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ERGO-ANALYSIS OF SCHOOL FURNITURE IN USE BY SECONDARY SCHOOL STUDENTS IN SOUTH WESTERN NIGERIA

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ABSTRACT

The anthropometric data of the students in secondary schools was obtained and possible mismatch between the relevant dimensions of students and the classroom furniture they use were examined.
A total of 480 students in Junior Secondary 1 through Senior Secondary 3 in sixteen (Eight Public and Eight Private) Secondary Schools participated in the study with ages ranging from 10 years to 18 years. Fourteen anthropometric measurements and the dimensions of four types of chairs and four types of desks prevalent in the students' classrooms were measured. The means, standard deviations, fifth, fiftieth and ninety fifth percentiles were calculated. The anthropometric dimensions of the students in the public schools were statistically compared with those in the private schools with use of SPSS 16.0 Statistical Package. Moreover, the student body dimensions and furniture dimensions were compared. The results show that that all the measured dimensions of the students in the public schools (Popliteal Height: 39.5 cm, Sitting Height: 77.3 cm, Knee Height: 53.0 cm, Elbow Height Sitting: 16.0 cm, Buttock-Popliteal Length: 43.8 cm; using the 50th percentiles) and private schools (Popliteal Height: 40.2 cm, Sitting Height: 80.3 cm, Knee Height: 53.3 cm, Elbow Height Sitting: 16.5 cm, Buttock -Popliteal Length: 44.0 cm; using the 50th percentiles) were not significantly different ($p = 0.00$) except Buttock-Popliteal Length ($p = 0.08$) and Hip Breadth ($p = 0.12$). Moreover, a degree of mismatch between the students' bodily dimensions and the classroom furniture available to them was established.
It was concluded that the anthropometric data of the .Nigerian Students were not employed in the manufacture of the school furniture and may be an indication that school furniture and students anthropometric dimensions are at variant nationwide.

Keywords: Anthropometry, Ergonomics, Furniture

INTRODUCTION

Students are required to sit for long periods of time during school hours (Knight and Noyes, 1999) and in poor sitting postures due to school chairs and tables (Troussier *et al*., 1999). Musculoskeletal discomfort and low back pain among school students have been traced to the mismatch between the school furniture and the anthropometric dimensions of the students (Parcells *et al*., 1999; Lin and Kang 2000).

Similarly, Molenbroek *et al*. (2003) noted that prolonged sitting by students for educational purposes may result in headache, neck pain and back pain particularly if there is a mismatch between the students and school furniture. 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. Moreover, inappropriate posture over a long period can result in back pain as school furniture compel students to poor sitting postures (Koskelo *et al*., 2007).

Bridger (1995) as well as Jeong and Park (1990) noted that physical dimensions of furniture, equipment, clothing and workspaces are specified using anthropometric data for proper ergonomics design. This may have an improvement in the health and comfort of the user of the products (Barroso *et al*., 2005). If poorly designed furniture, especially school desks and tables, that fails to take into account the anthropometric characteristics of its users are used, they may have a negative influence on human health (Tunay and Melemez, 2008).

Thus, to reduce the incidence of musculoskeletal discomfort and low back pain among school children, school furniture should be designed by taking into consideration the anthropometric dimensions of the user population.

There are very few reported anthropometric data for the Nigerian population. The reported anthropometric data includes the work of Okunribido (2000) which surveyed the hand anthropometry of female rural workers. Oguntona and Kuku (2000) similarly reported some anthropometric data (height, weight, upper arm, hip and waist circumferences) of the elderly in South Western Nigeria. Also, 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. Similarly, Ayodeji *et al*. (2008) also gathered anthropometric data of Nigerian paraplegics. Moreover, Ismaila (2008) obtained the anthropometric data of the foot of Nigerian University students. Also, Ismaila *et al*. (2010) noted that there exists a mismatch between the anthropometric dimensions of primary school pupils and the furniture they use. For proper ergonomic design of secondary school furniture, anthropometric data for Nigerian secondary school students are necessary and seems not reported.

Three main methods of obtaining anthropometric dimensions have been reported namely 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, apart from the fact that 3-D surface anthropometry methodology is presently not available in Nigeria, it is not flexible and very costly (Deros *et al*. 2009) necessitating the use of traditional anthropometry. Therefore, the objective of this work is to gather anthropometric data necessary for the design of secondary school furniture as well as compare the data with that of the school furniture presently in use by these students.

