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Anthropometric Evaluation of Tertiary Institution Mounted Desktop Furniture

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Abstract

Introduction: Students in the classroom often use mounted desktop furniture that is not the right size for lectures, studying, and completing coursework. Methods: A study measuring body composition was conducted on 300 university students at Kumasi Technical University, Ghana to design an ergonomic modeled mounted desktop furniture. The study focused on whether the existing designed dimensions fit the students body proportions so that the best recommended dimensions for newly ergonomic modeled mounted desktop classroom furniture can be tested to ascertain its effect on the ergonomics and comfort of the proposed design for the target user population. Results: The study compared students' anthropometry data with their furniture dimensions and reported on three furniture sizes (seat-to-desk clearance, backrest width, and desk width) that fit students' posture and comfort, while six furniture sizes (seat height, seat width, seat depth, seat to desk height, desk depth and upper edge of backrest) were unfit for the postural alignment and comfort requirements of university students in their study spaces. Conclusion: Implementing recommended furniture measurements to design the newly modeled classroom mounted desktop designs will optimise comfortable user seating position to mitigate the risk of musculoskeletal disorders to ensure students possess the physical, mental, and emotional well-being necessary for a successful career.

Keywords: Anthropometry, Classroom furniture, Ergonomics evaluation, Fit, Pain

Resumen

Introducción: Los estudiantes en el aula a menudo utilizan muebles de escritorio montados que no son del tamaño adecuado para las conferencias, el estudio y la realización de los trabajos del curso. Métodos: Se realizó un estudio de medición de la composición corporal en 300 estudiantes universitarios de la Universidad Técnica de Kumasi, Ghana, para diseñar un mueble de escritorio montado con un modelo ergonómico. El estudio se centró en si las dimensiones diseñadas existentes se ajustaban a las proporciones corporales de los estudiantes, de modo que se pudieran probar las mejores dimensiones recomendadas para el nuevo mobiliario de escritorio montado con un modelo ergonómico para el aula a fin de determinar su efecto en la ergonomía y la comodidad del diseño propuesto para la población de usuarios objetivo. Resultados: El estudio comparó los datos antropométricos de los estudiantes con las dimensiones de sus muebles e informó sobre tres tamaños de muebles (distancia entre el asiento y el escritorio, ancho del respaldo y ancho del escritorio) que se ajustaban a la postura y la comodidad de los estudiantes, mientras que seis tamaños de muebles (altura del asiento, ancho del asiento, profundidad del asiento, altura del asiento al escritorio, profundidad del escritorio y borde superior del respaldo) no eran adecuados para la alineación postural y los requisitos de comodidad de los estudiantes universitarios en sus espacios de estudio. Conclusión: La implementación de las medidas de mobiliario recomendadas para diseñar los nuevos modelos de escritorios montados en el aula optimizará la posición cómoda del usuario para mitigar el riesgo de trastornos musculoesqueléticos y garantizar que los estudiantes posean el bienestar físico, mental y emocional necesario para una carrera exitosa.

Palabras Clave: Antropometría, Mobiliario de aula, Evaluación ergonómica, Ajuste, Dolor Introducción

Introduction

Tertiary institutions, encompassing universities and colleges, are crucial for shaping young minds. Students spend significant time in classrooms, often using mounted desktop furniture for lectures, studying, and completing coursework. However, local furniture designs may not always consider student populations' diverse anthropometry, potentially leading to negative consequences (Ismaila, 2010).

Research highlights several issues associated with poorly designed furniture in educational settings. Mismatched furniture contributes to musculoskeletal disorders (strain muscles and ligaments), leading to pain and discomfort in the neck, back, shoulders, and wrists (Aiyegbusi et al., 2023). Discomfort caused by a poorly fitting desk and chair combination can significantly distract students. This can make it difficult to concentrate on lectures, participate in discussions, and retain information effectively (Parcells et al., 1999).

Anthropometry provides a scientific approach to evaluating how well furniture fits the human body. By analysing student body measurements and comparing them to the dimensions of mounted desktop furniture, we can identify potential mismatches contributing to discomfort and health concerns (Aiyegbusi et al., 2023).

This anthropometric evaluation aims to bridge the gap between traditional furniture design and the ergonomic needs of students in tertiary institutions. By understanding how well the current furniture accommodates students of various sizes and body proportions, we can make informed recommendations for improvements based on anthropometric principles. These recommendations can be used to guide the design and selection of ergonomic furniture, ultimately creating a comfortable and supportive study area that fosters successful study concentration.

Students in universities and colleges spend long hours at mounted desk furniture. To ensure their comfort and well-being, this furniture should be designed with ergonomics in mind. This study will focus on an anthropometric evaluation of mounted desktop furniture in tertiary institutions. By comparing these sizes to the furniture design, one can assess how well the desks fit the students and promote good posture. This evaluation identifies potential mismatches between student body size and the current furniture dimensions. Ultimately, the goal is to provide recommendations for improvements that create a more ergonomic and comfortable learning environment for all students.

