

# Development of Anthropometric Data for Benue State Nigeria Agricultural Workers

T. K. Kaankuka, M. T. Ikyator and V. I. Umogbai

Department of Agricultural and Environmental Engineering,  
University of Agriculture, P. M. B. 2373, Makurdi, Benue State, Nigeria.

## ABSTRACT

An anthropometric study for agricultural workers of Benue State, Nigeria was undertaken. Four hundred and seventy (470) workers comprising 235 males and females each, selected randomly were investigated. Thirty (30) anthropometric body dimensions considered useful for farm tools and equipment/machinery design were studied. Descriptive statistics was used to determine the 5<sup>th</sup>, 50<sup>th</sup>, 95<sup>th</sup> percentiles, Coefficient of Variation, Standard Error of Mean, Standard Deviation, and skewness index. Results indicates that female agricultural workers were smaller than their male counterparts in all body dimensions except in the mean values for body weight, hand breadth, hip breadth, and chest (bust) depth of 69.65 kg and 72.41 kg; 7.44 cm and 8.36 cm; 30.08 cm and 39.73; and 20.78 cm and 23.99 cm for men and women respectively. Using t-test to compare the results at  $p \leq 0.05$ , all anthropometric dimensions were significantly different except for mean grip diameter of 4.16 (males) and 4.06 (females).

**Keywords:** Anthropometric, Benue State, Agricultural Workers

## 1. INTRODUCTION

Benue State referred to as 'Nigeria's food basket' has a total land area of 310 million hectares, and agricultural land is estimated to be about 180 million hectares representing about 58% of the total land area (BMANR, 2003). Agricultural workers in the State play a significant role in food production. They engage in various agricultural activities starting from land preparation to post harvest operations where they use different types of farm tools, machinery and equipment. These farm machinery and equipment are often times imported and are not comfortable for use, with negative consequences on farm output. This is as a result of differences in body anthropometry between the manufacturing countries of these equipment and user countries.

Anthropometry involves the systematic study and measurement of the physical properties of the human body, mass and strength properties. 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 (Anema *et al.*, 2004). Most agricultural machines create discomfort and at times break down prematurely due to various inadequacies in ergonomic precepts in relation to the operators (Onouha *et al.*, 2012).

Differences in anthropometric characteristics exist between different populations. The body dimensions vary with age, sex, ethnic groups and occupation. Even within a particular group, the anthropometry differs due to nutritional pattern and nature of work (Liu *et al.*, 1999; Agrawal *et al.*, 2010). Studies in anthropometry have been carried out in some developed countries but anthropometric data for developing countries are limited. There are few regions in Nigeria that have anthropometric data but none exist for Benue State. This

study therefore aims at providing an anthropometric database for Benue agricultural workers. The collected anthropometric data are expected to be used as vital reference information for designing or redesigning agricultural hand tools and farm equipment for Benue agricultural workers. It is also to serve as a guide for introducing agricultural equipment and machinery into the State.

## 2. MATERIALS AND METHODS

Benue State the study area is located in central Nigeria, and is referred to as the "Food Basket of the Nation" (Nigeria). Benue State comprises 23 Local Government Areas (LGA). A sample population of four hundred and seventy (470) agricultural workers comprising of 235 males and females each were investigated from these LGA. The numbers for the sampled agricultural workers were selected proportionally to the size and distribution of the population in each Local Government Area. All the participants were in good physical health and able to stand unassisted. Sample size was determined according to the equation provided in Annex A of ISO15535 (2003). General requirements for establishing anthropometric database for a 95 percent confidence interval for the 5th and 95th percentile was used (Eq. 1). The study was carried out based on the parameters adopted by Syuaib (2015).

$$N \geq \left(3.006CV/\alpha\right)^2 \quad (1)$$

Where,

N = Sample size

CV = Coefficient of Variation

$\alpha$  = Percentage of desired relative accuracy

Thirty (30) anthropometric body dimensions considered useful for farm tools, equipment and machinery design were studied. Thirteen measurements were taken in a standing position (including body mass) and 17 measurements were taken in a seated position.

