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Evaluation of Library Furniture and Anthropometric Characteristics of St. Mary's Students for Ergonomics Design of Table and Chair

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Abstract: *As the design of a workstation can have significant effects on user fatigue, safety and user performance, ensuring that the workstations used in any work systems are agreeable with the principles of anthropometrics have become so important. In this research, a library furniture set (table and chair for student) currently used at a Main Library, St.Maty's Engineering College, has been evaluated. The study evaluated the potential mismatch between library furniture dimensions and anthropometric characteristics of St. Mary's students (50 females, 76 males) randomly selected, aged 18-35 years. Thirteen anthropometric measurements of students (Stature, Hip breadth, Mid-shoulder sitting height, Elbow rest height, Sitting height, Buttock-popliteal length, Buttock-knee length, Buttock-toe length, Popliteal height, Thigh clearance, Eye height sitting, Shoulder, Knee height) and five chair dimensions (Chair seat height, Chair seat depth, Chair seat width, Chair backrest height, Back rest width) from the existing library furniture were measured and then compared together (using match criterion equations) and also to identify any potential mismatch between them. The results indicated an all mismatch between body dimensions of the students and the existing library furniture. Also, the data collected was analyzed using descriptive statistics such as means, standard deviations, fifth, fiftieth and ninety fifth percentiles for the table and chair dimensions and student's body dimensions were calculated using Excel Microsoft Package. Moreover, the data obtained from the student's body dimensions was compared with the relevant dimensions of the furniture using independent samples t-test (2-tailed) and chi-square test at 95 percent level of confidence. Again, the results showed a degree of mismatch between the student's body dimensions and furniture dimensions. This may be an indication that the dimensions of locally manufactured library furniture and student's anthropometric dimensions are at variant. It was thus concluded that the anthropometric dimensions of the st.mary's students were not employed in the design and manufacturing of library furniture. The proposed dimensions of the library furniture more appropriate for the students were given.*

Keywords: *Library furniture, table, chair, anthropometric dimensions, ergonomics, mismatch, t-test, chi-square test.*

1. Introduction

Providing a workstation that fits with users' anthropometry in order to encourage better or the so-called natural working posture is usually one of the major objectives in ergonomics application. In many universities, students have been known to spend long period of time in classroom and library, staying in static sitting posture. Prolong sitting is one well known risk factor to the development of musculoskeletal disorders (both biomechanically and physiologically), particularly in the area of lower back. Usually change in posture is recommended in prolonged sitting. The presence of musculoskeletal symptoms in adolescence has been shown to be a significant risk factor for such symptoms in adulthood [1, 2]. Correct standing and sitting posture is considered as an important factor for the prevention of musculoskeletal problems [3].

Although many researchers investigated prolonged sitting in the work place and proposed well-design for seats and desks, purchasing off-the-shelf is what we found in many universities around the country. Therefore, the compatibility of these furniture dimensions to students' body dimensions is questionable and students may pose with discomfort feeling[4].

The use of appropriately designed furniture may leads to reduced fatigue and discomfort in the sitting posture [5].The use of poorly designed furniture that fails to accommodate the anthropometric characteristics of its user have a negative influence on human health.

Anthropometric measurements are therefore an important consideration in designing ergonomically appropriate furniture for students.

2. Materials and Methods

Our sample included 126St.mary's students (50 females, 76 males) randomly selected, aged 18-35 years, studying at St.Maty's Engineering College.

All anthropometric measurements, except for stature, were collected while each student was sitting in an erect position on chair with a horizontal surface, with knees bent at 90º. Measurements were taken in centimeter. During the measurements, the student was wearing shoes and military uniform clothing and all the body dimensions were taken only from the right side of their body.

Thirteen anthropometric measurements of students (Stature, Hip breadth, Mid-shoulder sitting height, Elbow rest height, Sitting height, Buttock-popliteal length, Buttock-knee length, Buttock-toe length, Popliteal height, Thigh clearance, Eye height sitting, Shoulder, Knee height)these measurements were recorded during a single session, and five chair dimensions (Chair seat height, Chair seat depth, Chair seat width, Chair backrest height, Back rest width)and four table dimensions (Table height, Underneath table height, Table width, Table depth)from the existing library furniture were measured. Illustration of the selected anthropometric variables shown in, Fig. 1.

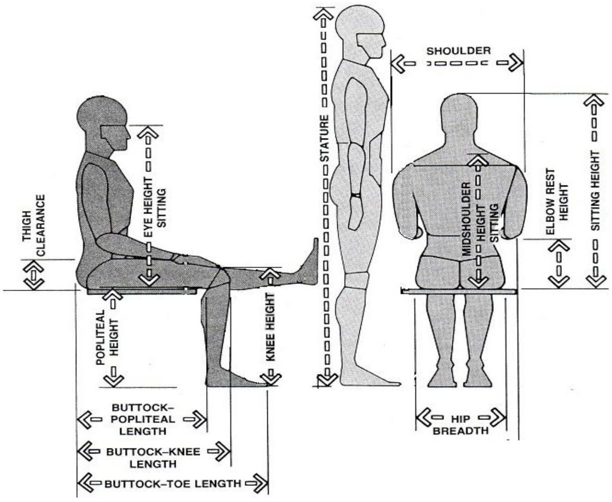

Fig1. *Illustration of selected anthropometric variables*

The measurement equipment consisted of set squares, bevel protractor, ruler, vernier calliper, a measuring tape and fixed measurement scale for stature. The measurements (including thirteen anthropometric measures and five chair dimensions and four table dimensions of the library furniture) were carried out by two members. The demographic details such as the region, age, gender and year level of each participating student were also collected.