MATERIALS AND METHODS

A total of 480 students were randomly selected from eight public secondary schools and eight private secondary schools that were also randomly selected from the secondary schools in Ibadan, South Western Nigeria. Their ages range from 10 to 18 years (n=480, SD=2.3 years) for all the schools under study. The anthropometric data were collected on the basis of age rather than levels in schools and gender since the schools were co-educational. In the study, only Nigerians in the schools were considered irrespective of tribes. Fourteen measurements as defined in Table 1 that were considered relevant were taken from the students. The stature was measured to the nearest 0.1 cm with the use of a standiometer (model-Health Scale ZT-160, Micro field, England) while the students were standing erect, barefooted, heels, feet flat and pointed outward while other dimensions were measured with the use of Vernier Calliper, T-square and flexible tape rule. Thirty samples from each age group from 10 to 18 years in both public and private schools were considered.

Random samples of the existing school furniture were taken and measured as defined in Table 2.The data generated were analyzed using descriptive statistics such as means, standard deviations, minimum values, maximum values. The fifth, fifty and ninety-five percentiles of the data were determined using Excel Microsoft Package.

The data obtained from the public school students were compared with those of the private school using Paired Samples T-test (2-tailed) on SPSS 16.0 Statistical Package.

Table 1: Definitions of anthropometric dimensions measured

Anthropometric dimension	Symbol	Definition
1. Standing height (Stature)	STH	Vertical distance from floor to vertex of head with hair pressed down.
2. Popliteal height (Sitting)	PH	Vertical distance from the floor to the underside of the thigh immediately behind the knee with the subject sitting.
3. Sitting height	SH	Vertical distance from the sitting surface to vertex of the head with hair pressed down.
4. Knee height (Sitting)	KH	Vertical distance from the floor to the uppermost point on the knee.
5. Elbow-elbow breadth	EEB	Horizontal distance between outer side of the elbows with subject sitting erect and arm at the sides at right angle to the trunk.
6. Shoulder height seated	SHS	Distance from the seat to the top of the shoulder with the subject sitting erect.
7. Elbow height sitting	ESH	Vertical height from the seat to the underside of the elbow with the subject sitting.
8. Buttock-knee length (Sitting)	BKL	Horizontal distance from the most posterior point on the buttocks to the most anterior point on the knee.
9. Buttock-popliteal length	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.
10. Functional arm reach	FAR	Horizontal distance from the shoulder to longest finger with subject sitting erect.
11. Thigh clearance height (Sitting)	TCH	Vertical distance from the sitting surface to the top of the thigh at its intersection with the abdomen.
12. Elbow-hand length	EHL	Horizontal distance from the elbow to the longest finger of the hand.
13. Hip breadth (Sitting)	HB	Maximum horizontal distance across the hips in the sitting position.
14. Biacromial breadth	BB	Horizontal distance across the middle deltoid between the outer aspects of the shoulder.

Table 2: Definitions of the dimensions of the furniture measured

Dimensions	Definition
1. Upper back rest height	Vertical distance from the floor to the topmost part of the backrest 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. Seat width	Horizontal distance from left hand side of the seat and the right hand side or vice versa.
5. Desk height	Vertical distance from the floor to the top of the front edge of the desk.
7. Desk width	Horizontal distance from left hand side of the desk and the right hand side or vice versa.

RESULTS AND DISCUSSION

The summary of the anthropometric dimensions in terms of means, standard deviations, fifth, fiftieth, and ninety fifth percentiles are presented in Table 3 for the students in public and private schools. The combined data with no consideration for the type of school is presented in Table 4. The data for the public school students were statistically compared with those of the private schools and the results presented in Table 5 which shows that all the measured dimensions were not significantly different except Buttock-Popliteal Length and Hip Breadth.

The classroom furniture under study consisted of four variants of chairs and tables. The dimensions of the chairs and desks are given in Table 6.