The 5<sup>th</sup> and 95<sup>th</sup> percentiles were computed using equations 2 and 3 respectively.

$$\text{For percentiles } < 50^{\text{th}}, x_p = \bar{x} - fs \quad (2)$$

$$\text{For percentiles } > 50^{\text{th}}, x_p = \bar{x} + fs \quad (3)$$

Where,

$x_p$  = value of the percentile,

$\bar{x}$  = sample mean,

f = factors corresponding to the percentile and

s = standard deviation.

A digital weighing machine incorporated with a floor type Standio-meter was used in the measurement of body weight and vertical dimensions respectively. Lateral measurements were done by the use an anthropometer, hand and foot measurements were done by the use of tape. The participants were asked to stand on a flat surface; their arms adjusted according to their height, with their feet closed and their body vertically erected, while their heels, buttocks and shoulders touching the same vertical plane. Data was collected and recorded on a computer spreadsheet. A statistical software package (SPSS version 21) was used to analyze them.

### 3. RESULTS AND DISCUSSION

The presented results provide some baseline information regarding all 30 body dimensions measured. Tables 1 and 2 are the anthropometric data for Benue male and female agricultural workers respectively. Table 3 is a comparison of the anthropometric data for the male and female agricultural workers. Table 1 shows that the skewness index for male agricultural workers for all dimensions are positively skewed except body weight, knuckle height, elbow span, sitting height, buttock-popliteal length, chest (bust) depth, hand breadth and grip diameter. For female agricultural workers (Table 2), all dimensions are positively skewed except sitting height, buttock-knee length, buttock-popliteal length, shoulder

breadth, hip breadth and fore-arm hand length. The skewness of all the thirty body dimensions are within  $\pm 0.81$  and  $\pm 0.55$  for males and females respectively, except hand length, hand breadth and grip diameter which were greater than 1 (one) for the female skewness. This means that the body dimensions are normal and skewness are not significantly different from normal. Hence we can use the mean, standard deviation and different percentile values to easily determine the proportion of the population who fall within a specific range of value for a given body dimension. These values may also be used for comparison with those published for other ethnic populations. Descriptive statistics are in line with results obtained by Chandra *et al.*, (2011); Yadav (2012) and Syuaib (2015).

The Standard Error of Mean (SEM) measures how well the mean of a sample approximates the mean of the overall population. In this study for the male dimensions, body weight has the highest SEM of 0.6630 while the SEM for the other dimensions ranges from 0.0271 to 0.4433 (Table 1). Similarly, for the female dimensions, body weight also has the highest SEM of 0.4594, and the SEM for other dimensions ranges from 0.1073 to 0.4283 (Table 2). These low values indicate that the error in the sample with respect to the population is small, and conform to those obtained by Karmegam *et al.*, (2011); Khadem and Islam (2014) and Syuaib (2015). These SEM values are acceptable within the 95% confidence limit, and therefore, indicate that, the number and distribution of sample is representative of the target population.

The Coefficient of Variation (CV) is a measure of variability in relation to the mean value. CV values are greater than 10% for body weight, fingertip height, sitting shoulder height, sitting elbow height, knee height, buttock-knee length, buttock popliteal length, chest(bust) depth, shoulder breadth, hip breadth, upper-arm length, fore-arm hand length, hand length, hand breadth, foot length and foot breadth. The highest CV is for hand length (35%) and lowest is stature (3.39%) for male subjects (Table 1). For female subjects, the CV values are greater than 10% for fingertip height, sitting shoulder height, sitting elbow height, knee height, chest (bust) depth, hip breadth, hand length, hand breadth and foot breadth. The highest CV observed in Table 2 was grip diameter (43.84%) and the lowest was vertical grip reach (3.42%). According to Pheasant (2003) as cited by Syuaib (2015), the common characteristic

