

UDK: 631.3

Originalni naučni rad
Original scientific paper
doi: 10.5937/PoljTeh1904039G

ASSESSMENT OF SITTING ANTHROPOMETRY OF MALE AND FEMALE TRACTOR OPERATORS IN ABIA STATE

Goziechukwu Inekwe¹, Okechukwu Oduma^{1*}, Chukwulebile S. Agu²,
Clifford E. Igboayaka² and Chineze G. Okeke³

¹Department of Agricultural & Bioresources Engineering,
Michael Okpara University of Agriculture, Umudike

²Department of Mechanical Engineering,
College of Engineering and Engineering Technology,
Michael Okpara University of Agriculture, Umudike, Abia state, Nigeria.

³Department of Agricultural and Bioresources Engineering,
Enugu state University of Science and Technology, Enugu

Abstract: The anthropometric body dimensions of the tractor operators in Abia state (Nigeria) were studied to obtain a database for their anthropometric body dimensions to enable the designers of tractors and agricultural equipment operated in sitting positions improve on their design in order to optimize their usage, enhance posture and comfort of the users and maximize output. Result revealed that the male agricultural workers have average hand length, hand breadth, arm reach from wall, elbow height, elbow rest height, grip strength, internal and external grip diameters, hand circumference, forearm length and forward grip reach of male agricultural workers are 161.05cm, 49.1cm, 143.75cm, 38.25cm, 19.55cm, 8.65cm, 85.75cm, 104.25cm, 24.9cm, 41.6kg, 4.7cm, 7.35cm, 7.35cm, 49.9cm and 75.2cm respectively while in that same order the female agricultural workers recorded 150.55cm, 38.9cm, 138.6cm, 36.45cm, 18.15cm, 7.2cm, 82.35cm, 100.4cm, 22.25cm, 40.25kg, 4.0cm, 6.7cm, 19.55 and 75.15cm respectively. Also result showed that the sitting height, sitting eye height, sitting shoulder height, hip breadth, knee height, buttock knee length, functional leg length, foot length of the male agricultural workers are 80.75cm, 81.8cm, 68.5cm, 54.0cm, 33.0cm,

*Corresponding Author. E-mail: odumaoke@gmail.com

55.8cm, 49.7cm, 65.0cm, 57.05cm, 48.65cm, 95.25cm, 32.55cm, 14.35cm, and 66.05cm respectively; and the female in the same arrangement had 85.8cm, 65.59cm, 65.07cm, 41.38cm, 29.14cm, 49.14cm, 44.97cm, 56.06cm, 47.86cm, 36.58cm, 80.51cm, 27.53cm, 3.35cm and 79.19cm respectively.

Key words: *Anthropometric, dimensions, operators, tractors, sitting positions.*

INTRODUCTION

Engineering anthropometry deals with the application of scientific physical measurement method to human subjects for the development of engineering design standards. It includes static and functional (dynamic) measurements of dimensions and physical characteristics of the body as they occupy space, move and apply energy to physical objects, as a function of age, sex, occupation, ethnic origin and other demographic variables (Sanders and McCormic 1992).

Agrawal *et al.*, (2010) noted that anthropometric body dimensions play significant roles in human-machine interaction and that the overall working efficiency of human-machine environment and resultant discomfort has severe impact while using farm tools and machinery. They also noted that anthropometric dimensions vary considerably across gender, race, age, and that within a particular group, the anthropometry differs due to nutritional status and nature of work, and to achieve better performance and efficiency along with higher comfort and safety to the operators, it is necessary to design tools, equipment and workplaces keeping in view of the anthropometric data of the agricultural workers.

One major reason for low agricultural productivity in some agricultural regions is due to prevalence of traditional method of cultivation and lower mechanization level. Machines or tools manufactured without application of human factors or ergonomic principles are low in working efficiency and most times fail to reduce drudgery and increase discomfort of the operators. Ergonomics is the science which considers human characteristics, expectations and behavior in the design of things mainly used in environment (Sanders and McCormic, 1992). The ergonomic principles or human factors are considered in machine design to enhance effectiveness, efficiency, safety and comfort of the users/operators of the equipment. In most cases, constraints are experienced in adoption of improved machineries being utilized in other parts of the country; the adopted equipment at times need to be modified before being introduced into other countries or regions to suit agricultural workers of the region for which body dimensions limits of local populations was required. To design any product for human use, engineers have to rely on anthropometric data, otherwise the resulting product may turn out to be ergonomically incompatible (Lewis, 1993; Hastegrave, 1986).

