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Stature estimation from humeral length amongst Nigerians: A radiographic approach

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Abstract

Stature is an essential anatomical parameter for creating the biological profile of persons in forensic analysis. The aim of the study was to establish regression formulae for the estimation of stature from plain radiographs of humerus. A total of 90 subjects (49 males and 41 Females) were recruited randomly for the study at the Lulu-Briggs Health centre, University of Port Harcourt. An x-ray of the humerus was taken after measuring the heights of volunteers. The films obtained were later fixed to an x-ray illuminator where the humeral length (HML) was measured using a lead pencil and ruler. Statistical analysis was done for all parameters (stature and humeral length) using SPSS. Pearson's co-efficient of stature versus HML were 0.66 for males and 0.50 for females. The regression equation for estimation of stature were 2.45 (HML) + 89.20 for males and 2.16 (HML) + 97.17 for females. Standard error for regression formula derived was observed to be 0.41cm in males and 0.59 cm in females which indicates a high level of reliability on the formula and proves further to show that the humerus is a good predictor of stature. In conclusion, the use of x-ray is a reliable procedure and a practical approach in stature estimation and the humerus is a good predictor of stature in the Nigerian population.

Keywords: Radiograph; X-Ray; Humeral Length; Stature; Nigerian

1. Introduction

Estimation of stature is fundamental to the creation of biological profile of persons and it is therefore an important aspect of forensic identification. Stature is one of the identifying factors in forensic anthropology and it refers to the natural standing height of an individual. It is the distance from the bottom of the feet to the vertex of head in a human body standing erect. Stature estimation is a major domain of medico-legal investigations in establishing the biological profile of the unknown fragmentary and mutilated remains [1, 2, 3]. The stature of an individual is influenced by genetic and environmental factors such as health, disease, nutrition and physical activity [4, 5]. Stature provides an idea about the size of a person. Due to the allometric relationship of the body parts with one another, stature can be estimated from almost all the bones of the body. Forensic anthropologists all over the world have attempted to estimate stature from various bones. Long bones of the extremities are reported to give more accurate estimates of stature as these directly contribute to the stature of the individual [6, 7].

There are two basic methods of stature estimation; Fully's anatomical method and the mathematical method. The anatomical method is the most accurate method in stature estimation as it involves the complete skeleton but its limitation is that all the individual long bones must be present [8]. On the other hand, the mathematical method involves the use of certain statistical formulae in estimating stature with just a single bone or fragments of a bone. The mathematical method includes other two sub-methods which are the multiplication method and the regression analysis

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method. Studies have shown that the regression method of stature estimation is more accurate than the multiplication factor method [1, 9]. Regression analysis is based on the linear relationship between dimensions of bones; body parts and stature. Various regression formula have been derived for estimation of stature from long bones [1, 6, 7, 8].

Studies have shown that radiographically determined long bone lengths could provide stature estimates using regression formula and x-ray imaging is valuable in anthropological assessment of an individual [9-19]. In this study, roentgenography (an imaging technique using x-rays to view the internal structure of an object) was applied to the process of stature estimation. Haskell, [20] in his roentgengraphic study of the relationship between tibial length and stature, highlighted some of the various problems associated with obtaining data from skeletal and cadaveric materials. Some of the limitations he discovered which prompted the use of x-ray for stature estimation are; First, accessing such materials is usually limited to laboratory or hospital collections where there has been no conscious control over criteria of selection; Secondly, the exact age at death may not be known. Trotter and Glesser, [20] discovered that age is an important consideration with regard to stature. The factor of age becomes a vital fact knowing that limb length does not change once growth has been completed and stature decreases with advancing years after the age of thirty. Another challenge faced in using skeletal and cadaveric materials is the limitation as to the number of population which can be investigated, hence the need for x-ray imaging. The application of x-ray imaging really becomes a more practical approach to stature estimation. In Nigeria, Igwe and Akpuaka [21] did a roentgen graphic study of the scapula to investigate the correlation between stature and different radiographic scapular measurements. The study involved analyzing 90 scapular radiographic films comprising 45 males and 45 females with ages ranging between 25 to 65 years. Six different radiographic scapular variables were measured with spreading caliper. The result obtained was analyzed and used to derive a formula between different radiographic scapular measurements and the total height of an individual. While there are several reports of estimation of stature from several regions of the body using direct anthropometry, there is paucity of data on the use of radiologic image techniques for estimation of stature in Nigeria population. The purpose of the study was to estimate stature from radiographically determined length of the humerus among in a sample of Nigerian population.

