

Anthropometric Analysis of Classroom Furniture Used in Colleges

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Abstract—*Anthropometric considerations play an important role in improving the efficiency of a person. Anthropometry of users is important in designing the products which suit with the user. Seating furniture plays an important role in making the workplace comfortable and suitable for the users. In the present study the classroom furniture's of different colleges of Gulbarga were studied and analyzed on the basis of anthropometry of the students. A sample of 400 students (200 males & 200 females) ageing between 18 to 25 years were selected and analyzed on the basis of their anthropometry , it was found that the five different models of furniture used were made without any anthropometric considerations and were found to be incompatible with the user population. Some features like seat height, width etc were not as per the anthropometry of the students and also some of the benches used were even without any backrest.*

Keywords—*Anthropometric dimensions. Classroom furniture. Musculoskeletal disorders. Percentile. User population.*

I. INTRODUCTION

Efficiency of a person depends strongly on the fact that how comfortable a person is with the work environment and also the suitability of workstation with the user. Colleges are the places from where we get qualified and talented graduates which then help in building the nations. Therefore it is very important to make the classrooms in colleges comfortable and suitable for students, so that they can concentrate and evolve as talented individuals. A comfortable classroom environment improves the efficiency of students by encouraging and motivating them to perform better. Students spend a major time on the chair and desk during college hours, Hence it is necessary that the college furniture should fit the requirements of the students. Therefore , the college furniture should be made on the basis of anthropometric dimensions of the user.

Anthropometry of people differs not only from region to region but also with in the region as well therefore it is very essential to consider the anthropometry of users while designing any product to assure the suitability of product in order to improve the efficiency of students. It is difficult to design the seating furniture that suits every student but anthropometry considerations can increase the suitability of furniture with majority of the user populations. In a research work [1] it is seen that the anthropometric dimensions vary not only from region to region but within the region as well which must be considered while designing of furniture's.

It has been reflected in many studies that there is a mismatch between the classroom furniture dimensions and the anthropometric dimensions of the students. Literature in this issue points to various consequences like; back pain prevalence among the students, musculoskeletal discomfort and low back pain, biomechanical problems, awkward postures adopted for long periods of time affecting academic performance of students etc. The prime factor affecting students posture is related to the furniture used, but other factors are just as important as students anthropometric dimensions and furniture design, college organization (time scheduling), different tasks a student has to perform etc. Studies have also shown that being confined in awkward postures for specific task demand at a given situation or as influenced by bad designed furniture for a long duration provokes psychological stress and imposes ill effects on human performance [2]

Improper design of classroom furniture may result in lack of concentration leading to reduced efficiency and may cause future MSD's therefore this study was taken up to show the importance of anthropometric considerations in designing the classroom furniture.

II. METHODOLOGY

Present study was focused on the degree colleges of North Karnataka region to explore the types of classroom furniture used in different colleges and their suitability with the user populations.

In the present study the classroom furniture's of different colleges of Gulbarga and surrounding places were studied and analyzed on the basis of anthropometry of the students. A sample of 400 students (200 males & 200 females) ageing between 18 to 25 years from 4 different colleges were selected and analyzed on the basis of their anthropometry dimensions.

Based on literature survey, 13 most common anthropometry parameters which are most necessary in design of seating chairs, desks, tables etc. were selected and measurements were taken for each student, wearing clothes including their weight. Anthropometric characteristics were directly measured using an anthropometer, weight measurements using a weighing scale and other measurements using measuring tapes.

It was found that 5 different models of classroom furniture's were used which were studied to observe the design features viz., Dimensions and materials used. It was found that the furniture's being used were designed without considering the anthropometry of user population. Important dimensions of furniture were taken and analyzed by comparing with anthropometric dimensions of the students to check the suitability of design.

Measurement of body dimensions-

A sample of 400 students from different colleges were selected and analyzed based on their anthropometric dimensions. Among the 43 anthropometric dimensions only 13 dimensions which are relevant to the study were considered. Fig-1 shows the anthropometric dimensions considered for the study..

