

RESEARCH ARTICLE

ESTIMATION OF HUMAN HEIGHT FROM THE HEAD LENGTH AND THEIR  
SEXUAL DIMORPHISM AMONG PRIMARY CHILDREN OF KAZAURE  
EMIRATE JIGAWA STATE, NIGERIA

\*Gudaji, A. <sup>1</sup>, Gaya, A.A. <sup>1</sup> and Abubakar, M. <sup>1</sup>

<sup>1</sup>Department of Anatomy, Faculty of Basic Medical Sciences, College of Health Sciences, Bayero University, Kano

**Abstract**

**Background:** Stature is the natural height and built of a human body or a person. It has been one of the most important factors in description of the human body characteristics. Various types of parameters are used in estimating stature of human body. Assessing the height of an individual from measurement of different parts of the body has been of importance to forensic scientists, anthropologists and archeologists. The aim of this study is to estimate stature of school children aged 5-12 years from Kazaure Emirate of Jigawa State, Nigeria using head length. **Materials and Methods:** This study was conducted on 863 primary school pupils from the four local government areas in Kazaure Emirate. Their height and head length were measured using stadiometer and sliding caliper respectively. Correlation and regression equation were carried out to establish the relationship between head length and height. **Results:** Sexual dimorphism in height and head length between males and females were statistically significant with  $p=0.041$  and  $p<0.0001$  respectively. Similarly, males had higher height and head length than females by age groups with statistically significant difference  $p=0.004$  and  $p=0.001$  at 5-7 years,  $p<0.0001$  and  $p<0.0001$  at 8-10 years,  $p<0.0001$  and  $p<0.0001$  at 11-12 years respectively. A statistically significant positive correlation between head length and height was obtained to be  $r=0.427$  for the population ( $p=0.01$ ), and  $r=0.444$  for females ( $p=0.01$ ) and,  $r=0.402$  for males, ( $p=0.01$ ) respectively. **Conclusion:** The findings from this study can be successfully used for estimating stature, if this part of the body could be obtained in a crime scene where greater parts are mutilated or dismembered. And this may help in forensic investigations.

**Keywords:** Age, Estimation, Head length, Kazaure emirate, Stature

**Introduction**

Stature is the natural height and built of a human body or a person. It has been one of the most important factors in description of the human body characteristics. Various types of parameters are used in estimating stature of the human body (Ashok *et al.*, 2018). Assessing the height of an individual from measurement of different parts of the body has been of importance to forensic scientists, anthropologists and archeologists (Ashok *et al.*, 2018).

Anthropometry, which is defined as the measurements of different parts of the body, is widely used in surveys

as an indicator of nutritional and health status (Khalid *et al.*, 1997; Al-Sendi *et al.*, 2003). Age, sex and stature are the primary characteristics of identification (Krishan, 2009). Anthropometric characteristics have a direct relationship with sex, shape and form of an individual and these factors are intimately linked with each other and are manifestation of the internal structure and tissue components which, in turn, are influenced by environmental and genetic factors (Krishan, 2007). Stature is one of the most important elements of identification of an individual. Establishment of the identity of an individual is essential in cases when only fragmentary remains of the human body is found (Mohanty *et al.*, 2001).

Estimation of stature is an important tool in forensic examination especially in unknown, highly decomposed, fragmentary and mutilated human remains (Ilayperuma, 2011). Studies carried out by Patel *et al.* (2012) and Ibrahim *et al.* (2023) have established a correlation between height and various anthropometric parameters such as skull height. Examination of skeletal remains recovered from a scene of crime have often been used by the forensic anthropologists to extract relevant information about the victim, and in the reconstruction of living stature from such skeletal remains (Bhavna and Nath, 2005). Estimation of stature occupies a relatively central position both in anthropological research and in identification which might be necessitated by medical jurisprudence or medico-legal experts (Rani *et al.*, 2011). It is known that body segments exhibit consistent ratios among themselves and relative to the total body height. The ratios between body segments are age, sex and race dependant (Jantz and Jantz, 1999; Williams *et al.*, 2000). Cephalo-facial anthropometry has been employed by many authors to estimate stature of the human body (Chiba and Terazawa, 1998; Patil and Mody, 2005; Ryan and Bidmos, 2007; Krishan, 2008a; Sahni *et al.*, 2010) because forensic investigators may be confronted with highly decomposed and mutilated dead bodies with fragmentary remains involving the head (cephalo-facial region). Ilayperuma (2010) investigated the relationship between stature and cranial dimensions in Sri Lanka, and proposed a gender and age-specific linear regression model between the cranial dimensions and the height of an individual. Cranial dimensions have been shown to be a reliable and precise means in predicting the stature in Italian (Introna *et al.*, 1993), Japanese (Chiba and Terazawa, 1998), Indian (Patil and Mody, 2005; Krishan, 2007) and South African populations (Ryan and Bidmos, 2007). Although many formulae for stature estimation have been proposed, there is a concern regarding the accuracy of the use of population-specific formulae on other human populations (Williams *et al.*, 2000; Duyar and Pelin, 2003). It is obvious that there are no universally applicable formulae as the relationship between head dimensions and cranial capacity is influenced by the race, sex and age of an individual. Thus, the need for race, age and sex-specific stature estimation formulae is proved beyond doubt (Krishan, 2007). Estimation of height from length of the head has also attracted many workers to derive a formula (Saxena *et al.*, 1981) but results concerning estimation of stature from cranial dimensions are scanty (Agarwal *et al.*, 2013). Cephalometry is an indirect form of facial

