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Estimation of Stature using Linear Regression Equations of Weight, Age, Sitting Height or Leg Length among Hausa Children in Kano State, Nigeria

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ABSTRACT

The study is aimed at investigating relationship (correalation) of stature with age, weight, sitting height and leg length with a view to developing linear regression equations for stature estimation among Hausa children. Statue of individuals could be estimated even if stadiometer or any measuring device is not available (especially in rural areas) or where they are faulty, also individuals that are too ill to be positioned for stature measurement could still have their stature estimated by using just their age for example. The findings of this study will add to the scarce forensic data for stature estimation in Hausa population. Estimation of stature is important in identification of decomposed dead bodies and skeletal remains and in doing this regression analysis has been the method of choice (Rajesh, Kewal, Deepica, Ajay and Vishal 2020). This study has achieved estimation of height using linear regression equations formed with age and each anthropometric measurement of weight, sitting height and leg length. A sample of 1050 school children (526 males and 524 females) was randomly selected for measurements of the anthropometric parameters (age calculated by way of birth certificate). All parameters were found to correlate positively with height using the Pearson's correlation analysis ($p<0.01$). Leg length was found to be better predictor of height of all the parameters due to its high coefficient of determination ($R^2 = 0.829$) for females and ($R^2 = 0.858$) for males. In conclusion, the study was able to established equations for prediction of height based on its correlation with the other anthropometric parameters.

Keywords: *Hausa children, Age, Height, Weight, Sitting height, Leg length.*

INTRODUCTION

Stature could be estimated using bone length, skeletal remains and unknown body parts by anthropologists, medical scientists and anatomists for decades (Ozaslan, Iscan, Ozaslan, Tugcu and Koc 2003). Malina (1994) study has

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established relationships between body parameters and these relationships vary among populations and ethnic groups due to differences in nutrition and levels of physical activities. Body height is usually estimated using a regression formula in any population of interest (Izzet, Can, and Ragiba, 2006).

The idea to estimate stature in this study relied largely on the strong positive correlation found among stature, weight, age, sitting height and leg length. The potential cause and consequences of adult height is a child's cumulative net nutrition (Jessica, Perkins,Subramanian, George and Emre 2016). Apart from that, Stature is a sensitive indicator of the socioeconomic or nutritional environment of an individual (Tanner, Hayashi, Piece and Cameroon 1982; Ashizawa, Noriko, Sumiyo, Xia, Feng, Yuling. Li and Shunhua 2008). Changes in body dimensions have attracted the attention of anthropologists (Ali, Uetake and Ohtsuki 2000) and in children of developed countries are well-documented phenomena (Loesch, Strokes and Huggins 2000, Adebisi, 2008). Child growth is recognized as an important indicator of nutritional status and health in populations (WHO, 1995; Gelander, 2006).

Some individuals present with sicknesses or abnormalities that make it difficult to have them stand in an erect posture for height measurement which is necessary for calculating their BMI. There is scarcity of data for stature estimation among Hausa population. The purpose of this study is evalute the relationship (correalation) of stature with age, weight, sitting height and leg length with a view to developing linear regression equations for stature estimation among Hausa children. Statue of individuals could be estimated even if stadiometer or any measuring device is not available (especially in rural areas) or where they are faulty, also individuals that are too ill to be positioned for stature measurement could still have their stature estimated by using just their age for example. Equations derived from the study could be used to estimate the height of a person even if the person could not be well positioned for height measurement. Secondly, in case of faulty or non-availability of a measuring device, the height can still be estimated. The study could further enrich the existing forensic and anthropological literature of Hausa population.

MATERIALS AND METHODS

Study Subjects

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The study was conducted among primary and secondary school students 6-15 years across the 44 local governments (526 males and 524 females) in Kano State. The subjects were randomly selected. Only subjects with no physical deformity that could affect the outcome of the study were selected. Weight (kg), Height(cm), Sitting height (cm), Leg length which is the difference between height and sitting height also called subischial length (cm) were measured according to (NHANES, 2007) protocol. Age (Years) was calculated from the birth certificates of the subjects.

Sampling Technique

Subjects were randomly selected for the study in the primary and secondary schools. A total of 1050 (526 males and 524 females) children with no physical deformity and with birth certificates were selected for the study.