This study aims to find ways to make sure classroom furniture better fits students' bodies so they can sit comfortably and avoid health problems. The research was conducted to investigate how well locally-made classroom furniture fits students' bodies and identify ways to improve their comfort and posture while learning. Assuming a student spends most of the day at school sitting in chairs and at desks that are not well-suited for him/her. This can lead to discomfort, back pain, leg cramps, and other health issues. That is what happens when classroom furniture does not match the different body sizes of students. Students have diverse body types, but some schools only provide furniture of a single size. This mismatch can force students to sit in awkward positions for long periods. This study is looking at how well classroom furniture fits students' bodies. This study seeks to quantify the discrepancy between student body types and furniture sizes and evaluate its potential effects on students' comfort, posture, and overall health.

The design is based on three fundamental principles of ergonomic classroom furniture based on student body measurements. To accommodate students with large body frames, furniture design should be based on the 95^{th} percentile of male body measurements. To cater to/for students of varying sizes and preferences, furniture design should consider both the 5^{th} and 95^{th} percentiles of female and male body measurements, respectively. To accommodate students with smaller body frames, furniture design should be based on the 5^{th} percentile of female body measurements (Alrashdan et al., 2014; Khaspuri et al., 2007). Focusing solely on the average population leaves 50 % of the population underserved. To accommodate a wider range of body sizes, adjustable furniture is suggested (Al-Saleh et al., 2013; Ziefle, 2003).

Classroom seating serves as study stations for university students. When classroom furniture does not fit students' bodies, it can lead to health problems (Agha, 2010; Castellucci et al., 2010; Chung and Wong, 2007; Saarni et al., 2007). Prolonged use of poorly fitting furniture can result in musculoskeletal disorders and decreased overall well-being (Dianat et al., 2013). If classroom furniture is not designed with ergonomics in mind, it can increase the risk of back pain, neck pain, and other musculoskeletal issues (Balague et al., 1999; Trevelyan and Legg, 2011).

Investigations have examined the standards for classroom furniture in primary and secondary education. While there are standards for primary and secondary education furniture, relatively few studies have focused on developing furniture dimensions tailored to the needs of tertiary students in their respective countries (Shah et al.,

2013; Thariq et al., 2010), with little to no Ghanaian participation. Ghanaian universities frequently import classroom furniture from other countries that is not well-suited for their students.

Many researchers have employed various methodologies to identify mismatches within the parameters of mounted desktop classroom seating and the body measurements of students. A study titled “Designing chairs with mounted desktop for university students: Ergonomics and comfort” by Thariq et al. (2010), used 385 subjects in two Sri Lanka Universities (the University of Peradeniya and the University of Moratuwa) found that the side-mounted desktop chair was unlikely to provide adequate support for students' posture and comfort while studying. However, we conducted a study to measure body measurements to focus on designing the mounted desktop and recommended its dimensions.

Secondly, a study titled “Consideration of anthropometrics in the design of lecture hall furniture” by Igbokwe et al. (2019), by 400 students from the Federal University of Technology in Owerri, Nigeria found that when they compared the sizes of the existing furniture to students' body measurements, the furniture did not meet ergonomic standards. In this present research, the anthropometric survey was conducted to measure students' bodies to design the best classroom seats.

Finally, a study titled “Design of classroom furniture for use at tertiary institutions” by Esmaeel et al. (2020), was participated by 382 students from four tertiary institutions (Moi University, University of Eldoret, Rift Valley Technical Training Institute, and Eldoret National Polytechnic) in Uasin-Gishu Country, Kenya found that they designed a new type of classroom desktop-chair that better fits students' body shapes and sizes. In this current research, the anthropometric survey was carried out to use the concept of ergonomics to design classroom desktop chairs for students.

Materials and methods

Statistical Sample Size

The study included participants from the Kumasi Technical University, Kumasi, Ghana who use the university's facilities. There were 1200 students with a sample size of 300 students – 176 males (58.70%) and 124 females (41.30%), was calculated using Equation 1 (Taifa and Desai, 2017). Students' safety and privacy were protected.

$$n = \frac{N}{1+N(e^2)} \quad (1)$$

Where n represents the sample size, N represents the population size, and e represents the allowable error margin at a 95% confidence level.

Student Body Measurements, Equipment, and Procedure

The anthropometry of students at Kumasi Technical University was assessed. A precise, accurate, and dependable anthropometer was used to measure 11 body dimensions that are important for good posture (Figure 1).

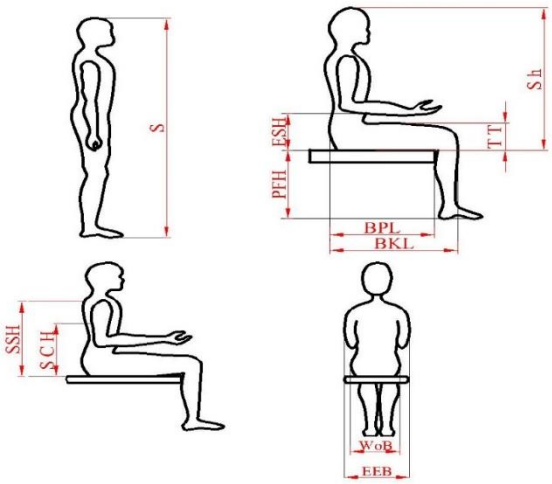

Figure 1. S = Stature, ESH = Elbow-seat height, PFH = Popliteal-floor height, BPL = Buttock-popliteal length, BKL = Buttock knee length, TT = Thigh thickness, Sh = Sitting height, SSH = Sitting shoulder height, SCH = Subscapular height, WoB = Width of bitrochanter, EEB = Elbow-elbow breadth.

