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Ergonomic Suitability of Library Readers' Furniture in a Nigerian University

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Abstract: *The use of library reading rooms is considered an important academic activity especially in a University environment and poorly-designed furniture may affect the benefits of using the library. The study aimed to evaluate the ergonomic suitability of reading room furniture at the main library of the Federal University of Technology, Akure, Nigeria. 184 students (92 males and 92 females) participated in the study. The anthropometric measures of the students were obtained using the traditional methods well reported by previous researchers and the results were compared with those of the furniture dimensions available at the library. A high level of mismatch was recorded particularly with the seat heights, seat depth and seat-desk height. In fact, only about 13.3% of the participants found seats with matching height and depth for one set of furniture and about 3.0% for another set of furniture. The nature of library furniture is highly connected with deriving maximum benefit from using a library; therefore, the furniture should fit the users as much as possible.*

Keywords*: anthropometric measures, ergonomics, furniture mismatch, library, musculoskeletal disorder.*

1. INTRODUCTION

An important objective of an ergonomic seat is to provide not only the primary function of sitting but also to ensure user's comfort and improve performance because productive output on a task is related to the level of comfort felt during the task [1]. The use of ill-fitted furniture predisposes users to negative effects [2] which are preventable through the adoption of right sitting postures [3] on well-designed seats. This problem, rampant in developing and underdeveloped countries, is attributable to the use of poorly designed and consequently unfit furniture [4]. It is important that furniture be designed to suit the end users [5]. This is applicable to the University environment because repetitive strain injuries which may occur from poor sitting postures not only affect primary school children and teenagers but are also appearing in college students [6].

The nature of activities performed with a furniture, the anthropometric data of the user, the design of the furniture [7, 8] as well as the individual's postural habits [9] all influence the sitting posture of a student. Ergonomic designs which suit users and reduce discomfort resulting from use rely on the anthropometric measurements of the end-user [10]. Unfortunately, there is need for anthropometric studies and information on the ergonomic suitability of educational furniture for students, especially in the higher institutions of learning in Nigeria [11], given that significant levels of mismatch exist between these furniture dimensions and the anthropometric measures of the users [12].

The anthropometric dimensions necessary for designing an ergonomic furniture include popliteal height (PH), buttock-popliteal length (BPL), knee height (KH), elbow-seat height (EHS), shoulder height (SHH), hip width (HW), thigh thickness (TT) [2, 6, 10–14]. Mismatch between furniture dimensions and these anthropometric dimensions can affect learning activities such as writing, reading and typing; causing pain in the back, shoulders, neck, legs and eyes [2, 15–17]. Mismatches between the human anthropometric measures and equipment, tools and furniture, also has the tendency of resulting in decline in productivity, discomfort, accidents, biomechanical stresses, fatigue, injuries, and cumulative traumas [18].

Therefore, the aim of this study is to obtain anthropometric data of students of the University, compare same with the dimensions of the furniture present at the University library and to determine the level of match/mismatch between the furniture dimensions and the anthropometric measures of the study population.

2. METHOD

A total of one hundred and eighty-four (184) students (92 males and 92 females) participated in the study. The

sample size was determined using the seating capacity of the reading rooms and a sample of convenience was used to select participants [11]. The sample size was obtained from equation 1 as presented in [2, 11–12, 19]. The reading rooms have a combined sitting capacity of about 336. The level of precision is ±5%. Therefore, applying Equation 1, the sample size was obtained as 183 students.

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

where n is the sample size to be determined, N is the population size, e is the level of precision.

Anthropometric dimensions were measured with a portable anthropometer with the exception of the standing height (stature) which was measured with a stadiometer. The classroom furniture dimensions were taken using a metal tape.

2.1 Furniture Dimensions at the University library

Three types of seats and the same table type exist in the library of the Federal University of Technology, Akure. The furniture dimensions are shown in Table 1.

Table 1: Dimensions of Library furniture

Furniture dimension (cm)	Type 1 (cm)	Type 2 (cm)	Type 3 (cm)
Seat height (SH)	43.8	46.5	45
Seat depth (SD)	42.5	40.5	40.5
Seat width (SW)	44	45	38
Backrest height (BRH)	36	49.5	42
Seat-desk height (SDH)	32.4	29.7	31.2
Seat-desk clearance (SDC)	16.2	13.5	15

The furniture dimensions are defined as presented by [6, 11, 17, 20].

2.2 Applications of the Measures and Criterion Inequalities

The anthropometric measures used in the present study are as defined by ISO 7250, 1996, and reported by [19-20]. The measurements were carried out in accordance with measurement techniques already reported by previous researchers.