2. Material and methods

2.1. Study Participants

Volunteer subjects were young adults recruited from University of Port Harcourt community. A total of 90 persons ranging from the age of 17 to 34 years including 49 males and 41 females were randomly selected. The inclusion criteria for the subjects include: absence of physical injuries; absence of visible shortening of the any of the limbs; absence of bone pathology, bone surgery and any other pathological process in medical history. Subjects above age 34 were not involved to exclude skeletal change attributable to advanced age. Those who have been exposed to x-ray in the last five years were also excluded. Informed consent was obtained from participants after explaining the process and purpose of the study. Heights of participants were measured and x-ray of the humerus was done in all cases to obtain films from which humerus maximum length (HML) was measured.

2.2. Measurement of height

The height of the body was measured by using a collapsible stadiometer. The individual was made to stand in an erect position barefoot and looking forward with the back against a graduated ruler. The scaled trap lowered until contact with the vertex of the head was achieved and then the reading was taken in centimeters.

2.3. Humeral length measurement from x-ray film

Measurement of the length of the humerus was taken directly from the illuminator/viewing box. Each of the films was placed on an x-ray viewing box. Care was taken to fix the film directly and in a straight line on the viewing box placing a transparent sheet on the x-ray film. A lead pencil was used to mark the landmarks on the humerus. The point measured on the film showing the humerus bone was from the projected distance between the most superior border on the head of the humerus and the most distal point of the trochlea, denoted as humeral maximum length. A horizontal line was drawn across the superior border of the head and another line drawn across the most distal part of the trochlea. Then a straight vertically orientated line was drawn in between the two points and the humeral maximum length was measured using a ruler.

Figure 1 A radiographic film showing the points to be measured from the projected distance between the most superior border on the head of the humerus and the most distal point of the trochlea to obtain the humeral maximum length, (HML)

2.4. Ethical Consideration

Ethical approval was given by the Ethics Review Committee of the College of Health Sciences, of the University of Port Harcourt for the study.

2.5. Statistical analysis

Computer assisted analysis was performed using the SPSS 14.0 program (SPSS, Chicago, Ill.) for all tests. Correlation among the values was examined by simple regression analysis with Pearson's correlation coefficient (R). A simple linear regression model was utilized for analysis of humerus length. The length of the humerus was regressed against the height of individuals to derive regression formula to determine stature for both males and females.

3. Results

Table 1 shows the result for all participants irrespective of sex. The mean and SEM for age, stature and humeral length were 22.16 ± 0.36 years, 171.64 ± 0.86 cm. 33.94 ± 0.23 cm. Tables 2 and 3 showed results for male and female subjects. The males had mean age, stature and humeral length of 22.16 ± 0.57 years, 175.07 ± 1.04 cm and 35.04 ± 0.28 respectively, while the females also had 22.15 ± 0.42 years, 167.54 ± 1.16 cm, and 32.63 ± 0.27cm respectively

Table 1 Descriptive statistics for measured parameters (all subjects)

Parameters	Sample size	Range	Minimum value	Maximum value	Mean	SEM	Std. Deviation	Variance
Age (years)	90	17.00	17.00	34.00	22.16	0.36	3.45	11.93
Stature (cm)	90	36.40	153.40	189.80	171.64	0.86	8.20	67.23
Humerus Length (cm)	90	11.00	29.00	40.00	33.94	0.23	2.20	4.85

SEM = standard error of mean

Table 4, 5 and 6 shows coefficients value, t score, Pearson correlation and regression formulae for the prediction of stature from humerus length for all subjects, male subjects and female subjects. All correlation values were high and significant (p=0.00)

Table 2 Descriptive statistics for measured parameters (male subjects)