The following are the definitions of the dimensions used in this study (Aravind and Ilangkumaran, 2019).

1 Sitting height: This is the vertical distance between the seat and the head.

2 Popliteal-floor height: The vertical distance from the floor to the back of the knee when the knee is bent at a 90-degree angle

3 Elbow seat height: The vertical distance between the seat and the lowest point of the elbow

4 Buttock popliteal length: The distance between the back of the buttocks and the back of the knee.

5 Buttock-knee length: The horizontal distance from the front of the kneecap to the uncompressed back of the buttock.

6 Width of bitrochanter: The horizontal distance between the widest points of the hips while seated

7 Sitting shoulder height: Vertical distance between the seat and the highest point of the shoulder

8 Elbow-elbow breadth: The horizontal distance between the outer edges of the elbows

9 Thigh thickness: Vertical distance from the underside of the thigh to the top part of the thigh when seated.

10 Subscapular height: Distance from lowest scapula point to the seat surface.

11 Stature: The total vertical length of a person's body

Furniture Sizes

A measuring tape (Sunrise, 5 m) was used to accurately measure the variable values of the mounted desktop furniture (Table 1). Figure 2 shows the working drawings of the mounted desktop furniture with a side view and plan of the orthographic projection.

Table 1. Measurements of existing mounted desktop classroom furniture

Variable	Measurement
Seat Height	42.00 cm
Seat Width	40.50 cm
Seat Depth	33.00 cm
Backrest Width	40.00 cm
Seat-Desk Height	30.70 cm
Upper Edge of Backrest	44.10 cm
Seat-to-Desk Clearance	29.50 cm
Desk Depth	35.40 cm
Desk Width	55.50 cm
Backrest Angle	102^{o}

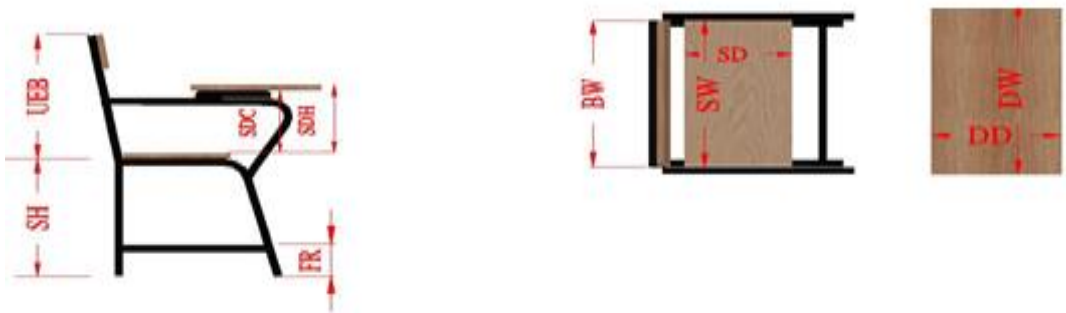

Figure 2. UEB = Upper edge of backrest, SH = Seat height, SDC = Seat-desk clearance, SDH = Seat-desk height, FR = Footrest, BW = Backrest width, SW = Seat width, SD = Seat depth, DD = Desk depth, DW = Desk width

The mounted desktop furniture is locally produced by furniture manufacturers. Below are the definitions of dimensions employed by Parvez et al. (2019).

1 Seat height: The vertical distance between the floor and the front edge of the seat

2 Seat width: The horizontal distance across the widest part of the seat

3 Seat depth: The horizontal distance from the back of the seat to its front edge

4 Backrest height: The vertical distance from the seat to the top of the backrest.

5 Desk width: The maximum distance between the desk edges.

6 Desk depth: The minimum distance from the front to the back edges of the desk.

7 Seat-desk height: The distance from the seat surface to the top of the desktop edge.

8 Seat-desk clearance: The vertical distance between the seat surface and the underside of the desktop.

9 Upper edge of the backrest: The vertical distance between the seat surface and the top of the backrest edge.

Relative Size Comparison

We compared the size of students to the size of the furniture to establish a size mismatch. This allows one to assess how well the current furniture meets students' needs and pinpoint areas where changes can be made. The degree of match or mismatch between students' body measurements and furniture dimensions was calculated employing established anthropometric and ergonomic formulas as outlined in Table 2 (Khoshabi et al., 2020; Osquei-Zadeh et al., 2012; Macedo et al., 2015; Parvez et al., 2019; Taifa and Desai, 2017; Pérez-Gosende, 2017; Altaboli et al., 2015; García-Acosta and Lange-Morales, 2007).

Table 2. Formulas for calculating the match or mismatch of students' body measurements with furniture dimensions

Furniture dimensions	Corresponding body measurements	Formula
Seat Height (SH)	Popliteal-Floor Height (PFH)	$(PFH + 3)Cos\ 30^o \leq SH \leq$ (PFH + 3)$Cos\ 5^o$
Seat Width (SW)	Width of Bitrochanter (WoB)	$1.10\ WoB \leq SW \leq 1.30\ WoB$
Seat Depth (SD)	Buttock-Popliteal Length (BPL)	$0.80\ BPL \leq SD \leq 0.95\ BPL$
Seat-Desk Height (SDH)	Elbow-Seat Height (ESH)	$ESH \leq SDH \leq ESH + 5$
Seat-Desk Clearance (SDC)	Thigh Thickness (TT)	$TT + 2 < SDC$
Backrest Width (BW)	Width of Bitrochanter (WoB)	$BW \geq$ WoB
Desk Depth (DD)	Buttock Knee Length (BKL)	$DD \geq BKL$
Desk Width (DW)	Elbow-Elbow Breadth (EEB)	$DW \geq EEB$
Upper Edge of Backrest (UEB)	Subscapular Height (SCH)	$UEB \leq SCH$

Levels of Agreement

When matching respondents' body dimensions with furniture sizes, the percentages of matches and mismatches between respondents' body dimensions and furniture sizes were calculated using one-way and two-way limit equations. Two-way limits categorise matches and mismatches into high, low, and exact.