Method of Data Collection

Height in cm was measured using a stadometer as distance from vertex to the standing surface, weight in kg was also measured with the stadiometer, sitting height in cm was measured from vertex to the sitting surface using a meter rule with the subject sitting on a chair in an anatomical position, and leg length in cm was measured as difference between standing and sitting positions, age was obtained from the students birth certificate in the school records. All the information for each subjected were recorded in a separate form.

Ethical Clearance

Ethical clearance was obtained from the Kano State Ministry of Education. Informed consent of the participants and the Parent-Teachers's Association (PTA) was obtained.

Statistical Analysis

Data were expressed as mean ± standard deviation. Student's t-test was used for differences between males and females in all variables studied. One way ANOVA was applied to assess differences between data across age. Pearson's correlation was applied to test relationship between each of the measured parameters, linear regression equation Y=MX+C (Y=Height which is the dependent variable, C= Constant, M= regression coefficient of the independent variable and X= the measured parameter which is the independent variable)

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was applied to predict height in males and females from the various anthropometric variables. Statistical significance was deemed acceptable at $p < 0.05$. SPSS version 16 for Windows was used for statistical analyses. Regression equations were plotted on a scatter diagrams at 95% confidence interval.

RESULTS AND DISCUSSION

Tables 1 & 2 present the predictive equations used to estimate height in both males and females using the measured parameters respectively. The predictive equations developed in the study were presented in both males and females in table 1 and 2 respectively. The accuracy of the equations was tested by randomly sampling 40 subjects whose heights were measured and compared with the predicted heights using the developed equations. Interestingly, the equations for both sexes were found to be reliable and more than 90% accurate (percentage accuracy was calculated). In addition, graphs of predicted height were found to form clusters when plotted against real (measured) height as presented in figures 1-8. The clustering nature of the of the dots in each graph of predicted height plotted against real height have revealed the accuracy, precision and reliability of the predictive equations

All the study anthropometric parameters (age, weight sitting height, and leg length) were found significantly and positively correlate with height in both sexes. From the study, leg length is a better predictor of height due to its high coefficient of determination ($R^2 = 0.829$) for females and ($R^2 = 0.858$) for males. The equations would be of help in estimating the Body Mass Index of individuals even if their heights are not measured, this could be achieved by only taking the weight, sitting height, leg length or age and inputting in the predictive equation to obtained the height. The equations would be of great help in forensic anthropology.

Table 1: Linear regression of Height from anthropometric parameters in males

Parameters	**Predictive equation**	**R**	**R^2**	**SEE**	**P value**
AGE	HT = 96.41+ (3.346 × AGE)	0.812	0.660	0.90	<0.0001
Weight	HT = 100.19 + (0.95 × WT)	0.887	0.787	0.60	<0.0001
Sitting height	HT = 23.14 + (1.765 × SH)	0.907	0.822	1.58	<0.0001

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Leg length	HT = 20.29 + (1.609 × LL)	0.927	0.858	1.42	<0.0001

HT = height, WT = weight, SH = sitting height, LL = leg length, SEE= standard error of the estimate, R = correlation coefficient; R^2 = coefficient of determination

Table 2: Linear regression of Height from Anthropometric parameters in females

Parameters	**Predictive equation**	**R**	**R^2**	**SEE**	**P value**
AGE	94.20 + (3.553 × AGE)	0.851	0.725	0.81	<0.0001
Weight	102.87 + (0.890 × WT)	0.873	0.763	0.61	<0.0001
Sitting height	26.71 + (1.772 × SH)	0.869	0.756	1.77	<0.0001
Leg length	30.37 + (1.444 × LL)	0.911	0.829	1.37	<0.0001

HT = height, WT = weight, SH = sitting height, LL = leg length, SEE = standard error of the estimate, R = correlation coefficient; R^2 = coefficient of determination.