Anthropometric Data Of Students :Table-1

Data No.		University Reg. No.	
Date of Birth		Age	
Weight		Sex	

Anthropometric Data	Unit/cm	Anthropometric Data	Unit/cm
1.Stature		8.Hip breadth	
2.Shoulder Breadth		9.Elbow rest height	
3.Sitting Height		10.Buttock popliteal length	
4.Sitting eye height		11.Buttock knee length	
5.Sitting mid shoulder height		12.Vertical reach height sitting	
6.Popliteal height		13.Side Arm reach	
7.Knee height			

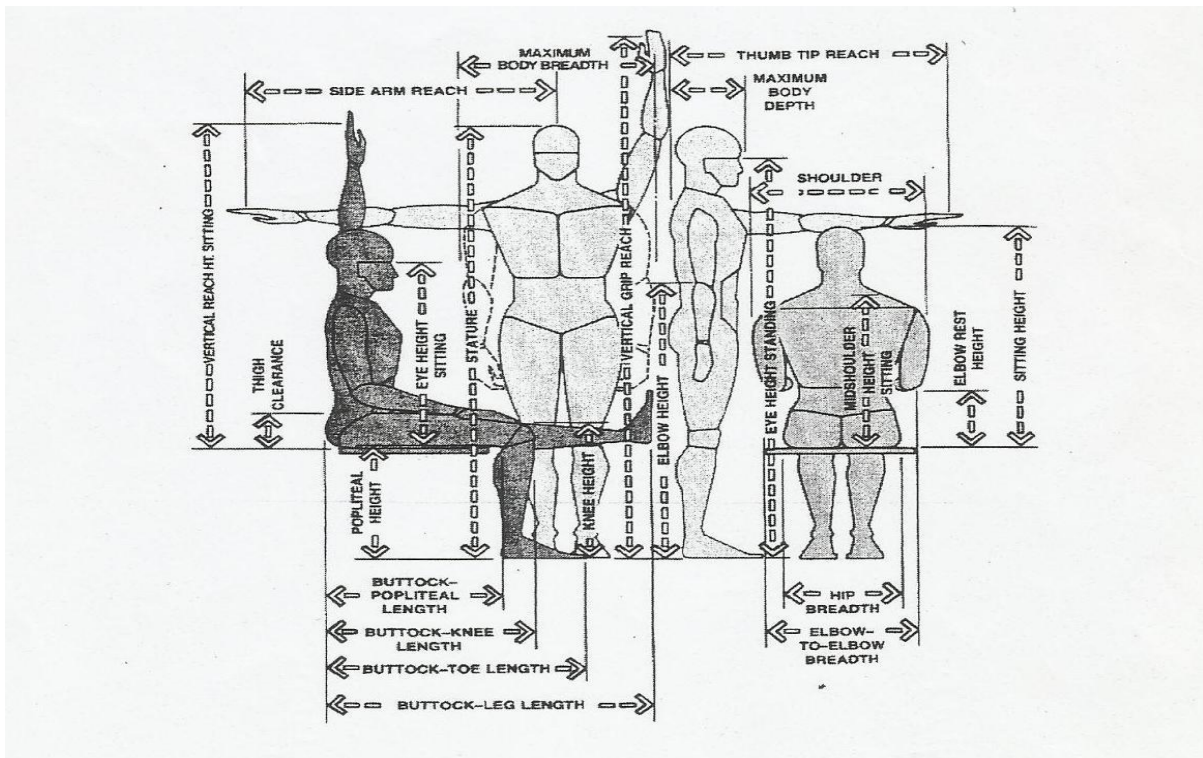


Fig-1 Anthropometric Data Of Students

The body dimensions of the students were taken as shown in above figure. The equipment used for that purpose was anthropometer .During measuring body dimensions under sitting condition, the subjects were asked to sit in such a way that the upper leg and lower leg remained at right angle to each other. The following anthropometric dimensions were taken for this study:

- **Stature:** Top of the head, standing in erect stretched posture.
- **Shoulder breadth:** Maximum horizontal distance across the shoulders, Breadth ensured to the protrusion of the deltoid muscles.
- **Sitting height:** Top of the head sitting in a normal relaxed posture.
- **Sitting eye height:** height of inner corner of the eye sitting in normal relaxed posture.
- **Sitting mid shoulder height:** Height of upper most point on the middle level of the shoulder.
- **Popliteal height:** Height of the underside of the thigh immediately behind the knee .
- **Knee height:** height of uppermost point on the knee.
- **Hip breadth:** Maximum horizontal distance across the hips.
- **Elbow rest height:** Distance between seat and lower most part of the elbow.

