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Focus and Scope

The African Journal of Tropical Medicine and Biomedical Research is a multidisciplinary and international journal published by the College of Health Sciences, Delta State University of Abraka, Nigeria. It provides a forum for Authors working in Africa to share their research findings on all aspects of Tropical Medicine and Biomedical Sciences and to disseminate innovative, relevant and useful information on tropical medicine and biomedical sciences throughout the continent. The journal will publish original research articles, reviews, editorials, commentaries, short reports, case reports and letters to the editor. Articles are welcome in all branches of medicine and dentistry including basic sciences (Anatomy, Biochemistry, Physiology, Pharmacology, Psychology, Nursing etc) and clinical sciences (Internal Medicine, Surgery, Obstetrics and Gynaecology, Dental surgery, Child Health, Laboratory Sciences, Radiology, Community Medicine, etc). Articles are also welcome from social science researchers that document the intermediating and background social factors influencing health in countries of Africa. Priority will be given to publication of articles that describe the application of the principles of primary health care in the prevention and treatment of diseases.

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Stature Estimation using Tibia Length in Young Adults of Urhobo Ethnic Group, in South-south, Nigeria

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Abstract

Introduction: Estimating stature is an essential part of the identification of human skeletal remains or body parts. The purpose of this study was to estimate stature using tibia length among young Urhobo Adults.

Materials and method: 350 subjects (144 males and 206 females) were utilized for the study. Stature was measured using a stadiometer and tibia length was measured using a digital Vernier calliper. The independent and paired samples t-test, Pearson's correlation test and linear regression equations were employed using Statistical Package for Social Sciences (SPSS) software.

Results: The mean height in males was 174.22cm and females was 163.97cm, the mean Right tibia length was 40.48cm in males and 37.67cm in females while the left tibia length was 40.41cm and 37.63cm in males and females respectively. There was significant difference between right and left tibia length in males and the general population ($p<0.001$). However, females showed no significant difference ($p>0.05$). There was a strong positive significant association between stature and bone lengths ($r>0.8$, $p<0.001$). There was no significant difference between the estimated and actual stature for subjects using the general and group-specific regression formulas ($p>0.05$).

Conclusion: The study showed that males have significantly higher mean values of parameters measured than females. Right tibia length was significantly longer than the left in males and total population. Group-specific formula gave more accurate results than the general formula making them better suited to estimate stature in forensic cases. Hence, tibia length can be used as an important tool in forensic examination as they provide elements of accuracy in stature determination.

Keywords: Stature, Estimation, Anthropology, Tibia length, Forensics

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Introduction

Stature is the natural height of an individual when standing in an upright position. Bickes defines it as the distance between the vertex of the head and the bottom of the feet [1]. Stature has been investigated as an indicator of health, environmental condition, as well as socioeconomic and political situations of an individual or population in numerous domains such as paleoanthropology, bioarchaeology, and physical anthropology [2].

Estimating stature is a critical component of identifying human skeletal remains or body parts [3]. Ideally, the fundamental goal of any investigation that involves an unidentified human corpse is to establish identification, regardless of the condition of the remains. This task is complicated when there are multiple remains (e.g., because of natural disaster, war, bombing, mass accidents, or genocide) or when the integrity of the remains has been compromised (e.g., because of mutilation or explosion). Similarly, it is difficult to identify victims following attacks by wild animals in deep forests [3]. In such situations, determining a presumed identity requires the utilization of various biological factors, including age, race, stature and personal attributes such as past dental treatments, injuries, or chronic skeletal conditions [4].

Environmental, nutritional, socioeconomic and climate factors have an impact on the relationships between stature and variable anatomical measurements [5, 6]. Since ancient times, different scientists have put forward different equations by regression analysis across the globe to estimate the height of different groups of populations by using different parts of the skeleton such as the vertebrae [7], craniofacial parameters [8, 9] and the sternum [10]. Studies on estimating stature using percutaneous body measures have also been conducted [11-13]. Percutaneous length of long bones is a more practical approach for estimating stature than dry bone, which is a time-consuming and difficult process that entails cleaning and preparing bones [14].