According to Mebarki and Davis (1990), anthropometric dimensions are one of the essential factors in designing machines and device. Gite and Yadav (1989), noted that the design and dimensions of agricultural tools and implements have great bearing on the body dimensions and physical built of the users, requiring compatibility essentially between machine devices and worker body dimensions. Dewangan *et al.*, (2005) suggested that the only way to fulfill this objective is to create database of anthropometric dimensions of the user population.

Gupta et al (1983) observed that most of the anthropometric data in India is limited to male agricultural workers; while it was discovered by Reddy *et al.*, (1994) that about 88% rural women working population is engaged in agricultural sector and stipulated that the value is nearly 50.2% of the total agricultural labour force in India. Dixit *et al.*, (2014) added that due to paucity of female anthropometric data, the anthropometric data of male workers are extrapolated to define women at work whenever necessary. Cox *et al.*, (1984) opposed this assumption and said that such an approach is likely to be inaccurate due to obvious anthropometric, physiological and biological differences between male and female subjects. As earlier noted in this review, the body dimensions vary with age, sex, ethnic groups (Sanders and McCormick, 1992). According to Dixit and Namigial (2012), there is considerable difference between the anthropometric data of India and Western population emphasizing the need for generating anthropometric database for agricultural workers as it is not feasible practically to design equipment for an individual sex (male and female).

Based on the foregoing, this study was conducted to generate and analytically compare the anthropometric data of the male and female agricultural workers in the rural areas of south-eastern region of Nigeria. The data so generated will be compared with those of other regions of the western countries for the consideration of ergonomic design of agricultural equipment and machines which will suit the male and female agricultural workers in the study area to enhance effectiveness, efficiency of production, safety and comfort of the users/ operators of the machines.

The placement of different controls in a tractor is a complex task for the designer and requires the anthropometric characteristics of the target population (Yadav *et al.*, 2000). The efficiency and comfort of the operator can be improved with properly designed tractor workplace. The dimensions of the seat, location of controls and access/exit provisions are the parameters where anthropometric data can provide help in matching the workplace according to the user's capabilities and to the physiological reach of the operator.

For design purpose, Yadav *et al.*, (2000) stipulated that either one of the boundary value (5th or 95th percentile) or the mean values is used depending upon the dimensional element. Anthropometrically, the authors noted that seat height from foot rest to suit female Indian 5th and 95th percentile population would be within the range of 37.0 to 40.0cm. While in the case of male Indians would be within the range of 41.6 to 47.1cm. If the equipment is to be operated by women, the anthropometric data of the female must be considered in the design along with men anthropometric data. Anonymous (1996) revealed that most Indian tractors are manufactured to suit the anthropometric measurements applicable to the countries where the tractors are designed.

The objective of this research work is to develop an anthropometric database for agricultural field machinery operators in Abia state and any other region with similar anthropometric dimensions for a better design of farm machinery to suit them for safety, comfort and efficient operation in sitting positions.

MATERIALS AND METHODS

Samples for the Study

The samples for the study consist of 400 tractor operators (200 each of male and female) within the age limit of 18- 50 years selected randomly from different areas of Abia states.

Apparatus Used

The following anthropometric equipment was used for the study:

1. An anthropometer was used in measuring various body dimensions at sitting postures.
2. Weighing balance of 1kg sensitivity and 150kg capacity was used for measuring the body weight of the subjects.
3. Measuring tape was used for measuring lengths and widths of some body parts.
4. Vernier caliper was used for measuring the internal and external grip diameters.
5. Grip strength dynamometer was used for measuring grip strength.

