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APPLICATION OF ANTHROPOMETRIC APPROACH IN LESSENING DISORDERS AND STRESS-RELATED ISSUES

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ABSTRACT
Local weaving is an occupation of making a local type of clothing in the South Western and some part of North-central Nigeria using local methods of weaving. This kind of clothing is called "aso-òkè". This method is an age-long one, which persist until today. However, due to the shortage of white collar jobs and there is little or no production of clothing materials by the nation's several textile companies coupled with the desire for the traditional wears as a form of social class, the number of youths involved in this vocation as a means of livelihood has increased considerably over the last few years. In consideration of previous studies, which have reported many health disorders and stress that arises from the uncomfortable sitting positions and unsuitable seats at work, anthropometric data obtained from some of the male local weavers in Ilorin, North-central Nigeria were analyzed. This study was designed to determine the ergonomic suitability of local weavers' seat and to propose ergonomically viable dimensions that will lessen disorders and pains. A standard dimension of an ergonomic chair that will help ease the disorder and stress-related injuries and illness experienced by these workers was proposed. A total of 100 male local weavers participated in this study. The data were analysed using descriptive statistics of mean, standard deviation, range and percentile. The results showed that there was a significant difference between the former seat being used and the anthropometric variables measured. The proposed dimensions from the study include Seat Height (40.3- 46.2 cm), Seat Breadth (36.5-41.8 cm) and Seat Backrest (49.6-60.2 cm). It was concluded that the seat being used by the local weavers in carrying out their daily work is not ergonomically suitable. Further studies that will include female weavers as well as weavers and other professionals from the South Western part of the country is envisaged. Apart from proposing standard dimension, this study presents several anthropometric data from North Central Nigerians, which could help production companies in the developing and developed world in designing appropriate workstations, worktables, office chairs for use in some part of the country.

Keywords: Ergonomics, anthropometric data, North Central Nigeria, Weavers, Disorder

INTRODUCTION
Ergonomics is a study which deals with the design of machines, tools and work environments that will best accommodate human performance and behaviour, thereby improving the practicality of the working environment, the efficiency and safety of the worker. It can be partly achieved from anthropometric studies due to the variability of human body dimensions across races, cultures, and geographical location. In ergonomics, anthropometry deals with the measurement of human body dimensions and certain physical characteristics [1, 2]. Anthropometric data varies considerably between regional populations [3] in which the variations must be considered when designing for a particular population [4]; thus, the need for a reliable anthropometric data from a target population that would be useful in designing products for such population.

Anthropometric data has been considered in the designs of several worktables in nearly all industrialized nations [5]. There are very limited anthropometric studies in the Nigeria [6], and this has led to the discomfort of many workers, and subsequent health disorders due to the unsuitable engineering designs for the populace. Ismaila [6] presented a limited anthropometric data, which

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includes hand, foot, and ear dimensions; the foot breadth and foot length was compared and it was reported that the former is larger in females than males and vice-versa for the latter. Studies by Ismaila *et. al.* [7] revealed a mismatch between the furniture in use by some one hundred (100) pupils and their anthropometric data, which could lead to discomfort and distraction in class. The resources involved and gathering anthropometric data is costly hence; Ismaila [8] presented a model that could help provide the popliteal height from the standing height, using about four hundred and eighty (480) students (aged 10 to 18 years) in public secondary schools in South Western Nigeria. Moreover, [9] studied the hand index classifications of some selected population of weavers in one of the cities in the North-central of Nigeria which will be of help in the design of useful hand tools. Biomechanics, which is the study of body movements and of the forces acting on the musculoskeletal system, deals with determining the dimension of several moveable parts of the body and their range of movement and it closely relates to anthropometry [10]. In Nigeria, several predicting anthropometric models have been developed by various researchers to mention but a few to include [11-14]. Comparison of the anthropometric dimensions of some selected secondary school students to the designed dimensions of their chairs and desks in order to ascertain the furniture's appropriateness was done by [11]. Some of the measurements showed agreement while major mismatches were also noted. Models were developed and with these models, three types of chairs and desks were proposed for the students that will ease health disorders and other musculoskeletal problems on the students. It was however concluded that no particular dimensions of chair and desk can be comfortably fit all students. Using Response Surface Methodology, [12] generated models from anthropometric data captured. These models found good applications in the prediction of studied anthropometric variables needed in the design and manufacture of drivers workplace and in-vehicle elements. Models to predict body dimensions that are required for the design of furniture of junior secondary school one to two students was performed by [13] whereas [14] derived models for estimating the anthropometric dimensions using standing height for the furniture design.

