

# ANTHROPOMETRIC DATA FOR ERGONOMIC DESIGN OF PEDAL OPERATED MULTI CROP THRESHER IN BORNO STATE, NIGERIA

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## ABSTRACT

*In this study a favorable relationship between pedal operated multi crop thresher and the operator's comfort is examined. An anthropometric survey was conducted to determine the anthropometric data in order to reduce and eliminate stresses of the pedal operated multi crop thresher operators in Borno State, Nigeria. The anthropometric data were collated from various individuals within the ages of (18 to 45) years from Borno, Nigeria. A total of 90 operators comprising of sixty (60) males and thirty (30) females were measured. Measuring instruments such as weighing balance, stadiometer, digital Vanier caliper and flexible tape were all used during the measurement which contains 11 different human body dimensions on standing and seating anthropometric positions. The obtained data were collated and analyzed statistically into mean, standard deviation, 5th and 95th percentiles. The mean age, stature and mass of male operators were  $31.4 \pm 3.7$  years,  $170.52 \pm 9.93$ cm and  $65.5 \pm 4.9$  kg, respectively while the corresponding parameters for female operators were  $24 \pm 4.1$  years,  $166.1 \pm 5.19$  cm and  $52.8 \pm 3.71$  kg. The percentile values of male operators have been found for 5<sup>th</sup> (167.1cm) and 95<sup>th</sup> (181.3cm) percentile stature respectively while the corresponding parameters for female operators were 5<sup>th</sup> (153.4cm) and 95<sup>th</sup> (168.7cm) percentile. The results obtained indicated that males have greater anthropometric dimension values than the females. The outcome of this research will be useful in the design and manufacturing of pedal operated multicrop thresher. It was recommended that for all machines construction anthropometric data should be incorporated for appropriate design and construction of machines.*

**Keywords:** Stadiometer, Anthropometric data, pedal operated multicrop thresher, Male, Female

## 1 INTRODUCTION

Anthropometry is the science that studies the physical measurement of human body and systematically measures dimensional descriptors of human body. During the past one decade, research in ergonomics has led to increased interest in the technology of machines, work and furniture design based on biomechanics of the human body. Today, anthropometric data is being used in designing machines. Equipment designers rely on the research community to develop reliable anthropometric data and to advise them when specific populations are significantly different. The use anthropometric data would assist in the appropriate design of equipment and machines for improved efficiency, safety and human comfort [1]. Manually operated equipment are extensively used in Nigerian agriculture for various farm operations starting from seedbed preparation to post-harvest operations. In the present era of user centeredness and market

competition, ergonomic considerations are a must for agricultural equipment design as the users are no more bound to cope with whatever design imposed on them [2]. The availability of an anthropometric database has unlimited applications. Western countries, where ergonomic awareness is much higher than in other areas of the world, have created huge databases for anthropometric design reference [3]. The anthropometric data bank assembled and maintained by Aerospace Medical Research Laboratories, Dayton, Ohio (USA) is the largest single repository of raw anthropometric data in the world. ERGODATA is another data bank located at Anthropology Laboratory of Paris University, France. However, it does not contain any data on Nigeria. In Nigeria, the ergonomic factors concerning safety are not adequately addressed by the legislators. While environmental factors such as noise, ventilation, illumination etc. have been dealt with in detail, factors relating to man-machine- interaction need more emphasis in the legislation [4]. Ergonomics can be used as a tool for retaining employees and increasing productivity. It is therefore recommended that such tools could be used to reduce turnover rates and increase employee engagement. High rates of attrition not only increase costs but signify poor working conditions and low brand equity. Ergonomic interventions are increasingly used to reduce labor turnover rates, lower costs, increase revenue and accomplish more work with a little work force [5].

## 2 THE STUDY AREA

The study was carried out in Maiduguri Metropolis, the capital city of Borno state as shown in figure 1 above. It is located on latitude 115°N and latitude 135°E. Maiduguri is the largest and main commercial city in the North Eastern Nigeria. It occupies an area of 69,436 square kilometers (km<sup>2</sup>). According to the 2006 population census, Maiduguri has a population of 521,492 people with an annual growth rate of 2.8%. Maiduguri Metropolis is ecologically characterized as a sahelian savannah with mainly grasses, shrubs, and few trees. The climate condition of the State is hot and dry for most part of the year. It has low rainfall which ranges from 500 mm to 1000 mm annually and a low relative humidity ranging from 42% to 49%. The average temperature is about 20°C [7].



Figure 1. Map of Maiduguri, Borno State

### 3 METHODOLOGY

The materials used to carry out various measurements in this study include Stadiometer, measuring tapes and Vernier caliper to measure different anthropometric dimensions of operators and weighing balance to measure the weight of the operators. [6] reported that Measuring tapes and Vernier caliper are also used in addition to Stadiometer for recording some parameters.

