

Anthropometric Prediction Models of Agricultural Workers in Benue State of Nigeria

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Abstract – Anthropometric prediction models of Agricultural Workers in Benue State of Nigeria were developed. The body anthropometry of four hundred and seventy (470) workers comprising of 235 males and females each were first determined. Regression analysis was carried out using a statistical software package (SPSS version 20); this was used to develop prediction models from the measured anthropometric dimensions. Only prediction models with high coefficient of determination (R^2) values were considered for this study. Thirteen prediction models were developed for the male agricultural workers based on their measured stature, sitting height, upper arm length, hand length, elbow span and foot length. Ten prediction models were developed for the female agricultural workers based on their measured stature, sitting height, elbow span and foot length. These developed prediction models will greatly reduce the drudgery involved in measuring anthropometric parameters.

Keywords – Agricultural Workers, Anthropometric, Body Anthropometry, Prediction Models, Nigeria.

I. INTRODUCTION

Anthropometry deals with the measurement of physical features of the human body including linear dimensions, weight and volume [1]. Application of anthropometric data in farm equipment and machinery design helps in achieving efficiency in farm output. Anthropometric studies have been undertaken in many countries and collected data have informed development of guidelines which are now used in the design of buildings, machines, workplaces and systems [2]. Ref. [3] reported that anthropometric dimensions of unorganized workers, including agricultural workers, were similar to those of industrial workers.

According to [1] major anthropometric concern in design and evaluation of engineering products is the statistical description of all those persons who may, throughout the life of the product's usefulness, be involved in its operation and maintenance. Dimensional relationships between the body segments and the whole body have been of interest to artists, scientists, anatomists, anthropologists and medicolegistics for a long time [4].

For efficient design of farm machinery and equipment, it is necessary to determine peoples' anthropometric characteristics. The use of anthropometry and ergonomics in design systems has reduced human error in system performance, minimized hazards to individuals in the work environment, reduced adverse health effects

and improved system efficiency [5]. [6] maintained that, anthropometric data has the greatest importance, when faced with problems of suitable design, and development of farm implements or machinery under ergonomic considerations.

Dimensional relationships between the body segments and the whole body have been of interest to many researchers. Stature is considered as one of the important parameters in the identification of persons. The mean anthropometric dimensions, for example stature and sitting height, are the most typical distinctions amongst ethnic groups [7]. [8] in their anthropometric survey of farm workers in India observed linear relationships between stature (standing height) and other body dimensions suggesting these dimensions could be predicted from the standing height. [9] used hand length and hand circumference to develop hand anthropometric prediction models for twenty eight (28) and (six) 6 hand dimensions respectively. [1] in developing anthropometric prediction equations, utilized 21 base dimensions to predict about 79 dimensions.

This study is aimed at developing anthropometric prediction models from some base dimensions of Benue agricultural workers from their measured body anthropometry and to find out the correlation between the determined and the predicted parameters. The developed prediction models will greatly safe time and reduce the drudgery involved in measuring anthropometric parameters.

II. MATERIALS AND METHODS

Benue State the study area is made up of 23 Local Government Areas. Four hundred and seventy (470) Benue Agricultural workers comprising of 235 males and females each, were investigated. Sample size for the study was determined according to the equation provided in ISO15535 [10]. The number of sampled subjects was then selected proportionally to the size and distribution of the population in each Local Government Area. The study was carried out based on the parameters adopted by [11].

A Digital weighing machine incorporated with a floor type Standio-meter was used in measurement of body weight and vertical measurements respectively. Horizontal and lateral measurements were determined using an anthropometer. A statistical software package (SPSS version 20) was used to develop the prediction

models. The prediction models that had high coefficient of determination (R^2) were considered for this study. Where X represents the measured dimensions (parameters) and Y represents the dimensions to be calculated (Table 1).