anthropometry (Rudolf-Martin, 1928; Vegter and Hage, 2000). Growth of upper craniofacial region shows a rapid development phase in the first year of life, significant growth up to the fifth year, and it is virtually complete at age 6 (Waitzman *et al.*, 1992; Likus *et al.*, 2014). Facial growth achieves 40% at birth and 65% at the age of 7. From there to 10 years, the change is 15% in bizygomatic width that has attained 80% of its full growth at the age of 7 (Scott, 1953). In Nigeria, most cephalic parameters have been studied extensively but none has correlated this to stature (Eroje *et al.*, 2010; Mador *et al.*, 2010; Maina *et al.*, 2011; Umar *et al.*, 2011; Esomonu and Badamasi, 2012) and given the frequent ethnic and religious clashes often witnessed in some parts of the country, as well as the incessant border clashes in many parts of the country, the effect is devastating, leading to mass casualties.

## Materials and Methods

The following materials were used for the study:

- i. Stadiometer (Holtain Ltd., Crymych, Dyfed, UK)
- ii. Sliding caliper (Ross craft Campbell 10 CAM 10 long bone caliper, Amazon, UK)

## Anthropometry

- a) **Height/ Stature (HT):** The subjects stood up perfectly upright with arms relaxed by the side, and ankles and knees placed together. They were encouraged to stand as upright as possible and barefooted before the measurements were taken. The stadiometer was positioned behind the subjects and the measurement was taken to the nearest 0.1 cm (Ibrahim *et al.*, 2023).
- b) **Head Length (HL):** This was measured as a straight distance between glabella and opisthocranium (occipital bone) using the sliding caliper and recorded to the nearest 0.1 cm (Ibrahim *et al.*, 2023).

**Study Design and Location**

This study is a cross-sectional survey that was carried out in four (4) Local Government Areas (LGAs) of Jigawa State. They are:

- i. Kazaure Local Government Area
- ii. Roni Local Government Area
- iii. Gwiwa Local Government Area
- iv. Yankwashi Local Government Area

From each of these LGA, three towns with their primary schools were randomly selected and the exercise carried out.

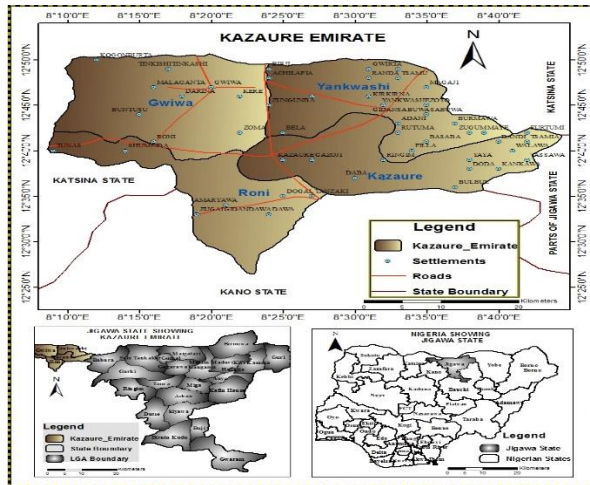


Figure 1: Map of Kazaure Emirate As Modified From the Administrative Map of Nigeria

**Selection Criteria**

**Inclusion Criteria**

- ✓ Age range 5-12 years
- ✓ Primary school pupils
- ✓ From Kazaure Emirate
- ✓ Apparently healthy
- ✓ Informed consent from guardians

**Exclusion Criteria**

- ✓ Any subject outside the inclusion criteria

**STATISTICAL ANALYSIS**

The data was presented using the mean ± standard deviation approach. A t-test was conducted to evaluate the differences in sexual characteristics between the male and the female subjects, while Pearson correlation was used to measure the relationships between the

variables studied. A simple linear regression model was used to estimate the person's height based on the length of their head. Data analysis was conducted using SPSS version 20. A p-value below 0.05 was used to determine statistical significance.