The estimation of stature from long bones is based on the assumption that the majority of our body's long bones have a positive correlation with stature [15]. The femur and tibia, which account for the majority of stature, are more accurate than the humerus and ulna [16]. Lower limb length is the greatest contributor to standing height; thus, the most productive equations are based on their length, such as the femur, tibia, and fibula [16]. The tibia is appropriate for this application because it resists degradation and retains its anatomical shape even after burial [17]. Tibia also contributes for 22% of total body length [16]. Among studies using tibia in estimating stature are: (Ugochukwu *et al.* [18] in Cross River, Nigeria; Blessing *et al.* [19] in Port Harcourt, Nigeria; Tika *et al.* [20] in Indonesia; Bickes [1] in Ethiopia; Madalina *et al.* [21] in Romania).

Because stature demonstrates population specific variation, it is generally accepted that it is inappropriate to apply equations generated for one population to another when identification of unknown human remains by metric analysis is required [22]. This study was therefore undertaken in view of paucity of data to provide relevant guiding tools for forensic anthropologists in the event of medico-legal eventualities on stature estimation using tibia length among young adults of Urhobo ethnic group.

This study is of utmost importance to identify fragmentary and dismembered human remains in young Adults of Urhobo ethnic groups which will be useful in forensic anthropology by law enforcement agents and forensic scientists. It will also provide predictive equations to estimate stature using tibia length following mass disasters and deformity or illness. The purpose of this study was to estimate stature using tibia length among Urhobo young adults in Delta State, Nigeria.

Materials and method

This was a descriptive cross-sectional study of the quantitative design. The stratified random sampling technique was used to select 350 students (144 males and 206 females) within the age range of 18-30 years from three South-South Nigerian universities who belonged to the Urhobo ethnic group and were registered with their ethnic associations in the study centres.

Selection criteria

Subjects who appear to be healthy with no visible physical malformation of the limbs or trunk and whose parents are Urhobo for up to two generations were included. Subjects with limb or spine abnormalities, evident injuries, or a history of surgical operations involving the limbs or spine were excluded from the study.

Ethical consideration

Approval was sought from the Research and Ethics Committee of the Faculty of Basic Medical Sciences, Delta State University, Abraka (REF: REC/FBMS/DELSU/22/153). All subjects were told the nature and purpose of the study, and only those who gave consent participated.

Method of measurements

A stadiometer (Health Medical Equipment, England) was used to measure the subject's standing height while standing erect on a horizontal resting plane, barefooted, with the subject's head, shoulders, buttocks, and heels contacting the vertical plate, palms turned inward, and fingers pointing downwards. Without a cap or hairstyle that could interfere with the measurement technique, the head was adjusted in the Frankfurt horizontal plane. The tibia length of the individual was also measured in millimetres while sitting with the knee flexed at 90^0. The distance between the most prominent, palpable upper part of the medial condyle and the tip of the medial malleolus of the tibia was measured with a 500mm digital sliding Vernier calliper (Shahe, China) (Martula *et al.*, 2017). The tibia length, however, was converted to centimetres for uniformity and precision during data analysis.

Figure 1: Measurement of tibia length.

Data analysis

The data from this study was analysed using SPSS (Statistical Package for Social Sciences, Version 23.0) computer software. The data was summarised using descriptive statistics. Inferential statistics were also used: The independent samples t-test was used to check for gender differences in stature and tibia length. The paired samples t-test was used to compare tibia length on the left and right sides in both genders. Pearson's correlation test was used to determine the relationship between stature and tibia length. Using linear regression equations, a group-specific and general formula was created. The sample was divided into three groups for the group-specific formula based on the lengths of their bones: short, medium, and long. As with the classification of long bone lengths, cut-off values at the 15th and 85th percentiles were used. [23] The tibia was specifically divided into three length categories: short (length ≤ 35.98cm), medium (length between 35.98-41.79cm), and long (length > 41.80cm). Statistical significance was defined as a P value less than 0.05.