Table 1. Parameters to be Measured (X) and Predicted (Y)

Data to be measured (X)	Data to be Predicted(Y)
Stature	Vertical grip reach
	Shoulder height
	Eye height
	Knuckle height
	Fingertip height
Sitting height	Knee height
	Sitting eye height
	Sitting shoulder height
	Sitting elbow height
Hand length	Fore-arm hand length
	Upper-arm length
	Grip diameter
	Hand breadth
Elbow span	Arm span
Foot length	Foot breadth

III. RESULTS AND DISCUSSIONS

Tables 2 and 3 are the prediction models with their corresponding coefficients of determination (R^2) for male and female Benue agricultural workers respectively. The best fit least square regression equations between the measured (independent variable) parameters and those to be calculated (dependent variable) were obtained for male and female agricultural workers from Figs. 1-23. The coefficient of determination (R^2) explains the relationship between the independent variable (X) and dependent variable (Y). The closer R^2 is to one (1), the stronger is the relationship i.e. the higher the R^2 , the more useful the model.

From Tables 2 and 3, the R^2 values between the male and female agricultural workers stature with the following parameters were; vertical grip reach (0.714 and 0.982), eye height (0.721 and 0.956), shoulder height (0.718 and 0.987), knuckle height (0.715 and 0.994) fingertip height (0.713 and 0.971) respectively. The R^2 values obtained indicates that stature is a better predictor of eye height (0.721) and knuckle height (0.994) for the male and female agricultural farmers respectively.

The R^2 values for the male and female agricultural workers between their sitting height and the following

parameters were; sitting eye height (0.982 and 0.917), sitting shoulder height (0.982 and 0.841) sitting elbow height (0.981 and 0.578) respectively. The R^2 for the male sitting height and the knee height was obtained as 0.977. The high R^2 obtained for the male indicates a strong relationship between the sitting height and the indicated parameters to be determined. While for the female, sitting height is a better predictor of sitting eye height (0.917).

The R^2 value between elbow span and arm span were 0.983 and 0.927, while between the foot length and foot bread were 0.988 and 0.95 for the male and female agricultural workers respectively. This is an indication of a strong relation between these parameters, showing that the prediction models can be used. The R^2 values obtained for male upper arm length and sitting shoulder height was 0.988 while for their hand length and forearm hand length it was 0.984.

Linear and quadratic equations (Tables 2 and 3) best fitted the relationships between the measured and predicted parameters. Quadratic predictions show that the dependent and independent variables do not have a direct relationship. Indicating variability in the variables which can still be predicted by the quadratic equations by the high R^2 values obtained. Linear predictions obtained, show that the dependent and independent variables have a more direct relationship than the quadratic equation. The high R^2 observed for the prediction models is indicative of a strong relationship between the measured and predictive anthropometric parameters.

IV. CONCLUSION

These prediction equations can be used to predict 13 anthropometric dimensions for the male agricultural workers by measuring the stature, sitting height, upper arm length, hand length, elbow span and foot length. Ten prediction models to predict anthropometric dimensions were also developed for the female population by measuring the stature, sitting height, elbow span and foot length. The high R^2 observed in the prediction models is indicative of the strong relationship between the measured and predictive anthropometric parameters. By measuring base parameters, other parameters can be predicted using mathematical modeling, thereby reducing the drudgery involved in measurement of anthropometric parameters.

Table 2. Anthropometric Prediction Equation for Benue Male Agricultural Workers

Parameter to be Measured (X)	Parameter to be Predicted (Y)	Prediction Equation	R ²
Stature	Vertical grip reach	$Y_{vgr} = 1.035x_s + 26.24$	0.714
Stature	Eye height	$Y_{eht} = 1.033x_s - 15.82$	0.721
Stature	Shoulder height	$Y_{sht} = 1.035x_s - 31.97$	0.718
Stature	Knuckle height	$Y_{kht} = 1.79x_s^2 - 0.02x_s - 160.68$	0.715
Stature	Finger tip height	$Y_{ftht} = 1.033x_s - 109.58$	0.713
Sitting height	Knee height	$Y_{kht} = 1.01x_{sht} - 33.20$	0.977
Sitting height	Sitting Eye height	$Y_{seht} = 0.695x_{sht}^2 + 0.002x_{sht} + 1.562$	0.982
Sitting height	Sitting Shoulder height	$Y_{ssht} = 0.91x_{sht}^2 + 0.001x_{sht} - 24.46$	0.982
Sitting height	Sitting Elbow height	$Y_{seht} = 0.44x_{sht}^2 + 0.003x_{sht} - 37.77$	0.981
Upper arm length	Sitting shoulder height	$Y_{ssht} = 0.985x_{ualt} + 25.12$	0.988
Hand length	Forearm hand length	$Y_{fhlt} = 1.006x_{hlt} + 28.05$	0.984
Elbow Span	Arm Span	$Y_{asn} = 0.999x_{esn} + 81.18$	0.983
Foot length	Foot breadth	$Y_{fbt} = 0.985x_{flt} - 9.823$	0.988