#### 3.1 Anthropometric Data

A large sample size was used for the study whose ages will be within 18 to 45 years because at this range individuals attain their highest strength level [8]. All the subjects were right handed, physically fit and were not suffering from any physical abnormalities to perform the selected activity. The measurements of different anthropometric parameters of the operators was carried out using stadiometer and measuring tape. The operators were asked to remove their shoes and stand erect without bending. Different measurements of the body segment or joints were taken and recorded. Measurements at the sitting posture was made with seats of adjustable heights [9]. The arithmetic mean, standard deviation, fifth (5<sup>th</sup>) and ninety-fifth (95<sup>th</sup>) percentile values was computed from the data collected for each of the body dimensions. Mean value was computed by adding the individual values and dividing the sum by the sample size. It indicates where the distribution is located on the horizontal axis. The standard deviation was computed using the formula.

$$SD = \sqrt{\frac{\sum(x-\bar{x})^2}{n-1}} \quad (1)$$

Where, SD = Standard deviation of the sample,  $\bar{x}$  = Mean value of the sample,  $x$  = Individual value of sample, n = the number of values (the sample size). The standard deviation is an index of degree of variability in the population concerned. It indicates the width of distribution to which individual values are scattered about the mean. The 5th and 95th percentile values were computed using equation 2 [9].

$$X_i = M + SD x Z \quad (2)$$

Where,  $X_i$  = *ith* percentile value of the dimension,  $M$  = Mean value of the dimension,  $SD$  = Standard deviation of the dimension,  $Z$  =  $Z$  – Score corresponds to the chosen confidence level. Confidence level tells us how confidence we are that if the study was repeated again and again we would get the same result. The confidence level chosen is 95% and the  $Z$  – score is  $\pm 1.645$ . For 5<sup>th</sup> percentile  $Z = -1.645$  and for 95<sup>th</sup> percentile  $Z = + 1.645$ . The range of the dimension measured will be taken by noting the minimum and maximum values among the subjects.

#### 3.2 Data analysis

The arithmetic mean, standard deviation, 5<sup>th</sup> and 95<sup>th</sup> percentile was computed for each body dimensions from the data collected during the survey as shown in Figure 2, Figure 3 and Plates 1 to 3. All dimensions were in centimeter (cm) except for age (years) and weight in kilogram (kg).

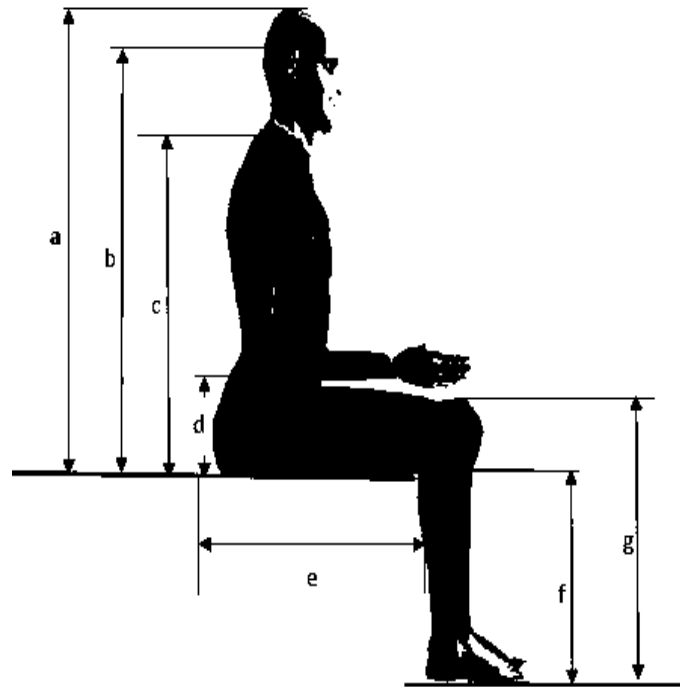


Figure 2. Anthropometric dimensions (Seated)