Results

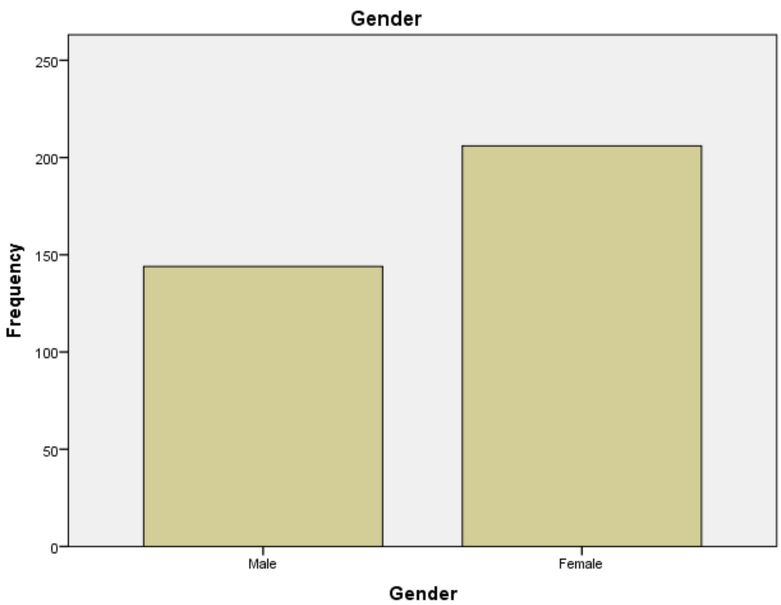

Figure 2: Distribution of study subjects according to

Figure 2 shows the distribution of study subjects according to gender. A total of 350 subjects (144 males and 206 females) with a mean age of 21.96±2.99 years (22.07±3.16 years for males and 21.41±2.60 years for females) participated in the research.

Table 1: Comparison of height and tibia length between males and females' subjects using independent t-test

Parameter (cm)	Sex	Mean± Std	Minimum	Maximum	t	Df	p-value
Height	Male	174.22±8.56	151.00	196.00			
	Female	163.97±8.14	135.00	192.00	11.36	348	<0.001*
Right tibia length	Male	40.48±2.62	33.41	49.46			
	Female	37.67±2.49	27.90	44.78	10.16	348	<0.001*
Left tibia length	Male	40.41±2.62	33.61	49.54			
	Female	37.63±2.39	27.61	44.57	10.30	348	<0.001*

std=standard deviation, t= t-test for results, Df= degree of freedom, *= p value is statistically significant

Table 1 shows comparison of height and tibia length between males and females using independent t-test. The mean values of all parameters studied were significantly ($p<0.001$) higher in males than females.

Table 2: Side comparison of the tibia length using paired t-test

Sex	Parameter (cm)	Mean± Std	T	Df	p-value
Male	Right tibia length	40.48±2.62			
	Left tibia length	40.41±2.62	4.43	143	<0.001*
Female	Right tibia length	37.67±2.49			
	Left tibia length	37.63±2.39	1.14	205	0.254
Total	Right tibia length	38.82±2.89			
	Left tibia length	38.77±2.84	2.36	349	0.019*

std= standard deviation, t=t test for results, Df= degree of freedom, *= p value is statistically significant

Table 2 shows side comparison of tibia length using paired t-test. The mean ± standard deviation of tibia length was significantly ($p<0.05$) greater on the right side than on the left side in males and total population but it was not significant ($p=0.254$) in females.

Table 3: Paired samples correlation of tibia length among the subjects

Sex	Pairs	Correlation parameters (cm)	N	r	p-value
Male	Pair 1	Right tibia length & Left tibia length	144	0.99	<0.001*
Female	Pair 1	Right tibia length & Left tibia length	206	0.98	<0.001*
Total	Pair 1	Right tibia length & Left tibia length	350	0.99	<0.001*

r=correlation coefficient, *= p value is statistically significant

Table 3 shows paired samples correlation of tibia length among the subjects. There was a strong positive correlation between the right and left tibia lengths in both sex and the general population studied. All the correlations were significant ($r>0.9$; $p<0.001$).