Table 3. Anthropometric Prediction Equation for Benue Female Agricultural Workers

Parameter to Measured (X)	Parameter to be Predicted (Y)	Prediction Equation	R ²
Stature	Vertical grip reach	$Y_{vgr} = 3.213x_s^2 - 0.07x_s - 139.88$	0.982
Stature	Eye height	$Y_{eht} = 2.22x_s^2 - 0.04x_s - 107.30$	0.956
Stature	Shoulder height	$Y_{sht} = 1.676x_s^2 - 0.02x_s - 77.57$	0.987
Stature	Knuckle height	$Y_{kht} = 0.991x_s - 85.86$	0.994
Stature	Finger tip height	$Y_{ftht} = 0.021x_s^2 + 0.003x_s - 15.40$	0.971
Sitting height	Sitting Eye height	$Y_{seht} = -0.73x_{sht}^2 + 0.10x_{sht} + 63.80$	0.917
Sitting height	Sitting Shoulder height	$Y_{ssht} = -1.45x_{sht}^2 + 0.015x_{sht} + 76.71$	0.841
Sitting height	Sitting Elbow height	$Y_{seht} = -1.61x_{sht}^2 + 0.014x_{sht} + 63.07$	0.578
Elbow span	Arm span	$Y_{asn} = -0.26x_{esn}^2 + 0.07x_{esn} + 128.75$	0.927
Foot length	Foot breadth	$Y_{fbt} = 1.018x_{flt} - 11.13$	0.951

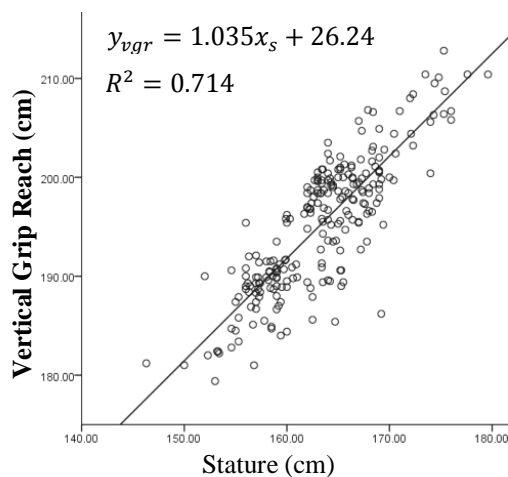


Fig. 1. Benue Male Agricultural Workers' Vertical Grip Reach (cm) versus Stature (cm)

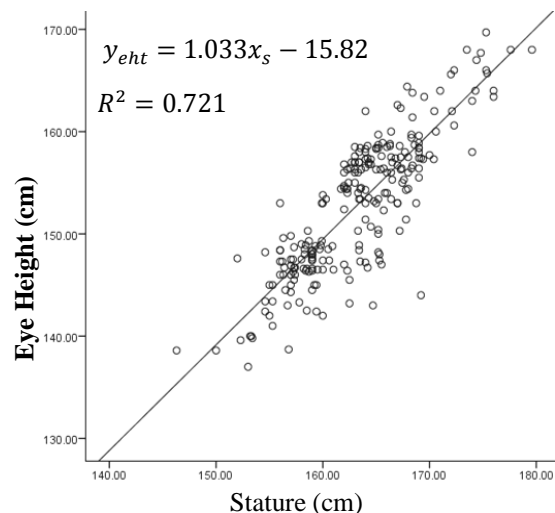


Fig. 2. Benue Male Agricultural Workers' Eye Height (cm) versus Stature (cm)

