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ANTHROPOMETRIC STUDY OF PRIMARY AND SECONDARY SCHOOL STUDENTS IN OSUN STATE, NIGERIA

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Abstract: Classroom furniture designs have been linked to musculoskeletal disorders among school age persons due to high level of mismatches between the furniture dimensions and student anthropometrics. The majority of the time students spend in the classroom is spent sitting on school furniture. Yet, designing school furniture in Nigeria based on anthropometric data of users has not received adequate attention. Anthropometric data of primary and secondary school students in Osun state, Nigeria, was therefore collected in order to study the mismatch in the chairs and tables used by students. Research was conducted in twelve primary and secondary schools in Osun State. During the study, 950 students, aged between 6 and 11 years in primary and 11–20 years in the secondary schools participated, with an equal number of males and females. The students' various body dimensions (seated elbow height, shoulder height, knee height, popliteal height, buttock–popliteal length, stature, and body weight) were measured using a standard anthropometer. Microsoft Excel was used to compute the percentiles of the measured data. In addition, the existing furniture dimensions were measured in the selected schools. For students in the selected schools, this study proposes dimensions for seat height, seat depth, seat width, backrest height (upper), armrest height, and desk height based on the obtained anthropometric data. As a result of the present study, it is evident that tables and chairs used in the schools were not designed with anthropometric data of the concerned students in mind.

Keywords: anthropometric, furniture, student, school, classroom

1. INTRODUCTION

The anthropometric measures of the intended users are supposed to be used to define the dimensions of school furniture, among other things. To guarantee that students keep the proper sitting position, anthropometric measurements such as popliteal height, knee height, buttock to popliteal length, and elbow height have to be used in furniture design (Parcells et al., 1999; Panagiotopoulou et al., 2004). An increasing amount of data indicates that students experience high levels of neck and back pain (Akkam et al., 2024; Azevedo et al., 2023; Chan et al. 2020; Murphy et al., 2004). These types of musculoskeletal issues cause discomfort in kids and have a long-term detrimental impact on their health (van Leeuwen et al., 2024; Filho et al., 2023). Nonetheless, studies have indicated that poorly made classroom furniture and awkward sitting positions are frequently the source of children's musculoskeletal aches (Bai et al., 2024; Fidelis and Ogundele, 2022; Balague et al., 1999). Furthermore, Oke et al. (2012) established that when school furniture dimensions don't match the anthropometric measurements of the kids, it will cause musculoskeletal pain in various body regions when the kids utilize it for learning.

Students face severe issues as a result of the mismatch between their anthropometric measurements and the furniture in their school. Research have demonstrated that school furniture can have an impact on a person's social habits, making kids despise learning and want to avoid attending classes (Starkey, et al., 2021; Altaboli et al., 2015; Ruda et al., 2014). It is now challenging to get kids to sit up straight (the "right angle") in the classroom due to uncomfortable chairs, which leads to restlessness, fidgeting, and movement of school chairs all the time. Inadequate furniture is linked to pain in various body parts (such as the neck, back, waist, etc.) in British schools (Murphy et al., 2004; Sejdiu et al., 2023). General discomfort during sitting is strongly correlated with thigh length and seat depth mismatches (Baharampour et al., 2013; Bello and Sepenu, 2013; Parvez et al., 2019). Additionally, there is a strong correlation between reported neck and shoulder pain and the mismatch between the height of the desk and the elbows when seated. In the meantime, it has

been demonstrated that anthropometric data may be used to effectively design classroom furniture (Mokdad and A1-Ansari, 2009)

There are a few anthropometric statistics available in Nigeria that offer basic descriptive measurements such as body measurements, composition, and nutritional status (Abiola et al., 2018; Na Nongkhai et al., 2022; Siega-Riz et al., 2023). Given that school-age children are susceptible to health and safety hazards arising from the physical state of classrooms and the mismatch between the size of the student body and the furniture in the classroom (Taifa and Desai, 2017; Oke et al., 2012). The study aims to collect anthropometric data of primary and secondary school students in Osun State, Nigeria, and establish standard selection criteria and dimensions that are necessary for designing classroom furniture for students. This is with a view to design an anthropometrically appropriate school furniture and improve the physical health of the students and correct sitting posture, which may affect their adulthood sitting habits.

2. METHOD

■ Study sample

The research was conducted across seven primary and secondary schools in Osun State with the consent and approval of the schools' principals. In this study, equal number of male and female students were randomly selected from each school. Students in primary school ranged from age five (5) to twelve (12) years old, while those in secondary school were eleven (11) to twenty (20) years. Student's body sizes were measured using standard anthropometric techniques. In all anthropometric measurements, the subject was seated in a relaxed and erect posture without shoes.