Table 4: Correlation between tibia length and height

		Height	Right tibia length	Left tibia length
Height	Pearson correlation	1	0.857**	0.862**
	Sig. (2-tailed)		<0.001*	<0.001*
	N	350	350	350
RTL	Pearson correlation	0.857**	1	0.989**
	Sig. (2-tailed)	<0.001*		<0.001*
	N	350	350	350
LTL	Pearson correlation	0.862**	0.989**	1
	Sig. (2-tailed)	<0.001*	<0.001*	
	N	350	350	350

**Correlation is significant at the 0.01 level (2-tailed), *= p value is statistically significant, RTL- Right Tibia Length, LTL- Left Tibia Length

Table 4 shows the correlation between tibia length and height. The parameters measured showed a strong positive correlation with height and the relationship was significant ($r>0.8$; $p<0.001$).

Table 5: General linear regression analysis for stature estimation using tibia length

Variable (cm)	Sex	Predictive equations	R	R^2	SEE	p-value
Right tibia length	Male	S=60.15+2.82RTL	0.86	0.74	4.34	<0.001*
	Female	S=69.17+2.52RTL	0.77	0.59	5.20	<0.001*
	Total	S=56.45+2.88RTL	0.86	0.73	5.02	<0.001*
Left tibia length	Male	S=60.27+2.82LTL	0.86	0.74	4.36	<0.001*
	Female	S=64.00+2.66LTL	0.78	0.61	5.10	<0.001*
	Total	S=53.62+2.96LTL	0.86	0.74	4.94	<0.001*

R= regression coefficient, R^2= Coefficient of determination, SEE= Standard error of estimate, *= p value is statistically significant, RTL- Right Tibia Length, LTL- Left Tibia Length, S= Stature

Table 5 shows the general linear regression analysis for stature estimation using tibia length. In males, females and the total population, the regression coefficient for the equations derived was very strong (r>0.7). Also, the standard error of estimates (SEE) was low, the highest being approximately 5.0 and the p-value for the regression analysis was in all cases <0.001.

Table 6: Group-specific linear regression analysis for stature estimation using tibia length

Parameter (cm)	Bone groups	Sex	Predictive equations	R	R^2	SEE	p-value
Right tibia length	Short	Male	S=429.11-7.67RTL	0.72	0.52	8.03	0.171
		Female	S=160.04-0.13RTL	0.04	0.00	6.22	0.801
		Total	S=163.32-0.21RTL	0.06	0.00	6.75	0.700
	Medium	Male	S=38.65+3.36RTL	0.79	0.63	3.67	<0.001*
		Female	S=49.60+3.02RTL	0.76	0.57	3.93	<0.001*
		Total	S=36.83+3.37RTL	0.80	0.64	4.00	<0.001*
	Long	Male	S=91.16+2.11RTL	0.66	0.45	4.09	<0.001*
		Female	S=107.37+1.81RTL	0.19	0.04	4.44	0.713
		Total	S=89.05+2.17RTL	0.65	0.42	4.14	<0.001*
Left tibia length	Short	Male	S=585.01-12.18LTL	0.95	0.90	4.49	0.054
		Female	S=170.66-0.44LTL	0.12	0.01	6.19	0.463
		Total	S=177.36-0.62LTL	0.15	0.02	6.67	0.328
	Medium	Male	S=44.92+3.21LTL	0.79	0.62	3.73	<0.001*
		Female	S=52.09+2.96LTL	0.75	0.57	3.86	<0.001*
		Total	S=40.67+3.28LTL	0.79	0.63	3.94	<0.001*
	Long	Male	S=94.94+2.03LTL	0.66	0.43	4.10	<0.001*
		Female	S=119.29+1.54LTL	0.16	0.02	4.47	0.769
		Total	S=93.20+2.08LTL	0.64	0.41	4.16	<0.001*

R= Regression coefficient, R^2= Coefficient of determination, SEE= Standard error of estimate, *= p value is statistically significant, RTL- Right Tibia Length, LTL- Left Tibia Length, S= Stature

Table 6 shows group-specific linear regression analysis for stature estimation using tibia length. Right and left tibia length: In the short group, males, females and the total population had a high SEE value and this was not significant; In the medium group, males, females and the total population had lower SEE values and this was significant, as well as in the long group, but that of females was not significant.