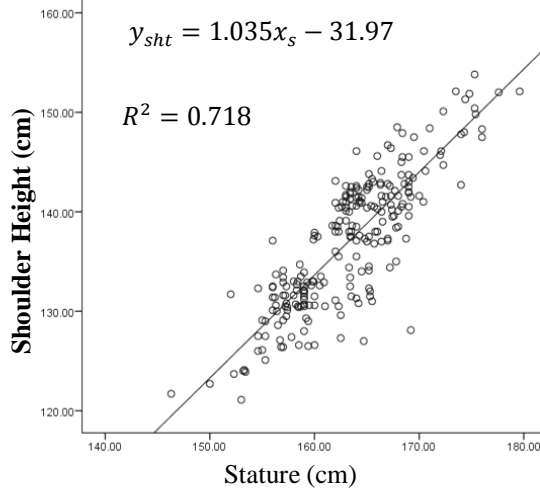


Fig. 3. Benue Male Agricultural Workers' Shoulder Height (cm) versus Stature (cm)

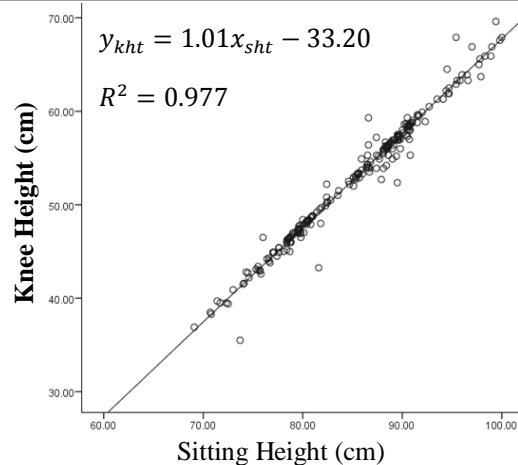


Fig. 6. Benue Male Agricultural Workers' Knee Height (cm) versus Sitting Height (cm)

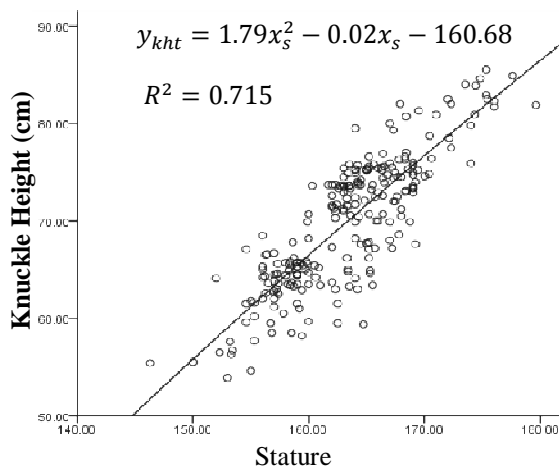


Fig. 4. Benue Male Agricultural Workers' Knuckle Height (cm) versus Stature (cm)

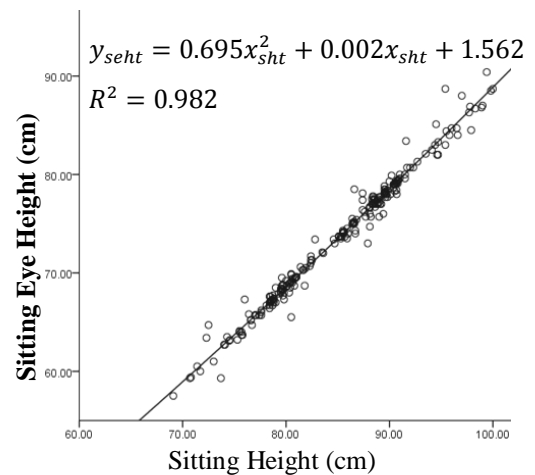


Fig. 7. Benue Male Agricultural Workers' Sitting Eye Height (cm) versus Sitting Height (cm)