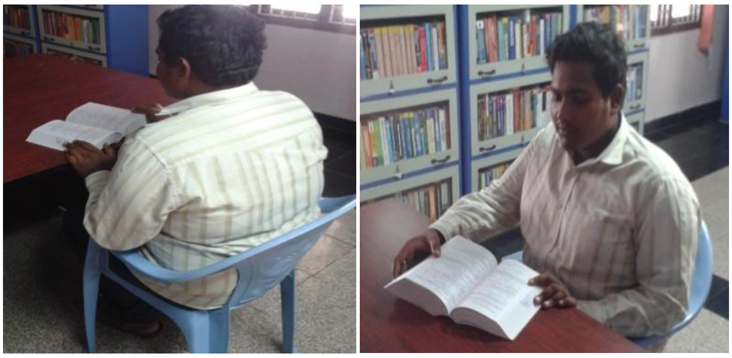

Fig2. *Usage of existing chair and table in the library*

3. Results and Discussion

There are enormous variations in body size among individuals. The body dimension should match with furniture, equipment etc in a workstation. On the other hand, any mismatch in the work environment leads to users' discomfort, low productivity, work hazards, and accidents. So, it can be said that body dimensions of students are important for the design of furniture, particularly which are used in schools. [23].

3.1. T-Test Analysis

The t-test was used to assess whether the means of the seat dimensions and the means of the related anthropometric dimensions of passengers are statistically different. The t-values were calculated with the following formula [24] and the calculated values were compared with the critical t-value.

$$t = (\bar{X}_2 - \bar{X}_2) \div \sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}} \quad (1)$$

Where: t =t- statistic, $\overline{X_1}$= sample-1 mean, $\overline{X_2}$= sample-2 mean, S_1= sample-1 standard deviation, S_2= sample-2 standard deviation, n_1 =number of sample-1 andn_2 = number of sample-2

The analysis by using the t-test of chair seat dimensions, table dimensions, and students' anthropometric dimensions were calculated using (1) shows in Tables II and III respectively.

3.2. Chi-Square Statistic *(χ^2)*

The chi-square test was used to evaluate whether there is an association between the dimensions of the seats and the anthropometric dimensions of the passengers. The chi-square statistic values are calculated with the following formula [24].

$$\chi 2 = \sum_{i=1}^{k} \frac{(\text{Observed} - \text{Expected})_i^2}{(\text{Expected})_i} \quad (2)$$

Where: χ^2= chi-square statistic, $\sum$ = sum of k-numbers

The chi-square statistic (χ^2) values for related anthropometric dimensions, chair seat dimensions, and table dimensions are calculated in Tables IV and V respectively.

Therefore, these results clearly suggest that the design and allocation of library furniture for university students based on anthropometric data is a major consideration to promote a correct sitting posture and consequently reduce musculoskeletal problems among this group. Thus, the findings from this study provide some useful contributions to our understanding of students' anthropometry that can be used as a basis for designing library and furniture. It has been noted that the seat height should be considered as the most important variable and the starting point for the design of the library chair furniture [9, 22].

TableI. *Statistics of the Student's Anthropometric Measurements*

Anthropometric dimension	Mean (cm)	SD (cm)	Minimum (cm)	Maximum (cm)	5th percentile (cm)	50th percentile (cm)	95th percentile (cm)
Buttock- knee length	61.50	3.38	51	73	56	62	79
Buttock- popliteal length	52.47	3.45	44	63	46.5	53	67
Buttock- toe length	73.78	4.88	53	84	67	74	81
Elbow rest height	19.82	2.38	14.5	26	16	19.5	24.5
Eye height sitting	71.77	4.48	54	82.5	65.5	72	79
Hip breadth	39.83	3.19	33	49	35	40	45
Knee height	56.27	2.87	49.5	63	51	57	60.5
Mid shoulder sitting height	58.63	3.45	49	67	53	59	64
Popliteal height	46.61	2.33	42	50.5	42.7	46.5	50.3
Shoulder	47.25	3.43	35	56	42	47	52
Sitting height	83.42	4.34	68	96	78	83	90
Stature	170.75	7.31	154.5	185.3	157.69	171.3	182.6
Thigh clearance	16.78	1.87	13	22	14	17	20

TableII. *T-Test Analysis Of Chair Seat Dimensions And Students Anthropometric Dimensions*

Anthropometric Dimensions (n_1=121)			Chair seat Dimensions (n_2=3)			Difference	t_{cal}	t_{cri}	Decision
	Mean	SD		Mean	SD				
Popliteal height(PH)	46.61	2.33	Chair Seat Height (CSH)	48.73	2.66	-2.12	-1.36	0.216	Reject
Buttock-popliteal	52.47	3.45	Chair Seat Depth (CSD)	40.56	1.96	11.91	10.14	0.216	Reject

length(BPL)									
Hip breadth(HB)	39.83	3.19	Chair Seat Width (CSW)	41.50	0.707	-1.67	-3.34	0.216	Reject
Mid shoulder sitting height (SSH)	58.63	3.45	Chair Backrest Height (CBH)	40.33	3.27	18.3	9.58	0.216	Reject
Shoulder(S)	47.25	3.43	Back rest width(BRW)	31.33	6.79	15.92	4.05	0.216	Reject
Note: t cal. - Calculated t-value, t cri. - Critical t-value.									