Anthropometric Measurement Procedure/Data Collection

Thirteen (13) anthropometric body dimensions considered useful for design of agricultural equipment/machines operated in sitting position were measured. The standard anthropometric definitions of measurements and techniques used by Pheasant (1986) as applied by Onuoha *et al.*, (2012) were adopted in the study. Prior to the collection of the data, some persons (male and female) were trained on how to take measurements of body dimensions (Oduma, 2017). The process for data collection was properly explained to the trained personnel so as to maintain accuracy in their measurements and to seek full cooperation from the subjects (Agrawal *et al.*, 2010 and Dixit *et al.*, 2014). Measurements were taking in sitting postures. In process the subjects were asked to sit with their body vertically erect, while their shoulders and head touch the vertical plane and their feet completely touch the base platform. In all the measurements with anthropometer, the subjects were bare footed. The measuring tape was used to measure waist breadth, waist circumference, foot length, and hand breadth across thumb, hand height at metacarpal etc. For every subject, measurements of a given body dimension was replicated for five times and average value of the dimension was taken as the real dimension; this is to avoid error in the measurements.

Data Analysis

The data collected from the measurement was analyzed using range, mean, standard deviation, percentile values (5th, 50th and 95th percentile) and percentages. The percentile was used to adjudge the proportion of a group of individuals who exceed or fall below some possible design limit.

Apart from the mean; the 5th and 95th percentile values of body dimensions were calculated to decide various possible sitting design limits of farm machinery and work place layout to be operated by tractor operators (Agrawal 2010). The percentage was used to determine the percentage difference or variation in the set of data obtained for male and female operators (Oduma, 2017).

The percentile was calculated from the formula suggested by Kothari (2013) as used by Oduma (2017).

$$X = \mu + ZQ \quad (1)$$

Where is:

X = Percentile

μ = mean values

Q = standard deviation

Z = constant = -1.645 for 5th percentile; 0 for 50th and 1.645 for 95th percentile

The standard deviation was computed using the expression:

$$S = \sqrt{\frac{\sum f(Y - \bar{Y})^2}{N}} \quad (2)$$

Where S = standard deviation

Σ = symbol of summation

f = frequency

Y = measures of body dimensions

\bar{Y} = mean values of body dimension given as

$$\frac{\sum fY}{N}$$

N = number of subjects measured

(3)

RESULTS AND DISCUSSION

Table 1. Anthropometric dimensions of tractor Male operators in Abia state

Body dimensions	Male						
	Range				Percentiles		
	Min	max	Mean	S.D	5 TH	50 TH	95 TH
Hand length	15.2	23.9	19.55	3.8	13.30	19.55	25.81
Elbow height	90.4	118.1	104.25	4.9	96.19	105.25	12.31
Elbow rest height	16.7	33.2	24.95	3.3	19.52	24.95	30.38
Hand circumference	15.2	25.6	20.9	1.6	18.27	20.9	23.53
forearm grip reach	59.1	91.3	75.20	0.6	74.38	75.20	76.02
Sitting height	64.2	99.3	81.75	5.1	73.36	81.75	90.14
Sitting eye height	56.8	80.2	68.50	0.3	68.00	68.50	68.99
Sitting shoulder height	44.2	63.8	54.00	5.8	44.45	54.00	63.54
Hip breadth	28.6	37.4	33.00	0.6	36.41	33.00	33.99
Knee height	47.2	64.4	55.80	1.6	53.17	55.8	58.43
Buttock knee length	43.7	70.4	57.05	4.8	49.15	57.05	64.95
Functional leg length	80.3	110.2	95.25	7.0	83.74	95.25	106.77
Foot length	20.6	44.5	32.55	0.8	31.23	32.55	33.87

