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Full Length Article

Anthropometric measurements for ergonomic design of students' furniture in India

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A B S T R A C T

This paper presents anthropometric measurements regarding engineering students in India. Health survey (ergonomic assessment) was carried out to know the health status of all students who have been using poorly designed furniture. The data were measured with the help of various tools. After data collection and analysis, authors came up with exhaustive dimensions for designing adjustable classrooms furniture. Dimensions recommended include; bench surface height, bench depth and width, back rest width and height, backrest angle, desk height, desk depth, width, and desk angle. Therefore, an implementation of these data will help to create comfortability, safety, well-being, suitability, reduce Musculoskeletal disorders, and improve performance of students in terms of attentiveness. Also, it is highly recommended to consider requirements from students in designing classrooms furniture and conduct seminar or workshop to educate students regarding the negative impact towards adapting poor posture in the long usage of classrooms furniture.

1. Introduction

Ref. [14] defines anthropometry as "the science of measurement and the art of application that establishes the physical geometry, mass properties, and strength capabilities of the human body". In simple meaning, Anthropometry can be defined as the study which deal with body dimensions i.e. body size, shape, strength and working capacity [13] for design purposes [44] and body composition [29]. All engineering colleges, institutes or universities are having classrooms furniture, but these furniture are of low comfort level to students since anthropometric data were not considered in the initial stage of designing furniture [34].

Anthropometric measurements whenever be considered for designing, it helps to students in achieving comfortability level [1], reduce Musculoskeletal disorders (MSDs) [41,42,31], and improve performance of students in terms of attentiveness while professors or instructors are teaching them [32,34]. Students from various countries spend many hours [3] per day while sitting on un-well designed furniture [45,8,23,30,15].

The basic philosophy of ergonomics is to make any design of furniture which lead to comfortability, physical health, safety [12], well-being, convenient and bring motive towards studies [49]. Students require well-designed furniture due to that whenever they become much confined in awkward posture while performing a certain task i.e. writing [2], lectures, drawing, reading on desk tops, etc. aggravates psychological stress and can impose ill effects on students' performance. Moreover, Ref. [50] states that "an incorrect body alignment reduces the ability of antigravity muscles to generate torque".

It is very essential for Asian population to have their own anthropometric measurements regarding students so as it can be easy for designers who are intending to make an ergonomic furniture which can result to comfortability, safety and increase satisfaction level and ultimately reduce Musculoskeletal disorders (MSDs). MSDs are said to be an injuries or pain in the joints of the body, muscles, ligaments, tendons, nerves, and structures that support limbs, back and neck. In long run these MSDs [9] which are degenerative diseases and inflammatory conditions can result to pain and impair normal activities of the students [1]. Refs. [39,43,30] suggest that, anthropometric measurements needs to be used during designing activities of furniture. In case students can use poorly designed furniture, such furniture can result to headache also [24].

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1.1. Purpose

The major aim of the study was to collect anthropometric measurements from population group (engineering students) and establish standard selection criteria and dimensions which are essential for designing an adjustable chair and table (or classroom furniture) at engineering colleges from Gujarat State in India. Students from three (3) engineering colleges aged (aged 17–37 years) participated in the study. The students helped in getting health survey (ergonomics assessment) and anthropometric measurements.

2. Literature review

Literature survey shows that many researchers conducted various researches regarding designing various furniture [36], though for colleges or school especially in India there is less findings regarding furniture design for students especially from engineering colleges. Many researches have been conducted to primary schools than the way it has been conducted at engineering colleges. India is a country with 29 states whereby there is variation of anthropometric measurements in many states. Anthropometric measurements vary from one state to another or country to country at least with some small variations [37]. Due to such variation, there is need of having good database of anthropometric measurements in state wise if possible, so as such data can be used for current time and future time in designing school furniture.

The presence of less survey regarding anthropometric data has been due to that majority of colleges or universities administration's procure ready-made furniture which mostly fit few users (students) [11]. Continuation of such habit of procuring ready manufactured furniture without giving attention to anthropometric measurements of students can results to un comfortability [16], Musculoskeletal disorders (MSDs) [15,22], and can also reduce the performance of students who use such furniture for more number of hours per day while sitting on such furniture [38,10].