- **Buttock popliteal length:** Horizontal distance from the most posterior point on the uncompressed buttocks to the back of the lower leg at the knee.
- **Buttock knee length:** Horizontal distance from the most posterior point on the uncompressed buttocks to most anterior point on the knee.
- **Vertical reach height sitting:** Maximum vertical distance from mid shoulder to the centre of the hand grip.

For analyzing the design dimension of the school furniture and classroom layout, different percentile values of the measured body dimensions of the students were calculated. Three percentile values, viz., 5th, 50th and 95th, for each body dimension were computed with the help of standard statistical packages (SPSS & Excel). The anthropometric dimensions were compared with the relevant dimensions of the furniture's and were analyzed.

With the increase of age, development of skeletal system, muscular system, and other systems of the body occurs, and as a resultant effect anthropometric measures increase. So, it may be said that furniture of the same size will not fit the body dimension of students of all age groups. The results indicate the need for separate design of furniture for different age group. In designing for a known individual, one's own body dimensions may be measured and used. But for mass application the percentile values of a study population are usually required.

III. RESULTS AND DISCUSSION

An anthropometry study was carried out

- to study the anthropometric dimensions of the student population and generate data of the students
- to measure the dimensions of the various desks available in the class rooms
- to compare the dimensions of the desks with the anthropometric measures of students
- to find out any mismatch between the anthropometric dimensions and the student desks used
- to suggest suitable corrective measures in the design.

Different anthropometric dimensions were measured in different age (grade) groups. A total 400 cases (200 boys and 200 girls) were selected and anthropometric data were measured and analyzed in these students. The age of the students was between 18 to 25 yr. Tables show anthropometric data measured in these students as well as key percentiles (5th, 50th, 95th) used for furniture design. The average of different dimensions between boys and girls were compared. The percentile values obtained were considered for analysis of anthropometry of students and compared with the furniture design dimensions to check the compatibility of the furniture designs used.

Anthropometric dimensions of students and their percentile values:									
R.NO.	PARAMETERS	GEN	MIN	PERCENTILES			MAX	MEAN	± SD
				5 TH	50 TH	95 TH			
1	WEIGHT (kg)	MALE	45	48	68	72	84	65.79	7.54
		FEMALE	35	38.95	47	58	84	47.25	6.13
		COMBINED	35	40	53.5	72	84	56.52	11.55
2	STATURE	MAE	152	155	168	175	182	167.19	5.48
		FEMALE	141	143.99	152.15	162.31	169	154.43	6.55
		COMBINED	141	147.19	161.2	172	182	160.8	8.78
3	SHOULDER BREADTH	MALE	38	39	46	49	52	44.4	3.08
		FEMALE	26.88	29.3	37.2	41.39	42.5	36.53	3.81
		COMBINED	26.88	31.3	40.5	48	52	40.47	5.25
4	SITTING HEIGHT	MALE	77	79	85	90	91	84.77	3.38
		FEMALE	60.9	66.02	71.6	79.5	80.6	73.13	4.73
		COMBINED	60.9	67.78	79.06	90	91	78.95	7.12
5	SITTING EYE HEIGHT	MALE	17	68	74	79	79	73.39	5.574
		FEMALE	37.2	55.5	61.28	69.4	79.8	60.54	4.57
		COMBINED	17	55.5	68	79	79.8	66.96	8.2
6	MID SHOULDER HEIGHT	MALE	38	53	61	68	73	61.31	4.69
		FEMALE	40.1	46.6	48.5	55.8	67.7	49.19	3.9
		COMBINED	38	46.6	54.1	67.16	73	55.24	7.44
7	POPLITEAL HEIGHT	MALE	32	36	41	46	67	41.76	3.42
		FEMALE	30	34	38	44	63	40	3
		COMBINED	32	34	40	45	64	41	3.2

