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Regression equations for estimating stature from anthropometric measurements of foot length and breadth in adults of efik ethnic group in cross river state

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Abstract:

INTRODUCTION: Estimation of stature is an important factor in forensic studies and occupies a foremost position in anthropometric research. The aim of the present work was to determine the reliability of foot dimensions in estimating stature in adult of Efik ethnicity in Cross River State.

MATERIALS AND METHODS: The individuals comprised of 600 adult indigenes (300 males and 300 females) of Efi k ethnic group in Cross River State between the ages of 18–45 years. Student's *t*-test, Pearson's correlation, and Regression analysis were used to estimate the stature in the study population.

RESULTS: Our results showed that stature in males had a mean value of 165.40 cm, whereas in females, it was 161.67 cm. More so, foot dimensions studied showed sexual dimorphism. Foot length in male individuals was 25.30 cm, while in females, foot length measured was 23.48 cm. Furthermore, the mean foot breadth in males was 9.20 cm, while in females, foot breadth was 8.37 cm. Statistical analysis revealed that the difference in foot length and foot breadth between males and females was statistically significant ($P < 0.05$). Furthermore, a positive correlation coefficient was observed between the foot dimensions measured and stature in both sexes.

CONCLUSION: Regression equations formulated showed that foot breadth was a better predictor of stature in males while foot length was more reliable in predicting stature in females of Efik descent. These findings will be of immense benefit to physical anthropology and forensic studies Kteuydwieos rodfs t:he study environment.

Keywords:

Anthropometry, Efik, foot breadth, foot length, forensic science, stature estimation

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Introduction

Dimensional relationship between body segments and the whole body has been the focus of scientist, anatomist, and anthropologist for many years (Kumar *et al.*, 2010). The reason for this because different populations or ethnic groups have unique genetic and phenotypic features which differs from other populations. The standards for one population may not give accurate results for another. Prediction of height is a vital factor in forensic studies. Prediction of height of an individual from skeleton or disfigured or severed limbs or their parts has apparent implication when identifying individuals. Creating the identity of a person from disfigured, decayed, and amputated body fragments has become a vital necessity in

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recent times due to natural disasters such as cyclones, earthquakes, floods, and man-made disasters such as bomb blasts, terror attacks, wars, plane crashes, and mass accidents (Mansur *et al*., 2012). In other instances, examination of skeletal remains recovered from a scene of crime has often been used by forensic anthropologists to extract relevant information about the victim. One such aspect pertains to reconstruction of living stature from such skeletal remains (Bhavna and Surinder, 2009).

Various researchers have worked on stature estimation and dimensions of the foot of Nigerians. The dependability of predicting stature from the foot dimensions was established by Egwu *et al*. (2012) using three hundred (300 individuals: 170 males and 130 females) adult Nigerians of Igbo descent, aged between 18 and 30 years. Estimated stature from measurement of foot length using two hundred and sixty-two healthy medical students of Imo State University, Owerri, aged between 18 and 28 years was also carried out by Iheanyi *et al*. (2009). In similar study, Mansur *et al*. (2012) derived regression equations which can be used in estimating stature from foot length for Nepalese individuals which consisted of 440 students of age group 17–25 years. The Turkish perspective of stature estimation was studied by Ozaslan *et al*. (2012) who measured dimensions of hand and feet and used these dimensions to predict the stature in Turkish adults (224 males and 132 females) whose age ranged from 20 to 51 years. Similarly, Rani *et al*. (2011) formulated regression equations for estimating stature in Delhi adult males and females when they used a total of 300 individuals (150 males and 150 females) aged 18–22 years for the study.

The measurements of the body parts of different ethnic groups may vary as a result of selective adaptation to different climatic zones and features of each ethnic group. Cross River State is found in the southern part of Nigeria, and the climate is the tropical rainforest climate. The State has different ethnic groups with the major ones being Efik, Ejagham, and Bekwarra and the three mainly located in the three senatorial districts of the State, namely Southern, Central, and Northern, respectively. When available literature was searched, it was observed that there was no published literature on the estimation of stature in the Efik ethnic group of Cross River State, in Nigeria, using foot dimensions. Hence, the aim of this work was to establish the standards for stature reconstruction in adults of Efik pedigree by deriving population-specific regression equations which can be used for estimating stature from anthropometric measurement of the foot.