Anthropometry has three major principles. These principles are mainly being followed in designing various products depending on the type of product. First principle is "*design for extreme individual*" which can be either Design for the maximum population as commonly the 95th percentile male or design for the minimum population value as commonly referred as 5th percentile female [25]. Second principle is "*designing for an Adjustable Range*" which put consideration of both 5th female and 95th male in order to accommodate 90% of the population [26,4]. Adjustability principle has been much suggested by many researchers as the main ergonomics principles to be followed in designing furniture [5,51]. Last principle is "*designing for the average*" which is mostly being used whenever the use of adjustability is impractical. There are so many designs especially for average but less designs are based on design for adjustability especially for government colleges.

3. Research methodology

Anthropometric parameters for population group were obtained from engineering colleges in India. The total number of students considered for this study was 2223. Through the use of Eq. (1) given by [18] or Eq. (2) given by [35], calculated sample size was 339 whereby the number of people involved in the study were 478 which shows that the collected data exceeded the calculated sample size. The study involved both male 290 (60.67%) while female was 188 (39.33%).

$$n = [p(1-p)Z^2]/e^2 \quad (1)$$

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

whereby n is the desired sample size; N is total population group; Z is standard normal deviation; for 95% confidence level, p is proportion in the target population estimated to have a particular characteristics i.e. p considered at 30%; $(1-p)$ is proportion in the target population not having the particular characteristics and e is the degree of accuracy required which usually is being set at 5% level as stated by [18].

It is important to know the health status of the participants [26]. In order to know the major problems (health status) with regard to the use of the available furniture, ergonomic assessment (health survey) for students who have been at colleges for longer period of time was performed with the help of designed questionnaires as it was also suggested by [20]. Table 1 shows the results of the conducted health survey.

In order to come up with well identified problems, Pareto chart (Pareto diagram) was prepared with the help of Minitab 17.0. Fig. 1 shows Pareto chart for the survey conducted.

Fig. 1 indicates various problems which need much focus and efforts so as students can be free from such problems. The major identified problems are such as back pain, neck pain, shoulder pain and muscles, leg's joint pain, neck or shoulder tension, pain at elbow, fatigue joint, Cumulative Trauma Disorder, hand pain and wrist pain which make 75–25% as the rule of Pareto Chart. Concentrating on these problems can ultimately solve majority of the problems and this can be achieved through good furniture design. It is not easy to eliminate all identified critical problems in a simplified way of just collecting anthropometric measurements for designing furniture. Therefore in order to reduce to the maximum all identified health problems through health survey (ergonomic assessment), all responsible administrations, college or institute boards and management are recommended to consider the following.

I. During the whole process of supplying or procuring classrooms furniture at various college, schools, institutes or universities; it is highly recommended that there should be proper considerations of various student's anthropometric measurements so as to avoid much possibility of causing Musculoskeletal disorders in the long run usage of the classroom furniture.
II. There is need of considering Voice of Students (requirements from students) in designing classrooms furniture, instead of supplying furniture without any direct or indirectly involvement of users (students) during the entire process of

Table 1
Ergonomic assessment (health survey) for students.

S/No.	Ergonomic problems due to un-ergonomic furniture	1	2	3	4	5	Sum of (1, 2 & 3)
A	Eye problems	14	96	57	69	242	167
B	Back pain	53	107	83	85	150	243
C	Difficulty breathing	10	46	47	51	324	103
D	Shoulder and muscles pain	28	112	62	84	192	202
E	Pain at elbow	33	86	81	47	231	200
F	Pain at wrist	34	81	47	72	244	162
G	Pain on legs joints	56	93	69	62	198	218
H	Hand pain	34	96	57	64	227	187
I	Neck pain	55	102	95	67	159	252
J	Insomnia (sleeplessness)	53	62	75	92	196	190
K	Fatigue joint and muscle pain	36	111	191	78	62	338
L	Headache	37	83	182	96	80	302
M	Neck or shoulder tension	35	92	208	81	62	335
N	Cumulative trauma disorder	35	57	42	75	269	134
O	Injury caused by slips, trips and falls Impotence	26	40	49	99	264	115

Most seriously (1); less seriously (2); seriously (3); not sure (4); not at all (5).