Data Analysis

Anthropometric Information about Respondents

Anthropometric information was collected for male and female participants. The minimum, maximum, mean, standard deviation, and 5th, 50th, and 95th percentile values were calculated in centimetres.

Results

Table 3 provides the key descriptive statistics for anthropometric measurements. These statistics offer insights into the distribution, central tendency, and dispersion of the data, aiding in understanding the characteristics of the variables. Table 4 presents the potential percentage of mismatches between the current furniture and students' body sizes.

Table 4 presents the potential percentage of how well mounted desktop furniture dimensions fit male and female users. It categorises the fit into three levels: match, low mismatch, and high mismatch.

Table 3. Anthropometric variables with their dimensions in centimetres between male (M) and female (F) respondents in the study

Anthropometric variable	Sex	Min	Max	SD	Mean	5th	50th	95th
Sitting height	M	65.00	89.60	5.45	80.07	69.43	81.00	87.00
	F	50.00	87.00	6.80	77.71	60.75	79.00	86.00
Popliteal-floor height	M	35.00	39.00	0.92	37.20	35.77	37.00	38.70
	F	35.00	39.00	0.93	37.25	35.83	37.10	38.73
Elbow-seat height	M	20.00	30.00	1.94	24.39	21.50	24.00	28.00
	F	19.50	28.50	1.94	23.50	21.00	24.00	28.00
Buttock-popliteal length	M	30.10	38.00	1.34	34.27	32.00	34.15	36.46
	F	28.90	35.30	1.34	30.79	29.00	30.55	33.05
Buttock knee length	M	42.00	68.00	5.52	57.40	47.00	57.75	66.00
	F	41.50	67.50	5.61	55.54	45.50	55.00	64.50
Width of bitrochanter	M	27.00	34.00	1.04	29.91	28.00	30.05	31.30
	F	31.00	38.00	1.41	31.78	33.00	34.60	37.00
Sitting shoulder height	M	40.00	62.00	4.31	52.44	43.47	53.00	59.00
	F	40.50	59.00	4.24	51.52	42.63	52.50	56.88
Elbow-elbow breadth	M	34.00	50.00	3.10	44.49	39.85	45.00	48.50
	F	36.00	49.50	3.44	43.51	38.00	44.00	48.08
Thigh thickness	M	14.00	24.00	1.60	16.88	15.00	16.70	20.00
	F	14.50	22.50	1.74	16.62	14.33	16.00	20.00
Subscapular height	M	33.00	52.00	3.72	41.34	35.00	41.00	48.00
	F	29.00	49.00	3.70	39.58	33.00	39.00	47.00
Elbow-fingertip length	M	40.00	57.00	3.45	49.29	42.43	49.00	55.00
	F	39.50	65.00	4.07	48.10	42.25	48.00	54.75
Stature	M	160.00	182.00	5.13	170.71	162.00	171.00	179.00
	F	148.00	180.00	5.19	165.68	160.00	164.25	177.00

Table 4. Percentages of match and mismatch of mounted desktop furniture

Dimension	Sex	Match	Low mismatch	High mismatch	Total Mismatch
Seat Height	M	0	0	100.00	100.00
	F	0	0	100.00	100.00
Seat Width	M	5.68	0	94.32	94.32
	F	59.68	0	40.32	40.32
Seat Depth	M	37.50	0	62.50	62.50
	F	4.03	0	95.97	95.97
Seat-Desk Height	M	25.00	0	75.00	75.00
	F	12.90	0	87.10	87.10
Seat-Desk Clearance	M	100.00			0
	F	100.00			0
Backrest Width	M	100.00			0
	F	100.00			0
Desk Depth	M	0			100.00
	F	0			100.00
Desk Width	M	100.00			0
	F	100.00			0
Upper edge backrest	M	1.70			98.30
	F	1.61			98.39

Table 5. Recommended measurements for mounted desktop furniture in centimetres

Dimension	Recommended Measurement	Sex	Low	High	Total
Seat Height	38.80	M	0	6.81	6.81
		F	0	7.26	7.26
Seat Width	37.00	M	1.14	8.52	9.66
		F	12.10	0	12.10
Seat Depth	29.00	M	0	0.57	0.57
		F	0	14.52	14.52
Seat to Desk Height	21.00	M	5.68	6.25	11.93
		F	4.84	5.65	10.49
Desk Depth	64.50	M			2.84
		F			1.61
Upper Edge of Backrest	29.00	M			0.57
		F			1.61
Angle between backrest and seat	102^{o}	Literature review suggestion			

Design specification

Table 5 reports recommended anthropometrically-based furniture dimensions in centimetres for the mounted desktop furniture for males and females.