The measurements were taken on a level floor in the various classrooms in each of the selected schools in Osun State. The study sample also played an important role in obtaining a representative sample of school students. A few characteristics were taken into consideration, such as age, gender, and socioeconomic level.

■ Data collection

Students grow differently with age (Okagbue et al., 2020; Drakulic, 2022). A good example is before puberty, legs grow faster than trunks, but during adolescents' growth spurts, trunks grow more rapidly than legs (Manna, 2014; Hermanussen, 2018). So, considering the age of the subjects; weight and body sizes of the subjects (Figure 1) were measured. All dimensions were taken as described by Oke et al., (2012).

1. Sitting height: The student sit erects with the head in the frank fort plane with arms hanging at the sides and hands resting on the thighs. Vertical distance from the seat surface to vertex of the head with hair pressed down was measured with a meter tape.

2. Sitting Elbow height: The vertical distance from the bottom of the tip of elbow (olecranon) to the sitting surface, measured with the elbow in 90° of flexion. The subject sits fully erect with thighs fully supported and the lower legs hanging freely. The upper arms hanging freely downwards, and forearms are horizontal. The Sitting Elbow height is required to determine the arm rest height.

3. Sitting Shoulder height: The student sit erects with his/her upper arms at the sides and hands on the thighs. The vertical distance from the top of the shoulder at the acromion process to the students' sitting surface was measured with a meter tape. This dimension is essential in the determination of Back rest Height (Upper).

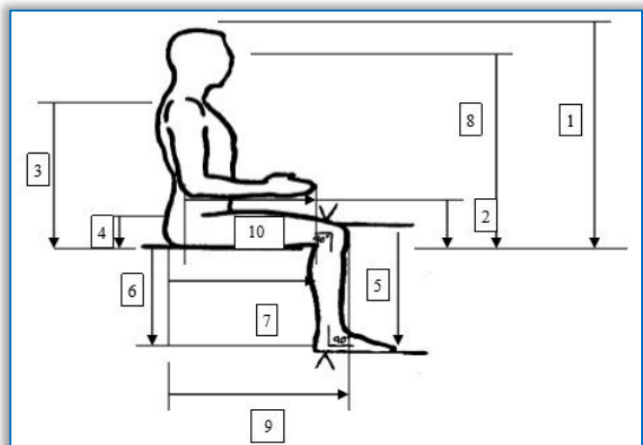


Figure 1: Anthropometric data collected (Ismaila et al., 2013)

4. Thigh Clearance: The student sit erects with the legs extended and relaxed. The vertical distance from the sitting surface to the top of the thigh at its intersection with the abdomen was measured. The thigh clearance, popliteal height and shoe clearance are necessary for the determination of the table height.

5. Sitting Knee Height: This is the vertical distance from the floor to the uppermost point on the knee. The subject sit erect on a chair and the knee is at the right angle. The measurement was taken with the use of a meter tape.

6. Popliteal height: This is the height of the underside of the thigh immediately behind the knee. The student sits fully erect with thighs fully support and sitting surface extending as far as possible into the hollow of the knee, the lower legs hanging freely. The distance was measured from the measuring block to the forward edge of the sitting surface. The measurement is necessary in the determination of seat height.

7. Buttock–Popliteal length: This is the horizontal distance from the most posterior point on the uncompressed buttocks to the back of the lower leg at the knee. The horizontal distance was measured with 90° knee flexion from the posterior surface of the buttock to the posterior surface of the knee or popliteal space. The subject sits fully erect with thighs fully supported and sitting surface extending as far as possible into the hollow of the knee, the lower legs hanging freely. The distance was measured from the measuring block to the forward edge of the sitting surface. The buttock–popliteal length is needed to determine the seat depth.

9. Buttock–knee length: The student sit erects with the feet on the floor at 90° knee flexion, arms at the sides and hands resting on thighs. The meter tape was held parallel to the long axis of the thigh to measure the horizontal distance from the most posterior point on the buttocks to the most anterior point on the knee.

10. Forearm–Hand length: The student sit erects with the upper and lower arms at right angles to one another and the hand was stretched out. The distance from the posterior end of the elbow to the longest finger of the hand while the upper arm will be at an angle of 90° with the lower arm was measured with a measuring tape. The forearm–hand length is the relevant measurement that is necessary to specify the table depth.