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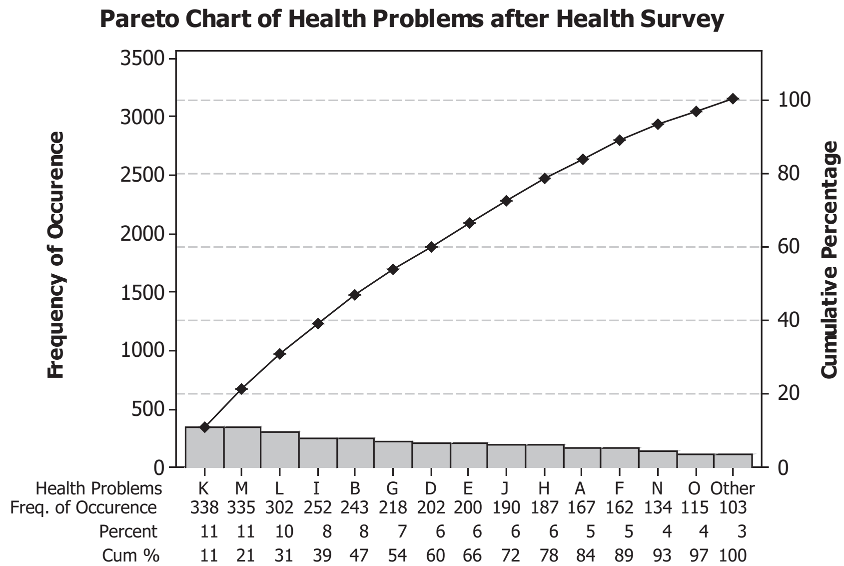

Note: Health problems “A” to “O” are defined in Table 1 above

Fig. 1. Pareto chart for ergonomic assessment (healthy survey).

procurement furniture. If student’s requirements can be considered, then there is need of making integration of ergonomics with other techniques like Quality Function Deployment and Kano Model.

III. Since there are many health problems which are due to adaptation of poor posture by students, then it is highly recommended that whenever possible there should be arrangement of seminar or workshop to educate engineering students regarding the negative impact toward adapting poor posture in the long usage of classroom furniture.

3.1. Measuring instruments

In order to measure various body dimensions of population group (students), there are various techniques and tools which are mostly used. According to [32], some of the methods include three-dimensional (3-D) scanners [28] which is too expensive and not available to all researchers. The other methods include traditional anthropometric tools which are considered to be simple, inexpensive and available to many researchers comparing to three-dimensional body scanner. In such scenario, Ref. [40] stated that, “Since many of the traditional measurements have been used for many years, and since it may be many years before everyone has a 3-D scanner with the ability to identify pre-marked landmarks, it was felt it would be important to take some measurements the traditional way”.

Also Ref. [46,19] explains the challenges which are available through the use of three-dimensional scanner. In this study the body dimensions were taken using traditional anthropometric tools same like other many researchers who used same tools [44,36,27]. The body mass (weight) for students was measured using a portable bathroom weighing scale (150 kg as a maximum