Table 7: Comparison between estimated and actual stature in the studied population using the general formula

Parameter (cm)	Estimated height	Actual height	Mean difference	t	p-value
Right tibia length	168.19	168.19	0.00	0.00	1.000
Left tibia length	168.18	168.19	-0.01	0.00	0.998

Difference = estimated height – actual height, t= t test for result

Table 7 shows the comparison between estimated and actual stature in the studied population using the general formula. There is no statistically significant mean difference between the estimated and actual height values in all parameters for both Urhobo and Ukwuani subjects (p>0.05).

Table 8: Comparison between estimated and actual stature in the studied population using the group-specific formula

Parameter (cm)	Estimated height	Actual height	Mean difference	T	p-value
Right tibia length					
Short	156.22	155.76	0.46	-0.70	0.486
Medium	167.74	167.70	0.04	-0.22	0.825
Long	183.63	183.77	-0.14	0.33	0.739
Left tibia length					
Short	155.95	155.55	0.40	-0.63	0.532
Medium	167.78	167.73	0.05	-0.27	0.785
Long	183.66	183.82	-0.16	0.41	0.683

Difference = estimated height – actual height, t= t test for results

Table 8 shows the comparison between estimated and actual stature in the studied population using the group-specific formula. There is no statistically significant mean difference between the estimated and actual height values in all parameters for the study population (p>0.05).

Discussion

The mean height of males was higher than that of females and this was significant. This is because females reach puberty earlier than males, and male growth spurts are longer, resulting in a longer growth period [9]. This implies that the method for males cannot be used to determine female stature. The findings of the current study are consistent with previous findings that males were significantly taller than females [1, 4, 21, 22, 24]. Isaac *et al.* [22] from Ghana found a mean height that was almost similar to our findings; this could be because both investigations were conducted in Western Africa [25]. In comparison to a study conducted in Edo, Nigeria, the mean height in this study was greater [26]. This could be because of racial and regional differences. Our study's mean height was likewise higher than the mean heights reported by Charanya *et al.* [27], Madalina *et al.* [21] and Oceane *et al.* [24] This could be explained by differences in ethnicity and population between this study and others.

The bilateral tibia length was significantly longer in males than in females. This could be due to the fact that bone growth and development are influenced by different sex hormones with testosterone causing more periosteal thickening

than estrogen [28]. This is in tandem with studies done by Martula *et al.* [17], Bickes [1] and Madalina *et al.* [21] However, the mean values of tibia length were higher than those documented in Ethiopia, Turkey, Nagaland, Romania and Belgium [1,17,21,24]. These discrepancies observed could be due to population, geographical and ethnic differences. Moreover, the differences in the sample size and methodology (tape rule vs digital Vernier calliper) may have contributed to the variations.
There was significant difference between right and left tibia lengths with the right having a greater value than left in males and total population. However, the females showed no significant difference. The aforementioned findings could be attributed to certain developmental factors such as hormonal levels, nutrition, physical activity and mechanical stress. Similar research on leg length differences has also noted that the left leg is typically the shorter than the right [1,17].

The right tibia length showed a significant strong positive correlation with the left. This is possibly due to the equal effects of genetic and hormonal factors like the growth hormone on growth and development [29]. There was also a strong positive correlation between stature and tibia length. This may be attributed to the delayed closure of the tibia's epiphyseal plate, resulting in an extended period of bone growth. Consequently, this extended growth period contributes to increased stature. The findings herein suggest that tibia length could be used in estimating stature. Studies from other populations have also shown a significant correlation between stature and the length of the tibia [1,17].

There was a strong positive correlation between stature and tibia length in the present study and this necessitated the need to generate general and group-specific regression equations. The proportion of the total variance in stature (R^2) explained by the general regression models generated using bilateral tibia length was within the range 0.59 to 0.74. Bickes [1] on 572 students (286 males and 286 females) in Ethiopia reported that the height variation due to bilateral tibial length was 40% in males and 6.7% in females. The variation in stature due to tibia length may be explained by differences in sample size and environmental factors such as climate in the study populations.