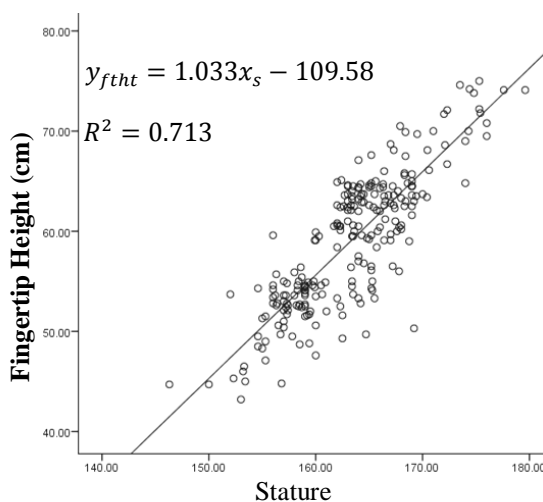


Fig. 5. Benue Male Agricultural Workers' Fingertip Height (cm) versus Stature (cm)

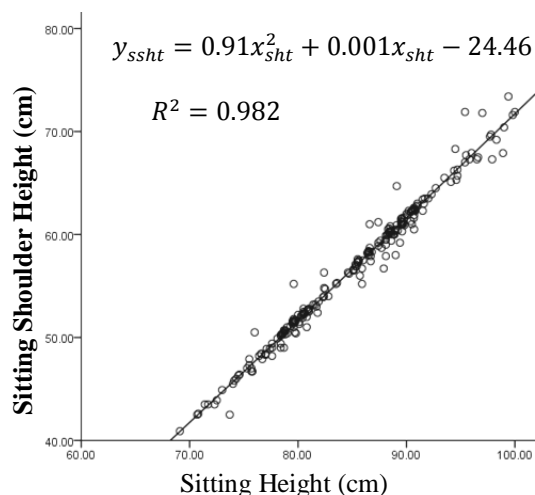


Fig. 8. Benue Male Agricultural Workers' Sitting Shoulder Height (cm) Vs Sitting Height (cm)

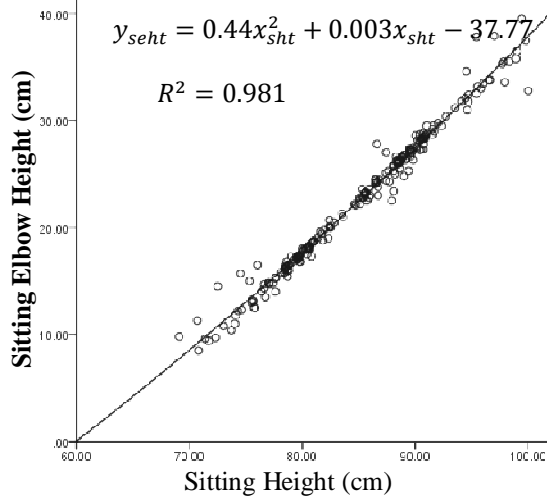


Fig. 9. Benue Male Agricultural Workers' Sitting Elbow Height (cm) Vs Sitting Height (cm)

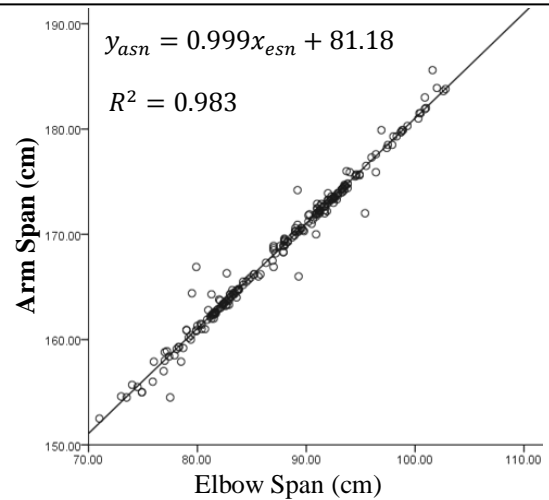


Fig. 12. Benue Male Agricultural Workers' Arm Span (cm) versus Elbow Span (cm)