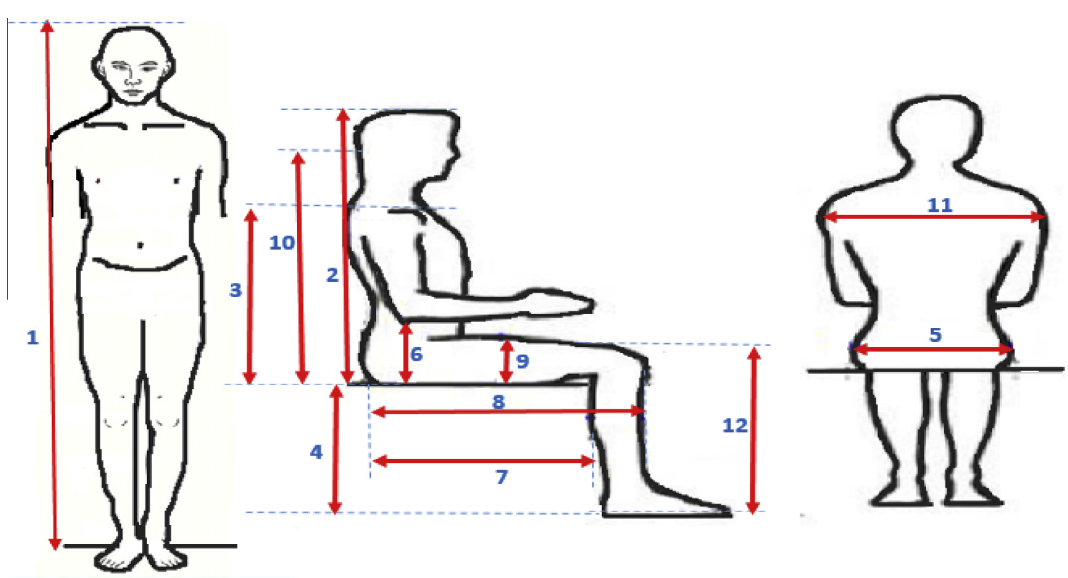

Fig. 2. Anthropometric data required in classroom furniture design: stature (body height) (1), sitting height (erect) (2), shoulder height, sitting (3), lower leg length (popliteal height) (4), hip breadth, sitting (5), elbow height, sitting (6), buttock-popliteal length (seat depth) (7), buttock-knee length (8), thigh clearance (9), Eye height, sitting (10), shoulder (bideltoid) breadth (11), knee height (12), and body mass (weight) (13).

capacity) with an accuracy of 0.01 kg, while other dimensions were measured using a flexible measuring tape with an accuracy of 0.1 mm, steel ruler for marking the level, non-adjustable wooden chair and plastic ruler. The non-adjustable chair with a flat wooden seat had a high back rest for reducing measuring error due to poor gesture of students was used to take measurements such as sitting height, shoulder height, etc.

Also a non-adjustable chair had no arm rest which could hinder elbow rest height measurement. The backrest and seat were lined up at right angle to each other and the seat acted as reference point during measurements taking especially in the sitting position. The engineering students height (stature) was measured using a wall mounted straight ruler with measuring tape attached to it while calibrated in centimetres. There was no any excessive clothing such as socks, jackets, overalls and shoes which were allowed to be wore during measurements.

3.2. Selection of body dimensions

Designing of standard furniture needs directly involvement of anthropometric measurements [33]. Various researchers suggested the body dimensions which are essential in designing furniture especially for students [47,48,7,6]. But for this research, collection of all required anthropometric dimensions from engineering students in India adapted ISO 7250 as the standard for all 13 selected student's body dimensions. Fig. 2 shows all twelve (12) body dimensions which were selected for this study with additional of weight as the thirtieth (13th) body measurement while Table 2 indicates the serial number and descriptions of the selected student's body dimensions according to ISO 7250. These body dimensions were wisely selected for the study with the consideration of the body dimensions to help in enhancing comfort, safety and easy of getting the required dimensions for designing furniture.

4. Data analysis

The collected anthropometric data were thoroughly analysed with the help of Minitab 17, SPSS 16.0 as Statistical Package and Microsoft Excel 2013. The data were analysed in terms of minimum (min), maximum (max), Standard Deviation (SD), 5th, 50th, 95th percentile and mean which is equal to 50th percentile. All dimensions are in millimetres (mm) except for body mass (weight) which is in kilogram (kg).

5. Results and discussion

Tables 3 and 4 present descriptive statistics of all the measured anthropometric measurements for both male and female (first to fourth year) students respectively.

Anthropometric measurements (data) are normally distributed [17]. For all collected data for male students, the normal distribution curves are hereby presented by Fig. 3 as the means to examine the shape and spread of all collected anthropometric data. There has been less difference in the normal distribution curves for female students also.

With the help of literature survey, Ref. [21] encourages designers to adapt "*designing for an Adjustable Range*", this means that classrooms furniture are required to be adjustable. Adjustable fur-

Table 2
Selection of body measurements for classroom furniture design.