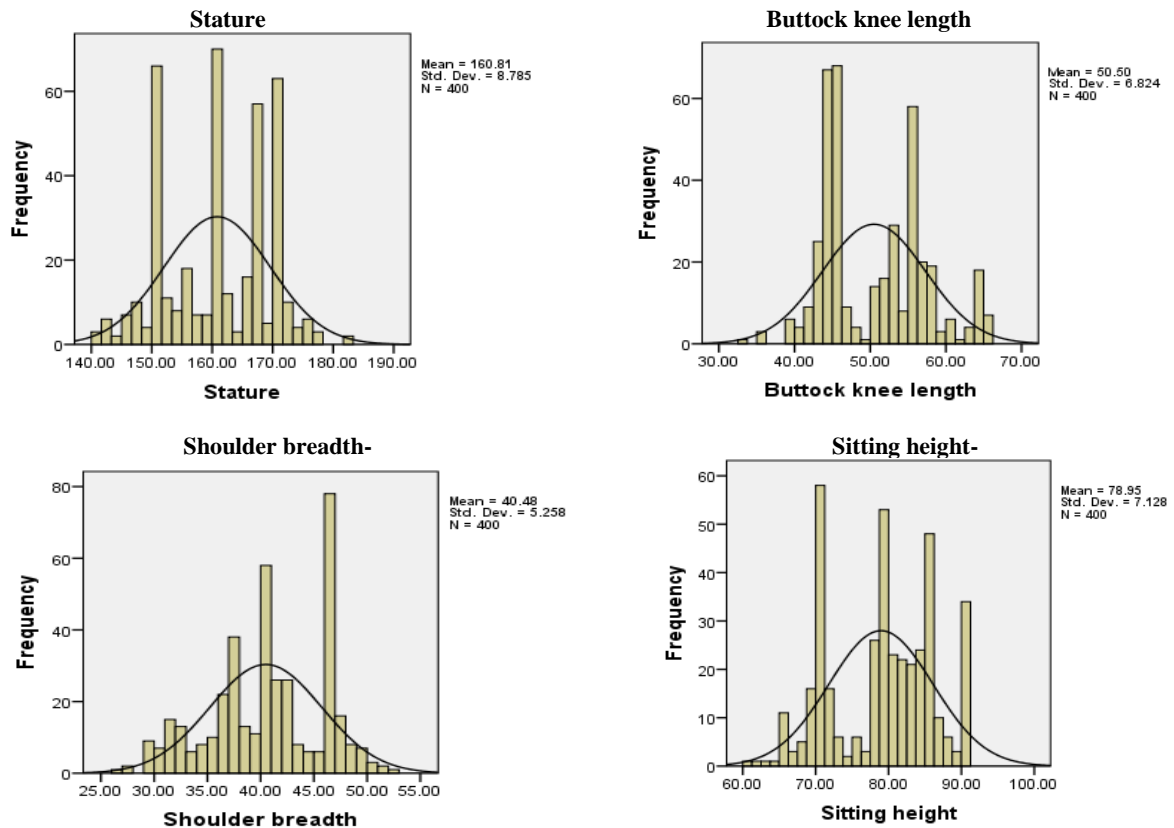
8	KNEE HEIGHT	MALE	43	44	50	54	58	49.66	3.29
		FEMALE	32.1	39	44.8	47.8	95.5	44.7	4.94
		COMBINED	32.1	39.8	47.4	54	95.5	47.16	4.88
9	HIP BREADTH	MALE	28	30	35	38	41	34.97	2.54
		FEMALE	26.2	31.3	33.72	38.4	43.6	33.82	2.85
		COMBINED	26.28	30	34	38.4	43.6	34.39	2.76
10	ELBOW REST HEIGHT	MALE	17	18	21	25	27	21.6	2.35
		FEMALE	19.01	20.16	24.09	28.6	36.8	24.45	3.04
		COMBINED	17	19	22.5	28.6	36.8	23.02	3.06
11	BUTTOCK POPLITEAL LENGTH	MALE	40	42	46	50	53	46.39	2.31
		FEMALE	21.2	35.99	42.5	45.6	48.4	41.53	3.5
		COMBINED	21.2	37.1	44.8	49	53	43.95	3.83
12	BUTTOCK KNEE LENGTH	MALE	50	51	56	64	65	56.5	3.9
		FEMALE	32.6	40.51	44.8	47.04	52.6	44.48	2.35
		COMBINED	32.6	41.785	50.5	64	65	50.49	6.82
13	VERTICAL REACH HEIGHT SITTING	MALE	120	123	131	135	142	130.4	3.76
		FEMALE	95.2	100.8	106.2	118.3	120.1	109.18	6.76
		COMBINED	95.2	100.89	120.1	134	142	119.81	11.97
14	SIDE ARM REACH	MALE	78	79	85	89	94	84.5	3.06
		FEMALE	70	73	79	85	87	78.43	4.3
		COMBINED	70	74	83	88	94	81.5	4.84