**Table 1: Anthropometric Data for Benue Male Agricultural Workers**

S/N	Anthropometric Measures	Percentile								
		Min.	Max.	Mean (50 <sup>th</sup> )	SD	5 <sup>th</sup>	95 <sup>th</sup>	SEM	CV (%)	Skewness
1	Body weight <sup>1</sup>	55.60	87.50	69.65	10.16	52.94	86.36	0.6630	14.59	-0.810
2	Stature	146.30	179.60	163.30	5.54	154.19	172.41	0.3613	3.39	0.130
3	Eye height	137.00	169.70	152.89	6.74	141.80	163.98	0.4395	4.41	0.042
4	Shoulder height	121.10	153.80	137.06	6.76	125.94	148.18	0.4412	4.93	0.035
5	Elbow height	85.60	118.00	101.51	6.77	90.37	112.65	0.4415	6.67	0.056
6	Waist height	81.40	114.10	97.29	6.73	86.22	108.36	0.4396	6.92	0.042
7	Knuckle height	53.90	85.50	69.85	6.73	58.78	80.92	0.4392	9.63	-0.004
8	Fingertip height	43.20	75.00	59.04	6.77	47.90	70.18	0.4285	11.47	0.043
9	Arm span	152.50	185.60	168.75	6.74	157.66	179.84	0.4399	3.99	0.003
10	Elbow span	71.00	102.80	87.70	6.69	76.69	98.71	0.4367	7.63	-0.012
11	Vertical grip reach	179.40	212.80	195.22	6.78	184.07	206.37	0.4424	3.47	0.042
12	Forward grip reach	54.00	86.70	70.06	6.73	58.99	81.13	0.4391	9.61	0.051
13	Forward fingertip reach	65.00	98.50	81.74	6.75	70.64	92.84	0.4396	8.26	0.029
14	sitting height	69.10	100.00	85.04	6.65	74.10	95.98	0.4336	7.82	-0.011
15	Sitting eye height	57.50	90.40	73.62	6.69	62.61	84.63	0.4365	9.09	0.048
16	Sitting shoulder height	40.90	73.40	56.68	6.70	45.66	67.70	0.4371	11.82	0.031
17	Sitting elbow height	16.60	39.50	22.69	6.57	11.88	33.50	0.4283	28.96	0.094
18	Knee height	35.50	69.60	52.65	6.79	41.48	63.82	0.4429	12.90	0.015
19	Buttock-knee length	41.40	74.10	57.27	6.72	46.22	68.32	0.4398	11.73	0.050
20	Buttock popliteal length	31.80	64.50	47.73	6.63	36.82	58.64	0.4327	13.89	-0.013
21	Chest(bust) depth	12.30	28.80	20.78	2.78	16.21	25.35	0.1811	13.38	-0.045
22	Shoulder breadth	26.80	59.50	42.71	6.72	31.66	53.76	0.4389	15.73	0.034
23	Hip breadth	15.70	46.30	30.08	6.66	19.12	41.04	0.4347	22.14	0.050
24	Upper- arm length	16.10	48.70	32.04	6.76	20.92	43.16	0.4410	21.10	0.020
25	Fore-arm hand length	31.20	64.00	47.20	6.80	36.01	58.39	0.4433	14.41	0.037
26	Hand length	12.30	37.50	19.04	6.70	8.02	30.06	0.4240	35.19	0.048
27	Hand breadth	4.50	9.60	7.44	1.04	5.73	9.15	0.0678	13.98	-0.145
28	Grip diameter( internal)	3.20	5.30	4.16	0.41	3.49	4.83	0.0271	9.86	-0.019
29	Foot length	16.50	34.70	24.00	4.02	17.39	30.61	0.2611	16.75	0.071
30	Foot breadth	9.70	24.20	13.81	3.97	7.28	20.34	0.2596	28.75	0.065

<sup>1</sup> Body weight is in Kilograms, while all other parameters are in centimeters

