Anthropometric Survey and Appraisal of Furniture for Nigerian Primary School Pupils

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Abstract

The aim of this study was to obtain some anthropometric dimensions of pupils in primary schools and examine the likelihood of mismatch between the relevant body dimensions of the pupils with the furniture they presently use in class. Random samples of 200 pupils in 4 randomly selected public primary schools were used for the study. The age range of the children was from 5 to 14 years (mean =9.8 years, SD=2.9 years). Twenty one anthropometric dimensions of the pupils and the dimensions of the furniture in the schools were measured. From the data obtained; means, standard deviations, minimum values, maximum values, 5th, 50th and 95th percentiles were computed using SPSS 16.0 statistical package. Also, Paired samples T-Test was conducted for the measurements of the male and female pupils at 0.05 level of significance using Microsoft Excel. The measured dimensions of the pupils were also compared with those of the desks and tables. The results of the study showed that all the anthropometric dimensions of the males differ significantly from those of the females with the exception of the elbow hand grip and that there exists a mismatch between the anthropometric dimensions of pupils and the furniture they are currently using.

Keywords: Anthropometry; School Furniture; Primary School; Pupils; Mismatch.

INTRODUCTION

Anthropometry is a research area in ergonomics dealing with the measurement of human body dimensions and certain physical characteristics (Bridger, 1995; Chou and Hsiao, 2005). Wang et al. (1999) considered anthropometry as the very basic core of ergonomics in an attempt to "fitting people to machines" and thus ensure compatibility of people with their work stations.

Abeysekera (1985) stressed the importance of anthropometry data when he stated that a product designed to fit 90 percent of British population was found to suit 90 percent Americans, 90 percent Germans, 84 percent Swedes, 81 percent France population, 70 percent Italians, 59 percent Egyptians, 57 percent South Africans, 43 percent Japanese, 35 percent Srilankans, 32 percent Latin Americans, 25 percent Thailand population and 13 percent Vietnamese. Thus, for effective design of workstation and products, it is essential to know the characteristics of the user (Das and Kozey, 1999). Similarly, Ashby (1978) stated that reliable anthropometric data

for a target population were necessary when designing for that population otherwise the product may not be suitable for the user.

Knight et al (1999) noted that children spend most of their school hours in the classroom and yet the effect of the design of school furniture and their behaviour and health has received comparatively little attention (probably if compared to their adults' counterpart). Prolonged sitting by students for educational purposes may result in headache, neck pain and back pain (Molenbroek et al, 2003) particularly if there is a mismatch between the students and school furniture. In fact, Lin and Kang (2000) as well as Parcells et al (1999) established that mismatch between school furniture and body size is a causative factor for low back pain or musculo-skeletal disorders among school students. Also, Mandal (1991) and Troussier et al (1999) stated that students may experience neck, shoulder and back pain problems due to school tables and chairs. Similarly, inappropriate posture over a long period can result in back pain as school furniture compel students to poor sitting postures (Koskelo, 2003).

In Nigeria, studies on anthropometric data are few. Igboanugo et al (2002) reported the anthropometric data of Nigerian adult working class to serve as a data base for designers of domestic and industrial population. Ayodeji et al (2008) also gathered anthropometric data of Nigerian paraplegics. Similarly, Ismaila (2008) obtained the anthropometric data of the foot of Nigerian University students. Thus there seems to be no reported (to the authors' knowledge) anthropometric data of the primary school pupils in Nigeria to serve as data base for the design of products to be used by this category of Nigerians. Moreover, Ismaila (2009) obtained the anthropometric data of hand, foot and ear of University Students in Nigeria.

The current study is not only to obtain anthropometric data that could aid in the design of school furniture for primary school pupils but to also compare the data with that of the school furniture presently in use by these pupils. Three main methods of obtaining anthropometric dimensions that have been reported are tailor's method, traditional anthropometry and very recently 3-D surface anthropometry.

Robinette et al (1999) used 3-D surface anthropometry and the method was said to provide data that allowed for effective design of better fitting clothes, protective equipment, better seats and workstations design. However, 3-D surface anthropometry methodology is presently not available in Nigeria necessitating the use of traditional anthropometry.