Weaving is the act of making materials especially clothing materials by interlacing strands or strips of the materials in repeated patterns and this involves rapid and seemingly unending simultaneous movement of the hands, legs, neck and eyes of the weaver. It also involves sitting with the back nearly perpendicular to the buttocks for long hours, this could bring great discomfort since the best shape of the vertebrae column at a sitting position should be an elongated-S shape [3]. Therefore, an unsuitable workstation could led to several ageing characteristics due to the stress-related health disorders even in the young weaving population

There are three (3) well-adopted methods of taking anthropometric data at present. These are the tailor's method, the traditional method and the 3-Dimensional surface anthropometry method. Robinette *et. al.* [15] adopted the last of the three because it is the easiest, cheapest and the most accurate method of obtaining anthropometric data however, the equipment for the measurement unlike for the traditional method is not moveable; it has to be installed at a fixed point and then volunteered participant would be brought to the equipment to be measured. At present in Nigeria, the use of 3-Dimensional method surface has not be employed because it would have been impossible to make volunteers come to a point just to be measured since they are have little knowledge of the importance of such studies to their health and productivity at work.

Many studies have been carried out in Nigeria which has assessed the design of furniture and anthropometric measures of workplace and workers in the factory. However, information on the ergonomic suitability of seating furniture for local weavers has not been looked into. This study was

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designed to help cater for the shortage of anthropometric data for the Nigerian population, to help in the ergonomic design of adjustable chairs for local weavers of various physical dimensions as well as to design environmentally safer and more user-friendly workstations. The end product of all the above is to drastically reduce the painful experience these local workers encounter in their daily means of livelihood. In addition, active and productive years will be enhanced hence increase their profit margins and increase their life span.

MATERIALS AND METHODS

Participants

This study covers one hundred (100) male local weavers that volunteered. The belief of the natives of the population sample area, forbids a man from touching a woman who is not his wife and vice-versa, could not allow us take measurements of the female weavers. The age range of the volunteers is 16–35 years old. This range of the participants for the collection of the anthropometric data comes from all the ages fitting into the 95th percentile of the weavers. The occupation is more appealing to the younger population probably because (i) it does not require much physical energy like other occupations such as automobile mechanics, panel beaters and bricklayers. (ii) it does not involve lying in the dirt or working with mild corrosives such as cements. (iii) it does not segregate the male from the female folks unlike the three other occupations mentioned above.
Local weavers who gave their informed consent participated in this study.

Measured Dimension

Twenty (20) dimensions from different body parts were taken from each of the volunteered participants in which two more enumerators were specially trained in capturing the required dimensions. These are the stature, shoulder breadth, chest depth, sitting height, sitting eye height, sitting shoulder height, popliteal height, sitting knee height, forearm hand length, sitting elbow height, thigh clearance, head length, hand length, hand depth, hip breadth, foot length, foot breadth, elbow to elbow breadth, elbow height and malleolus height with the weight, age and sex of each individual. Each dimensions measured were repeated twice and the average value derived was utilized. Table 1 presents the definition of the terminologies used for different measured part of the volunteer's body. These terminologies are the standard. All these dimensions are very important for an ergonomic chair design and good user- friendly environment.