Table 1a: Anthropometric dimensions of tractor Female operators in Abia state

Body dimensions	Female						
	Range				Percentile		
	Min	max	Mean	S.D	5TH	50TH	95 TH
Hand length	14.60	21.7	18.15	3.2	12.89	18.15	23.41
Elbow height	88.50	112.3	100.4	3.8	94.15	100.4	106.65
Elbow rest height	14.20	30.1	22.25	3.1	17.51	22.25	27.00
Hand circumference	14.8	23.9	19.35	1.4	17.05	19.35	21.65
forearm grip reach	55.2	89.1	75.15	1.2	73.18	75.15	77.12
Sitting height	52.4	95.1	73.75	4.9	65.59	73.75	81.81
Sitting eye height	52.2	78.6	65.4	0.2	65.07	65.4	65.73
Sitting shoulder height	40.5	59.7	50.1	5.3	41.38	50.1	58.82
Hip breadth	25.2	34.4	29.8	0.4	29.14	29.8	30.46
Knee height	43.4	60.8	52.1	1.8	49.14	52.1	55.06
Buttock knee length	39.8	68.1	53.95	3.7	47.86	53.95	60.04
Functional leg length	78.1	105.3	91.7	6.8	80.51	91.7	102.89
Foot length	18.7	40.3	29.5	1.2	27.53	29.5	31.47

Table 2: Effect of gender on the anthropometric dimension of tractor operators in Abia state

Sources of variation	DF	Sum of squares	Mean squares	F. cal	F. tab 5%
Gender	1	-70945.01	-70945.01	0.08 ^{NS}	4.21
Body dimensions	13	507137.26	39010.56	0.04 ^{NS}	2.03
Error	13	12051818.57	927062.97		
Total	27	12488010.82			

NS = Not significant

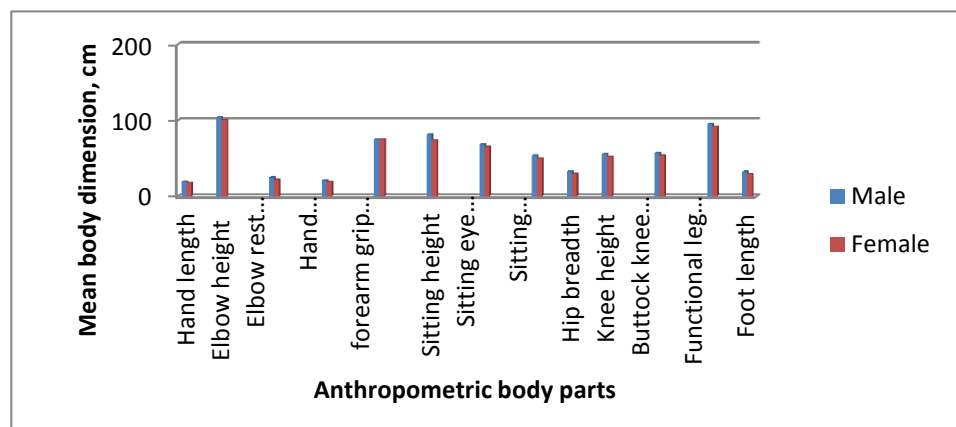


Figure 1: Mean Anthropometric body dimensions of Abia state male and female tractor operators

DISCUSSION

Table 1., and Table 1a., showed the body dimensions of Abia state male and female agricultural workers in sitting positions. Result revealed that the male agricultural workers have average hand length, elbow height, elbow rest height, hand circumference, and forearm grip reach of male tractor operators are 49.1cm, 38.25cm, 19.55cm, 8.65cm, and 104.25cm, respectively while in that same order the female agricultural workers recorded 38.9cm, 36.45cm, 18.15cm, 7.2cm, and 100.4cm, respectively. Also result showed that the sitting height, sitting eye height, sitting shoulder height, hip breadth, knee height, buttock knee length, functional leg length, foot length of the male tractor operators are 80.75cm, 81.8cm, 68.5cm, 54.0cm, 33.0cm, 55.8cm, 49.7cm, and 65.0cm, respectively; and the female in the same arrangement had 85.8cm, 65.59cm, 65.07cm, 41.38cm, 29.14cm, 49.14cm, 44.97cm, and 56.06cm, respectively.

Figure 1., revealed the mean body dimensions of the male and female tractor operators in Abia state in sitting position. The figure showed that the mean body dimensions of the male are slightly higher than the female except in the hand length, hand circumference and forearm grip reach where they maintained a very close values of 19.55cm, 20.9cm and 75.2cm respectively for males and 18.15cm, 19.35cm and 75.15cm respectively for female operators. However, the discrepancies in the rest of the dimensions are very infinitesimal and could be ignored in tractor design.