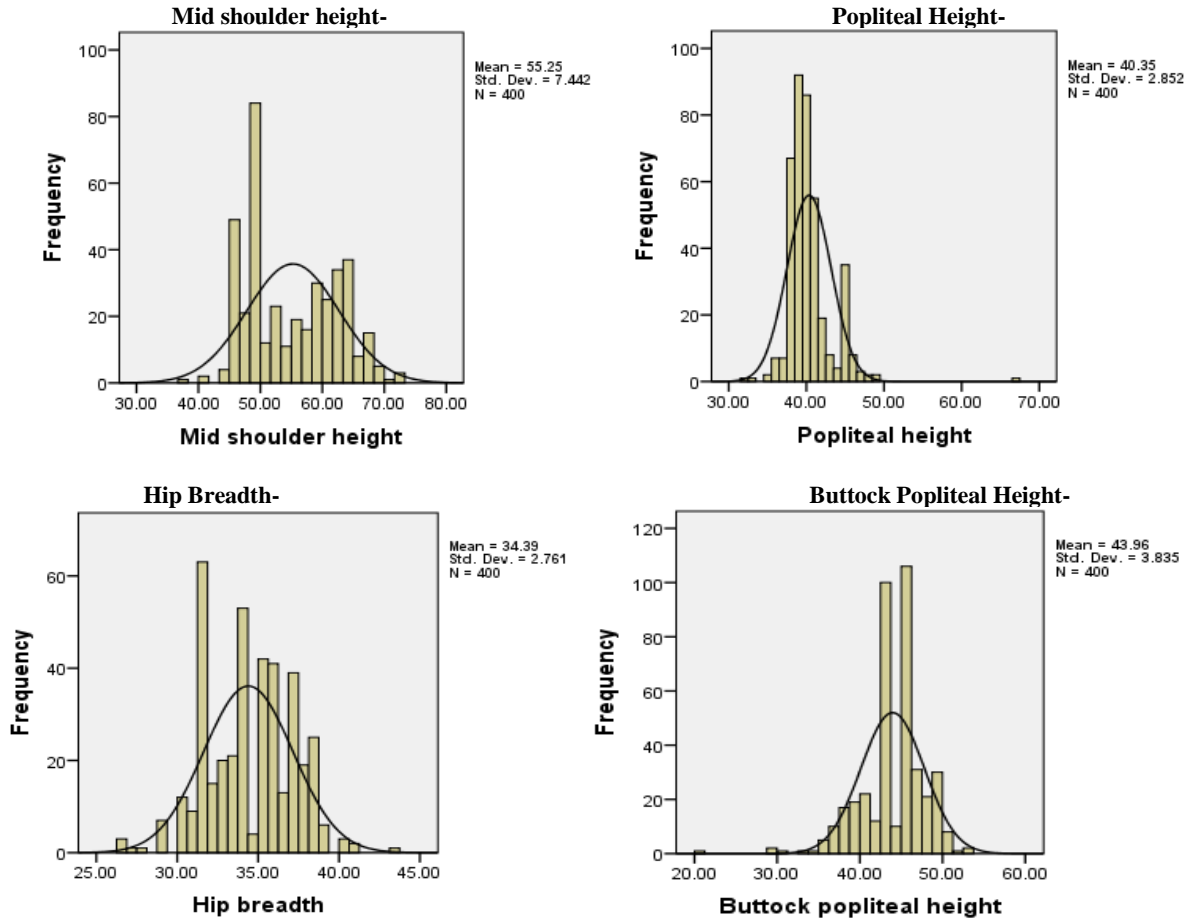
Table-2 : Anthropometric dimensions of students