Equipment

Traditional method of measurement was adopted which involves the use of simple moveable instruments such as a chair, a mechanical mass-measuring scale, a wooden divider, a wooden meter rule, a steel tape rule, measurement data form (to capture the individual dimension measurement), a set of writing materials, and a vernier caliper. This method was adopted because the instruments used are easily movable to the weavers' occupational territories. The combination of wooden divider and wooden meter rule was used in measuring all the twenty (20) anthropometric dimensions except for age and weight. Each of the anthropometric variables was taken twice in which an average value was recorded for each participant. This was to ensure reliability of the data derived.

Sample size and sampling Technique

The population size of the local weavers in the area was obtained from the one of the executives of the association and the sample of convenience was used to select participants. The sample size for the study was obtained from the equation (1) [16]

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$$n = {}^{N}/_{(1 + N[e]^2)} \quad (1)$$

where n is sample size to be determined, N is the population size, and e is the level of precision. The precision level used is 6% with population size of 156 local weavers which brought sample used to approximately one hundred (100) participants.

Procedure for data collection

A total of 100 participants of the local weavers were selected from the different areas under the scope of the study. The rationale and procedure for this study was explained to the participants in which they consented to the rationale and procedures. The following anthropometric data measurements were taken for each participant ensuring that their shoes were removed and light clothing worn.

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Table 1. Anthropometric terminologies used in this work, their symbol (as used) and their respective definitions

S/N	Anthropometric Dimension	Symbol	Definition
1	Stature	ST	Vertical distance of the subject in a standing position
2	Shoulder Breadth	SB	Distance between the two shoulders of the subject
3	Chest Depth	CD	Distance between the posterior chest and the dorsal
4	Sitting Height	SH	Vertical distance between a sitting surface and the subject's head
5	Sitting Eye Height	SEH	Vertical distance between a sitting surface and the subject's nasion
6	Sitting Shoulder Height	SSH	Vertical distance between a sitting surface and the subject's highest bone at the shoulder
7	Popliteal Height	PH	Vertical distance from the floor to the underside of the thigh immediately behind the knee
8	Sitting Knee Height	SKH	Vertical distance between the highest bone at the elbow and the middle finger
9	Forearm Hand Length	FHL	Horizontal distance between the highest bone at the elbow and the middle finger
10	Sitting Elbow Height	SHE	Vertical distance between the elbow and the horizontal surface of the subject.
11	Thigh Clearance	TC	Vertical distance between the seating surface and the tail bone (coccyx) of the subject
12	Head Length	HL	Distance from the glabella landmark and the posterior of the head
13	Hand Length	HNL	Length of the hand between the stylon landmark on the write and the tip of the middle finger
14	Hand Depth	HND	Length of the hand measure at distal end of the metacarpal
15	Hip Breadth	HB	Distance between both hips while sitting
16	Foot Length	FL	Distance between the tip of the longest toe and vertical line that intercepts malleolus landmark
17	Foot Breadth	FB	Distance between the biggest and the smallest toes
18	Elbow to Elbow Breadth	EEB	Distance between the elbow on the right and that on the left
19	Elbow Height	EH	Distance between the elbow and the horizontal surface
20	Malleolus Height	MH	Vertical distance between the ankle bones to the horizontal surface

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Equipment

Traditional method of measurement was adopted which involves the use of simple moveable instruments such as a chair, a mechanical mass-measuring scale, a wooden divider, a wooden meter rule, a steel tape rule, measurement data form (to capture the individual dimension measurement), a set of writing materials, and a vernier calliper. This method was adopted because the instruments used are easily movable to the weavers' occupational territories.