Subjects and Methods

A cross-sectional sample of 600 adult Efik indigenes of Cross River State (300 males and 300 females) between the age group of 18–45 years were recruited for this study. The research was carried out between February and November 2014. Data were obtained from Calabar Municipality, Calabar South, and Akpabuyo. The benchmarks for selecting the individuals were that their parents and grandparents were Efiks and have been resident in the area of study from birth. Individuals whose age fell between 18–45 years were included in the study. This age range was used because that is the active population and maximum stature is attained within this age range while individuals with cases where the skeletal growth was stunted (dwarfism) or cases where the skeletal growth was abnormally enhanced (Gigantism) were not included in the study sample. More so, individuals who were <18 years and above 45 years were excluded from this study.

The objectives and the methods of the study were explained to each individual, and informed consent was obtained from the individuals before measurements were taken. Three anthropometric measurements, namely stature, foot length, and foot breadth were measured separately for each individual. All the measurements were recorded thrice, and then, their mean was calculated and recorded for accuracy.

Anthropometric measurements

Stature

This was taken as the distance between the vertex and the floor [Figure 1]. It was measured with a meter rule in the erect vertical position with the individual standing barefooted and head in Frankfurt plane as described by Ilayperuma *et al*. (2009).

Foot length

This was measured as a straight distance between the most posterior projecting point of the heel and anterior projecting point (the end of 1st or 2nd toe) using an osteometric board [Figure 2].

Foot Breadth

It was taken as the distance between the most prominent point on the medial aspect of head of first metatarsal and the most prominent point on the lateral aspect of head of fifth metatarsal [Figure 3] as outlined by Modibbo *et al*. (2012).

Statistical analysis

Statistical package for social sciences (SPSS) for Windows, Version 17.0, SPSS Inc., Chicago, IL, USA was used for the statistical analysis. The results were expressed as mean ± standard error of the mean; comparisons were made of stature and foot dimensions studied between males and females using the Student's *t*-test. The differences were considered statistically significant at 95% confidence level ($P < 0.05$).

Ethical approval

The objectives of the research were explained to each individual, and written informed consent was obtained from each of them before the commencement of measurement. In line with Helsinki Declaration of 1975, as revised in 2000, ethical approval was obtained from the Ethics/Research Committee of the Faculty of Basic Medical Sciences, Cross River University of Technology, Okuku Campus, Yala, Nigeria.

Results

The results obtained from the present study are presented in Tables 1-4. From the results, it was observed that the values of stature, foot length, and foot breadth in the male individuals were significantly higher than their female counterparts ($P < 0.05$). Stature in the male individuals had a mean value of 165.40 cm, while females had a mean stature of 161.67 cm. Foot length in the male individuals was 25.30 cm, whereas in the females, foot length was 23.48. Foot breadth in the males was 9.20 cm, and in the females, it was 8.37 cm [Table 1].

The relationship between the different foot dimensions and stature is shown in Table 2. This relationship was studied using Pearson correlation. In the male individuals, all the parameters exhibited positive correlation with the stature which was statistically significant ($P < 0.05$). More so, in males, the highest correlation was exhibited by foot breadth ($r = 0.543$) and the lowest was by foot length ($r = 0.426$). In females, both foot length and foot breadth exhibited positive correlation with stature and these values were statistically significant ($P < 0.05$). The maximum correlation coefficient was observed in foot length ($r = 0.572$) and the lowest was recorded in foot breath ($r = 0.421$).

Table 3 shows the linear regression equations that were derived to estimate stature from the different dimensions of the foot. Regression analysis of the measurements was performed separately for the males and females since statistically significant differences were observed between these two groups and also for each parameter studied. The equations that were formulated revealed standard error of estimate which predicts the deviations of estimated stature from the actual stature. A small value shows greater reliability in the predicted stature.

The degree of reliability of these regression equations that was derived by comparing the estimated stature and actual measured stature is shown in Table 4. In male individuals, it was observed that all values of the actual and estimated stature were very close and independent *t*-test was done to ascertain whether or not the estimated and actual (measured) stature had any statistically significant difference from the estimated stature. The result obtained showed that there was no statistically significant difference between the estimated and measured stature. More so, the same comparisons were carried out in the female individuals and *t*-test also revealed that there was no statistically significant difference between the estimated and measured stature when foot length and foot breadth were the variables.