According to (Mahantesh et al., 2023), the angle of the backrest and seat pan, should be 102 degrees.

Discussions

Anthropometric Dimensions of Respondents

Interpretation of Table 3 is expressed in pairs of comparisons that exist among anthropometric measures in height-related comparisons (stature vs. sitting height, stature vs. popliteal to floor height, and elbow to seat height vs. buttock to popliteal length); width and breadth comparisons (width of bitrochanter vs. elbow to elbow breadth and scapular height vs. elbow to seat height); and length and thickness comparisons (buttock to popliteal length vs. buttock to knee length and thigh thickness vs. buttock to popliteal length).

Sitting height (Sh) and stature (S) have a larger range in males and females, reflecting greater variation in their heights compared to the height above the buttock and the floor, respectively. The standard deviation is higher for Sh, indicating more overall height variability than S. The mean values for both Sh and S are higher for males than females, reflecting the typical height differences between genders. The percentiles for both Sh and S follow similar patterns, with higher values for males and lower values for females.

Stature (S) has a larger range than popliteal to floor height (PFH), reflecting the greater variation in overall height compared to the distance from the knee to the floor. The standard deviation is higher for S, indicating more variability in overall height compared to PFH. The mean values for S and PFH are higher for males and females, respectively, reflecting the height differences between genders. The percentile values for S and PFH are higher in males and females, respectively.

Elbow-to-seat height (ESH) and buttock-to-popliteal length (BPL) have relatively smaller ranges compared to stature (S) or sitting height (Sh), reflecting the more limited variation in these measurements. The standard deviation for both measurements is generally lower than for S or Sh, indicating less variability in these areas. The mean values for both ESH and BPL are generally higher for males than females, reflecting the typical size differences between genders. The percentiles for both ESH and BPL follow similar patterns, with higher values for males and lower values for females.

Both widths of bitrochanter (WoB) and elbow-to-elbow breadth (EEB) have relatively smaller ranges compared to stature (S) or sitting height (Sh), reflecting the more limited variation in these measurements. The standard deviation for both measurements is generally lower than for S or Sh, indicating less variability in these areas. The mean values for WoB and EEB are higher for females and males, respectively, reflecting the typical size differences between genders. The percentiles for WoB measurements for females are higher than for males, while the reverse occurs in EEB.

Subscapular height (SCH) and elbow-to-seat height (ESH) have relatively smaller ranges compared to stature (S) or sitting height (Sh), reflecting the more limited variation in these measurements. The standard deviation for both measurements is generally lower in SCH and ESH than for S or Sh, indicating less variability in these areas. The mean values for both SCH and ESH are generally higher for males than females, reflecting the typical size differences between genders. The percentiles for both SCH and ESH follow similar patterns, with higher values for males and lower values for females.

With the exception of male range value of buttock to knee length (BKL) which is higher than both males in stature (S) or sitting height (Sh), buttock to popliteal length (BPL) has relatively smaller ranges compared to S or Sh. The standard deviation for males in BKL is higher than for S or Sh. The mean values for both BPL and BKL are higher for males than females, reflecting the typical size differences between genders. The percentiles for both BKL and BPL follow similar patterns, with higher values for males and lower values for females.

Thigh thickness (TT) and buttock to popliteal length (BPL) have relatively smaller ranges compared to stature (S) or sitting height (Sh), reflecting the more limited variation in these measurements. The standard deviation for both measurements is generally lower in TT and BPL than for S and Sh, indicating less variability in these areas. The mean values for both TT and BPL are generally higher for males than females, reflecting the typical size differences between genders. With the exception of 95th percentile of TT having the same value in both sexes, percentiles for BPL, S and Sh measurements follow similar patterns, with higher values for males and lower values for females.

Analysis of Mismatch for Mounted Desktop Furniture

According to Table 4, the data suggests that 100.00% of each gender, are using chair seats that are too high for their legs. This could indicate a mismatch between the size of the chairs and the students' stature. In this regard, students may experience pressure on the backs of their knees, leading to discomfort and circulation issues. Students will also find it difficult to place their feet flat on the ground resulting in improper posture thereby affecting spinal alignment. A higher seat height can make it challenging for students to maintain balance, potentially leading to accidents. Furthermore, discomfort and instability can disrupt concentration and hinder learning.

A significant portion of students, ranging from 40.32% to 94.32%, utilised chairs too wide for their hips. Wider seats can take up more space, potentially limiting the number of chairs in a given area. Wider chairs may be more expensive to manufacture and purchase due to the increased material used. Wider seats may limit the design options for chairs, as they need to be wider overall dimensions to accommodate the wider seat.

A significant proportion of students (62.50% to 95.97%), were using deep chairs. Deeper chairs can make it more difficult to stand up or get out of, especially for individuals with limited mobility or older adults. Deep chairs can take up more space than shallower chairs, limiting the number that can fit in a given area. The depth of a chair can constrain design options, as the overall dimensions of the chair need to be adjusted to accommodate the deeper seat.

A very high percentage of students (between 75.00% and 87.10%) are using desktops that are at an inappropriate height for them. This mismatch between ideal and actual desk height can lead to several ergonomic issues as students tend to hunch their shoulders and elevate their arms to work, leading to neck, shoulder, and back pain.