S/No. according to ISO 7250	Basic student's body dimensions	Description of the body dimensions according to ISO 7250
4.1.2	Stature (body height)	Vertical distance from the floor to the highest point of the head (vertex)
4.2.1	Sitting height (erect)	Vertical distance from a horizontal sitting surface to the highest point of the head (vertex)
4.2.4	Shoulder height, sitting	Vertical distance from a horizontal sitting surface to the acromion
4.2.12	Lower leg length (popliteal height)	Vertical distance from the foot-rest surface to the lower surface of the thigh immediately behind the knee, bent at right angle
4.2.11	Hip breadth, sitting	Breadth of the body measured across the widest portion of the hips
4.2.5	Elbow height, sitting	Vertical distance from a horizontal sitting surface to the lowest bony point of the elbow bent at a right angle with the forearm horizontal
4.4.6	Buttock-popliteal length (seat depth)	Horizontal distance from the hollow of the knee to the rearmost point of the buttock
4.4.7	Buttock-knee length	Horizontal distance from the foremost point of the knee-cap to the rearmost point of the buttock
4.2.13	Thigh clearance	Vertical distance from the sitting surface to the highest point on the thigh
4.2.2	Eye height, sitting	Vertical distance from a horizontal sitting surface to the outer corner of the eye
4.2.9	Shoulder (bideltoid) breadth	Distance across the maximum lateral protrusions of the right and left deltoid muscles
4.2.14	Knee height	Vertical distance from the floor to the highest point of the superior body of the patella
4.1.1	Body mass (weight)	Total mass (weight of the body) which was measured with the help of weighing scale

Table 3
Descriptive statistics for measured anthropometric dimensions for male students.

S/No.	Body dimensions	Min	Max	Male percentile			Mean	SD
				5th	50th	95th		
1	Stature (body height) (mm)	1520	1890	1600	1710	1810	1712	62
2	Sitting height (erect) (mm)	680	920	730	805	880	805	43
3	Shoulder height, sitting (mm)	470	650	520	570	620	569	33
4	Lower leg length (popliteal height) (mm)	390	510	410	450	487	450	23
5	Hip breadth, sitting (mm)	260	425	270	320	380	319	30
6	Elbow height, sitting (mm)	130	310	160	200	245	200	28
7	Buttock–popliteal length (seat depth) (mm)	360	540	390	450	520	453	38
8	Buttock–knee length (mm)	460	640	496	560	610	556	35
9	Thigh clearance (mm)	80	200	100	140	185	139	25
10	Eye height, sitting (mm)	600	810	630	710	780	708	43
11	Shoulder (bideltoid) breadth (mm)	350	480	380	420	462	423	24
12	Knee height (mm)	460	600	490	530	570	532	27
13	Body mass (weight) (kg)	400	1100	476	635	915	653	131

Table 4
Descriptive statistics for measured anthropometric dimensions for female students.

S/No.	Body dimensions	Min	Max	Female percentile			Mean	SD
				5th	50th	95th		
1	Stature (body height) (mm)	1410	1770	1465	1600	1730	1598	81
2	Sitting height (erect) (mm)	680	830	730	780	820	779	29
3	Shoulder height, sitting (mm)	500	610	500	550	580	548	27
4	Lower leg length (popliteal height) (mm)	340	470	375	420	470	422	30
5	Hip breadth, sitting (mm)	300	450	320	400	430	389	37
6	Elbow height, sitting (mm)	130	250	155	200	240	198	25
7	Buttock-popliteal length (seat depth) (mm)	390	540	390	470	520	463	40
8	Buttock-knee length (mm)	450	620	505	550	620	556	38
9	Thigh clearance (mm)	90	200	100	130	180	135	25
10	Eye height, sitting (mm)	560	770	630	680	720	679	33
11	Shoulder (bideltoid) breadth (mm)	320	460	350	400	440	398	27
12	Knee height (mm)	390	550	420	470	530	474	36
13	Body mass (weight) (kg)	370	1000	400	550	782	559	116