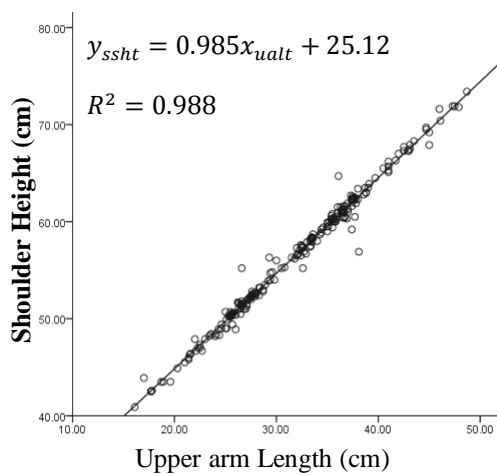


Fig. 10. Benue Male Agricultural Workers' Sitting Shoulder Height (cm) Vs Upper arm Length (cm)

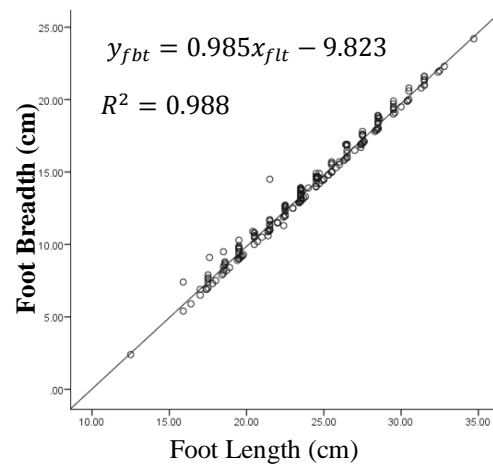


Fig. 13. Benue Male Agricultural Workers' Foot Breadth (cm) versus Foot Length (cm)

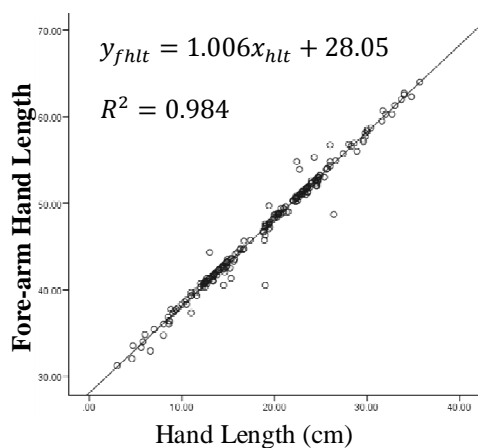


Fig. 11. Benue Male Agricultural Workers' Fore-arm Hand Length (cm) Vs Hand Length (cm)

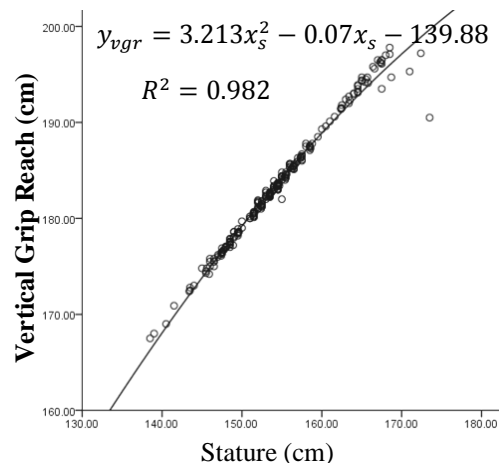


Fig. 14. Benue Female Agricultural Workers' Vertical Grip Reach (cm) versus Stature (cm)

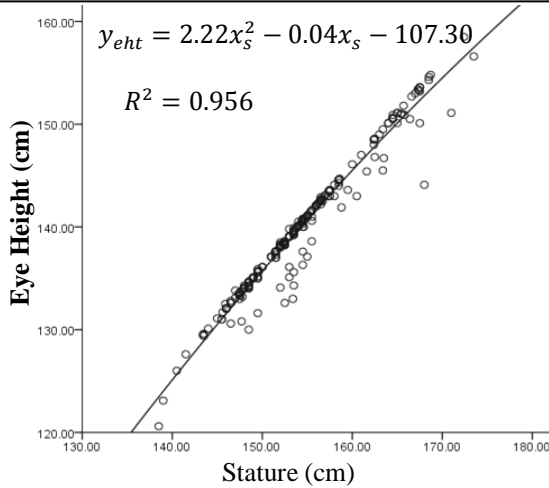


Fig. 15. Benue Female Agricultural Workers' Eye Height (cm) versus Stature (cm)