An inappropriate desk depth contributes to ergonomic issues that can impact one’s comfort and health, especially if he/she spends long hours working at his/her desk. Shallow desks provide insufficient space for writing and reading materials. Students may hunch over or adopt awkward postures to reach their work area, leading to back, neck, and shoulder pain. Cluttered workspace and discomfort can distract students, impairing their ability to concentrate. An excessively deep desk can create unused space, making it difficult for students to reach items at the back. Also, students may lean forward to reach their work area, leading to poor posture.

A poorly positioned backrest can result in various issues: Firstly, a low backrest provides inadequate support for the upper back and neck, leading to discomfort and fatigue. Additionally, lack of support encourages slouching and poor posture, contributing to back, neck, and shoulder pain. A backrest that is too high can create pressure on the neck and shoulders, leading to discomfort and fatigue. In addition, it can limit head movement, affecting students' ability to look around the classroom.

Furniture Size Recommendations

To accommodate most women comfortably, seat height should be designed using the 5th percentile popliteal height measurement, plus 3 centimetres for shoe clearance (Parvez et al., 2018; Oyewole et al., 2010). Ensure adequate hip room by setting seat width at the 95th percentile female bitrochanter width. Seat depth should be 5th percentile female buttock-to-popliteal length (Gouvali & Boudolos, 2006). Seat-to-desk height size is obtained by using 5th percentile female elbow-to-seat height. The backrest upper edge should be the minimum female scapular height (Kahya, 2018). Desk depth should be 95th percentile female buttock-to-knee length (Castellucci et al., 2015).

According to the recommended dimensions of mounted desktop furniture in Table 5, the mismatch percentages are far lower than the mismatch percentages displayed in Table 4. A popliteal to floor height mismatch of 6.81% to 7.26% between students and furniture seat height indicates a moderate mismatch. While not as severe as a very high mismatch, it could still lead to discomfort and potential health issues for some students. A mismatch in this range may not be immediately noticeable to all students, but it can contribute to discomfort, fatigue, and poor posture over time. This can negatively impact concentration, learning, and overall well-being. Secondly, improper chair height can stress the lower back, hips, and legs. In the long run, this can increase the risk of developing musculoskeletal problems like back pain, sciatica, or poor circulation. Also, chronic discomfort and pain can affect a student's ability to focus and learn effectively. If students are experiencing pain, they may be distracted, and unable to concentrate, and their academic performance may suffer.

For students’ width of bitrochanter mismatching furniture seat width by 9.66% to 12.10%, it suggests that the seat is both too narrow and too wide for a significant portion of the student population. Too narrow can lead to pressure on the hips, thighs, and buttocks, potentially causing pain, discomfort, and reduced blood flow; while too wide can cause instability and discomfort, as students may feel like they are sliding around or not fully supported. Secondly, too narrow a seat will force students to lean forward or to the side to find a more comfortable position,

leading to poor posture and potential back pain; while too wide a seat forces students to slouch or lean back to fill the extra space leading to poor posture. Poor posture and prolonged sitting in an uncomfortable position can increase the risk of musculoskeletal injuries, such as back pain or hip problems. Finally, physical discomfort can distract students and make it difficult to concentrate on their studies.

Concerning students' buttocks to popliteal lengths mismatch furniture seat depth by 0.57% to 14.52%, it indicates that the seat depth was too long for a significant portion of the student population, and this can cause pressure on the back of the thighs and knees, as well as limiting leg movement and potentially contributing to discomfort. In addition, students may lean forward or to the side to avoid pressure on their knees leading to poor posture. Poor posture and prolonged sitting in an uncomfortable position can increase the risk of musculoskeletal injuries, such as back pain or hip problems.

Furthermore, if students' elbow-to-seat heights mismatch furniture seat-to-desk height by 10.49% to 11.93%, it indicates that the seating arrangement is either too high or too low for a significant portion of the student population. Too high seating arrangement can lead to strain on the shoulders, neck, and upper back, as well as discomfort in the elbows and wrists; while too low: seating arrangement can cause discomfort in the wrists, elbows, and shoulders, as students may need to hunch over to reach the desk. Poor posture and potential back pain are exhibited in the sense that too high seating arrangement forces students to lean forward or to the side to reach the desk; while too low seating arrangement may force students to hunch over or slouch to reach the desk. In addition, poor posture and prolonged sitting in an uncomfortable position can increase the risk of musculoskeletal injuries, such as back pain, neck pain, or carpal tunnel syndrome.

A mismatch between students' buttocks-to-knee lengths and desk depth by 1.61% to 2.84%, it indicates that the desk depth is either too short or too long for a significant portion of the student population. When the depth is too short it can lead to pressure on the knees and thighs, causing discomfort and potentially limiting leg movement, while too long depth can cause pressure on the knees and thighs, as well as limiting leg movement and potentially contributing to discomfort. Secondly, too short and long depth can lead to poor posture, back pain, and pressure on the knees. Also, physical discomfort can distract students and make it difficult to concentrate on their studies, while poor posture and prolonged sitting in an uncomfortable position can increase the risk of musculoskeletal injuries, such as back pain or hip problems.