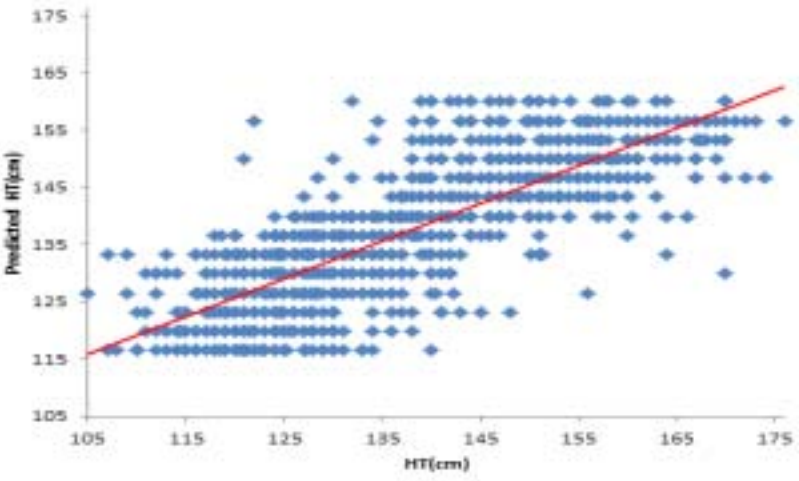

Figure 1: Scatter plot of predicted height (cm) against real height (cm) using age (years) in males

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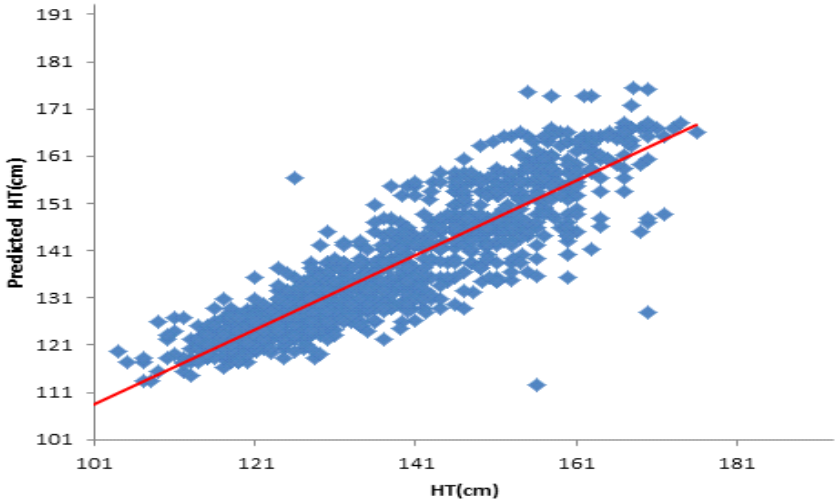

Figure 2: Scatter plot of predicted height (cm) against real height (cm) Using weight (kg) in males

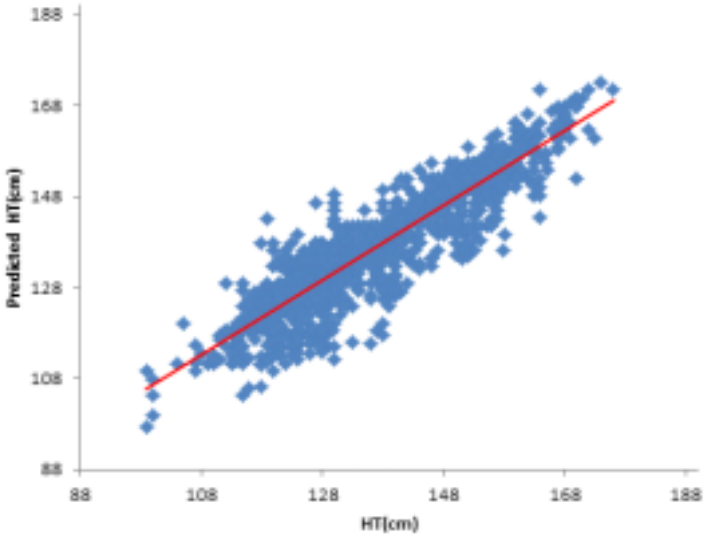

Figure 3: Scatter plot of predicted height (cm) against real height (cm) using sitting height (cm) in males