**Results**

Table 1 shows the descriptive statistics of the general population of the pupils with the minimum and maximum values of their height, age and head length along with the overall means.

Table 1: Descriptive Statistics of the General Population

Variables	N	Minimum	Maximum	Mean ± SD
Height (cm)	863	101.00	147.00	126.92±12.66
Age (yrs)	863	5	12	8.50±2.31
Head Length (cm)	863	10.00	20.20	17.55±1.29

Table 2 shows the descriptive statistics of the general population of the pupils by age groups of 5-7years, 8-10 years and 11-12 years with the minimum and maximum values of their height and head length along with the overall means.

Table 2: Descriptive Statistics by Age Groups

Variables	N	Minimum	Maximum	Mean ± SD
<b>Height (cm)</b>	328	101.00	126.00	113.75±7.69
<b>Age (yrs)</b>	328	5	7	5.99±0.81
<b>Head Length (cm)</b>	328	10.00	20.20	16.90±1.66
<b>Height (cm)</b>	316	123.00	140.00	129.80±3.99
<b>Age (yrs)</b>	316	8	10	9.02±0.82
<b>Head Length (cm)</b>	316	16.00	20.00	17.83±0.74
<b>Height (cm)</b>	219	139.00	147.00	142.48±2.28
<b>Age (yrs)</b>	219	11	12	11.50±0.50
<b>Head Length (cm)</b>	219	16.00	20.20	18.11±0.76

Table 3 shows the descriptive statistics of the female population of the pupils with the minimum and the maximum values of their height, age and head length along with the overall means.

Table 3: Descriptive Statistics for Female Population

Variables	N	Minimum	Maximum	Mean ± SD
Height (cm)	427	103.00	145.00	126.03±12.88
Age (yrs)	427	5	12	8.49±2.32
Head Length (cm)	427	10.00	19.00	17.29±1.26

Table 4 shows the descriptive statistics of the male population of the pupils with the minimum and the maximum values of their height, age and head length along with the overall means.

Table 4: Descriptive statistics for Male Population

Variables	N	Minimum	Maximum	Mean ± SD
Height (cm)	436	101.00	147.00	127.79±12.39
Age (yrs)	436	5	12	8.50±2.30
Head Length (cm)	436	12.00	20.20	17.80±1.27

Table 5 shows the independent t-test of the pupils with the males having higher height and head length than the females (p=0.041, p<0.0001) respectively.

Table 5: Independent Sample t-test

Variables	Sex	N	Mean ± SD	F	t	p-value
Height (cm)	F	427	126.03±12.88	0.64	-2.042	0.041
	M	436	127.79±12.39			
Head Length (cm)	F	427	17.29±1.26	1.521	-	<0.0001
	M	436	17.80±1.27		5.938	

Table 6 shows the independent t-test of the pupils with the males having higher height and head length than the females (p=0.004, p=0.001) at the age of 5-7 years, (p<0.0001) at the age of 8-10 years, and (p<0.0001), at the age of 11-12 years.

Table 6: Independent Sample t-Test by Age Groups

Variables	Sex	N	Mean SD	F	T	p-value
Age (yrs)	5-7					
Height (cm)	F	161	112.50±7.83	1.330	-2.915	0.004
	M	167	114.95±7.38			
Head Length (cm)	F	161	16.59±1.63	1.489	-3.423	0.001
	M	167	17.21±1.63			
Age (yrs)	8-10					
Height (cm)	F	158	128.97±3.83	.000	-3.805	<0.0001
	M	158	130.64±3.97			
Head Length (cm)	F	158	17.59±0.68	.129	-6.067	<0.0001
	M	158	18.07±0.73			
Age (yrs)	11-12					
Height (cm)	F	108	141.90±2.05	7.094	-3.809	<0.0001
	M	111	143.05±2.36			
Head Length (cm)	F	108	17.90±0.62	3.382	-4.204	<0.0001
	M	111	18.31±0.82			

Table 7: Correlations of the General Population (n=863)

	Height	Age	Head Length (cm)
Height (cm)	1		
Age (yrs)	0.982**	1	
Head Length (cm)	0.427**	0.417**	1

\*\* . Correlation is significant at the 0.01 level

Table 7 shows the correlation of the anthropometric variables for the general population at Kazaure Emirate with age correlating positively with height (r=0.982), HDL correlating with height (r=0.427) and age (r=0.417) respectively.