Analysis of the obtained data using standard static tools-(combined data of both male & female)

The data obtained in the above table was analyzed using standard statistical packages such as Excel and SPSS. The following normal distribution and histogram were obtained for some of the important parameters and are plotted as follows..

Histogram and normal distribution for some relevant parameters –

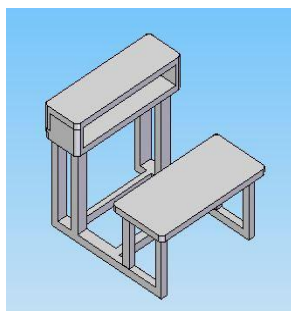




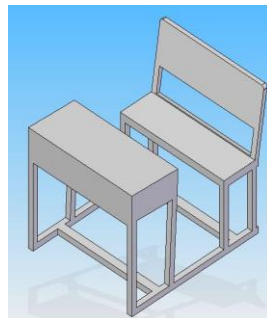
Analysis of the anthropometric data of students shows that there is a considerable variation between anthropometry of male and female students which makes the selection of design parameters of furniture a difficult task. Design compatible with majority of the user population should match the percentile values of the anthropometric data of user population.

Design Features of Each Model and its Compatibility to Users Needs

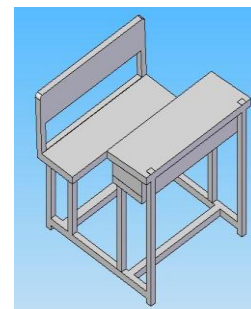
Different types of furniture used and the variations in different models of each types are discussed. The dimensions of different models of desks are tabulated as follows.