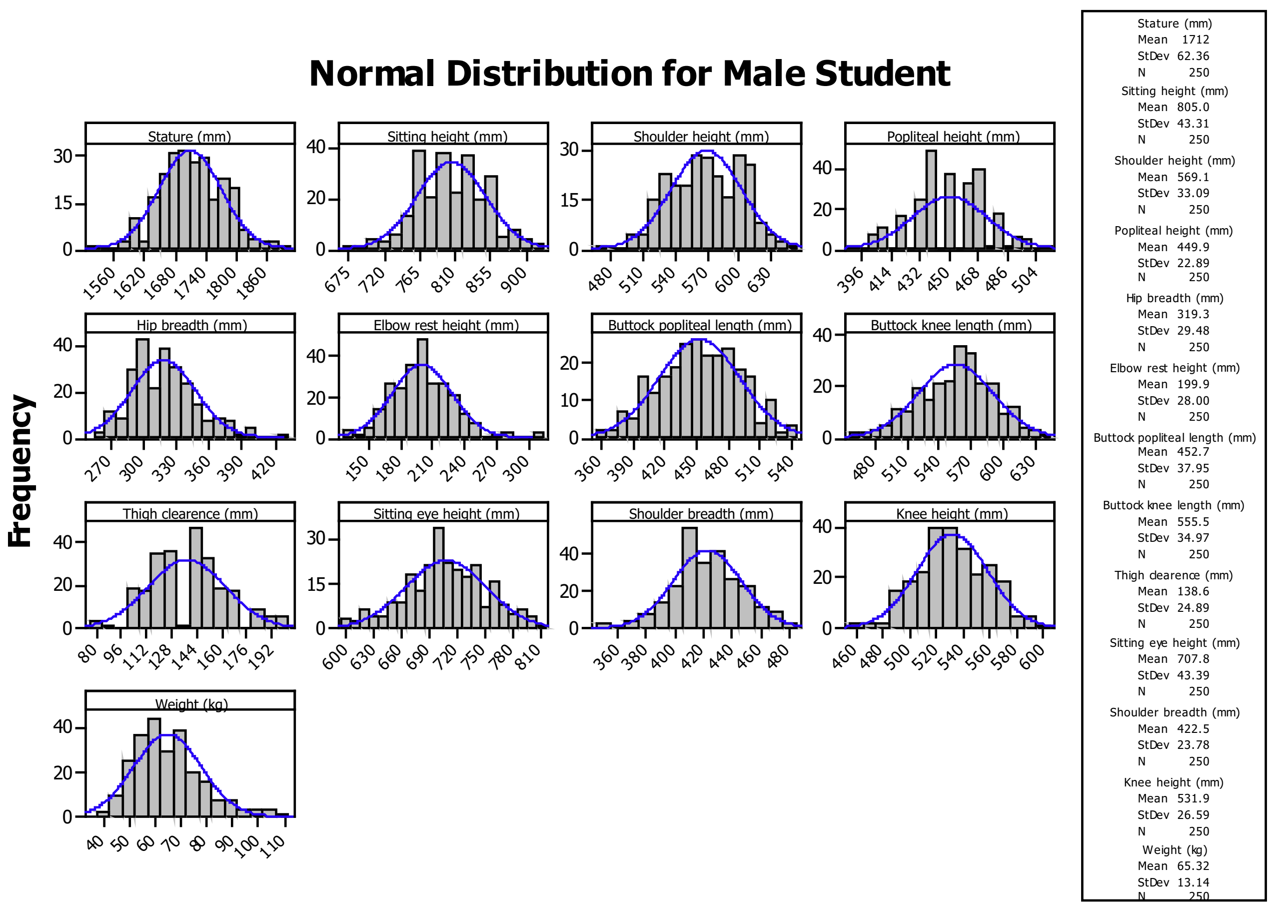

Fig. 3. Normal distribution curve for male anthropometric data.

niture is currently being preferable due to its capability of increasing the comfortability while reducing the chance of MSDs in the long run. Table 5 shows various criteria which have been suggested as the guidelines at whatever time there can be a need of designing adjustable furniture for engineering students and other population group.

Correlation coefficients were also computed to determine the relationship between different student's body dimensions. All computed correlation coefficients were of positive value. From Tables 6 and 7, number 1–13 are defined as follows: stature (body height) (1), sitting height (erect) (2), shoulder height, sitting (3), lower leg length (popliteal height) (4), hip breadth, sitting (5), elbow height, sitting (6), buttock-popliteal length (seat depth) (7), buttock-knee length (8), thigh clearance (9), eye height, sitting (10), shoulder (bideltoid) breadth (11), knee height (12) and body mass (weight) (13).

This *p*-value has the range of ($0 < p < 1$). This value indicates the probability of obtaining a test statistic that is at least as extreme as the calculated value if the null hypothesis is true. In this research, the null hypothesis was set such that, there is strong positive relationship between various student's body dimensions. Table 6 and 7 shows the correlation coefficients between anthropometric measurements for males and females students respectively. For male students, the high correlation was found between "*Buttock-*

Table 5
Determinant criteria for adjustable classroom furniture.