The ANOVA of the effect of gender on the anthropometric body dimensions of Abia state male and female tractor operators (Table 2) revealed that there is no significant difference among the body dimensions of male and female tractor operators, hence $P < 0.05$. Thus, the body dimensions of the male and female in Abia state do not differ much, therefore, tools and equipment designed based on data collected can effectively be utilized by both male and female agricultural workers within the region, which is in agreement with the study of Agrawal (2010) and also observed by Oduma and Oluka (2017).

CONCLUSION

From the findings made, the following conclusions can be drawn about the study: The mean body dimensions of the male are slightly higher than the female except in the hand length, hand circumference and forearm grip reach where they maintained a very close values of 19.55cm, 20.9cm and 75.2cm respectively for males and 18.15cm, 19.35cm and 75.15cm respectively for female operators. However, the discrepancies in the rest of the dimensions are very infinitesimal and could be ignored in tractor design.

The ANOVA of the effect of gender on the anthropometric body dimensions of Abia state male and female tractor operators revealed that there is no significant difference among the body dimensions of male and female tractor operators, hence $P < 0.05$.

Recommendation: Based on the above conclusions, it is therefore recommended that study of anthropometric body dimensions should be extended to different geographical regions of Nigeria to guide the engineers or designers of agricultural equipment in designing and manufacturing the equipment to match the users and make them work in good postures and maximize their output.

REFERENCES

- [1] Agrawal, K.N, Singh, K.P, and Satapathy, K. K. (2010). *Anthropometric consideration for farm tools/machinery design for tribal workers of North Eastern India*.
- [2] Anonymous (1996). Basic human body measurements for technological design. Iso 7250, International standard organization Geneva.
- [3] Cox, T, Thirlaway, M, and Cox, S. (1984). Occupational well-being, sex difference at work. *Ergonomics* 27(5):499-510.
- [4] Dewangan, K. N.,Prasanma, G.V, Suja, P. L and Choudhury, M. D (2005). Anthropometric dimensions of farm youth of the north eastern region of India. *International Journal of Industrial Ergonomics*, 35(11): 979-989.
- [5] Dixit, J. and Namgial, D. (2012). Anthropometry of farm workers of Kashmir region of India for equipment design. *Journal of agricultural engineering* 49(2): 8-15.
- [6] Dixit, J. and Namgial, D. Sharma, S., Loanan, S.K, Kumar, D.(2014). Anthropometric survey of farm workers of ladakl region of India and its application in equipment design. *Agric eng. Int; CIGR Journal*. 16(2):80-88
- [7] Gite, L. P. and Yadav, B.G. (1989). Anthropometric survey of agricultural machinery design. *Applied Ergonomics*. 20(3):191-196.

- [8] Gupter, P.K., Sharma, A. P., Gupter, M.L. (1983). *Anthropometric survey of Indian farm workers. Agricultural mechanization in Asia. Africa and Latin America.* 16(1):27-30.
- [9] Hastegrove, C.M. (1986). Anthropometric profile of British car drivers. *Ergonomics*, 23(5):437-467.
- [10] Kothari C. R. (2013). *Research methodology. methods and techniques: second revised edition.* New Age International Publishers. New Delhi. Pp185-344.
- [11] Lewis, W. G and Narayan, C.N. (1993). Design and sizing of ergonomic handles for hand tools. *Applied Ergonomics*, 24(5): 351-356.
- [12] Marbarki, B. and Davis, B. T (1990). Anthropometry of Algeria women. *International Journal of Industrial Ergonomics*. 33(12): 15337-1547
- [13] Oduma O. and S. I. Oluka (2017). Comparative analysis of anthropometric dimensions of male and female agricultural workers in south-eastern Nigeria. *Nigerian Journal of Technology (NIJOTECH) Vol. 36, No. 1, January 2017, pp. 261 – 266*
- [14] Onuoha, S. N. Idike F. I and Oduma, O. (2012). Anthropometry of South-Eastern Nigeria Agricultural Workers. *International Journal of Engineering and Technology*. 2(6):962-968.
- [15] Pheasant, S. (1986). *Body-space: anthropometry, ergonomics and design.* Taylor and Francis, London.
- [16] Reddy, A. R, Reddy, Y.S. and Reddy, P. M. (1994). *Women and rural development. A case study of DWCR in Cuddapah district.* Kurukshetra, 9:19-21.
- [17] Sanders, M. S and McCormic, E. J. (1992). *Human factors in engineering and design.* McGraw-Hill International Edition McGraw-Hill Incorporation, Singapore.
- [18] Yadav, R.L.P, Gite, N. K, and Randhawa, J. (2000). *An anthropometric of India female agricultural workers: agricultural mechanization in Asia. Africa and Latin America*, 31(3); 56-60.