The standard error of estimate (SEE) in all equations for males, females, and the total population is relatively low, with the highest value being approximately 5.0. A low SEE value suggests that the predicted stature values from the regression equations are close to the actual stature values, indicating the reliability of the estimation. Right tibia length had the lowest SEE values of 4.34 and 5.02 in males and the total population respectively and left tibia length had the lowest SEE value of 5.10 in females. These aforementioned findings in the present research can be compared with similar available studies on different populations across the globe. Bickes [1] reported that right tibia length had the lowest SEE value in males and left tibia length had the lowest SEE value in females which is in tandem with the present study. Variations in SEE values observed across the different populations can be attributed to factors such as genetics and environmental factors.

The proportion of the total variance in stature (R^2) that explained the group-specific regression model ranged from 1%-90% in the short group, 57%-64% in the medium group and 1%-45% in the long group. These variations observed in the bone groups suggest the importance of considering bone group characteristics for more accurate stature estimation. A study done by Osman *et al.* [23] on 140 cadavers (78 males and 62 females) in Turkey reported an R^2 value of 9%-

36% in the short group, 25%-31% in the medium group 41%-71% in the long group for both males and females between stature and tibia lengths. Izzet *et al.* [30] conducted a study on 242 males in Turkey and reported an R^2 value of 26% in the short group, 54% in the medium group and 30% in the long group between stature and tibia length. The variation observed could be attributed to differences in sample size, environmental factors such as climate and nutrition and also genetics [30].

In the group-specific regression analysis, there was variability observed in the standard error of estimates (SEE) across tibia bone groups and sexes. The SEE values varied within each bone group: the short tibia group ranged from 4.49 to 8.03, the medium tibia group ranged from 3.37 to 3.94, and the long tibia group ranged from 4.09 to 4.47. The lowest standard error of estimates (SEE) suggests that the predicted stature values from the regression equations are close to the actual stature values, indicating the reliability of the estimation. Therefore, in males, the equation for medium right tibia length had the lowest SEE value of 3.67 while in females and in the total population, the equation for medium left tibia length had the lowest SEE value of 3.86 and 3.94 respectively suggesting that they are better predictors of stature. This showed that the equations generated in the medium and long groups can better predict stature than the general equations. However, the general regression equation is a better predictor of stature than the short group in the present study. Izzet *et al.*, in Turkey reported that in the tibia bone group, the long tibia equation gave the highest prediction of stature based on the lower SEE values [30]. The variations observed could be due to differences in the sample size used for the studies.

The group-specific regression equations showed the best prediction and reliability in estimating stature based on the lowest SEE values. A study done by Izzet *et al.* compared group-specific formula based on tibia length with a general formula and found that the group-specific formula gave more reliable stature estimates [30]. However, their SEE values for all regression equations ranged from 26.90 to 35.64 which is quite higher than our study of <8.5. The differences observed could be due to population and ethnic differences and also differences in sample size used for the studies. Osman *et al.* also compared general and group-specific formulas using tibia length to predict stature and observed a higher reliability for the group-specific formula, but, the SEE values were not reported [23].

There was no significant difference between actual stature and the stature estimated using the bone lengths which showed that parameters may better be used to predict stature in our studied population. The stature estimations done with the group-specific formula gave more reliable results than the general formulae. Previous studies done by Osman *et al.* [23] and Izzet *et al.* [30] also found that the group-specific formula gave more better estimation of stature than the general regression models. The group-specific formulas provide more reliable results; hence, priority should be given to them when estimating stature in forensic cases. In circumstances where intact tibia bones are recovered, the application of group-specific equations for estimating stature is likely to yield positive identification [31].

The present study utilized only subjects within the age range of 18-30 years and did not involve younger and older age groups. Hence, further studies using group-specific regression formulas to estimate stature on the aforementioned age groups are recommended.

In conclusion, the study showed that males have significantly higher mean values of parameters measured than females. There was significant difference between right and left tibia lengths However, females showed no significant difference. There is a significant positive paired samples correlation between right and left tibia lengths. The bilateral tibia length had a strong positive correlation with stature. Hence, tibia length shows acceptable reliability in estimating stature, since all associations were statistically significant. The study provided general and group-specific regression formulae for the estimation of stature from tibia length. The bone group-specific regression formula showed higher reliability in predicting stature than the general regression formula. Hence, tibia length can be used as important tools in forensic examination as they provide elements of accuracy in the field of forensic anthropology and medico-legal investigations.

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