Features	Anthropometric measure	Design dimension	Criteria Determinant (adjustable desk)
Seat surface height	Popliteal height	399–512 (mm)	5th percentile (female) to the 95th percentile (male) of popliteal height + 25 mm for shoes allowance.
Seat depth	Buttock popliteal length	450 (mm)	50th percentile (male) of Buttock popliteal length
Seat width	Hip breadth, Sitting	430 (mm)	95th percentile (female) of Hip breadth
Back rest width	Hip breadth, Sitting	420 (mm)	50th percentile (male) of Shoulder breadth
Backrest height above seat	Sitting Shoulder height	500 (mm)	5th percentile (female) of Sitting Shoulder height
Backrest angle	–	110°	Literature review suggestions
Arm rest height	Elbow rest height	155 (mm)	5th percentile (female) of elbow sitting height
Table height	Elbow rest height and popliteal height	555–757 (mm)	5th–95th percentile of the elbow rest heights is added to chair heights.
Table depth	Buttock knee length	620 (mm)	95th percentile (male) of arm reach of the target groups.
Table width	Shoulder breadth	460 (mm)	95th percentile of shoulder breadth (elbow to elbow length)
Table angle	–	0°–20°	Literature review suggestions
Bag shelf depth	Size of medium bag	620 (mm)	Direct measurements of the available bags for students
Bag shelf depth	Size of medium bag	200 (mm)	Direct measurements of the available bags for students

Table 6
Correlation coefficients between measurements for males ($n = 290$) [without star: $p < 0.01$; *: $p < 0.05$; **: $p < 0.2$ and ***: $p < 0.992$].

S/No.	1	2	3	4	5	6	7	8	9	10	11	12	13
1		0.631	0.623	0.681	0.135*	0.163*	0.299	0.464	0.305	0.577	0.356	0.767	0.3
2	0.631		0.734	0.506	0.247	0.418	0.302*	0.391	0.266	0.841	0.445	0.446	0.323
3	0.623	0.734		0.513	0.244	0.335	0.24	0.37	0.295	0.736	0.4	0.48	0.366
4	0.681	0.506	0.513		0.193*	0.19*	0.392	0.427	0.238	0.443	0.332	0.748	0.22
5	0.135*	0.247	0.244	0.193*		0.251	0.336	0.446	0.473	0.214*	0.572	0.013*	0.767
6	0.163*	0.418	0.335	0.19*	0.251		0.109*	0.089**	0.128*	0.497	0.253	0.099**	0.244
7	0.299	0.302*	0.24	0.392	0.336	0.109*		0.862	0.135*	0.27	0.393	0.358	0.298
8	0.464	0.391	0.37	0.427	0.446	0.089**	0.862		0.291	0.329	0.505	0.48	0.438
9	0.305	0.266	0.295	0.238	0.473	0.128*	0.135*	0.291		0.252	0.451	0.25	0.649
10	0.577	0.841	0.736	0.443	0.214*	0.497	0.27	0.329	0.252		0.37	0.407	0.348
11	0.356	0.445	0.4	0.332	0.572	0.253	0.393	0.505	0.451	0.37		0.31	0.638
12	0.767	0.446	0.48	0.748	0.013*	0.099**	0.358	0.48	0.25	0.407	0.31		0.274
13	0.3	0.323	0.366	0.22	0.767	0.244	0.298	0.438	0.348	0.348	0.638	0.274	

Table 7
Correlation coefficients between measurements for females ($n = 188$) [without star: $p < 0.01$; *: $p < 0.05$; **: $p < 0.2$ and ***: $p < 0.992$].

S/No.	1	2	3	4	5	6	7	8	9	10	11	12	13
1		0.74	0.529	0.752	0.419	0.523	0.629	0.591	0.326*	0.435	0.495	0.663	0.462
2	0.74		0.499	0.619	0.399	0.409	0.465	0.441	0.33	0.495	0.333	0.575	0.375
3	0.529	0.499		0.674	0.347	0.289*	0.499	0.425	0.2*	0.615	0.383	0.532	0.248*
4	0.752	0.619	0.674		0.498	0.322*	0.688	0.578	0.33	0.433	0.537	0.751	0.358
5	0.419	0.399	0.347	0.498		0.001***	0.458	0.497	0.314*	0.457	0.682	0.573	0.355
6	0.523	0.409	0.289*	0.322*	0.001***		0.264**	0.299**	0.097***	0.343	0.15***	0.341	0.32*
7	0.629	0.465	0.499	0.688	0.458	0.264**		0.862	0.27**	0.252**	0.429	0.54	0.277*
8	0.591	0.441	0.425	0.578	0.497	0.299**	0.862		0.256**	0.304*	0.368	0.507	0.383
9	0.326*	0.33	0.2*	0.33	0.314*	0.097***	0.27**	0.256**		0.183**	0.001**	0.309**	0.649
10	0.435	0.495	0.615	0.433	0.457	0.343	0.252**	0.304*	0.183**		0.389	0.564	0.265**
11	0.495	0.333	0.383	0.537	0.682	0.15***	0.429	0.368	0.001**	0.389		0.631	0.389
12	0.663	0.575	0.532	0.751	0.573	0.341	0.54	0.507	0.309**	0.564	0.631		0.436
13	0.462	0.375	0.248*	0.358	0.355	0.32*	0.277*	0.383	0.649	0.265**	0.389	0.436	