ANTROPOMETRIJSKA PROCENA SEDIŠTA TRAKTORA ZA MUŠKARCE I ŽENE U DRŽAVI ABIA (NIGERIA)

**Goziechukwu Inekwe¹, Okechukwu Oduma^{1*}, Chukwulebile S. Agu²,
Clifford E. Igboayaka² and Chineze G. Okeke³**

¹*Department of Agricultural & Bioresources Engineering,
Michael Okpara University of Agriculture, Umudike*

²*Department of Mechanical Engineering, College of Engineering and Engineering
Technology, Michael Okpara University of Agriculture, Umudike, Abia state, Nigeria.*

³*Department of Agricultural and Bioresources Engineering, Enugu state University of
Science and Technology, Enugu*

Sažetak: Antropometrijske procene dimenzije korisnika karoserije traktora (muškarci i žene) u državi Abia (Nigeria) su proučavane zbog dobijanja baze podataka za dimenzije karoserije kako bi konstruktori traktora i poljoprivredne opreme bolje dizajnirali mesto (sedište i kabinu) gde operateri rade u sedećim položajima.

Dizajneri traktora tako mogu da poboljšaju svoj dizajn i optimiziju njegovu upotrebu i poboljšaju držanje i udobnost korisnika mašine za najveći učinak u radu.

*Corresponding Author. E-mail: odumaoke@gmail.com

Rezultat istraživanja je pokazao da poljoprivredni radnici (muški) imaju prosečnu dužinu ruku, širinu ruku, dohvat ruku od zida, visinu lakta, visinu oslonca za laktove, čvrstoću držanja, unutrašnji i spoljni prečnik držanja, obim šake, dužinu podlaktice i opseg dohvata napred, imao je vrednosti 161.05cm, 49.1cm, 143.75cm, 38.25cm, 19.55cm, 8.65cm, 85.75cm, 104.25cm, 24.9cm, 41.6kg, 4.7cm, 7.35cm, 7.35cm, 49.9cm, odnosno 75.2cm. Istim redosledom parametara, žene poljoprivredne radnice imale su vrednosti: 150,55 cm, 38,9 cm, 138,6 cm, 36,45 cm, 18,15 cm, 7,2 cm, 82,35 cm, 100,4 cm, 22,25 cm, 40,25 kg, 4,0 cm, 6,7 cm, 19,55 i 75,15 cm.

Takođe je rezultat ispitivanja pokazao da: visina sedenja, visina preglednosti, visina kukova, visina kolena, dužina kolena, funkcionalna dužina nogu, dužina stopala muških poljoprivrednih radnika iznosi: 80,75cm, 81,8cm, 68,5cm, 54,0cm, 33,0cm, 55,8cm, 49,7cm, 65,0cm, 57,05cm, 48,65cm, 95,25cm, 32,55cm, 14,35cm, i 66,05cm, respektivno. Kod žena, isti raspored parametara ima vrednosti: 85,8cm, 65,59cm, 65,07cm, 41,38cm, 29,14cm, 49,14cm, 44,97cm, 56,06cm, 47,86cm, 36,58cm, 80,51cm, 27,53cm, 3,55cm, odnosno 79,19cm, respektivno .

Ključne reči: antropometrija, dimenzije, operatori, traktori, sedeće pozicije.

Prijavljen:	20.09.2019.
Submitted:	
Ispravljen:	10.10.2019.
Revised:	
Prihvaćen:	30.10.2019.
Accepted:	