RESULTS AND DISCUSSION

The descriptive statistical analysis of the collected anthropometric data is presented in Table 2. The statistical parameter used are the mean, standard deviation, and the 5th, 50th, 95th percentile of each of the variables listed in Table 1 as well as the age and weight of the subjects (see Table 2). The mean age of the local weavers was found to be 25.8 years, which implies that able-bodied men are very much involved in the local weaving. The 95th percentile of the weight of the local weavers is an indication that when the ergonomic chair is designed, it should be able to accommodate such a kind of weight as close to 70 ± 5.97 kg.

Table 2. Statistical Analysis of Anthropometric Dimensions of Male Local Weavers

S/N	Anthropometric Dimension	Mean	5th Percentile	50th Percentile	95th Percentile	Standard Deviation
1	Age, A (yrs)	25.8	18.95	26	33.1	5.11
2	Weight, W (kg)	60.46	53	60	70	5.97
3	ST (cm)	168.94	160.48	170	179	6.08
4	SB (cm)	46.32	41.95	46	50.22	2.76
5	CD (cm)	20.11	19.09	20.15	21.51	0.89
6	SH (cm)	80.92	77.19	81	86.5	3.4
7	SEH (cm)	72.2	66.2	72.3	77.7	3.22
8	SSH (cm)	54.78	49.6	55	60.2	3.61
9	PH (cm)	43.61	40.29	44	46.17	2.4
10	SKH (cm)	52.13	48.19	52.1	55.54	2.62
11	FHL (cm)	48.77	44.99	49	51.61	2.29
12	SE (cm)	52.78	49	52.6	56.59	2.64
13	TC (cm)	17.82	16.88	17.9	19	0.68
14	HL (cm)	21.2	19.6	21.1	23.15	1.11
15	HNL (cm)	19.96	18.95	20	21.01	0.76
16	HND (cm)	8.03	7.5	8	8.5	0.31
17	HB (cm)	38.41	36.5	38	41.8	1.58
18	FL (cm)	27.17	25.39	27	29.32	1.35
19	FB (cm)	10.46	9.3	10.5	11.62	0.73
20	EEB (cm)	40.08	34	40.2	47.5	4.07
21	EH (cm)	106.67	98.31	108.5	114.28	6.47
22	MH (cm)	7	6.8	7	7.3	0.15

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The average height of the local weavers used for this study is 168.94cm. The 5th, 50th and 95th percentiles of the height were also recorded. Though the anthropometric data varies considerably for the weavers, it was observed that the chair they use for their work has almost the same dimensions, which implies that they are not aware of the magnitude of the disorders they can bring to their health and body. A sample of former design for the same local weavers presented in Table 3 showed that the designer did not put the anthropometric data of these workers into consideration. Furthermore, it was also observed that many of them reverted to the usage of any seat available. This made many of them to be experiencing health disorder such as backache, fatigue and so on, as reported by many of them since the design underestimated the SSH and overestimated the PH. These contrasting estimations revealed that there are mismatches and will bring about great discomfort to the weavers. Hence, they reverted to using their old chairs.

Mismatch of Local Weaver Popliteal Height with Seat Height

The seat height was too low for 55.2% of the participants, fit for 32.5% of the participants and too high for 12.5% of the participants of the study. A total of 67.5% of the participants were found to be unfit. A large percentage of the participants fell into the categories of participants that do experience disorders and stress-related issues due to the mismatch of their body and the seat. Castellucci *et. al.* [17] stated that furniture with low percentage of fit among a sample population is found to be unsuitable; hence furniture must be constructed with the application of ergonomic consideration with the aid of anthropometric data. It is observed that the seat used by the local weaver is unsuitable and this might be due to inadequate ergonomics consideration and anthropometric data that will be useful in the design of the ergonomic seat.