**Table 2: Anthropometric Data for Benue Female Agricultural Workers**

S/N	Anthropometric Measures	Min.	Max.	Mean (50th)	SD	Percentile		SEM	CV (%)	Skewness
						5 <sup>th</sup>	95 <sup>th</sup>			
1	Body weight <sup>2</sup>	56.40	87.50	72.41	7.04	60.83	83.99	0.4594	9.72	0.123
2	Stature	138.50	173.50	154.46	6.52	143.73	165.19	0.4252	4.22	0.525
3	Eye height	120.60	158.50	140.00	6.47	129.36	150.64	0.4222	4.62	0.387
4	Shoulder height	111.10	146.20	127.04	6.34	116.61	137.47	0.4138	4.99	0.485
5	Elbow height	79.70	114.70	95.62	6.40	85.09	106.15	0.4176	6.69	0.496
6	Waist height	75.30	110.00	91.04	6.43	80.46	101.62	0.4197	7.06	0.514
7	Knuckle height	51.30	86.40	67.22	6.48	56.56	77.88	0.4226	9.64	0.533
8	Fingertip height	41.00	76.50	57.29	6.13	47.21	67.37	0.4009	10.70	0.548
9	Arm span	140.70	175.40	156.89	6.34	146.46	167.32	0.4139	4.04	0.502
10	Elbow span	65.00	97.80	81.51	6.35	71.06	91.96	0.4141	7.79	0.354
11	Vertical grip reach	167.50	197.80	183.39	6.27	173.08	193.70	0.4093	3.42	0.369
12	Forward grip reach	50.30	85.50	66.48	6.55	55.71	77.25	0.4274	9.85	0.526
13	Forward fingertip reach	63.00	94.20	77.27	6.23	67.02	87.52	0.4062	8.06	0.544
14	Sitting height	54.50	85.60	72.39	6.57	61.58	83.20	0.4283	9.08	-0.146
15	Sitting eye height	56.00	77.30	65.74	5.25	57.10	74.38	0.3426	7.99	0.096
16	Sitting shoulder height	39.90	63.50	51.29	5.17	42.79	59.79	0.3373	10.08	0.095
17	Sitting elbow height	11.90	32.60	20.72	3.69	14.65	26.79	0.2407	17.81	0.302
18	Knee height	32.30	67.30	48.26	6.52	37.53	58.99	0.4252	13.51	0.525
19	Buttock-knee length	45.40	59.00	52.68	3.44	47.02	58.33	0.2247	6.53	-0.202
20	Buttock popliteal length	35.10	53.80	44.83	4.07	38.13	51.53	0.2656	9.08	-0.298
21	Chest(bust) depth	18.00	31.50	23.99	2.85	19.30	28.68	0.1860	11.88	0.055
22	Shoulder breadth	34.60	47.60	41.09	2.95	36.23	45.94	0.1926	7.18	-0.114
23	Hip breadth	24.90	52.00	39.73	5.93	29.98	49.48	0.3865	14.93	-0.245
24	Upper- arm length	24.00	37.50	30.63	2.54	26.45	34.81	0.1661	8.29	0.170
25	Fore-arm hand length	33.00	51.80	42.92	4.06	36.24	49.60	0.2648	9.46	-0.324
26	Hand length	14.20	23.50	17.48	1.80	14.52	20.44	0.1174	10.30	1.057
27	Hand breadth	5.10	14.40	8.36	1.78	5.43	11.29	0.1161	21.29	1.078
28	Grip diameter( internal)	0.80	8.70	4.06	1.78	1.13	6.99	0.1161	43.84	1.077
29	Foot length	16.80	23.70	20.27	1.64	17.57	22.97	0.1073	8.09	0.122
30	Foot breadth	6.00	13.80	9.51	1.72	6.68	12.34	0.1120	18.09	0.170

<sup>1</sup> Body weight is in Kilograms, while all other parameters are in centimeters