MATERIALS AND METHODS

The sample for the study comprised 200 children without any physical disability that were randomly selected from a population of 2180 pupils in four public primary schools that were also randomly selected within Ibadan Municipality. Roscoe (1975) had stated that a sample size between 30 and 500 is adequate for most research. The age of range of the children was from 5 to 14 years (mean =9.8 years, SD=2.9 years). One hundred (100) of the pupils were males and the same numbers were females.

Twenty one anthropometric dimensions as defined in Table 1 were measured with the use of Vernier Calliper, Standiometer and measuring tape. The dimensions of the school furniture in use in these randomly selected schools were also measured as defined in Table 2. The measurements were taken thrice to ensure their correctness and no changes were noticed in the dimensions. The data obtained from the recorded measurements on prepared forms were combined into a file from which statistics (means, standard deviations, minimum values, maximum values, 5^{th}, 50^{th} and 95^{th}

percentiles) were computed with the use of SPSS 16.0 statistical package. Paired Samples T-Test was conducted for the measurements of the male and female pupils at 0.05 level of significance using Microsoft Excel Package. The measured dimensions of the pupils were also compared with those of the desks and tables.

Table 1: Definitions of Anthropometric Dimensions Measured

Anthropometric dimension	**Symbol**	**Definition**
1. Standing Height (Stature)	STH	Vertical distance from floor to crown of head
2. Eye Height (Standing)	EHS	Vertical distance from floor to the middle of the eye.
] 3. Eye Height (Sitting)	SHE	Vertical distance from the sitting surface to the middle of the eye.
4. Functional Arm Reach	FAR	Horizontal distance from the shoulder to the tip of the longest finger.
5. Overhead Reach	OR	Vertical distance from the floor to the tip of the longest finger while standing and the arm raised up with elbow and wrist straight.
6. Sitting Height	SH	Vertical distance from the sitting surface to crown of the head.
7. Buttock- Popliteal Length (Sitting)	BPL	Horizontal distance from the back of the uncompressed buttocks to the popliteal angle, at the back of the knee, where the back of the lower legs meets the underside of the thigh.
8. Shoulder Height (Sitting)	SDH	Vertical distance from the floor to the bony tip of the shoulder.
9. Buttock-Knee Length (Sitting)	BKL	Horizontal distance from the most posterior point on the buttocks to the most anterior point on the knee.
10. Popliteal Height (Sitting)	POH	Vertical distance from the floor to the underside of the thigh immediately behind the knee.
11. Knee Height (Sitting)	KH	Vertical distance from the floor to the uppermost point on the knee.
12. Thigh Clearance Height (Sitting)	TC	Vertical distance from the sitting surface to the top of the thigh at its intersection with the abdomen.
13. Waist Depth	WD	Horizontal distance between the back and abdomen at the level of the greatest lateral indentation of the waist.
14. Elbow Rest Height (Sitting)	ERH	Vertical distance from the sitting surface to the bottom of the right elbow.
15. Hip Breadth (Sitting)	HPB	Maximum horizontal distance across the hips in the sitting position.
16. Head Breadth	HB	Maximum horizontal breadth of the head above the ears.
17. Head Length	HL	Horizontal distance between the most anterior point on the forehead and the most posterior point at the back of the head.
18. Head Length (Maximum)	HLM	Distance between the most anterior point of the nose and the most posterior point at the back of the head in the middle line.
19. Hand Length	HDL	Distance from the wrist crease to the longest finger of the right hand.
20. Hand Breadth at Metacarpal	HBM	Maximum breadth across the hand where the fingers join the palm.
21. Elbow- Hand Grip	EHG	Horizontal distance from the elbow to the middle of the hand.

Table 2: Dimensions of the Existing School Furniture

1. Chair Height	Vertical distance from the floor to the topmost part of the Chair.
2. Seat Height	Vertical distance from the floor to the highest point on the front of seat.
3. Seat Depth	Horizontal distance of the sitting surface from the back of the seat to the front of the seat.
4. Desk Height	Vertical distance from the floor to the top of the front edge of the desk.
5. Desk Depth	Horizontal distance from the front of the desk to the back at the top of the front edge of the shelf under the writing surface.
6. Seat Breadth	Horizontal distance from left hand side of the seat and the right hand side or vice versa.