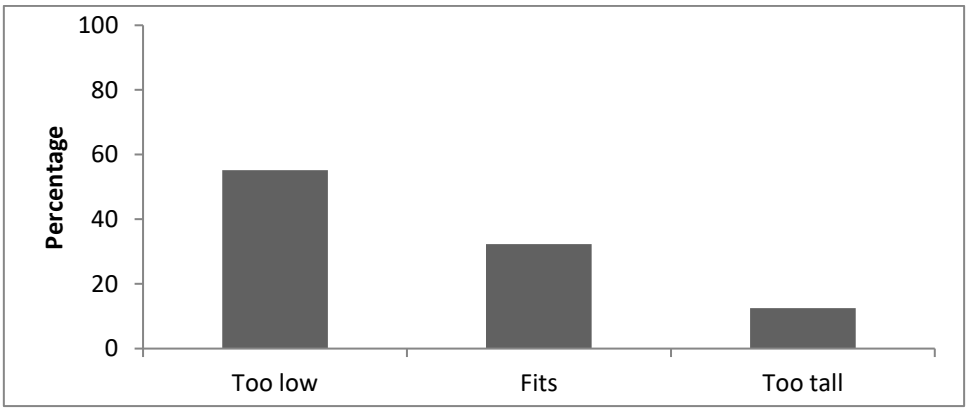

Figure 1. Percentage Popliteal - Seat Height Mismatch

Mismatch of Local Weaver Hip Breadth with Seat Width

The seat width was too shallow for 20.2% of the participants, fit for 68.4% of the participants, and 11.4% of the participants were found to be too deep. Based on the analysis, the seat was fit for most of the participants of this study. However, it should be noted that through the analysis, an ideal proposed maximum value of 42 cm was derived for the seat width that will accommodate any of the participant.

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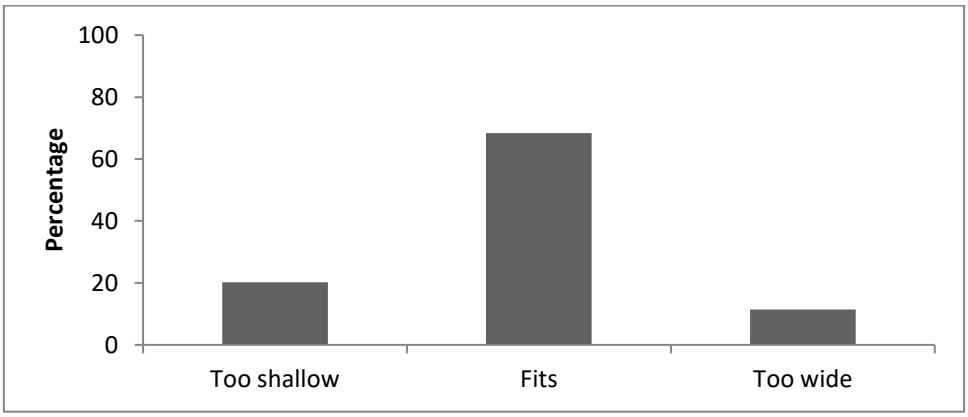

Figure 2. Percentage Hip breadth-Seat width Mismatch

Mismatch of Local Weaver Sitting Shoulder Height with Seat Backrest

The seat was too low for 47.6% of the participants but was fit for 30.7% of the participants and too tall for 21.7% of the participants. Large percentage of participants falls into the categories of unfit. This is a great mismatched and could cause disorder and stress-related issues for the participants.