For students' subscapular heights which mismatch furniture upper edge backrests by 0.57% to 1.61%, it indicates that the backrest height is either too high or too low for a significant portion of the student population. As the backrest height becomes too high, pressure is created on the shoulders and neck, causing discomfort and contributing to strain. Unlike too low height of backrest, there is inadequate lumbar support, leading to discomfort in the lower back and potential strain. Secondly, poor posture is associated with too high and too low backrest height. Too high a backrest leads to forward-leaning or siding to avoid pressure on their shoulders, while too low a backrest leads to students slouching or leaning forward in order to find support. Furthermore, physical discomfort can distract students by making it difficult to concentrate on their studies together with increasing risk of musculoskeletal injuries (back pain, neck pain, or shoulder problems) due to poor posture and prolonged sitting in an uncomfortable position.

Conclusion

High seat heights can negatively impact students' physical and cognitive development. It is vital to provide seating appropriately adjusted to each student's height to promote good posture, comfort, and optimal learning conditions. Concerning narrow and wide seats, wider seats will become more conducive to a positive learning environment. Ideal seat depth on the other hand allows for proper thigh and lower back support without causing pressure or discomfort. Furthermore, correct seat-to-desk height will allow students to maintain a neutral spine, with feet flat on the floor, thighs parallel to the ground, and forearms resting comfortably on the desktop. Subsequently, ideal desk depth allows enough space to work comfortably without taking up more space than needed. Finally, a perfect upper backrest height supports the spine's natural curve and extends to the mid-back or shoulder blade area.

The recommended furniture dimensions reported in this newly modeled mounted desktop furniture (such as seat height, seat width, seat depth, seat-to-desk height, desk depth, and upper edge backrest) together with the already existing mounted desktop dimensions (such as seat-to-desk clearance, backrest width, and desk width), modeled mounted desktop furniture can be constructed as newly modeled mounted desktop furniture to achieve optimal ergonomics. Using the users' body sizes for furniture design will reduce pains and improve users' sitting position. The recommended dimensions in furniture design will ergonomically fit students' anthropometric measurements.

References

Agha, S.R. (2010). School furniture match to students' anthropometry in the Gaza Strip. *Ergonomics*, 53(3): 344–54. https://doi.org/10.1080/00140130903398366

Aiyegbusi, A.I., Gbiri, C.A., Oyeniran, T.O., Balogun, O.J. (2023). Mismatch between school furniture dimensions and anthropometric parameters is a risk for spinal deformities in secondary school students in Lagos, Nigeria: a cross-sectional study. *Bulletin of Faculty of Physical Therapy*, 28(1): 34. https://doi.org/10.1186/s43161-023-00145-8

Alrashdan, A., Alsudairi, L., Alqaddoumi, A. (2014). Anthropometry of Saudi Arabian female college students. In Proceedings of the industrial and systems engineering research conference, 4075 – 4083.

Al-Saleh, K.S., Ramadan, M.Z., Al-Ashaikh, R.A. (2013). Ergonomically adjustable school furniture for male students. *Educational Research and Reviews*, 8(13): 943.

Altaboli, A., Belkhear, M., Bosenina, A., Elfsei, N. (2015). Anthropometric evaluation of the design of the classroom desk for the fourth and fifth grades of Benghazi primary schools. *Procedia Manufacturing*, 3: 5655 – 5662. https://doi.org/10.1016/j.promfg.2015.07.778

Aravind, S., Ilangkumaran, M. (2019). Ergonomic Assessment of Classroom Furniture in KS Rangasamy College of Technology. *Bulletin of Scientific Research*, 1(2): 59 – 72.

Balague, F., Troussier, B., Salminen, J.J. (1999). Non-specific low back pain in children and adolescents: risk factors. *European Spine Journal*, 8: 429 – 38. https://doi.org/10.1007/s005860050201

Castellucci, H.I., Arezes, P.M., Molenbroek, J.F. (2015). Analysis of the most relevant anthropometric dimensions for school furniture selection based on a study with students from one Chilean region. *Applied ergonomics*, 46: 201 – 211. https://doi.org/10.1016/j.apergo.2014.08.005

Castellucci, H.I., Arezes, P.M., Viviani, C.A. (2010). Mismatch between classroom furniture and anthropometric measures in Chilean schools. *Applied ergonomics*, 41(4): 563-568. https://doi.org/10.1016/j.apergo.2009.12.001

Chung, J.W., Wong, T.K. (2007). Anthropometric evaluation for primary school furniture design. *Ergonomics*, 50(3): 323 – 334. https://doi.org/10.1080/00140130600842328

Dianat, I., Karimi, M.A., Hashemi, A.A., Bahrampour, S. (2013). Classroom furniture and anthropometric characteristics of Iranian high school students: proposed dimensions based on anthropometric data. *Applied ergonomics*, 44(1): 101 – 108. https://doi.org/10.1016/j.apergo.2012.05.004

Esmaeel, A., Starovoytova, D., Maube, O., Asad, R. (2020). Design of Classroom Furniture for Use at Tertiary Institutions. Innovative Systems Design and Engineering, 11(5), 42-49.

furniture for Bogotá schools based on anthropometric criteria. *Ergonomics*, 50 (10): 1626 – 1642. https://doi.org/10.1080/00140130701587541

García-Acosta, G., Lange-Morales, K. (2007). Definition of sizes for the design of school

Gastro-Intestinal Parasitism and Anthelmintic Resistance in Gi Nematodes of Small Ruminants in Semi-Intensive Farms of Kalyana-Karnataka Region of Karnataka, India. *Journal of Experimental Zoology,* 26(1): 595 – 604. https://doi.org/10.51470/jez.2023.26.1.595

Gouvali, M.K., Boudolos, K. (2006). Match between school furniture dimensions and children's anthropometry. *Applied ergonomics*, 37(6): 765-73. https://doi.org/10.1016/j.apergo.2005.11.009

Igbokwe, J.O., Osueke, G.O., Opara, U.V., Ileagu, M.O., Ezeakaibeya, K.U. (2019). Considerations of anthropometrics in the design of lecture hall furniture. *International Journal of Regulation and Governance*, 7(8): 374 – 386.