popliteal length" and "*Buttock-knee length*" likewise to female students. The next high correlation found for male was found between "*Sitting height (erect)*" and "*Eye height, sitting*" while for female students the next high correlation was found between "*Stature*" and "*Lower leg length (Popliteal height)*". After computing the correlation coefficient, the null hypothesis has been accepted.

5.1. Design Implications for the collected anthropometric data

The data collected in the study can be used for designing various classroom facilities such as single seated desks, double seated desks, drawing table (special for engineering graphics), adjustable desk, non-adjustable desk, site of the blackboard due to consideration of seating height, shelves for classes, location of projectors, office chairs, tables, storage space, and so forth, which can help students to work easily and comfortably. In this 21st century, it is highly recommended to design adjustable facilities whenever possible. But in trying to apply adjustability for designing product then factors like cost, design constraints, mechanism of adjustability, time factor and so forth should be considered as the hindrance for not allowing to have 100% adjustable.

5.2. Data validation

An internal consistency for anthropometric measurements was computed with the help of SPSS 16.0 as Statistical Package whereby for male measurements Alpha value was 0.825 while for female alpha was 0.867. This Cronbach's alpha determined the internal consistency of the collected and analysed data. Since the alpha value is high, hence all collected data and analysed data were of high consistency.

5.3. Overview of design challenges

In designing products there are some design challenges which need to be addressed in order to achieve major objectives of collecting anthropometric measurements. Some of the design challenges are as follows:

i. Design for all; this means the strategy to try to exclude as less as possible so as all people can be able to use the designed product.
ii. Design one size which fits all; for example a public outdoor chair should be designed in such way that there is mostly only one size which fits all.
iii. Made to measure; for example for astronauts, their suits are made to fit their body size and shape.
iv. Design for average; this is almost the same as one size fits all. Many people be excluded from comfortable usage. This is due to the reality that there is no body who is average. In case a person has an average body height (stature), still he or she might be having hip width, popliteal height etc. which are not of an average size.

6. Conclusion

From the present study it is well expected that Criteria Determinant for an adjustable Desk shown in Table 5 need to be used whenever designers wish to have adjustable classroom furniture (which is ergonomic furniture) in engineering colleges or elsewhere provided that the population have the same characters or there are very minimal differences within the targeted population. Achieving this, will help to create safety, comfort, adaptability, suitability, free MSDs, and ultimately satisfaction to users as stated by [47].

Also there are some suggestions which need to be considered at various engineering colleges so as to achieve the major aim of conducting health survey (ergonomic assessment) and collection of anthropometric measurements. Through interview and direct observation, it was observed and noted that majority students need proper training for developing acceptable posture during the time for using classrooms furniture which might be designed or those which are currently available at their education institutes. This is due to that, majority of people in India has a culture of sitting in awkward posture for long time at a floor or any furniture provided. In long run such habit has a great chance of causing to some ergonomic problems including MSDs, student's dissatisfaction and all ergonomic problems due to un-ergonomic furniture as indicated in Table 1.

Moreover, the authors suggest that, an anthropometric application for the school furniture should consider culture of the place at the time of furniture designs for the engineering students so as the culture can enhance good designs depending on what is much preferable at the particular place. This will be much helpful for the health status of students in the long run.

Lastly, it is hereby recommended that similar study should be carried out in other states or regions of the country in order to have enough database of anthropometric measurements which can help designers to come up with the solutions for students who will continue to suffer from using un-ergonomically designed furniture in the country.

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