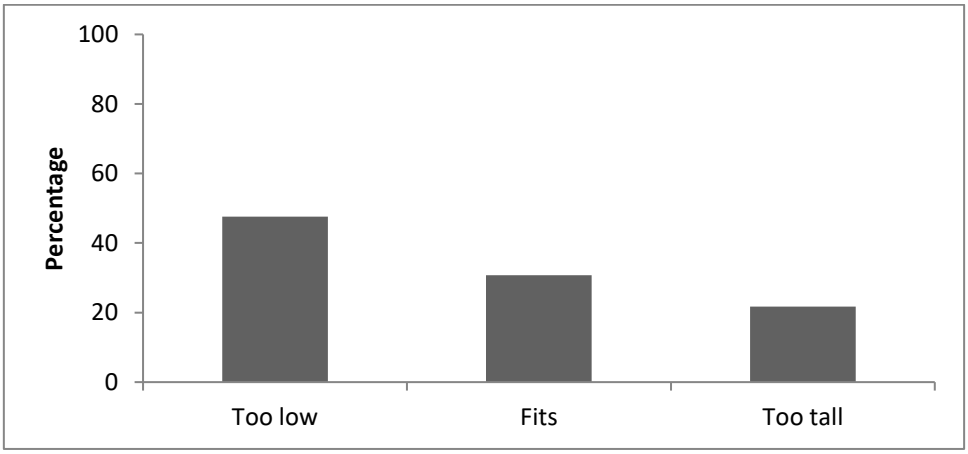

Figure 3. Percentage Sitting Shoulder height - Seat back rest Mismatch

It is important to note that at this point, these findings may pose health disorder and stress-related challenges. The implication is that the unfit participants using the seat may be faced with musculoskeletal problems such as neck pain, back pain, etc. Apart from these, efficiency at work will be reduced due to loss of concentration on the work being done due to the earlier health challenges being faced.

Table 3 shows the comparison of the dimensions of the existing ergonomic chair designed for the weavers and with the anthropometric data obtained from the measurements of these participants.

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Table 3. Comparison of the dimensions of existing ergonomic chair and the anthropometrically designed chair

Features	Dimension (Former Design) (cm)	Dimension (Anthropometric) (cm)
PH	47.6 – 56.7	43.3 – 46.2
HB	39	36.5 – 41.8
SSH	45	49.6 – 60.2

Therefore based on this study, in designing ergonomic chair for weavers in North Central Nigeria, it is suggested that the seat height be in the range 40 and 46 cm. Seats that are too high will not be comfortable for a short weaver and vice-versa. A prolong usage of such seats would pose pain to the weavers. This is the main essence for the adjustability of the seat to different convenient height of the user.

The seat breadth for the existing seat was found to be 39 cm. Based on this study; the seat breadth should be given allowance up to 42 cm to accommodate all weavers no matter the size of their hips. This allows their hipbone to rest, thus preventing dislocation or fracture of this bone.

As stated earlier, stature varies from one geographical region to another. In lieu of this, the stature of the subjects takes a vital role when designing any workstation. For example, our analysis in Table 2 included the sitting height (SH) and the sitting shoulder height (SSH) which could be considerably useful for determining the height of certain tools or equipment that could make the workplace less stressful and help them perform their tasks with minimal or no health issues.

The weaving profession, like most other professions, requires a good vision and rapid eye movement. Therefore, the sitting eye height (SEH) analysis can help determine the proper height of the local weaving stand. Although, the weaving art does not allow armrest due to the constant pendular movement of the hand, the analysis of the elbow-to-elbow breadth can be useful for other designs targeted at populations from this part of Nigeria. Likewise, other data obtained are not meant for the design of the local weavers' chair however, they could be used in designing some other tools used by the local weavers in local weaving industries; also they could be used to design a better work space for the local weavers and some other tools that may involve gripping such as shuttle. Generally, the analyses in this study can be useful in the improvement of manual materials handling, interface and furniture design, posture, workplace and workstation layout.

CONCLUSION

We have obtained very important anthropometric data from 100 male local weavers at Ilorin, a North Central city in Nigeria. Based on the results of this study, conclusion can be made that seat being used by the local weavers is ergonomically not suitable for them at their work place. This was the major cause of health disorders and related stress issues being experienced. Proposed dimensions for an ideal seat such as seat height (43.3 – 46.2 cm), seat width (36.5 – 41.8 cm) and seat backrest height (49.6 – 60.2 cm) were obtained from anthropometric data such as Popliteal height, Hip breadth and Sitting shoulder height, respectively for the local weavers. To the best of the authors' knowledge, there has been no anthropometric data for male local weavers in Ilorin hence; the anthropometric data collected would provide baseline information for the local weavers of Ilorin. This will help in designing ergonomically suitable seats hence alleviating disorders and stress-related issues.