**Table 3: Comparison between Benue Male and Female Agricultural Workers**

Anthropometric Measures	Male Mean	Female Mean	Mean Difference	DF	T-Cal	SED	Sig (2 tailed)
Body weight	69.65	72.41	2.76	468	-3.280	0.7617	0.001*
Stature	163.30	154.46	8.84	468	15.856	0.5579	0.000*
Eye height	152.89	140.00	12.89	468	21.154	0.6094	0.000*
Shoulder height	137.06	127.04	10.02	468	16.566	0.6049	0.000*
Elbow height	101.51	95.62	5.89	468	9.700	0.6077	0.000*
Waist height	97.29	91.04	6.25	468	10.288	0.6078	0.000*
Knuckle height	69.85	67.22	2.63	468	4.314	0.6095	0.000*
Fingertip height	59.04	57.29	1.75	468	2.921	0.5965	0.004*
Arm span	168.75	156.89	11.89	468	19.642	0.6040	0.000*
Elbow span	87.70	81.51	6.19	468	10.294	0.6018	0.000*
Vertical grip reach	195.22	183.39	11.38	468	19.628	0.6027	0.000*
Forward grip reach	70.06	66.48	3.58	468	5.854	0.6128	0.000*
Forward fingertip reach	81.74	77.27	4.47	468	7.470	0.5986	0.000*
Sitting height	85.04	72.39	12.65	468	20.756	0.6094	0.000*
Sitting eye height	73.62	65.74	7.88	468	14.203	0.5549	0.000*
Sitting shoulder height	56.68	51.29	5.39	468	9.762	0.5521	0.000*
Sitting elbow height	22.69	20.72	1.97	468	4.016	0.4913	0.000*
Knee height	52.65	48.26	4.39	468	7.151	0.6140	0.000*
Buttock-knee length	57.27	52.68	4.66	468	7.277	0.4932	0.000*
Buttock popliteal Length	47.73	44.83	2.90	468	5.078	0.5171	0.000*
Chest (bust) depth	20.78	23.99	3.21	468	-12.321	0.2602	0.000*
Shoulder breadth	42.71	41.09	1.62	468	3.360	0.4792	0.001*
Hip breadth	30.08	39.73	9.65	468	-16.584	0.5817	0.000*
Upper arm length	32.04	30.63	1.41	468	2.987	0.4713	0.000*
Fore-arm hand length	47.20	42.92	4.28	468	8.294	0.5164	0.000*
Hand length	19.04	17.48	1.56	468	3.440	0.4526	0.001*
Hand breadth	7.44	8.36	0.92	468	-6.851	0.1345	0.000*
Grip diameter (internal)	4.16	4.06	0.1	468	0.782	0.1192	0.450 <sup>ns</sup>
Foot length	24.00	20.27	3.73	468	13.191	0.2832	0.000*
Foot breadth	13.81	9.51	4.3	468	15.231	0.2828	0.000*

\* Significant at 5% Probability Level <sup>ns</sup> not Significant at 5% Probability Level.

ranges of CV% of the various anthropometric dimensions are: 3-4 for stature, 4-5 for parts of limbs, 5-9 for body breadths, 6-9 for body depths, 4-11 for dynamic reach and 10-21 for body weight. Thus 65% of male dimensions and more than 70% of female dimensions conform to these ranges. However, the CV of body measures, such as fingertip height, sitting shoulder height, sitting elbow height, hip breadth, upper-arm length, hand length, foot length and foot breadth for the male subjects are relatively higher (Table 1). Similarly, sitting elbow height, knee height, hip breadth, hand breadth, grip diameter and foot breadth for female subjects are relatively higher (Table 2). These high values of CV show a high relative dispersion in these body dimensions.

Table 3 presents the comparison of anthropometric data between male and female agricultural workers in Benue State. The data indicates that Benue female agricultural workers are smaller than their male counterparts in all body dimensions except body weight, chest (bust) depth, hip breadth and hand breadth where the males had lesser dimensions by 96.2%, 86.6%, 75.7% and 89% respectively. Onouha *et al.*, (2012) reported that female South-Eastern Nigerian agricultural workers are smaller than their male counterparts in all body dimensions except waist circumference, hand breadth and hip breadth. T-test analysis at  $P \leq 0.05$  shows that all anthropometric dimensions are significantly different (between males and females), except grip diameter (Table 3). The difference in values suggests that the design parameters

for both males and females on the affected dimensions must be different in order not to exceed data range obtained for each gender.