The popliteal height was used to determine the level of mismatch of the seat height according to Inequality (2) adapted from [2, 21 – 22].

$$0.88PH \leq SH \leq 0.95PH \quad (2)$$

The buttock-popliteal length was used to determine the level of mismatch of the seat depth with respect to Inequality (3) adapted from [2, 12, 21 – 23].

$$0.80BPL \leq SD \leq 0.95\ BPL \quad (3)$$

The level of mismatch between the seat width and the hip width of students was determined using Inequality (4), adapted from [13].

$$HW < SW \quad (4)$$

Shoulder height and backrest height of the seats were also analysed to determine the level of mismatch according to Inequality (5) adapted from [6, 23].

$$0.6\ SHH \leq BRH \leq 0.8\ SHH \quad (5)$$

Furthermore, the thigh thickness was used to determine the level of mismatch of the seat-desk clearance according to Inequality (6) adapted from [13].

$$TT + 2 < SDC \quad (6)$$

And finally, the elbow height was used to test the level of mismatch of the seat-desk height according to the criterion Inequality (7) adapted from [13].

$$EHS \leq SDH \leq EHS + 5 \quad (7)$$

3. RESULTS AND DISCUSSIONS

The anthropometric measures of the study sample are shown in Table 2. The result is expressed as minimum and maximum values as well as the median values, the mean and standard deviations of anthropometric measures of the study sample.

Table 2: The anthropometric measures of the participants in the study

Anthropometric measure	Male				Female			
	Min	Max	Median	Mean±SD	Min	Max	Median	Mean±SD
Shoulder height (SHH)	44.0	63.0	56.0	55.9±3.8	44.0	60.0	52.0	52.2±3.1
Elbow height (EHS)	11.4	25.0	18.0	18.2±3.4	11.0	30.0	17.0	17.6±3.9
Knee height (KH)	43.0	69.0	56.0	55.7±4.1	44.3	60.0	51.0	51.7±3.7
Popliteal height (PH)	37.0	55.0	45.0	44.9±2.9	38.5	50.0	43.0	43.1±2.3
Buttock-popliteal length (BPL)	41.2	59.0	48.0	48.5±3.2	40.0	53.0	46.0	46.4±2.6
Hip width (HW)	22.0	38.0	30.5	30.7±2.6	23.0	43.5	34.0	33.9±3.9
Thigh thickness (TT)	9.5	18.0	13.7	13.3±1.9	8.5	19.0	13.0	12.9±2.0
Sitting height (HS)	37.4	91.0	81.0	81.0±5.9	53.0	87.0	76.7	76.8±4.5

Shoulder breadth (SB)	30.4	49.0	42.0	41.6±3.3	33.0	49.0	39.0	39.4±2.9
Body weight (BW)	41.0	104.0	65.0	65.3±9.1	41.0	90.0	58.0	59.5±9.6
Stature (STA)	146.0	190.0	172.0	172.3±7.4	148.0	174.0	163.0	162.5±5.3

All dimensions are in centimetres (cm)
Min=minimum; Max=maximum; SD=standard deviation

The following result [Table 3] was obtained by applying Inequalities 2-7. Results for furniture dimensions obtained with the use of the two-way Inequalities (2, 3, 5 and 7) are interpreted as a 'match' (when furniture dimension is between the lower and upper limits of the criterion inequality), a 'low mismatch' (when furniture dimension is lower the lower limit of the criterion inequality) or as a 'high mismatch' (when furniture dimension is higher than the upper limit of the criterion Inequality) [12–13] while results for dimensions obtained with the one-way Inequalities (4 and 6) are defined as either a 'match' (when anthropometric measure is less than furniture dimension) or a 'mismatch' (when anthropometric measure is higher than furniture dimension).

For the Type 1 furniture combinations, the study reveals that 17.2% of the males had their popliteal height match with the seat height. For females, the match level is 11.5%. 78.8% of the males and 87.5% of the females had seats too high and 4.0% of the males and 1.0% of the females found the seats too low, according to the study. The seat depth matched the buttock-popliteal length of a large number of the study participants. It was too shallow for 7.1% and 0% of males and females respectively and too deep for 7.1% and 19.8% of males and females respectively. The seat-desk height recorded a very high level of mismatch – being too high for all the males and 99.0% of the females.

Table 3: Levels of match/mismatch of furniture dimensions with anthropometric measures of the study participants

Furniture dimensions	**Male**			**Female**		
	Type 1	Type 2	Type 3	Type 1	Type 2	Type 3
Seat height (SH)	17.2% match; 78.8% high mismatch; 4.0% low mismatch	9.1% match; 90.9% high mismatch	14.1% match; 83.8% high mismatch; 2.0% low mismatch	11.5% match; 87.5% high match; 1.0% low mismatch	1.0% match; 99% high mismatch	3.1% match; 96.9% high mismatch
Seat depth (SD)	85.9% match; 7.1% high mismatch; 7.1% low mismatch	80.8% match; 2.0% high mismatch; 17.2% low mismatch	80.8% match; 2.0% high mismatch; 17.2% low mismatch	80.2% match; 19.8% high mismatch	88.5% match; 5.2% high mismatch; 6.3% low mismatch	88.5% match; 5.2% high mismatch; 6.3% low mismatch
Seat width (SW)	100% match	100% match	98.0% match; 2.0% mismatch	100% match	100% match	90.6% match; 9.4% mismatch
Backrest height (BRH)	72.7%match; 17.7% high mismatch	5.1% match; 94.9% low mismatch	94.9% match; 5.1% low mismatch	97.9% match; 1.0% low mismatch; 1% high mismatch	100% low mismatch	42.7% match; 57.3% low mismatch
Seat-desk height (SDH)	100% high mismatch	97.0% high mismatch; 3.0% match	100% high mismatch	1.0% match; 99.0% high mismatch	5.2% match; 94.8% high mismatch	2.1% match; 97.9% high mismatch
Seat-desk clearance (SDC)	72.7% match; 27.3% mismatch	8.1% match; 91.9% mismatch	37.4% match; 62.6% mismatch	68.7% match; 31.3% mismatch	21.9% match; 78.1% mismatch	44.8% match; 55.2% mismatch