11. Measurement of Body mass: The weight of the student was taken using a calibrated balance upon which the student stands.

Furniture dimension

1. Seat depth: The chair seat depth is the horizontal distance of the sitting surface from the back of the seat, at a point where it is assumed that the buttock begins at the front of the seat. This should be deep enough to ensure that the region behind the knees would not hit the front of the seat.

2. Seat slope: The chair seat slope is the direction and the angle of pitch of the chair seat.

3. Table height: The table height is the vertical distance from the floor to the top of the front edge of the desk or table.

4. Table clearance: The table clearance is the vertical distance from the floor to the bottom of the front edge of the desk or table.

5. Table slope: The table slope is the angle of pitch of the top of the desk.

Statistical analysis

In this study, IBM SPSS Statistic 20 and Microsoft Excel 365 programs were used to analyze the data. The analysis was done by finding the mean, standard deviation (SD), 5th percentile, 50th percentile, and 95th percentile of the anthropometric data. In addition, the minimum and maximum dimensions, as well as body mass, were included.

3. RESULTS

A total of 11 anthropometric characteristics, such as, Sitting Height (SH), Sitting Elbow Height (SEH), Sitting Shoulder Height (SSH), Thigh Clearance (TC), Sitting Knee Height (SKH), Popliteal Height (PH),

Buttock–Popliteal Length (BPL), Buttock–Knee Length (BKL), Forearm–Hand Length (FHL) and Measurement of Body Mass (BM) of primary and secondary school students measured on population of 124 primary school students and 776 secondary school students are as shown in Table 1 and 2 respectively.

Table 1: Summary of Anthropometric Characteristic of Students in Selected Primary Schools in Osun State

	Population	Mean	Standard Deviation	Minimum	Maximum	5th Percentiles	50th Percentiles	95th Percentiles
Age (Yrs.)	124	8.79	1.9	5	12	5	9	12
Sitting Height [SH] (cm)	124	63.2	5.2	48.3	83.2	56.0	62.2	71.1
Sitting Elbow Height [SEH] (cm)	124	16.5	2.1	10.2	21.4	14.0	16.3	20.3
Sitting Shoulder Height [SSH] (cm)	124	39.1	4.0	26.7	50.2	33.0	38.9	45.3
Thigh Clearance [TC] (cm)	124	15.1	2.8	8.9	23.5	11.4	15.2	20.2
Sitting Knee Height [SKH] (cm)	124	41.0	4.7	29.2	54.6	33.9	40.6	47.9
Popliteal Height [PH] (cm)	124	33.6	4.5	20.3	50.6	27.9	33.7	40.5
Buttock Popliteal Length [BPL] (cm)	124	39.7	3.5	30.5	47.0	33.2	40.2	45.7
Buttock Knee Length [BKL] (cm)	124	48.1	4.3	36.8	60.7	41.9	48.3	55.6
Forearm Hand Length [FHL] (cm)	124	34.9	4.7	25.4	49.3	27.9	34.3	43.0
Hip Breadth [HB] (cm)	124	21.1	2.5	16.4	27.6	17.9	20.5	25.8
Body Weight [BM] (Kg)	124	23.5	4.8	14.0	40.3	18.0	22.0	32.9

Table 2: Summary of Anthropometric Characteristic of Students in Selected Secondary Schools in Osun State

	Population	Mean	Standard Deviation	Minimum	Maximum	5th Percentile	50th Percentile	95th Percentile
Age (Yrs.)	776	15	1.97	10	20	12	15	18
Sitting Height [SH] (cm)	776	75.3	5.79	49.8	94	66.04	75.18	83.96
Sitting Elbow Height [SEH] (cm)	776	17.5	2.79	10.2	26.7	12.73	17.71	22.34
Sitting Shoulder Height [SSH] (cm)	776	47.9	4.06	33.0	57.3	40.64	48.26	54.39
Thigh Clearance [TC] (cm)	776	18.5	3.71	9.2	29.1	12.70	18.05	24.16
Sitting Knee Height [SKH] (cm)	776	51.1	3.84	38.1	59.6	44.72	50.83	57.15
Popliteal Height [PH] (cm)	776	42.2	3.24	31.5	53.2	37.10	41.91	47.28
Buttock Popliteal Length [BPL] (cm)	776	46.2	6.07	33.3	62.3	38.10	45.24	58.35
Buttock Knee Length [BKL] (cm)	776	54.3	6.21	40.5	74.2	45.70	53.34	65.82
Forearm Hand Length [FHL] (cm)	776	44.4	3.94	28.9	54.5	38.10	44.45	50.81
Hip Breadth [HB] (cm)	776	29.1	4.1	18.8	45.1	22.26	28.96	34.97
Body mass [BM] (kg)	776	40.7	7.21	19.0	59.3	28.75	40.65	53.00

Design of school furniture

The design of school furniture may be influenced by a variety of factors, including education, economics, culture, and ergonomics.