RESULTS

The anthropometric data for the female and male pupils are presented in Table 3 and Table 4 respectively. Also, the results of the statistical comparison of the female and male data are presented in Table 5 while Table 6 shows the dimensions of the furniture presently in use in the schools where the anthropometric data of the pupils were obtained.

Table 3: Statistical Analysis of Anthropometric Dimensions for Female Pupils

Dimensions	Minimum	Maximum	Mean	Standard Deviation	5^{th} Percentile	50^{th} Percentile	95^{th} Percentile
AGE (Years)	5	14	9.8	2.9	5	9.5	14
STH (cm)	100.0	161	126.6	12.6	102.0	125.0	147.3
EHS (cm)	90.0	148	113.5	11.2	95.0	112.0	133.2
FAR (cm)	38.0	61	46.3	4.7	40.0	46.0	54.0
OR (cm)	130.0	193.0	157.5	13.1	134.0	159.5	179.0
SH (cm)	54.0	83.0	67.4	7.4	57.0	66.5	78.0
SHE (cm)	42.0	70.0	56.1	7.2	44.9	56.0	66.0
BPL (cm)	27.0	43.0	33.5	3.5	28.0	33.0	39.1
SDH (cm)	26.0	54.0	38.9	5.1	30.0	39.0	47.0
BKL (cm)	34.0	56.0	42.5	5.1	35.0	42.0	51.2
POH (cm)	26.0	44.0	33.7	3.9	27.0	34.0	40.1
KH (cm)	33.0	53.0	41.0	4.6	35.0	40.0	50.0
TC (cm)	10.0	15.0	11.8	1.4	10.0	12.0	14.0
WD (cm)	12.9	17.4	15.2	1.2	13.3	15.3	17.0
ERH (cm)	12.0	20.0	15.0	1.8	13.0	15.0	18.1
HPB (cm)	20.0	34.0	24.5	2.8	20.0	24.0	29.0
HB (cm)	13.1	16.0	14.2	0.5	13.4	14.2	15.0
HL (cm)	16.3	19.8	17.9	0.6	17.1	17.7	18.8
HLM (cm)	16.4	21.5	18.3	1.1	16.6	18.2	19.8
HDL (cm)	11.9	17.1	14.0	1.3	12.0	14.2	16.5
HBM (cm)	5.6	7.7	6.8	0.4	6.1	6.8	7.5
EHG (cm)	32.0	39.0	35.5	1.5	33.0	36.0	38.0

Table 4: Statistical Analysis of Anthropometric Dimensions of Male Pupils

Dimensions	Minimum	Maximum	Mean	Standard Deviation	5th Percentile	50th Percentile	95th Percentile
AGE (Years)	5	14	9.5	2.9	5	9.5	14
STH (cm)	104.0	164	130.5	14.4	109.9	127.0	157.1
EHS (cm)	90.0	153.0	117.1	13.5	100.6	114.5	143.0
FAR (cm)	36.0	61	46.9	5.6	37.0	47.0	55.0
OR (cm)	127.0	210.0	160.8	15.8	136.0	159.0	187.2
SH (cm)	54.0	83.0	68.0	7.9	56.0	67.0	80.0
SHE (cm)	45.0	70.0	57.0	7.1	47.0	54.5	69.0
BPL (cm)	26.0	44.0	33.5	3.5	27.0	34.0	42.1
SDH (cm)	29.0	55.0	39.9	5.1	30.0	40.0	48.0
BKL (cm)	32.0	55.0	43.3	5.7	35.0	43.0	54.0
POH (cm)	26.0	43.0	34.1	4.2	28.0	33.0	40.1
KH (cm)	30.0	54.0	42.3	5.6	33.0	42.0	51.1
TC (cm)	8.0	16.0	12.2	1.7	10.0	13.0	15.0
WD (cm)	12.9	18.2	15.2	1.6	12.9	15.3	17.6
ERH (cm)	12.0	20.0	15.4	1.8	13.0	15.0	18.0
HPB (cm)	18.0	32.0	24.6	2.9	20.0	24.0	29.0
HB (cm)	13.2	17.8	14.4	0.8	13.2	14.3	16.1
HL (cm)	15.9	19.6	18.0	0.7	16.5	18.1	19.1
HLM (cm)	15.4	21.5	18.5	1.2	16.3	18.6	20.2
HDL (cm)	11.5	18.0	14.2	1.3	12.2	14.0	16.3
HBM (cm)	5.8	8.2	6.9	0.6	6.0	6.8	7.8
EHG (cm)	33.0	34.0	36.1	1.8	34.0	36.0	39.1