TableIII. *T-Test Analysis of Table Dimensions And Students Anthropometric Dimensions*

Anthropometric Dimensions (n_1=121)			Table Dimensions (n_2=4)			Difference	t_{cal}	t_{cri}	Decision
Dimension	**Mean**	**SD**	**Dimension**	**Mean**	**SD**				
Popliteal height + Elbow rest height (PH + ERH)	66.43	4.71	Table Height (TH)	76.15	1.08	-9.72	-14.1	0.711	Reject
Knee height + clearance (KH + C(10 cm)	66.27	2.87	Underneath Table Height (UTH)	66.80	4.02	-0.53	2.02	0.711	Reject

TableIV. *Chi-Square Statistic for Related Anthropometric Dimensions and Chair Seat Dimension*

Anthropometric dimensions and Chair seat dimensions	Values	Percentile			Total $\chi^2 = \sum(O_i - E_i)^2 \div E_i$	Critical value of χ^2 (d.f.=2)	Decision
		5th	**50th**	**95th**			
Popliteal height(PH) and Chair Seat Height (CSH)	Observed values (O)	42.7	46.5	50.3	0.40	0.103	Reject
	Expected values (E)	46.73	47	51.95			
	$(O_i - E_i)^2 \div E_i$	0.3475	0.0053	0.0524			
Buttock-popliteal length(BPL) and Chair Seat Depth (CSD)	Observed values (O)	46.5	53	67	19.38	0.103	Reject
	Expected values (E)	38.65	40	42.88			
	$(O_i - E_i)^2 \div E_i$	1.5943	4.225	13.5675			
Hip breadth(HB) and Chair Seat Width (CSW)	Observed values (O)	35	40	45	1.06	0.103	Reject
	Expected values (E)	41	41	42.35			
	$(O_i - E_i)^2 \div E_i$	0.8780	0.0243	0.1658			
Mid shoulder sitting height (SSH) and Chair Backrest Height (CBH)	Observed values (O)	53	59	64	25.13	0.103	Reject
	Expected values (E)	36.85	40	44.05			
	$(O_i - E_i)^2 \div E_i$	7.0779	9.025	9.0352			
Shoulder(S) and Back rest width(BRW)	Observed values (O)	42	47	52	25.72	0.103	Reject
	Expected values (E)	23.2	34	37.6			
	$(O_i - E_i)^2 \div E_i$	15.2344	4.9705	5.5148			

TableV. *Chi-Square Statistic for Related Anthropometric Dimensions and Table Dimension*

Anthropometric dimensions and Chair seat dimensions	Values	Percentile			Total $\chi^2 = \sum(O_i - E_i)^2 \div E_i$	Critical value of X^2 (d.f.=3)	Decision
		5th	**50th**	**95th**			
Popliteal height + Elbow rest height (PH + ERH)and Table Height (TH)	Observed values (O)	58.7	66	74.8	4.99	0.352	Reject
	Expected values (E)	75.26	75.7	77.67			
	$(O_i - E_i)^2 \div E_i$	3.6438	1.2429	0.1060			
Knee height + clearance (KH + C(10 cm)) and Underneath Table Height (UTH)	Observed values (O)	61	67	70.5	1.89	0.352	Reject
	Expected values (E)	69.93	66.85	63.6			
	$(O_i - E_i)^2 \div E_i$	1.1403	0.00030	0.7485			

4. Conclusion

The present study was able to establish a picture of mismatch between body dimensions of St.mary's students and existing library furniture's may be a pointer to the effect that in the design of tables and chairs for use in higher institutions, the anthropometric data of the St.mary's students were probably not considered. The chairs and tables for use by the students in St. Mary's institutions were designed using the 'one-size-fits-all' approach, as adjustable furniture would increase the cost of production.

The study reveals that the mismatch of existing furniture among both is due to ignorance of anthropometric measurements of students during manufacturing of the furniture. Due to mismatch of furniture design with body dimensions of students faced posture related problems during studying in the library. Thus it is essential to make library furniture user friendly, designing each component of furniture by considering the body dimensions of user carefully.

Therefore, the furniture should be made on the basis of target population's anthropometric dimensions. Both optimization and design for average methods suggest no significant difference in design results. Thus, if anthropometric data is normal distributed, the easier and more convenient method of design for average should be utilized to define the furniture height[8]. Similarly, the table heights also support the use of fifth percentile value of elbow height distribution rather than mean value [2].

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