Parameters	Sample size	Range	Minimum value	Maximum value	Mean	Std. Error	Std. Deviation	Variance
Age (years)	49	17.00	17.00	34.00	22.16	0.57	4.00	16.01
Stature (cm)**	49	28.00	161.00	189.00	175.07	1.04	7.24	52.50
Humerus Length (cm)**	49	7.80	31.70	39.50	35.04	0.28	1.95	3.80

** p = 0.00

Table 3 Descriptive statistics for measured parameters (female subjects)

Parameters	Sample size	Range	Minimum	Maximum	Mean	Std. Error	Std. Deviation	Variance
Age (years)	41	11.00	18.00	29.00	22.15	0.42	2.71	7.33
Stature (cm)**	41	36.40	153.40	189.80	167.54	1.16	7.41	54.95
Humerus Length (cm)**	41	7	29	36	32.63	0.27	1.73	2.99

** p = 0.00

Table 4 Regression equation formulae for estimation of stature (cm) from radiological measured humerus maximum length (HML)

Gender	Measured Parameter	Regression Equation	Correlation coefficient	P value	Standard Error
Both	Humerus	Stature = 2.57 (HML) + 84.32	0.69	0.00	0.29
Male	Humerus	Stature = 2.45 (HML) + 89.20	0.66	0.00	0.41
Female	Humerus	Stature = 2.16 (HML) + 97.17	0.50	0.00	0.50

4. Discussion

The study has investigated the allometric relationship of stature to x-ray dimension of humerus length with a view of formulating regression formulae for stature estimation. The estimation of stature from human skeleton has been the focus of many fields of forensics over the past decades due to the increasing need for human identification. Long bones have been found to have given the most reliable results in this regard [6.7.8].

In the present study, Nigerian males were found to be taller than the females with an average height of 175 .07± 1.04 cm and 167. 54 ± 1.16 cm respectively. The difference is statistically significant (p=0.00). Our findings are similar to studies of some major ethnic groups in Nigeria [22, 23, 24]. Numan *et al*, [24] reported an average height of 174.79 ± 0.86 cm and 167.03±1.04cm for males and females of Hausa ethnic group; 171.58±1.23 cm and 169.40±0.73 cm for males and females of Igbo ethnic group; 170.53±1.00cm and 164.05±0.80 cm for Yoruba ethnic group. Among Malaysians, males were also reported to be taller than females [25,26] The findings on stature in the study are useful for predictive anthropometry as they indicate sexual dimorphism. The features of sexual dimorphism in human anatomy are essential in creating the biological profile of groups and individuals for sex estimation.

Roentgenographic study of the humeral length for stature estimation among Nigeria population is very rare. A major limitation factor may be cost and health implication of exposure of people to x-rays. This is also a major limiting factor in the sample size of this study. The mean humeral length in males (35.04±1.95) is higher than females (32.63±1.73).This was in agreement with Bagali *et al*, [11] who reported a similar findings in a study conducted among Indian adult population. This affirms the fact that humeral length demonstrates sexual dimorphism and can be very useful in sex determination.

The reliability of stature estimation from bone using regression formulae is shown by the standard error of the estimate. The Pearson correlation coefficient was highly significant in both sexes; however, correlation coefficient was higher in males than females. Petrovecki *et al*. [12] was of the view that correlation between stature and long bones appears to be more accurate with upper limbs. In this study, regression formulae for male and female participants were obtained with respective standard error which actually predicts the reliability of the derived equation. This is comparable to the work of Bagali *et al* [11] who reported a regression equation (2.589 x HML) + 78.58) for males and ((2.585 x HML) + 72.01 for females of North Karnataka in India.

5. Conclusion

In conclusion, this study has demonstrated that roentgenographic study of long bones like humerus is a reliable method for stature estimation among Nigerian adults. Differences in sex should also be noted as they play a major in accurate estimation of stature due to sexual dimorphism.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

The authors (Dr Loveday E. Oghenemavwe, Dr Chukwuemeka E. Agi) declare no conflict of interest.

Statement of ethical approval

Ethical approval was given by the Ethics Review Committee of the College of Health Sciences, of the University of Port Harcourt for the study.

Statement of informed consent

All participants were adequately prepared for the study; were given health education, all necessary information provided and voluntarily signed consent form.

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