Ismaila, S.O., Akanbi, O.G., Adekunle, N.O., Adetunji, O.R., Kuye, S.I. (2010). An ergonomics assessment of passenger seats in buses in South Western Nigeria. *Sigurnost*, 52(4): 329.

Kahya, E. (2018). Evaluation of the classroom furniture for university students. *Eskisehir Osmangazi University Journal of Engineering and Architecture*, 26(1): 20 – 29. https://doi.org/10.31796/ogummf.330136

Khaspuri, G.C., Sau, S.K., Dhara, P.C. (2007). Anthropometric consideration for designing class room furniture in rural schools. *Journal of human ecology*, 22(3): 235 – 244.

Khoshabi, P., Nejati, E., Ahmadi, S. F., Chegini, A., Makui, A., Ghousi, R. (2020). Developing a Multi-Criteria Decision Making approach to compare types of classroom furniture considering mismatches for anthropometric measures of university students. *PloS one*, *15*(9): e0239297. https://doi.org/10.1371/journal.pone.0239297

Macedo, A. C., Morais, A. V., Martins, H. F., Martins, J. C., Pais, S. M., Mayan, O. S. (2015). Match between classroom dimensions and students' anthropometry: re-equipment according to european educational furniture standard. *Human factors*, 57(1): 48 – 60. https://doi.org/10.1177/0018720814533991

Mahantesh, M.T., Prasad, K.C., Sreedhara, J.N., Ram10, J. (2023). Prevalence Of

Osquei-Zadeh, R., Ghamari, J., Abedi, Z., Shiri, H. (2012). Ergonomic and anthropometric consideration for library furniture in an Iranian public university. *International Journal of Occupational and Environmental Medicine*, *3*(1): 19 – 26.

Oyewole, S.A., Haight, J.M., Freivalds, A. (2010). The ergonomic design of classroom furniture/computer workstation for first graders in the elementary school. *International Journal of Industrial Ergonomics*, 40(4): 437-447. https://doi.org/10.1016/j.ergon.2010.02.002

Parcells, C., Stommel, M., Hubbard, R.P. (1999). Mismatch of classroom furniture and student body dimensions: empirical findings and health implications. *Journal of adolescent health*, 24(4): 265 – 273. https://doi.org/10.1016/S1054-139X(98)00113-X

Parvez, M. S., Parvin, F., Shahriar, M.M., & Kibria, G. (2018). Design of ergonomically fit classroom furniture for primary schools of Bangladesh. *Journal of Engineering*, 2018(1), 3543610. https://doi.org/10.1155/2018/3543610

Parvez, M.S., Rahman, A., Tasnim, N. (2019). Ergonomic mismatch between student's anthropometry and university classroom furniture. *Theoretical Issues in Ergonomics Science*, 20(5): 603 – 631. https://doi.org/10.1080/1463922X.2019.1617909

Pérez-Gosende, P. (2017). Anthropometry-based approach for side-mounted desktop chairs design evaluation for university students in Ecuador. *In 2017 IEEE Second Ecuador Technical Chapters Meeting (ETCM)*, *IEEE*, Ecuador. https://doi.org/10.1109/ETCM.2017.8247516

Saarni, L, Nygård, C.H., Kaukiainen, A., Rimpelä, A. (2007). Are the desks and chairs at school appropriate?. *Ergonomics,* 50(10): 1561 – 1570. https://doi.org/10.1080/00140130701587368

Shah, R.M., Bhuiyan, M.A.U., Debnath, R., Iqbal, M., Shamsuzzoha, A. (2013). Ergonomics issues in furniture design: a case of a tabloid chair design. In *Advances in Sustainable and Competitive Manufacturing Systems: 23rd International Conference on Flexible Automation & Intelligent Manufacturing*, *International Publishing*. https://doi.org/10.1007/978-3-319-00557-7_8

Taifa, I.W., Desai, D.A. (2017). Anthropometric measurements for ergonomic design of students' furniture in India. *Engineering science and technology, an international journal*, 20(1), 232 – 239. https://doi.org/10.1016/j.jestch.2016.08.004

Thariq, M.M., Munasinghe, H.P., Abeysekara, J.D. (2010). Designing chairs with mounted desktop for university students: Ergonomics and comfort. *International Journal of Industrial Ergonomics*, 40(1): 8 – 18. https://doi.org/10.1016/j.ergon.2009.10.003

Trevelyan, F.C., & Legg, S.J. (2011). Risk factors associated with back pain in New Zealand school children. *Ergonomics*, 54(3), 257-262. https://doi.org/10.1080/00140139.2010.547608

Ziefle, M. (2003). Sitting posture, postural discomfort, and visual performance: a critical view on the interdependence of cognitive and anthropometric factors in the VDU workplace. *International Journal of Occupational Safety and Ergonomics*. 9(4): 503 – 514. https://doi.org/10.1080/10803548.2003.11076586

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Full access to data on request.

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