Table 3: Anthropometric data of Public and Private Secondary Students in cm

	Minimum		Maximum		5th Percentile		50th Percentile		95th Percentile		Standard Deviation		Mean	
	Pu	Pr	Pu	Pr	Pu	Pr	Pu	Pr	Pu	Pr	Pu	Pr	Pu	Pr
Age (Years)	11	10	18	17	11	10	14.5	13.5	18	17	2.3	2.3	14.5	13.5
Stature	115.2	129.3	195.1	195.1	122.7	139.8	151	159.7	175.1	176.3	15.7	11.5	151.8	158.3
PH	27.8	30.6	48.4	44.8	28.6	38.0	39.5	40.2	41.7	42.1	3.8	1.8	38.0	40.0
SH	70	73.4	85	87.1	72.8	75.0	77.3	80.3	83.7	85.0	3.5	3.5	77.5	80.1
KH	37.3	41.6	61.0	59.5	40.0	49.3	53.0	53.3	56.5	55.9	5.1	2.4	51.3	53.0
EEB	24.1	28.7	90.1	90.1	26.1	29.3	39.1	36.8	50.1	43.2	8.1	6.1	38.1	36.1
SHS	25.8	35.0	55.1	56.5	30.1	43.3	44.1	47.9	54.3	55.0	7.1	4.0	43.5	48.4
ESH	12.8	13.5	25.3	18.7	13.5	15.0	16.0	16.5	18.0	17.9	1.4	0.9	15.9	16.6
BKL	33.9	43.2	62.8	61.9	35.9	46.8	48.0	54.6	59.8	58.0	6.8	3.4	48.7	53.4
BPL	33.2	36.0	60.3	50.1	35.1	36.9	43.8	44.0	56.1	47.3	6.5	3.0	43.8	43.2
FAR	39.8	42.1	63.4	61.0	43.3	49.6	52.8	54.8	59.0	58.8	4.6	3.2	52.2	54.3
TCH	8.9	10.0	18.0	18.0	9.9	11.3	13.0	13.7	16.3	16.1	2.0	1.4	13.0	13.7
EHL	26.4	21.2	42.0	40.1	28.2	30.7	32.1	34.0	40.0	38.6	3.2	3.0	32.7	34.4
HB	18.7	18.7	44.3	39.8	21.0	23.2	26.7	26.7	39.8	34.5	5.6	3.7	28.2	27.6
BB	26.2	29.7	46.7	49.2	27.3	30.7	38.1	38.1	44.7	44.8	5.9	5.2	36.6	37.2

Legend
Pu-Public School Students
Pr-Private School Students

Table 4: Anthropometric Data for all Students in cm

	Minimum	Maximum	5th Percentile	50th Percentile	95th Percentile	Standard Deviation	Mean
Age (Years)	10	18	10	14	18	2.3	14
Stature	115.2	195.1	130.1	158.0	175.3	14.1	155.0
PH	27.8	48.4	30.2	39.8	41.9	3.2	39.1
SH	70.0	87.1	73.2	79.1	84.3	3.7	78.8
KH	37.3	61.0	41.7	53.2	56.5	4.1	52.2
EEB	24.1	90.1	28.0	38.1	48.6	7.3	37.1
SHS	25.8	56.5	31.0	47.0	54.8	6.2	46.0
ESH	12.8	25.3	13.8	16.3	18.0	1.3	16.2
BKL	33.9	62.8	42.2	53.7	58.1	5.9	51.0
BPL	33.2	60.3	36.1	44.0	54.3	5.1	43.5
FAR	39.8	63.4	44.5	53.8	59.0	4.1	53.3
TCH	8.9	18.0	10.1	13.5	16.3	1.8	13.4
EHL	21.2	42.0	29.0	32.7	39.6	3.2	33.6
HB	18.7	44.3	22.1	26.7	37.0	4.7	27.9
BB	26.2	49.2	28.8	38.1	44.8	5.6	36.9

Table 5: Comparison between Anthropometric Data of Students in Public and Private Secondary Students

	Mean	Standard Deviation	Standard Error Mean	T	Df	Sig. (2-tailed)
Stature	-6.55	14.26	0.92	-7.11	239	0.00
PH	-2.03	3.82	0.25	-8.22	239	0.00
SH	-2.63	3.70	0.24	-11.04	239	0.00
KH	-1.73	4.88	0.31	-5.50	239	0.00
EEB	2.01	5.26	0.34	5.91	239	0.00
SHS	-4.84	6.80	0.43	-11.03	239	0.00
ESH	-0.66	1.41	0.09	-7.28	239	0.00
BKL	-4.73	7.04	0.45	-10.40	239	0.00
BPL	0.68	5.94	0.38	1.79	239	0.08
FAR	-2.13	4.22	0.27	-7.83	239	0.00
TCH	-0.63	1.83	0.12	-5.36	239	0.00
EHL	-1.70	3.03	0.20	-8.72	239	0.00
HB	0.58	5.81	0.38	1.55	239	0.12
BB	-0.57	4.39	0.26	-2.02	239	0.04

Table 6: Dimensions of existing furniture

	Seat Height	Seat Depth	Seat Width	Back Rest Height	Desk Height	Desk Depth	Desk Width
Type 1	42	30	91	31	72	28	91
Type 2	46	32	91	31	71	30	91
Type 3	40	37	120	31	76	44	120
Type 4	41	37	120	23	76	39	120

Relationship between popliteal height and seat height

A mismatch in the popliteal height and seat height was defined as suggested by Parcells *et al*. (1999) as a chair whose seat height is >95% or <88% of popliteal height. based on this, the seat height of chairs in the Public Schools should lie between 33 and 36cm (using the mean value) while that of the Private Schools should be between 35 and 38cm (using the mean value). From Table 6, it is evident that none of the chairs has a seat height between the ranges as the lowest is 40cm while the highest is 46cm which shows that the seats were too high for the students.