Table 3: Dimensions recommended for chairs and tables for primary schools in Osun State

Features	Anthropometric Measure	Design Recommended Dimension	Design criteria
Seat surface height	Popliteal Height	28.35 cm	5th percentile of popliteal height + 0.45 cm shoe allowance
Seat surface depth	Buttock Popliteal Length	33.2 cm	5th percentile of buttock popliteal length
Seat surface width	Hip Breadth	29.67 cm	95th percentile of hip breadth + 15% clothing allowance
Seat angle to horizontal		0 degree	
Upper seat backrest height	Sitting Shoulder Height	33.0 cm	5th percentile of sitting shoulder height
Lower seat backrest height	Armrest height	14.00 cm	5th percentile of sitting elbow height
Arm rest height	Sitting Elbow Height	14.00 cm	5th percentile of sitting elbow height
Backrest angle to horizontal		1100	
Desk surface height	Sitting Elbow Height, Sitting Shoulder Height	Min = 42.80 cm Max = 45.61 cm	Max acceptable height = seat height + functional elbow height + shoe heel allowance
Desk surface width	Hip Breadth	33.54 cm	95th percentile of hip breadth + 15% clothing allowance + 15% clearance allowance
Desk surface depth	Forearm hand length	34.30 cm	50th percentile of forearm hand length
Desk angle to horizontal		150	

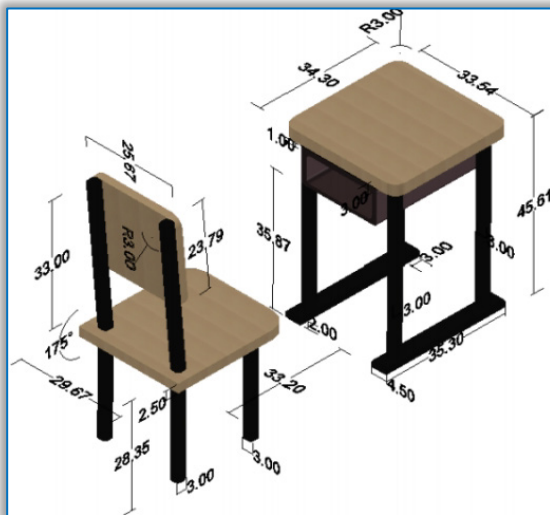


Figure 2: Design of table and chair using the recommended dimension for primary schools in Osun State

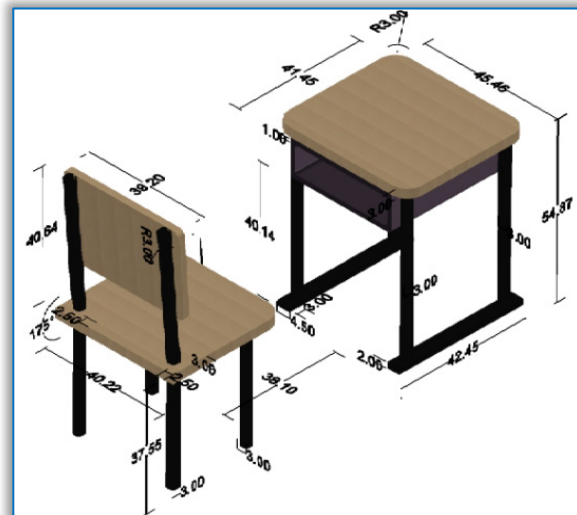


Figure 3: Design of table and chair using the recommended dimension for secondary schools in Osun State

Table 4: Dimensions recommended for chairs and tables for secondary schools in Osun.