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Finally, the work also presented some additional data that may be useful in the design of other products for local weavers and similar professions in the locality of North Central Nigeria. In an era where, local manufacturing companies are being encourage to take-up the challenge of producing for local consumption, this type of study is timely and it is recommended that it is extended to the female folks and other professions too.

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REFERENCES

[1] Bridger R S, *Introduction to Ergonomics*, McGraw- Hill, New York (1995), ISBN 9780070077416.

[2] Chou J R & Hsiao S W, An anthropometric measurement for developing the electric scooter, *International Journal of Industrial Ergonomics*, 35 (2005), 1047-1063.

[3] Openshaw S & Taylor E, *Ergonomics and Design: A reference guide*, Allsteel Handbook. (2006), 1-66. (http://www.allsteeloffice.com/ergo)

[4] Ashby P, *Ergonomics handbook 1: Human factors Design Data, Body Size and Strength. Pretoria*, (1978), Tute publication.

[5] Parcells C, Manfred S & Hubbard R, Mismatch of classroom furniture and body dimensions, Empirical findings and health implications, *Journal of Adolescent Health*, 24 (1999), 265 – 273.

[6] Ismaila S O, Anthropometric data of Hand, Foot and Ear of University students in Nigeria, *Leonardo Journal of Sciences*, 15 (2009), 15-20.

[7] Ismaila S O, Akanbi O G & Oderinu S O, Anthropometric Survey and Appraisal of Furniture for Nigerian Primary School Pupils, *E-Journal of Science & Technology*, 4 (2010) 5, 29-36.

[8] Ismaila S O, Akanbi O G & Oriolowo K T, Relationship between standing height and popliteal height, in *Proceedings of the 2012 International Conference on Industrial Engineering and Operations Management*, Istanbul, Turkey, 2008-2011, 3-6 July, 2012.

[9] Ikubanni P P & Akande K A, Hand Index classification of some selected male in Ilorin, North-Central Nigeria, *E-Journal of Science and technology*, 10 (2015) 1, 65-69.

[10] McCormick E J, *Human Factors in Engineering and Design*, Fourth Edition, (1976), 267-289.

[11] Ajayeoba A O, Oladosu K O, Adekoya L O & Olajimi A O, Ergonomics evaluation and establishment of suitable classroom furniture design specifications for secondary school children in South-West Nigeria, *Innovative Systems and Design Engineering*, 7 (2016) 3, 15-19.

[12] Onawumi A S, Adebiyi K A, Fajobi M & Oke E O, Development of predictive models for some anthropometric dimensions of Nigerian occupational bus operators, *European Journal of Science and Technology*, 5 (2016) 5, 12-27.

[13] Oladapo S O & Akanbi O G, Models for predicting body dimensions needed for furniture design of junior secondary school one to two students, *The International Journal of Engineering and Science*, 4 (2015) 4, 23-36.

[14] Ismaila S O, Akanbi O G & Ngassa C N, Models for estimating the anthropometric dimensions using standing height for furniture design, *Journal of Engineering, Design and Technology*, 12 (2014) 3, 336-347.

[15] Robinette K M, Daanen H & Paquet L, The Caesar Project: A 3-D Surface Anthropometric Survey, in *Proceedings of IEEE Second International Conference on 3-D Imaging and Modelling*, 380-386, 1999

[16] Yamane T, *Statistics: An Introductory Analysis*, 2nd ed. NY: Harper and Row, 1967.

[17] Castellucci H I, Arezes P M & Viviani C A, Mismatch between classroom furniture and anthropometric measures of Chilean Schools, *Applied Ergonomics*, 41 (2010) 4, 563-568.