Table 5: Results of Paired Samples T-Test for Male and Female Pupils

Dimensions	N	T	Df	Sig. (2-tailed)	Std Error
STH (cm)	100	1.587	99	0.116	109.9
EHS (cm)	100	-1.636	99	0.105	100.6
FAR (cm)	100	0.741	99	0.460	37.0
OR (cm)	100	-1.281	99	0.203	136.0
SH (cm)	100	0.404	99	0.687	56.0
SHE (cm)	100	0.664	99	0.509	47.0
BPL (cm)	100	-1.391	99	0.167	27.0
SDH (cm)	100	1.265	99	0.209	30.0
BKL (cm)	100	0.882	99	0.413	35.0
POH (cm)	100	-0.552	99	0.584	28.0
KH (cm)	100	-1.373	99	0.173	33.0
TC (cm)	100	-1.785	99	0.077	10.0
WD (cm)	100	-0.124	99	0.902	12.9
ERH (cm)	100	1.402	99	0.164	13.0
HPB (cm)	100	0.233	99	0.816	20.0
HB (cm)	100	-1.707	99	0.091	13.2
HL (cm)	100	-1.010	99	0.315	16.5
HLM (cm)	100	-1.643	99	1.2	16.3
HDL (cm)	100	0.274	99	0.785	0.2
HBM (cm)	100	0.697	99	0.487	0.08
EHG (cm)	100	-2.141	99	0.035	0.28

Table 6: Dimensions of Existing Furniture (cm)

Desk Height	62
Desk Depth	28
Drawer Depth	20
Floor to Desk Height	42
Chair Height	72
Seat Height	35
Seat Breadth	90
Seat Depth	31
Upper Back Rest	38
Lower Back Rest	26

DISCUSSION

A comparison of the anthropometric dimensions of the female and male pupils show that the arithmetic means of the males were most of the times higher than those of the females.
The results of the T-Test showed that all the anthropometric dimensions of the males differ significantly from those of the females except the elbow hand grip. This is clearly shown in Table 5.
Parcells et al (1999) and Panagiotopoulou et al (2004) stated that a mismatch occur when the seat height is greater than 95 percent and less than 88 percent of the popliteal height. Thus, the seat height of the pupils should be between 35.3cm and 38.1 cm for a perfect match. The chair in use has a seat height of 35cm which suggests that the seat is a bit low than the recommended dimension.
Based on the current study the seat breadth should lie between 23.2cm and 27.8cm but the seat breadth of the chair in use is 90cm.Actually the present design was to accommodate three pupils at a time. For the seat depth which should be between 29.5 cm and 31.8cm, the actual seat depth is 31cm which may not totally accommodate the pupil. Too shallow a seat may cause the user to have sensation of falling off and may result in lack of support of the lower thighs (Panero and Zeinik, 1979). The desk clearance which should be between 50cm and 51.1cm was measured to be 62cm. This makes the desk too high for the pupils. The desk depth was measured to be 28cm instead of it to lie between 30.4cm and 37.1cm. This suggests that the desk is too shallow. Moreover, the drawer depth which should be between 15.2cm and 18.6cm was measured to be 20cm. Though the chairs currently in use were not provided with armrest, the arm rest should be between 14.4cm and 17.2cm based on the current study.