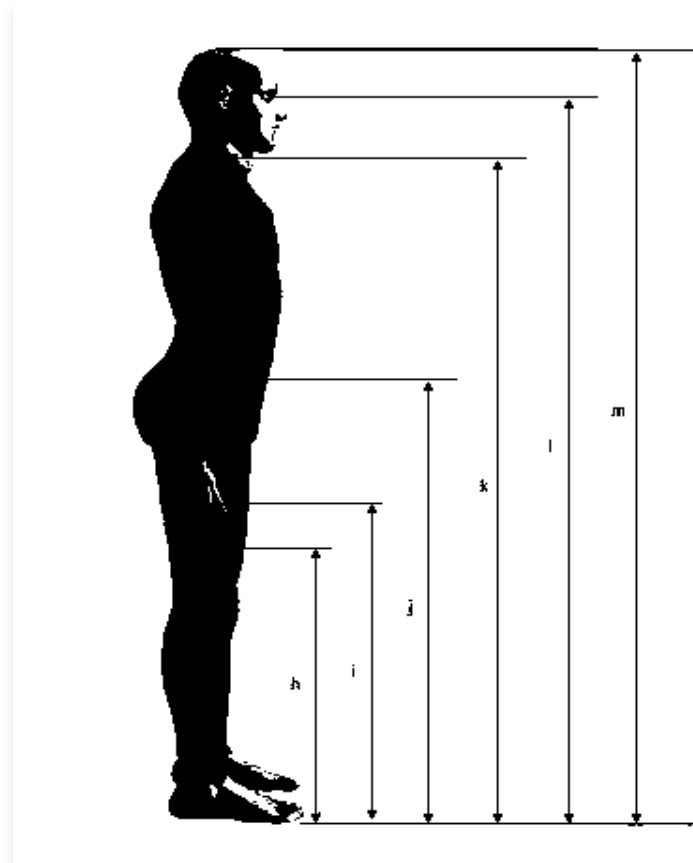


Figure 3. Anthropometric dimensions (Standing)



Plate 1. Stadiometer



Plate 2. Anthropometric measurement of Female operator



Plate 3. Anthropometric measurement of Male operator

#### 4 RESULTS AND DISCUSSION

Tables 1 and 2 present the mean, standard deviation, 5th and 95th percentile values for the anthropometric parameters of male and female operators, respectively, the details of the study are presented below. The mean age, stature and mass of male operators were  $31.4 \pm 3.7$  years,  $170.52 \pm 9.93$ cm and  $65.5 \pm 4.9$  kg, respectively while the corresponding parameters for female operators were  $24 \pm 4.1$  years,  $166.1 \pm 5.19$  cm and  $52.8 \pm 3.71$  kg. The percentile values of male operators have been found for 5<sup>th</sup> (167.1cm) and 95<sup>th</sup> (181.3cm) percentile stature respectively while the corresponding parameters for female operators were 5<sup>th</sup> (153.4cm) and 95<sup>th</sup> (168.7cm) percentile. In general, the male operators were heavier in terms of weight as against female operators. The mean lean body mass of male operators was also higher than female operators. Earlier studies reported similar results. [9] while studying the anthropometrics of (n =10) male and female pedal millet thresher operators reported the weight, stature, standard deviation, 5<sup>th</sup> and 95<sup>th</sup> percentile of male operators as follows  $54.7 \pm 8$ kg,  $168.0 \pm 2.32$ ,cm, 164.1cm and 171.8cm respectively while the corresponding result for female operators was  $55 \pm 5.22$ kg,  $160.2 \pm 3.27$ cm, 154.8cm and 165.6cm respectively [10] investigated the anthropometrics of (n=12) selected subjects from both sexes in agro-climatic zones of Odisha and reported the mean stature and weight of the male subjects as follows  $164.8 \pm 9.62$ cm and  $57.4 \pm 10.57$ kg respectively while the corresponding parameters for females was  $152 \pm 7.61$ cm and  $51.7 \pm 4.91$ kg respectively. [11] made a comparison of static anthropometric characteristics among workers of three Iranian ethnic groups. The mean, standard deviation, 5th, and 95th percentile values for male were: Fars ( $1730 \pm 70.2$ , 1634.9 and 1845.5) Arab ( $1715 \pm 70.2$ , 1614.8 and 1825.5) Azeri ( $1693 \pm 60.7$ , 1693 and 1815.4) respectively while the corresponding parameters for females: Fars ( $1584 \pm 70.1$ , 1471.5, 1691.7) Arab ( $1579 \pm 60.1$ , 1484.4 and 1681.7) Azeri ( $1590 \pm 60.1$ , 1503.0, 1680.0).

Table 1. Analysis of Anthropometric Data of Male Operators (n = 60)

S/N	Dimension	Mean	SD	5th Percentile	95th Percentile
1	Age years	31.4	3.7	27.8	38.3
2	Weight kg	65.5	4.9	58	69
3	Stature, cm	170.52	9.93	167.1	181.3
4	Eye height, cm	158.32	8.23	147	179.3
5	Shoulder height, cm	146.87	5.13	129.4	149.5
6	Arm length, cm	80.4	7.2	59.9	77.6
7	Sitting height, Stature, cm	88.3	5.02	73.6	90.5
8	Sitting eye height	76.4	4.1	69.4	79.9
9	Knee height, cm	58.2	4.82	53.1	60.4
10	Popliteal height	45.7	3.79	30.3	58.4
11	Foot length	27.8	3.24	23.4	27.2