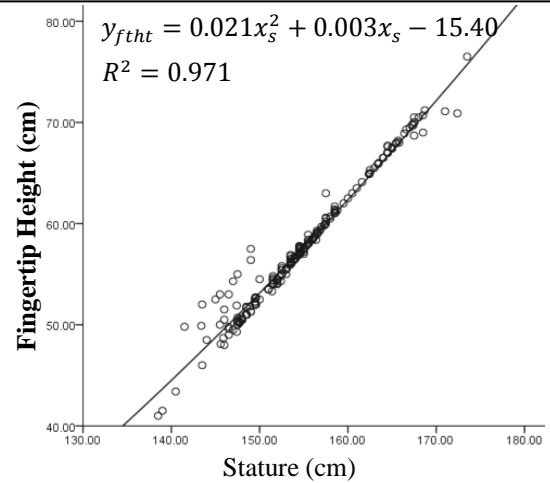


Fig. 18. Benue Female Agricultural Workers' Fingertip Height (cm) versus Stature (cm)

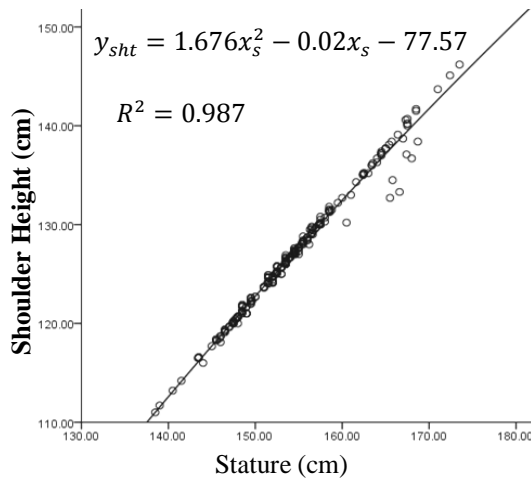


Fig. 16. Benue Female Agricultural Workers' Shoulder Height (cm) versus Stature (cm)

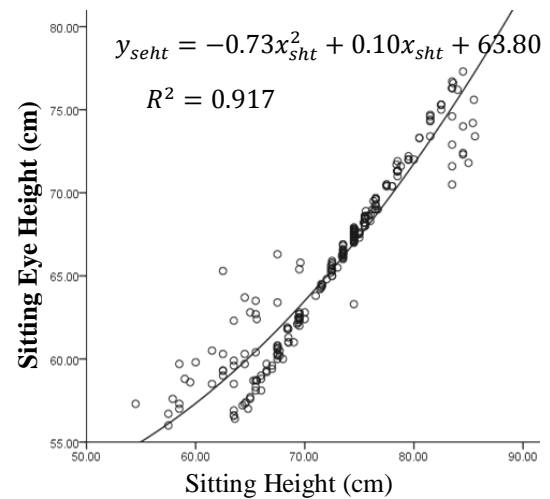


Fig. 19. Benue Female Agricultural Workers' Sitting Eye Height (cm) versus sitting height (cm)

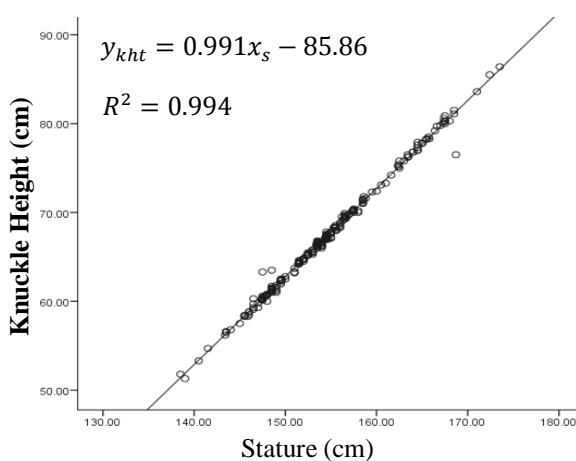


Fig. 17. Benue Female Agricultural Workers' Knuckle Height (cm) versus Stature (cm)