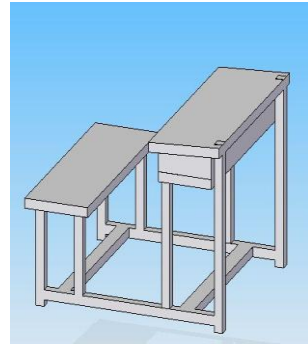
Model-1



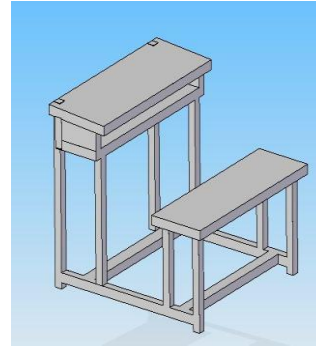
Model-2



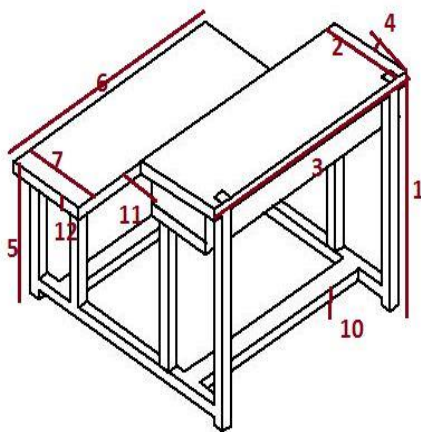
Model-3



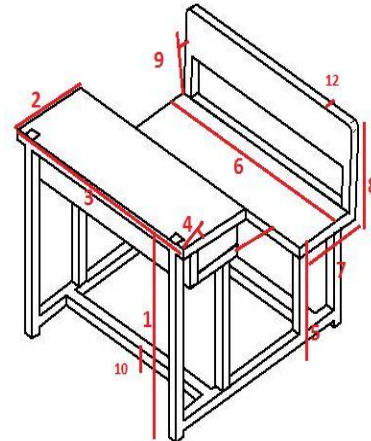
Model-4



Model-5



MODEL WITHOUT BACKREST



MODEL WITH BACKREST

Fig- 2 : Models of desks used

- 1. DESK HEIGHT
- 4. DESK SLOPE
- 7. BENCH DEPTH
- 10. FOOTREST HEIGHT

- 2. DESK DEPTH
- 5. BENCH HEIGHT
- 8. BACKREST HEIGHT
- 11. DIST B/W DESK & BENCH

- 3. DESK LENGTH
- 6. BENCH LENGTH
- 9. BACKREST SLOPE
- 12. THICKNESS

Dimensions of sled desks of different models (Measurements in cm) : Table -3

DIMENSIONS OF SLED DESKS OF DIFFERENT MODELS (IN CM)						
SI NO.	FURNITURE PART	MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5
1	DESK HEIGHT	75	76	76	83	84
2	DESK DEPTH	45	45	35	41	34
3	DESK LENGTH	91	91	92	93	113
4	DESK SLOPE	0	10°	8°	8°	6°
5	BENCH HEIGHT	47	46	44	50	40
6	BENCH LENGTH	91	91	92	93	113
7	BENCH DEPTH	31	32	27	33	26
8	BACKREST HEIGHT	-	48	32	-	-
9	BACKREST SLOPE	-	10°	4°	-	-
10	FOOTREST HEIGHT	11	7	7	7	4
11	DIST B/W DESK & BENCH	22	32	35	30	32
12	THICKNESS	5	4	4	4	4

ANTHROPOMETRIC CONSIDERATION FOR DESIGNING CLASS ROOM FURNITURE

The relevant dimensions in anthropometric design of school furniture. Table-4

<i>User-dimensions</i>	<i>Product-dimensions</i>
A) Popliteal height, sitting	1) Upper surface height of the bench
B) Bi-deltoid breadth, sitting	2) Length of the bench (in case of multiple user)
C) Buttock-popliteal length, sitting	3) Depth of the bench
D) Elbow height from the floor, sitting	4) Height of the desk
E) Knee height, sitting	5) Free knee room under the desk
F) Sitting height	6) Backrest height
G) Buttock-feet length, sitting	7) Horizontal clearance below the desk
H) Elbow to elbow length (writing position), sitting	8) Length of the desk
I) sitting eye height	9) Upper edge height of the backrest from the bench surface
J) Maximum horizontal distance between the bench and the desk.	10) Horizontal clearance for standing between the desk calf and the thigh, standing and the bench

According to anthropometric measurements, it was observed that there was a mismatch between -

- popliteal height and seat height
- knee height and desk clearance
- buttock to popliteal length and seat depth
- sitting height and desk height
- shoulder breadth and distance b/w desk and bench

IV. CONCLUSION

It may be suggested from the present study that the design criteria should be selected based on the anthropometric dimensions of the students. There are chances of mismatch between the students dimensions and available furniture. The ill and improper design of desks may create many problems for the students such as fatigue, muscular stress, and discomfort/pain in different body parts.

Based on the relevant dimensions, the anthropometric data of students in table-1 were compared with the dimensions of different models of furniture's in table-2. The analysis shows that most of the models of furniture's used which were designed without considering the anthropometry of users don't match with the user population and were not compatible with the majority of the user population and causes a feeling of discomfort which may result in lack of concentration and future MSD's .

In model-1, 4, & 5 the main problem was the absence of backrest which leads to back problems & MSD's. only model-1 has comfortable footrest ,model-5 was with lowest footrest which causes discomfort. the lowest bench depth was in model-3 &5 which needs to be increased. A design with combined appropriate values from the 5 models can give a better design model which can reduce the problems and improve the efficiency.

While making school furniture the anthropometric dimension of the user population should be used. The furniture should be designed to suit majority of the user population therefore it should be concentrated between 5th percentile female to 95th percentile male which covers majority of the user population. Even though it is difficult to design for all the users but a product that matches majority of the user population can be designed and the problems solved up to a considerable extent. The anthropometric measurements from the present study may be helpful in designing the college desks and other furniture used in the colleges for students. The authors intend to further investigate this problem of mismatch between students body dimensions and furniture used by investigation further in more number of colleges and taking anthropometry dimensions from a more number of students.

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