Table 2. Analysis of Anthropometric Data of Female Operators (n = 30)

S/N	Dimension	Mean	SD	5th Percentile	95th Percentile
1	Age, years	24	4.1	19	29
2	Weight, kg	52.8	3.71	48	62
3	Stature, cm	166.1	5.19	153.4	168.7
4	Eye height, cm	150.6	4.13	130.6	155.3
5	Shoulder height, cm	137.2	5.72	128.9	144.4
6	Arm length, cm	73.4	3.81	50.9	79.4
7	Sitting height, Statue, cm	80.3	3.9	65.6	84.2
8	Sitting eye height, cm	65.4	4.1	59.4	71.9
9	Knee height, cm	53.6	2.3	48.9	59.1
10	Popliteal height, cm	39.5	1.59	35.3	47.6
11	Foot length	25.4	3.24	20.1	27.2

#### 4 CONCLUSIONS

This study reveals that the data obtained be used for design of a pedal operated multicrop thresher. This is to reduce physical and mental stresses and improve comfort in operation. The results obtained indicated that the mean age, stature and mass of male operators were found to be  $31 \pm 3.7$  years, 170.52cm and 65.5kg respectively while the corresponding parameters for female operators were  $24 \pm 4.1$  years, 166.1cm and 52.8 kg. The percentile values of male operators have been found for 5<sup>th</sup> (167.1cm) and 95<sup>th</sup> (181.3cm) percentile stature respectively, while the corresponding parameters for female operators were 5<sup>th</sup> (153.4cm) and 95<sup>th</sup> (168.7cm) percentile. In general, the male operators were heavier in terms of weight (63.4kg) as against female operators with a value of 51.6kg. The anthropometric data will be use in the designing the frame of the thresher to prevent inadequate design that could cause discomfort, inappropriate sitting posture and musculoskeletal disorders. The findings of the study are important addition to local knowledge on anthropometry and it has increased anthropometric databases of the study population. It was recommended that for all machines construction anthropometric data should be incorporated for appropriate design and construction of machines.

#### REFERENCES

1. Yadav, R., Kaur, N., Gite, L.P. and Randhawa, J. (2000). An anthropometry of Indian female agricultural workers. *Agricultural Mechanization in Asia, Africa and Latin. America*, vol. 31, no. 3, pp. 56-60.
2. Kumar, P. and Chakrabarti, D. (2009). User centered design input in mechanical engineering and design: ergonomics relevance, In: D. Sen, ed. *6th International Ergonomics Conference on Humanizing Work and Work Environment (HWWE)*, 17-19 December 2009 Kolkata.

3. Syed, A.N. (1993). Need for anthropometric databases for developing countries. *J. King Saud University, Eng. Sci.*, vol. 1, no. 5, pp. 153-154.
4. Periyar, N. and Iqbal, R. (2009). Addressing ergonomic concerns through safety legislation – A gap analysis, In *6th International Ergonomics Conference on Humanizing Work and Work Environment (HWWE), Kolkata*, vol. 42, no. 3, pp. 369-372.
5. Dempsey, P.G. (2007). Effectiveness of ergonomics interventions to prevent musculoskeletal disorders. Beware of what you ask. *International Journal of Industrial Ergonomics*, vol. 37, no. 2, pp. 169-173.
6. Tewari, V.K., Ailavadi, R., Dewangan, K.N. and Sharangi, S. (2007). Rationalized Database of Indian Agricultural Workers for Equipment Design. *Agricultural Engineering International: the CIGR Ejournal*. Manuscript MES 05 004, Vol.
7. Maryah, U.M. (2005). Forage availability and Livestock Management Systems in Semiarid Zone of North East Nigeria. Ph.D. Thesis submitted, Department of Geography, Bayero University, Kano. *Nig. Geogr. Journal*, vol. 5, no. 1, pp. 34-42.
8. Mc Ardle W.D., Katch, F.I. and Katch, V.I. (2001). Exercise physiology, 5<sup>th</sup> edition. *Pennsylvania: Lippincott Williams and Wilkins publication*.
9. Parmanand, P., Verma, D. and Guru, P.K. (2015). Development of pedal Operated thresher for finger millets. *International Journal of Agricultural Science and Research*, vol. 5, no. 6, pp. 15-24.
10. Mohanty, S.K., Gbosal, M.K. and Mishra, J.N. (2012). Circulo - respiratory efficiency of agricultural workers in Odisha. *Engg. and Tech. in India*, vol. 3, no. 2, pp. 111-115.
11. Sadeghi, F., Bahrami, A.R. and Joneidi, J. (2014). Comparison of Static Anthropometric Characteristics among workers of Three Iranian Ethnic Groups anthropologist, vol. 18, no. 2, pp. 601-608.