Features	Anthropometric Measure	Design Recommended Dimension	Design criteria
Seat surface height	Popliteal Height	37.55 cm	5th percentile of popliteal height + 0.45 cm shoe allowance
Seat surface depth	Buttock Popliteal Length	38.10 cm	5th percentile of buttock popliteal length
Seat surface width	Hip Breadth	40.22 cm	95th percentile of hip breadth + 15% clothing allowance
Seat angle to horizontal		0 degree	
Upper seat backrest height	Sitting Shoulder Height	40.64 cm	5th percentile of sitting shoulder height
Lower seat backrest height	Armrest height	12.73 cm	5th percentile of sitting elbow height
Arm rest height	Sitting Elbow Height	12.73 cm	5th percentile of sitting elbow height
Backrest angle to horizontal		110°	
Desk surface height	Sitting Elbow Height, Sitting Shoulder Height	Min = 50.73 cm Max = 54.87 cm	Max acceptable height = seat height + functional elbow height + shoe heel allowance
Desk surface width	Hip Breadth	45.46 cm	95th percentile of hip breadth + 15% clothing allowance + 15% clearance allowance
Desk surface depth	Forearm hand length	41.45 cm	50th percentile of forearm hand length
Desk angle to horizontal		15°	

This study takes ergonomic factors into account. Study results may or may not be applicable, depending on how they are presented. For ease of use by designers, the results of this study are presented in percentiles. For school furniture design (mainly chairs, and tables), designs shown in Table 3 and 4, Figure 2 and 3 respectively are presented with body dimensions that are relevant to their design.

4. DISCUSSION

As shown in Tables 3 and 4, the dimensions of chairs and tables in primary and secondary schools are recommended in Osun State. The results show that primary and secondary schools should have seats that are 28.35 cm and 37.55 cm high, respectively. An extremely high seat surface compresses the underside of the thigh, resulting in discomfort and restricted blood flow (Chaleat-Valayer, 2019). Zacharkow (2000) states that a sitting individual compensates for this by moving forward on the seat, resulting in the body losing its stability.

The results explain that the seat depth should be 33.2 cm and 38.10 cm for primary and secondary school respectively. The seat depth should not exceed these, as a larger depth prevents correct use of back support, causing kyphosis and uncomfortably curved spine. In the case of excessively shallow seats, the user may feel as if they are falling off and may not receive sufficient support for their lower thighs (Romelfanger and Kolich, 2019; Hamaoui et al., 2015).

The study revealed that primary and secondary schools in Osun State should have seats width measuring 29.67 cm and 40.22 cm, respectively. As part of the requirements for a good chair, this study recommends upper backrest heights of 33.0 cm and 40.64 cm, respectively, and lower backrest heights of 14.00 cm and 12.73 cm, respectively. It is essential that a backrest be used in order to maintain a straight back while sitting, which reduces associated back pain (Vergara and Page, 2000; Singh et al, 2016; Maniarasu and Rajesh, 2018). Also included in the chair design are armrests measuring 12.73 cm and 14.00 cm in height. This is necessary as armrest is needed to reduces weight on the seat pan and reduces stress on the spine and other structures (Nag et al., 2008; Syamala et al., 2018).

The minimum and maximum height for primary school table is set at 42.80 cm and 45.61 cm respectively while for secondary school, it is set for 50.73 cm and 54.87 cm respectively. The height of the table with respect to the person using it is very important for the bottom, shoulders and torso height depending on the position and supporting arms (Baten and Blum, 2014; Masanovic et al., 2019; Alahudin et al., 2021) as a work surface above the elbow causes arm abduction resulting in an increase in the stress on the shoulders, arms and necks (Wærsted et al., 2020; Wong et al., 2021; Hanvold et al., 2015). A high table height may make a person bend forward or raise shoulders resulting in muscle strain on the back and shoulders as the user would not be able to use the backrest (Marmaras and Nathanael, 2006; Toomingas and Gavhed, 2008; Mandahawi et al., 2008).

5. CONCLUSION

The ill designed furniture of the school children has created many problems for students such as fatigue, and musculoskeletal discomfort in different body part in the children (Musa et al., 2011; Saes et al, 2015; Kahya, 2019). This pain is likely to be concentrated in the neck, back, right wrist, right elbow and hand. This may result in poor academic performance of the student due to inadequate dimension and mismatch in the dimension. Anthropometric data is in no doubt helpful for designing school furniture. The study therefore suggests that design of classroom furniture should be made based on anthropometric measurements of the student to avoid misfit, discomfort and pains.

In conclusion, this study has successfully suggested dimensions for primary and secondary school student's furniture to take care of not less than 95% populace of the students. While the need to conduct a similar study in other parts of the country is necessary to develop a sufficient database of anthropometric measurements, it is recommended that range of dimensions could be suggested for both primary and secondary school furniture design to take care of the outliers (remaining 5%). Design solutions will continue to be provided to students who will continue to suffer from unergonomically designed furniture in the country.

APPENDIX



Appendix 1: Anthropometric Measurement of a Primary School Student



Appendix 2: Anthropometric Measurement of a Secondary School Student

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