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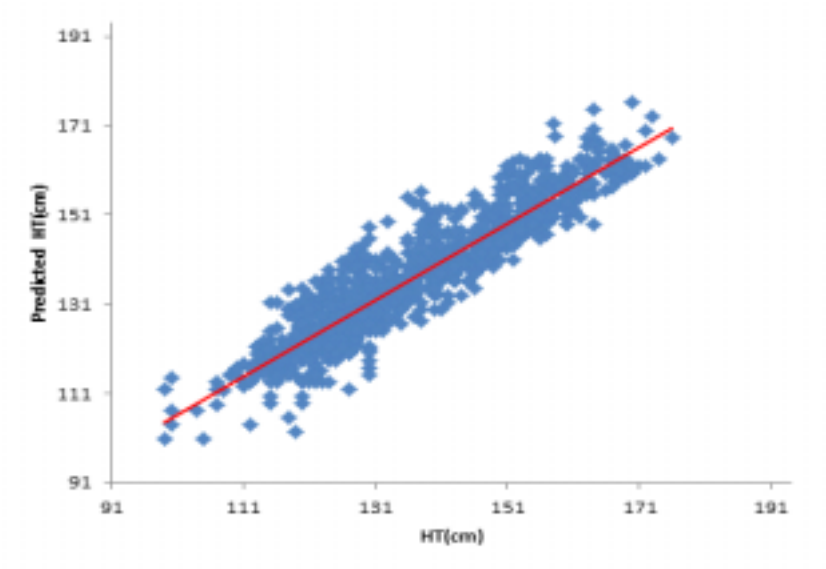

Figure 4: Scatter plot of predicted height (cm) against real height (cm) using leg length (cm) in males

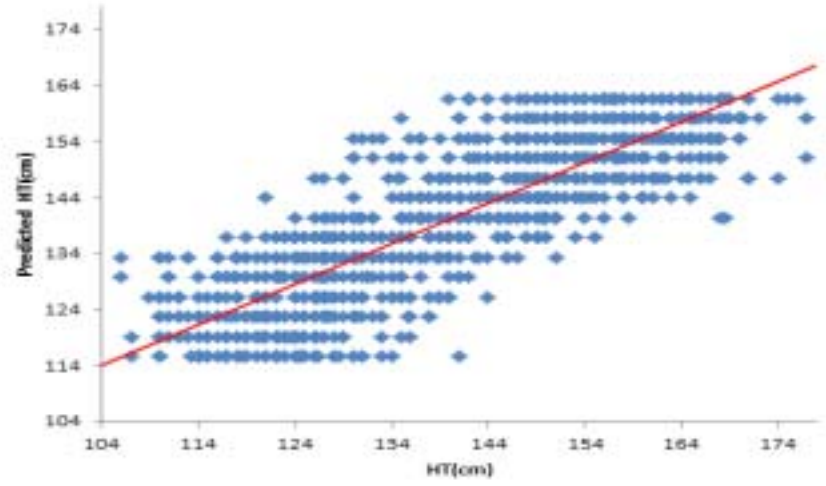

Figure 5: Scatter plot of predicted height (cm) against real height (cm) using age (years) in females

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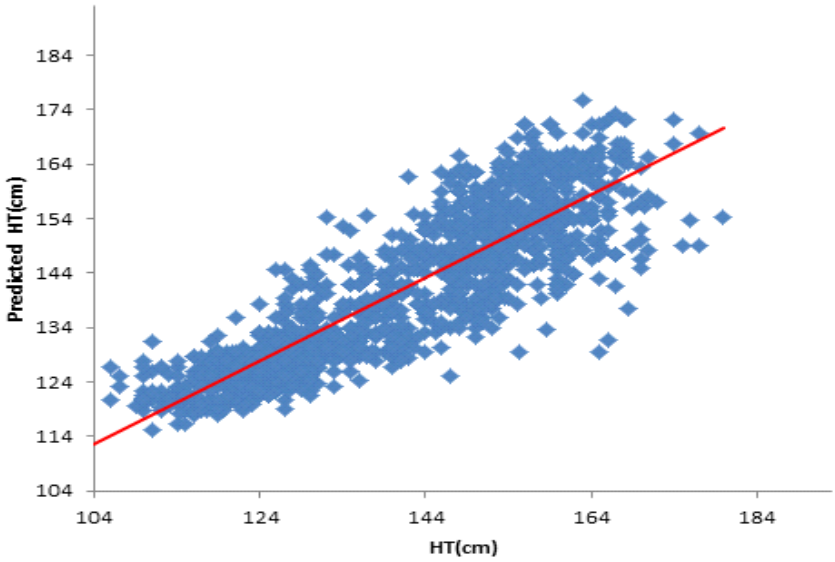