CONCLUSIONS

The results of this study show that the anthropometric data of pupils in primary schools were probably not used when designing the furniture currently in use. While some of the dimensions were low, others were high for the primary school pupils. It is important that if products are to be designed, they should be based on the anthropometric dimensions of the user population to reduce negative effects on the muscle due to poor sitting postures and also reduce neck, shoulder and back pain that may result. The study also provides some additional anthropometric data that may be

useful in the design of other products for pupils in primary schools.

REFERENCES

1. Abeysekera J. D. A. (1985). "A Comparative Study of Body Size Variability Between People in Industrialized Country and Industrially Developing Countries, its Impact on the Use of Imported Goods". *Proceedings of International Symposium on Ergonomics in Developing Countries*, Jakarta, Indonesia
2. Ashby P. (1978). "Ergonomics Handbook 1: Body Size and Strength". Tute Publication
3. Ayodeji S. P., Adejuyigbe S., B. and Abiola-Ogedengbe A., K. (2008). "Anthropometry Survey of Nigeria Paraplegics". *Journal of Science and Technology* 28 (3): 71-81.
4. Bridger R., S. (1995). "Introduction to Ergonomics". Mc Graw-Hill, New York.
5. Chou J., R. and Hsiao S, .W. (2005). "An anthropometric measurement for developing an electric scooter". *International Journal of Industrial Ergonomics* 35: 1047-1063.
6. Das B. and Kozey J., W. (1999). "Structural anthropometric measurements for wheelchair for mobile adults". *Applied Ergonomics* 30: 385-390.
7. Igboanugo A. C., Egharevba F. and Ibhadode A.O.,.A. (2002). "Anthropometric Survey of Nigeria Adult Working Class". *Nigerian Journal of Engineering Management* 3: 7-21.
8. Ismaila S., O. (2008). "Anthropometric data of the foot of Nigerian University Students". *Ergonomics SA* 20 (2): 45-50.
9. Ismaila S., O. (2009). "Anthropometric data of hand, foot and ear of University Students in Nigeria". *Leonardo Journal of Sciences* 15: 15-20.
10. Knight G. and Noyes J. (1999). "Children's behaviour and the design of school furniture". *Ergonomics* 42(5): 747-760.
11. Koskelo R. and Harninen O. (2003). "Adjustable tables and chairs correct posture and lower muscle tension and pain in high school students". Department of Physiology, University of Kuopio, Finland.
12. Lin, R, Kang, YY, (2000). "Ergonomics design for senior high school furniture in Taiwan". *Proceedings of the International Ergonomics Association/Human Factors Society Congress*, San Diego, USA.
13. Mandal A., L. (1991). "Investigation of the lumbar flexion of the seated man" *International Journal of Industrial Ergonomics* 8: 75-87.
14. Molenbroek J.F., Kroon-Ramaekers N. and Snidjers C., J. (2003). "Revision of the design of a standard for the dimensions of school furniture". *Ergonomics* 46 (7): 681-694.
15. Panagiotopoulou G., Christoulas K., Papanckolaou A. and Mandroukas K. (2004). "Classroom furniture dimensions and anthropometric measures in primary school" *Applied Ergonomics* 35:121-128.
15. Panero J. and Zeinik M. (1979). "Human Dimension and Interior Space". New York: Watson-Guptill.
16. Parcells C., Stommel M. and Hubbard R., P. (1999)." Mismatch of classroom furniture and student body dimensions". *Journal of Adolescent Health* 24: 265-273.

17. Robinette K.M., Daanen H. and Paquet L. (1999).” The Caeser Project: A 3-D Surface Anthropometry Survey”. *Proceedings of IEEE Second International Conference on 3-D Imaging and Modelling*. :380-386.
18. Roscoe J.T. (1975). “Fundamental Research Statistics for the Behavioral Sciences”. 2nd Edition. New York: Holt, Rinehart and Winston.
19. Troussier B., Tesniere C., Fauconnier J., Grison J., Juvin R. and Phelip X. (1999). “Comparative study of two different kinds of school furniture among children” *Ergonomics* 42(3):516-526.
20. Wang E.M.Y., Wang M.J., Yeh W.Y., Shih Y.C. and Lin Y., C. (1999). “Development of anthropometric work environment for Taiwanese workers”. *International Journal of Industrial Ergonomics* 23: 3-8.