Table 8 shows the correlation of the anthropometric variables for the female population at Kazaure Emirate with age correlating positively with height (r=0.984), HDL correlating with height (r=0.444) and age (r=0.452) respectively.

Table 9 shows the correlation of the anthropometric variables for the male population at Kazaure Emirate with age correlating positively with height (r=0.985), HDL correlating with height (r=0.492) and age (r=0.399) respectively.

Table 10 shows the correlation according to age groups for the population at Kazaure Emirate with age correlating positively with height (r=0.987), HDL correlating with height (r=0.171) and age (r=0.150) at the age of 5-7 years respectively. Similarly, age correlates positively with height (r=0.952), HDL correlating with height (r=0.327) and age (r=0.277) at the age of 8-10 years respectively. Furthermore, age correlates positively with height (r=0.917), HDL correlates with height (r=0.102) and age (r=0.092) at the age of 11-12 years respectively.

Table 8: Correlations in Female Population (n=427)

	Height	Age	Head Length (cm)
Height (cm)	1		
Age(yrs)	0.984**	1	
Head Length (cm)	0.444**	0.452**	1

\*\* . Correlation is significant at the 0.01 level

Table 9: Correlations in Male Population (n=436)

	Height	Age	Head Length (cm)
Height (cm)	1		
Age(yrs)	0.985**	1	
Head Length (cm)	0.402**	0.399**	1

\*\* . Correlation is significant at the 0.01 level

Table 10: Correlations of the Population by Age Groups

5-7 years(n=328)			
	Height	Age	Head Length (cm)
Height (cm)	1		
Age(yrs)	0.987**	1	
Head Length (cm)	0.171**	0.150**	1
8-10 years (n=316)			
	Height	Age	Head Length (cm)
Height (cm)	1		
Age(yrs)	0.952**	1	
Head Length (cm)	0.327**	0.277**	1
11-12 years(n=219)			
	Height	Age	Head Length (cm)
Height (cm)	1		
Age(yrs)	0.917**	1	
Head Length (cm)	0.102	0.092	1

\*\* . Correlation is significant at the 0.01 level

**Regression Equation**

Model (y = mx + c)	R	R <sup>2</sup>	SEE	F value	P-value
H= 7.1HDL -1.09	0.348	0.121	11.461	118.744	<0.0001

y=mx+c, where y=height, c=constant, m=regression coefficient, x=parameter (cm)

**Discussion**

This study has shown that males have higher height than females, possibly due to their exposure to a bit more strenuous activities that may increase blood flow carrying nutrients to the tissues than females who are somehow involved in sedentary life style and less exposure to physical activities. This is in line with the studies conducted by Pena Reyes *et al.* (2002); Donald, (2002); Al-Sendi *et al.* (2003); Ilayperuma, (2010); Kharyal and Nath, (2008); Ezekie *et al.* 2015; Ibrahim *et al.*, (2023) which showed that males have a higher height than the females. Similarly, in this study, males are shown a higher head length than their females counterpart. This is in line with the studies carried out by Kharyal and Nath, (2008); Olotu *et al.* (2008); Ilayperuma, (2010); Omotoso *et al.* (2011); Bugaighis

*et al.* (2013); Ezekie *et al.* (2015); Shah *et al.* (2015); Kpela *et al.* (2016) which showed that males have a higher head length than females. This may possibly be associated to a little bit early closure of the fontanelles in females than in males. This study has also shown variation in growth with age as observed in height and head length. This agrees with the study conducted by Thompson *et al.* (2002) which showed that there is a wide variation among children in growth parameters at any given age and in the velocity of these parameters from one age to another.

In this study, it was observed that there is a positive correlation between the head length and the body height. This indicates that head length could be a good tool for estimation of stature among the population under study. This agrees with the study carried out by Ashok *et al.* (2018) where head length was used as a good tool to estimate stature. We recommend that this regression equation formula be applied on children that cannot stand erect to measure their height directly so that their head length can be measured and substituted in the equation to get their height indirectly. One of the limitations of this study is the challenge in obtaining either permission from the authorities or consent of the parents/guardians due to security threat the country is facing especially in the Northern region.

**Conclusion**

From this study, it was observed that parts of the body can be used as tools for the estimation of stature of both known and unknown individuals. The observed variation and similarities between the results of this work and the ones conducted in other populations further confirms that factors such as age, sex, geographical location, ethnicity and race can influence cephalometrics.

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**Authors' Contributions:**

AG; Data collection and entry, Discussion, Referencing, GAA; data analyses AG; Discussion and Reference review, IYA; Data analyses and interpretation.

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