Figure 6: Scatter plot of predicted height (cm) against real height (cm) using weight (kg) in females

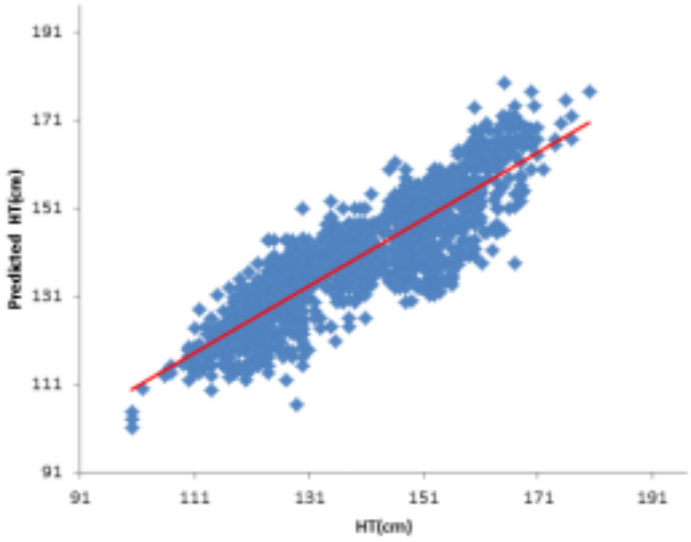

Figure 7: Scatter plot of predicted height (cm) against real height (cm) using

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sitting height (cm) in females

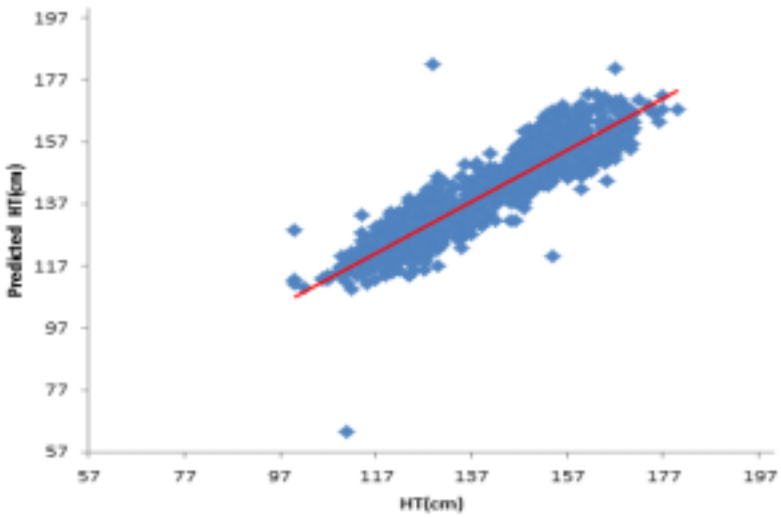

Figure 8: Scatter plot of predicted height (cm) against real height (cm) using leg length (cm) in females

CONCLUSION

The purpose of this study is evalute the relationship (correalation) of stature with age, weight, sitting height and leg length with a view to developing linear regression equations for stature estimation among Hausa children. Statue of individuals could be estimated even if stadiometer or any measuring device is not available (especially in rural areas) or where they are faulty, also individuals that are too ill to be positioned for stature measurement could still have their stature estimated by using just their age for example. The study was conducted among primary and secondary school students 6-15 years across the 44 local governments (526 males and 524 females) in Kano State. The subjects were only those with no physical deformity. Weight (kg), Height(cm), Sitting height (cm), Leg length which is the difference between height and sitting height also called subischial length (cm) were measured according to (NHANES, 2007) protocol. Age (Years) was calculated from the birth certificates of the subjects. Equations derived from the study were used to estimate the height of a person even when the person could not be well positioned for height measurement. All the measured anthropometric parameters correlate positively

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with stature. Linear regression equations for prediction of stature using other anthropometric parameters in children were established.

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