For the Type 2 furniture combinations, 9.1% of the males had their popliteal height match with the seat height. For females, the match level is 1.0%. 90.9% of the males and 99.0% of the females had seats too high, the study reveals. The seat depth matched the buttock-popliteal length of a large number of the study participants. It was too shallow for 17.2% and 6.3% of males and females respectively and too deep for 2.0% and 5.2% of males and females respectively. The seat-desk height recorded a very high level of mismatch – being too high for 97.0% of the males and 94.8% of the females.

For the Type 3 furniture combinations, 14.1% of the males had their popliteal height match with the seat height. For females, the match level is 3.1%. 83.8% of the males and 96.9% of the females had seats too high with an additional 2.0% of the males finding the seats too low for their anthropometric measures. The seat depth matched the buttock-popliteal length of a large number of the study participants – 80.8% males and 88.5% females. It was too shallow for 17.2% and 6.3% of males and females respectively. The seat-desk height was found to be too high for all the males and 97.9% of the females, according to the study.

Due to the small under-desk clearance, a high level of mismatch for seat-desk clearance was also recorded across all furniture types. The seat width matched almost all the participants across the furniture types except in the Type 3 furniture combination where a mismatch was found for 9.4% of the females. Seat-desk clearance was found to be grossly inadequate across board.

The match levels for a two-way combined analysis of furniture dimensions (seat height and seat depth) are also shown [Table 4].

Table 4: Combined analysis of seat height (SH) and seat depth (SD) for the study participants.

	Seat Height (SH)					
Seat Depth (SD)	Type 1		Type 2		Type 3	
	Male (%)	Female (%)	Male (%)	Female (%)	Male (%)	Female (%)
	15.2	11.5	1.0	0	5.1	1.0

For the Type 1 furniture combination, only 15.2% of the male participants and 11.5% of the females had seats that matched their popliteal height and buttock-popliteal length. This is equivalent to 13.3% of the total population studied. For the Type 2 furniture combination, 1.0% of the males had a match with the furniture dimensions. No female had a seat with matched dimensions as the anthropometric measures. Finally, with the Type 3 furniture, 5.1% of the males and 1.0% of the females (equivalent to 3.0% of the total study population) had matched anthropometric-furniture dimensions. When a similar analysis of seat height and seat-desk height was performed, not a single participant could find a match. In other words, none of the participants had a seat height and a seat-desk height that matched when considered at once.

As revealed from the results of the present study, many students are sitting on seats that are too high for their popliteal height and either too deep or too shallow for their buttock-popliteal length. The implication of such furniture mismatches is well documented in literature. According to a previous study [2], when seating surfaces are too high, it causes discomfort and impaired blood circulation around the thighs. The user often has to move forward on the seat as a compensatory measure, thus, assuming a kyphotic posture due to lack of back support. When a seat is too low, the weight of the user is transferred to a small area of the ischial tuberosities resulting in an uneven distribution of pressure over the posterior thigh.

Seats that are too deep for a user usually result in reduced blood flow to the legs and feet because the front edge of the seat presses against the back of the knee. If the user moves forward on the seat as a compensatory measure, a kyphotic posture results. On the other hand, when seat depth is too shallow, there is a lack of support for the lower part of the thighs [14]. Furniture with ill-fitted seat-desk clearance also presents a problem. Usually, the user will lean forward to use the desk, again resulting in a kyphotic posture. With desk heights that are higher than the elbow rest height, the user ends up raising the shoulders to use the desk. This puts excess pressure on the shoulders and result in pain and discomfort.

The use of poorly designed furniture will require greater muscular force and control to maintain stability and equilibrium [2], and often results in discomfort (in the form of irritation) as well as pain on the back and neck and even an alteration in the normal posture of the individual. Conversely, maintaining an upright sitting posture is beneficial to the back muscles [21] just as much as well-fitting reading room furniture will improve comfort and facilitate learning [4, 21].

4. CONCLUSION

Although the present study did not attempt to establish a relationship between furniture suitability and use of the library for studying by the students, it may be concluded that the ergonomic non-suitability of the furniture may be implicated in a case of low library usage by the students as revealed by personal communications between the authors and some of the participants. It is therefore suggested that policy makers put into consideration the anthropometric measures of users in furniture designs and specifically library room furniture to ensure that the users do not suffer musculoskeletal disorders as a result of library usage.

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