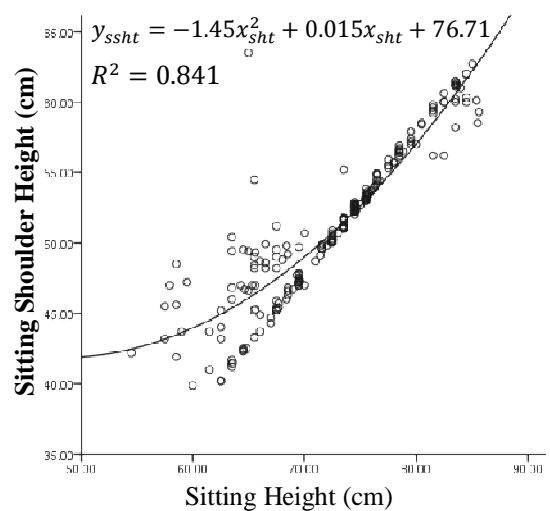


Fig. 20. Benue Female Agricultural Workers' Sitting Shoulder Height (cm) Vs Sitting Height (cm)

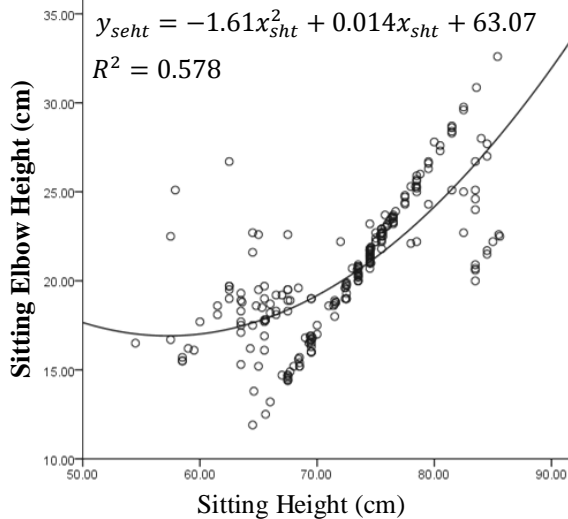


Fig. 21. Benue Female Agricultural Workers' Sitting Elbow Height versus Sitting Height

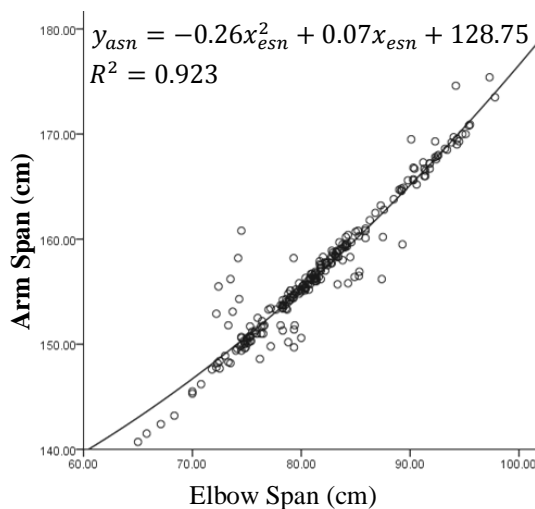


Fig. 22. Benue Female Agricultural Workers' Elbow Span versus (cm) Arm Span (cm)

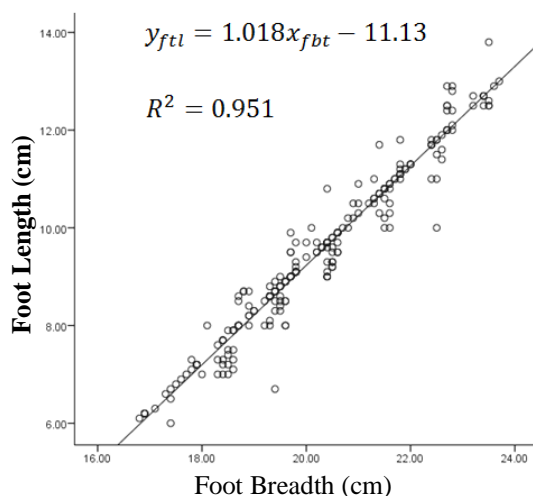


Fig. 23. Benue Female Agricultural Workers' Foot Length (cm) versus Foot Breadth (cm)

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