Relationship between Buttock-Popliteal Length and Seat Depth

Similarly, Parcells *et al*. (1999) stated a mismatch exists between Buttock-Popliteal Length and seat depth when the seat depth is >95% or <80% of the buttock popliteal length. The seat depth for chairs in Public Schools should be between 35cm and 42cm (using the mean value of 43.8cm) while that of the Private Schools should be between 34.6 and 41cm (using a mean value of 43.2cm). The seat depths of the current furniture lie between 30 and 37cm which show that the seat is too shallow for the students.

Relationship between hip breadth and seat width

Molenbroek *et al*. (2003) recommended that the seat width should be equivalent to 99 percentile value plus 15%. This gives a seat width of 51cm (using the maximum value of 44.3cm) for chairs in Public Schools and 46cm (using the maximum value of 39.8cm) for chairs in Private Schools. From Table 6, the seat width range between 91cm and 120cm indicating that the seat is too wide for the students.

Relationship between knee height and desk clearance

Mandal (1981) recommended that desk-knee clearance should be more than 2 cm. A mismatch then occurs when a desk is <2 cm higher than the knee height. From the study, the Knee Height of students in Public Schools is 51.3cm while that of the students in Private schools is 53cm. Thus, the lowest part of the desk should have a height of at least 53.3cm for desks in Public Schools and 55cm for those in Private Schools.

Relationship between elbow height and desk height

Chaffin *et al*. (1999) noted that the table height should depend on the elbow height of the user and he recommended that the height of the desk should be between 3 and

4 cm above the elbow height. The maximum desk height acceptable for an individual student was determined by that student's shoulder height and elbow height. Thus, the maximum desk height for students in Public schools should be 63cm and 69cm for desks in Private schools. The desk height of the current furniture ranges between 71 and 76cm which make them too high for the students.

The data in the study indicate that the seats are too high for the students which makes the underside of the thigh to become compressed causing discomfort and restriction in blood circulation and in order to compensate for this, a sitting person moves forward his buttocks on the seat making the body stability to be weakened (Zacharkow, 1988) and may result in low-back pain if the posture is prolonged (Chaffin and Anderson, 1991).

Also, the seats are too shallow which may cause the user not only to have the sensation of falling off the front of the chair but may also result in a lack of support of the lower thighs (Panero and Zeinik, 1979).

Moreover, the desks are too high for the users and may cause abduction of the arms, elevation of the shoulder and kyphosis of the neck causing fatigue in the shoulder and neck muscles (Chaffin and Anderson, 1991). The anthropometric characteristics of the users are essential for the accomplishment o various tasks safely and economically. If mismatches exist between the human anthropometric data and equipments, tools and furniture, it may result in 'decreased productivity, discomfort, accidents, biomechanical stresses, fatigue, injuries, and cumulative traumas' (Mandahawi *et al*., 2008). It may therefore not be a surprise if a higher percentage of the students complain neck and low back pain.

It thus means that the anthropometric data of the Nigerian students were not used in the design and manufacture of school furniture presently in use in these schools.

In order to ensure proper match between the school furniture and the anthropometric data of the students, it may be essential to use their data for the construction of the school furniture.

CONCLUSION

The current study shows the seat height of chairs in the Public Schools should lie between 33 and 36cm (using the mean value) while that of the Private Schools should be between 35 and 38cm (using the mean value). However, none of the chairs has a seat height between the ranges as the lowest is 40cm while the highest is 46cm which shows that the seats were too high for the students. Similarly, the seat depth for chairs in Public Schools should be between 35cm and 42cm (using the mean value of 43.8cm) while that of the Private Schools should be between 34.6 and 41cm (using a mean value of 43.2cm). The seat depths of the current furniture lie between 30 and 37cm which show that the seat is too shallow for the students. Also, the seat width should be 51cm (using the maximum value of 44.3cm) for chairs in Public Schools and 46cm (using the maximum value of 39.8cm) for chairs in Private Schools. However, the seat width ranges between 91cm and 120cm indicating that the seat is too wide for the students. From the study, the Knee Height of students in Public Schools is 51.3cm while that of the students in Private schools is 53cm. Thus, the lowest part of the desk should have a height of at least 53.3cm for desks in Public Schools and

55cm for those in Private Schools. The maximum desk height for students in Public schools should be 63cm and 69cm for desks in Private schools. The desk height of the current furniture ranges between 71 and 76cm which make them too high for the students.

The current study thus shows that there is a high level of mismatch between the dimensions of school furniture and the anthropometric data of secondary students in sixteen schools in Ibadan, South Western Nigeria. This confirms that anthropometric data of the Nigerian Students were not employed in the manufacture of the school furniture. This study may be an indication that school furniture and students anthropometric dimensions are at variant nationwide.

The study also provided additional anthropometric data that may be used by manufacturers for the design of the products to suit this segment of the Nigerian population.

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