#### 4. CONCLUSION

In this study 30 anthropometric data for Benue agricultural workers of Nigeria were determined; this was used to develop a database for the user group which was hitherto not available. The study revealed that anthropometric dimensions for Benue male agricultural workers were higher than that of their female counterparts except for body weight, chest (bust) depth, hip breadth and hand breadth where the males had lesser

dimensions by 96.2%, 86.6%, 75.7% and 89% respectively. All anthropometric dimensions were significantly different except for mean grip diameter of 4.16 (males) and 4.06 (females). The observed differences in the anthropometric data of the male and female agricultural workers are a useful guide in the area of designing and redesigning of agricultural tools and equipment. This information will also serve as a guide for introducing agricultural tools, equipment and machinery into the State. The various agricultural equipment and machinery used in Nigeria are foreign and are based on foreign anthropometry and therefore, need appropriate modification for optimum output.

#### REFERENCES

- Agrawal, K. N., Singh, K. P. and Satapathy, K. K. (2010). Anthropometric Considerations for Farm Tools/Machinery Design for Tribal Workers of North Eastern India. *Agricultural Engineering International: the CIGR Ejournal*. **7**, 1-11. <http://www.cigrjournal.org>
- Anema, J., Cuelenaere, B., Vander-Beek, A., Knol, D., de Vet, H., van Mechelen, W. (2004). The Effectiveness of Ergonomic Interventions on Return-to-work After Low Back Pain; A Prospective Two Year Cohort Study in Six Countries on Low Back Pain Patients Sicklisted for 3–4 months. *Occup. & Environ Med.* **61**(4), 289–294. doi: [10.1136/oem.2002.006460](https://doi.org/10.1136/oem.2002.006460)
- BMANR (2003). Benue State Ministry of Agriculture and Natural Resources. Benue State: A Haven for Cassava Agro Investment in Nigeria. Seminar paper, 24<sup>th</sup> August, 4 pp.
- Chandra, A., Chadna, P. and Deswal, S. (2011). Analysis of Hand Anthropometric Dimensions of Male Industrial Workers of Haryana State. *Int. J. Eng.* **5**(3), 242-256.
- ISO 15535 (2003) *General Requirements for Establishing an Anthropometric Database*. Geneva: International Standard Organization.
- Karmegam, K., Sapuan, S. M., Ismail, M. Y., Ismail, N., Shamsul, M. T., Shuib, S., Mohana, G. K., Seetha, P., TamilMoli, P. and Hanapi, M. J. (2011). Anthropometric Study among Adults of Different Ethnicity in Malaysia. *Int. J. Phys. Sci.* **6**(4), 777-788.
- Khadem, M. M. and Islam, M. A. (2014). Development of Anthropometric Data for Bangladeshi Male Population. *Int. J. Ind. Ergon.* **44**, 407-412. <http://dx.doi.org/10.1016/j.ergon.2014.01.007>
- Liu, W.C., Sanchez-Monroy, V. D. and Parga, G. (1999). Anthropometry of Female Maquiladora Workers. *Int. J. Ind. Ergon.* **24**(3), 273–280. <http://dx.doi.org/10.1016/j.ergon.2015.11.010>
- Onuoha, S.N., Idike, F. I. and Oduma, O. (2012). Anthropometry of South Eastern Nigeria Agricultural Workers. *Int. J. Eng. & Tech.* **2**(6):1089-1095. [iet-journals.org](http://iet-journals.org)
- Pheasant, S. (2003). *Bodyspace: Anthropometry, Ergonomics and the Design of Work*, Second Ed. Taylor & Francis, London.
- Syuaib, M. F. (2015). Anthropometric Study of Farm Workers on Java Island, Indonesia and Its Implication for the Design of Farm Tools and Equipment. *Appl. Ergon.* **51**, 222-235. <http://dx.doi.org/10.1016/j.apergo.2015.05.007>
- Yadav, L. S. (2012). An Ergonomic Study to Match Anthropometric Dimensions of Tractor Operators with Their Seat in Occupational Conditions of Tea Plantations in North-East India. *Crop Res.* **44** (3), 473-478.
- Yadav, R., Tewari, V. K. and Prasad, N. (1996). Anthropometric Data of Indian Farm Workers – A Module Analysis. *Appl. Ergon.* **28**(1), 69-71.