Table 1: Descriptive statistics of parameters measured in male and female individuals

Sex	Stature (cm)	Foot length (cm)	Foot breadth (cm)
Male	165.40±5.35	25.30±1.15	9.20±0.50
Female	161.67±5.20	23.48±1.21*	8.37±0.40*

*Significantly different from male at $P<0.05$

Table 2: Correlation between stature and foot dimensions in male and female individuals

Variables	Male		Female	
	Correlation (*r*)	r^2	Correlation (*r*)	r^2
Foot length	0.426**	0.181	0.572**	0.327
Foot breadth	0.543**	0.295	0.421**	0.177

**Correlation is statistically significant ($P<0.01$) two-tailed

Table 3: Linear regression equations for foot dimensions studied in males and female individuals

Sex	Regression equation
Male	Stature=115.588+(1.960 × foot length)±3.426
	Stature=120.295+(4.756 × foot breadth)±2.434
Female	Stature=90.631+(2.416 × foot length)±3.544
	Stature=122.381+(4.143 × foot breadth)±3.862

Discussion

Attempts at estimating stature from the human skeleton have been conducted by different researchers. There are several methods used to estimate stature from the bones but the simplest and most reliable method is by regression analysis. Regression is an ideal method for establishing the association that exists between the length of long bones and stature of individuals and between measured anthropometric parameters of the long bone fragments

Table 4: Comparing the estimated stature and actual measured stature in male and female individuals

	Prediction formula	Measured stature	Predicted stature	*t*	Significant (two-tail)
Male	Stature=115.588+(1.960 × foot length)±3.426	165.40±5.35	165.346±0.134	0.051	0.941
	Stature=120.295+(4.756 × foot breadth)±2.434	165.40±5.35	165.481±0.142	−0.005	0.992
Female	Stature=90.631+(2.416 × foot length)±3.544	161.67±5.20	161.602±0.104	0.051	0.965
	Stature=122.381+(4.143 × foot breadth)±3.862	161.67±5.20	161.818±0.109	−0.011	0.934

Figure 1: Measurement of stature

Figure 2: Measurement of foot length

Figure 3: Measurement of foot breadth

and their maximum length (Krogman and Iscan, 1986). Furthermore, the significance of linear regression method that was formulated by Trotter and Gleser for the prediction of stature is a well-known fact among physical anthropologists (Trotter and Glesser 1958). However, it has been reported that all regression formulae employed in stature estimation must be unique to the population where samples were obtained (Lundy and Feldesman, 1987). Stature estimation is useful when height cannot be measured directly due to deformities such as kyphosis and scoliosis (Oria *et al*., 2016). In the present study, the Efik male individuals had higher values of foot length and foot breadth than their female counterparts and the difference in these dimensions were statistically significant suggesting the existence of sexual dimorphism in the measured variables. The result of the present study is in agreement with what Onuoha *et al*. (2013) reported when they studied the foot and head anthropometry in Polytechnic Students, in Nigeria. In their study, sexual dimorphism was observed with the male students having higher foot dimensions than the female students. This finding was in consonance with that of Egwu *et al*. (2012) who estimated stature from foot dimensions in adult Nigerian population and reported sexual dimorphism in foot length and foot breadth.

Studies on other Nigerian ethnic groups also supported these findings. For instance, Iheanyi *et al*. (2009) reported sexual dimorphism in foot length of an adult Igbo population in Imo state. It is relevant because the present study reveals sexual dimorphism in foot length in Efiks which agrees with the result of that research on Igbo ethnic group where sexual dimorphism was reported in foot length. An observation in the results obtained by Egwu *et al*. (2012) (DATE) and Iheanyi *et al*. (2009) (DATE) was that the dimensions of the foot they measured were similar probably because their study was carried out on the same ethnic group (Igbo) but in different states of Ebonyi and Imo, respectively, all in Nigeria. Some researches carried out on foreign populations also supported the fact that sexual dimorphism exists in foot dimensions. For instance, Mansur *et al*. (2012) in their work on Nepalese individuals reported sexual dimorphism in foot dimensions. Another remarkable observation made was that the values of foot length obtained from their work for both sexes were lower than the results obtained for Efik individuals in the present study and from other Nigerian ethnic groups which revealed that people from this part of the world have longer feet.

