most prominent and veritable tool parameters in the identification of an individual, though some anthropometric parts showed biological relation with Bh. In some climes, some used body parts or skeletal remains to determine the Bh. But

references to this present study, Fl have been identified as a predictor of Bh estimation. Theodoros [16] stated that foot length is an independent predictor of body height.

The regression model has a constant and a factor of the variable. The Fl is multiplied by the factor and added to the constant (Equation 1) and this shows the relationship between the Bh and Fl. The present study is consistent with Qamra *et al.*, [17] computed a simple linear regression equation for determining the Bl from Fl, found that Fl is more suitable and agreed that a true close connection existed between Fl and Bh. Similarly, Giles *et al.*, [18] also agreed that Fl displayed correlation with Bh and in view of this, Bh can be estimated from Fl. Furthermore, Singh and Phookan [19] also supported that Fl is a better and more reliable predictor of Bh.

The present study was further compared with other similar studies (Table 4). The result shows that the present study is relatively similar with a slight difference. These differences arise from the environmental and regional factors in respect of the study. The correlation coefficient (R) between Bh and length of the foot was 0.77, but when compared with other studies, it has the most similarity with Iran, Turkey and Malaysia citizens were reported to as 0.78, 0.70 and 0.789 respectively.

#### 4. CONCLUSION

The present study has successfully estimated the body height of an adult individual in southwest Nigeria from foot length using the regression equation model derive from this study. It was observed that this model can be used for forensic examination to be used by medical practitioners, law enforcement agents and the like. The reliability and prediction of Bh and Fl by the regression model are very good compared to other division factor methods. The results of the present study are quite encouraging and would assist the investigating officer and forensic experts to determine the body height of an individual with the ad of foot length. The determination of body height from foot length will be easy and economical with the model derived. The study also adds to the body of methods to determine the body height from foot length. Authors therefore recommended that researchers should be encouraged to conduct similar studies in different regions of Nigeria among the youth and other world and thereafter harmonized the data to establish a generalized model for both youths and adults.

#### Abbreviations

Bh – Body height  
Fl – Foot length

SEE – standard error of Estimate

CI – Coefficients interval

R – Correlation coefficient

**Funding:** This research received no funding.

**Data and materials:** Data sharing was declined so as to protect the participants' confidentiality.

**Conflict of Interests:** There is no conflict of interest(s).

#### References

- [1] S. Choudhary, H. Singh, N. Gupta. Estimation of stature from combined length of forearm and hand in Jammu region of India *International Journal of Basic and Applied Sciences*. 2013; 3(1):8-10.
- [2] A.A Ahmed. Estimation of stature from the upper limb measurements of Sudanese adults. *Forensic Science International*. 2013; 228(1):178. 1-7.
- [3] Gholamreza Hassanzadeh , Ghazaleh Moshkdanian, Simin Mahaki Zadeh, Fatemeh Moghani Ghoroghi, Tahmineh Mokhtari, Stature estimation from lower limb measurement in Iranian adults. *Anatomical Sciences*, Volume 11, number3, page 149 – 153, 2014
- [4] M. Tanko., W. Ahmadu. A.N Agbon, Z.M.Bauchi, A.A Sadeeq. and M. Musa.. Determination of Stature using Anthropometric Parameters in Adolescents from Selected Secondary Schools, Samaru- Zaria, Kaduna State, Nigeria. *Dutse Journal of Pure and Applied Sciences (DUJOPAS)*, Vol. 6 No. 4, 57 - 66, December 2020
- [5] O.A Ebeye.,D.E.O Ebo. and F.L Ayeyemi. Estimation of stature from hand length among Itsekiri of Southern Nigeria. *Advances in Environmental Biology*, 9(8): 156-158, 2015
- [6] S.M Chiroma, J. Philip, O.O Attah. and N.I Debal. Comparison of foot height, length, breadth and foot types between males and females Ga'anda people, Adamawa, Nigeria. *IQSR – Journal of Dental and Medical Science*, 14(8)1: 89 – 93, 2015
- [7] S. Agarwal, S.H. Hasan, Z. Surendra K. Agarwal. Correlation of Body Height By Foot Length And Knee Height Measurements In Population Of North India. *Int J Anat Res* 2015;3(3):1225-1229. DOI: 10.16965/ijar.2015.197
- [8] M. Hairunnisa, A Khan. T.N Moorthy. Stature estimation from anthropometric measurements of foot outline in adult indigenous Malenu Ethnic of East Malaysia by regression analysis. *Sri – Lanka Journal of Forensic Medicine, Sciences and Law*, 4(27): 27 – 36, 2013
- [9] I.J Okafor, I.S Etoniru, C.O Elemuo Estimation of Stature from Foot Length of Students in Anambra State University. *CARD International Journal of Science and Advanced Innovative Research (IJSAIR)* ISSN: 2536-7315 (Print) 2536-7323, 2017 (Online) Volume 2, Number 2, June 2017 <http://www.casirmediapublishing.com>
- [10] M. Vukotic.. Body height and its estimation utilizing foot length measurements in adolescents: a national survey. *Nutr Hosp* 2020;37(4):794-798

- [11] D. Mansur, M. Haque, K. Sharma, K. Karki, K. Khanal, K. Karna.. Estimation of stature from foot length in adult Nepalese population and its clinical relevance. Kathmandu University Medical Journal. 2012; 10(1):11-5.
- [12] A. Özaslan, M.Y İřcan, In Özaslan, h. Tuğcu, s. Koç. Estimation of stature from body parts. Forensic Science International. 2003; 132(1):40-5.
- [13] J.K Jakhar, V. Pal, P. Paliwal. Estimation of height from measurements of foot length in Haryana Region. Journal of Indian Academy of Forensic Medicine. 2010; 32(3):237-241.
- [14] M. Hairunnisa, T.N Moorthy. Stature estimation from the anthropometric measurements of footprint in Iban ethnics of east Malaysia by regression analysis. Journal of Forensic Science & Criminology. 2014; 2(2): 1 – 7, ISSN 2348 -9804.
- [15] L.M Jantz and R.L Jantz.. Secular changes in long bone length and proportion in the United States 1800-1970. Am. J. Phys. Anthropol., 1999, 110:57- 67.
- [16] B.G Theodoros. Correlation of foot length with height in school age children. J Forensic and Legal Medicine; 15(2): 89-95, 2008.
- [17] S.R Qamra, I. Jit, S. D Deodhar. A model for reconstruction of height from foot measurements in an adult population of North West India. Indian J Med Res. 1980; 71: 77 – 83.
- [18] E. Giles, P.H Vallandigham. (1991) Height estimation from foot and shoeprint length. J Forensic Sci;36(4):1134-51.
- [19] T.S Singh, M.N Phookan.. Stature and foot size in four Thai communities of Assam, India. Anthropol ANZ. 1993; 51(4): 349 – 355.