In addition, all the dimensions of the foot that were measured in the present study showed positive correlation with stature. The correlation coefficient between foot length and stature in Efik individuals in the present study was higher in female individuals than in their male counterparts. This finding is congruent with the results of studies carried out by other researchers. Furthermore, Egwu *et al*. (2012) found positive correlation between stature and foot dimensions in both male and female individuals, and the correlation coefficient

was higher in females than males. Similarly, Iheanyi *et al*. (2009) reported positive correlation between foot length and stature with the correlation coefficient also higher in female individuals than their male counterparts.

The existence of a positive correlation between foot dimensions and stature facilitates the formulation of linear regression equations which can be successfully utilized for stature estimation in a Cross River State population. Linear regression equations for predicting stature using these dimensions in Efik males and female individuals in Cross River State were derived. The regression equations formulated showed that foot breadth was a better predictor of stature in Efik males while foot length was more reliable in predicting stature in Efik females.

Conclusion

The results of the present study will serve as a reference point for other studies regarding stature estimation in other ethnic groups in Cross River State and Nigeria at large. Nevertheless, the regression equations obtained from the present study should be authenticated by forensic experts so that it can be used as a tool in the prediction of stature using foot dimensions in the Efiks of Cross River State. Therefore, it is concluded that foot breadth in the males and foot length in the females present the strongest association with stature and are the most reliable for estimation of stature in Efik males and females, respectively.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patients have given consent for images and other clinical information to be reported in the journal. The patients understand that names and initials will not be published and due efforts will be made to conceal identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

References

1. Bhavna N., Surinder N. (2009). Use of lower limb measurements in reconstructing stature among Shia Muslims. Internet J Biol Anthropol 2 (2):86-97.
2. Egwu O.A., Nto N.J., Bello E.F., Egwu E.O., Ukoha U.U., Ajah D. (2012). Stature estimation from foot dimensions of an adult Nigerian population. Anat Karnataka 6 (2):8-12.
3. Iheanyi O., Godwin A., Godwin U. (2009). Stature prediction from length of the foot in a Nigerian population. J Exp Clin Anat 8 (1):33-5.
4. Ilayperuma I., Nanayakkara G., Palahepitiya N. (2009). Prediction of personal stature based on the length of the hand. Galle Med J 14:15-8.
5. Iscan M.Y. (1998). Rise of forensic anthropology. Yearb Phys Anthrop 31:203-30.
6. Krogman W.M., Iscan M.Y. (1986). The Human Skeleton in Forensic Medicine. 2nd ed. Charles C. Thomas, USA, Springfield.
7. Kumar S., Srivastava A.K., Sahai M.K. (2010). Estimation of stature by anthropometric examination of forearm and hand. J Indian Acad Forensic Med 32 (1):62-5.
8. Lundy J.K., Feldesman M.R. (1987). Revised equation for estimating living stature from long bones of South African Negro. S Afr J Sci 83:54-5.
9. Mansur D.I., Haque M.K., Sharma K., Karki R.K., Khanal K., Karna R. (2012). Estimation of stature from length of the foot in adult Nepalese population and its clinical relevance. Kathmandu Univ Med J 37 (1):16-9.
10. Modibbo M.H., Taura M.G., Agu O.C., Bashir U. (2012). Estimation of stature from hand and foot dimensions in Hausa neonates: A hospital-based study. Bayero J Pure Appl Sci 5 (2):110-4.
11. Onuoha S.N., Okafor M.C., Oduma O. (2013). Foot and head anthropometry of 18-30 years old Nigerian polytechnic students. Int J Curr Eng Technol 3 (2):352-55.
12. Oria R.S., Igiri A.O., Egwu O.A., Nandi M.E. (2016). Prediction of stature from hand length and breadth-Anthropometric study on an adult cross river State population. Ann Bioanthropol 4:12-6.
13. Ozaslan A., Karadayi B., Kolusayin M.O., Kaya A., Afsin H. (2012). Predictive role of hand and foot dimensions in stature estimation. Rom J Legal Med 20:41-6.
14. Rani M., Tyagi A.K., Ranga V.K., Rani Y., Murari A. (2011). Stature estimates from foot dimensions. J Punjab Acad Forensic Med Toxicol 11 (1):31-3.
15. Trotter M., Glesser G.C. (1958). A re-evaluation of estimation of stature based on measurement of stature taken during life and long bones after death. Am J Phys Anthropol 16:79-123.