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Ergonomic Evaluation of School Desks With Reference To Bureau of Indian Standards Specifications

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Abstract: *It is believed that there is a growing mismatch between design features of the furniture used in the classrooms and the anthropometric parameters of the students. Bureau of Indian Standards has specified a dimension of school furniture taking into consideration the anthropometric dimensions of the Indian students and ergonomic design principles in IS 4837:1990. The objective of the present study is to evaluate the existing school furniture with reference to IS 4837:1990. The authors have proposed a new methodology for ergonomic assessment of the school desks. A new concept of Ergonomic Quality Assessment Index (EQAI) is developed. Accordingly, the school desks from the three schools located in Solapur city from the state of Maharashtra in India is evaluated. The desks are divided in two sizes, as recommended in the IS standards. In all, 15 dimensions of each size of school desk are measured and weights are assigned to these dimensions of the school desk according to their importance from ergonomic aspects. These dimensions are then compared with the recommended standard values. The deviations from the standards are computed. EQAI values are computed based on the deviations and weights assigned. The scale is developed based on value of EQAI, for assessment of the risk. It is revealed that desks of both sizes I and II from school A, and desks of size II from school C lie in critical risk zone (EQAI value 30). Size I desk from school C and desks of both sizes from school B lie in risky zone (EQAI value >26). It indicates that there is urgent need of replacement of the existing school desks by ergonomically designed school desks, adhering to standards recommended by IS 4837:1990.*
Keywords: *School furniture, Ergonomic design, BIS.*

I. Introduction

During their lives, children spend approximately a quarter of the day at school, and 80% of that time sitting down doing their school work. Considering the amount of time spent at school and specifically while sitting, it is fundamental that school furniture suit the children's requirements [1]. However, many studies have shown that school children frequently use furniture that is not suitable to their anthropometric measures [2], [3], [5], [6], [13], [15]. Recent studies have reported the increasing prevalence of musculoskeletal problems in school children and adolescents. Design of school furniture is one of the contributing factors to the development of such symptoms among school children [4], [19], [20]. In addition, it is common observation of many experts in the field that, proper design of classroom furniture reduces fatigue and greatly helps to increase student's concentration during their lectures or study.

Although, the ergonomic standards for school furniture have been specified in many countries including India, it is revealed from the literature review that the furniture being used in many nations is not up to the mark from ergonomic point of view. Bureau of Indian Standards has published the standards well back in 1990's. In lieu of this, the authors decided to evaluate the status of school furniture in Solapur city from Maharashtra state in India. The objective of the present study is to evaluate the design of classroom furniture from some schools in Solapur city, ergonomically, with reference to BIS standards IS 4837:1990 [8] and IS 4838:1990 [9].

1.1Subjects

Three sample schools located in different locations of the Solapur city were identified. Care was taken to see that, these schools cover students from different socioeconomic strata of the society in Solapur. Necessary permissions from the Education officer, School authorities, parents and students are taken before the measurements. School desks from standards 5^{th} to 10^{th} are included for the measurements. Five school desks from each class were randomly selected for measurement. Similarly, statures of students studying in 5^{th} to 10^{th} standards are also measured. 10 students from each of the different divisions of each standard (5^{th} -10^{th}) are randomly selected. Three schools A, B and C were having 2 to 4 divisions of each standard.

1.2 **Method and equipment used for Measurement**

The stature measurements of each student are carried out using standard anthropometric measurement techniques [13]. The consents of the students were obtained before the commencement of the measurements. All

measurements are taken with the subjects wearing regular school uniform and without shoes. The measurements were taken on level floor in one of the classrooms in each of the selected institutions. Students were asked to stand erect close to the wall. Measurements are taken on the working day for around 30 days with the assistance of a team consisting of two persons, one for taking measurement and another for data- recording, in the month of October and November in year 2015. To ensure accuracy of recorded data, the persons were given training of using measuring devices and trial runs were conducted. The measurements during the trial runs were checked for consistency and accuracy.

Measuring Equipment consists of measuring tape, steel rule. Dimensions are measured to the accuracy of 1mm. Furniture in all the three schools was of similar design i.e. combined desk bench unit typically called as dual desk which is common design in Solapur district from Maharashtra State of India. Two sizes of the furniture are found in all the schools, smaller one for grades from 5^{th} to 7^{th} and larger one for standards 8^{th} to 10^{th}. All the relevant dimensions of these dual desks are measured with steel measuring tape and steel rule to the accuracy of 1mm.

II. Measurements

Two types of measurements are carried out. One was related to anthropometric characteristics and another related with desk dimensions.

2.1 Anthropometric measures: According to IS 4838:1990 [9]Standing heights of children alone can be taken as standards for designing school furniture. In this IS code, body measurements, reach dimensions, eye-levels and ratios of body segments with standing height are presented graphically. Ratios between standing height and dimensions used in designing educational spaces and furniture are also given in this code (IS 4838:1990) [9]. Hence it was decided to measure the standing height or stature of the students. Stature is defined as follows.
Stature (S): Standing height of subject from feet on the floor to top of head.

2.2. Desk Dimensions

On the basis of literature survey and IS 4837:1990 [8], it was decided to measure following dimensions of the desk for the ergonomic evaluation. Accordingly, measurements of the existing classroom furniture are carried out. It was found that 2 sizes of the desk-bench unit are being used in all the 3 schools. It is further noted that the furniture is local made and the dimensions of the furniture from different schools show little variations. The terms related to desk dimensions and their definition are referred to from the paper [17] and IS 4837:1990 [8], are described below.

1. Seat Height (SH): measured as the vertical distance from the floor to the middle point of the front edge of the seat.
2. Seat Depth (SD): measured as the distance from the back to the front of the sitting surface.
3. Seat width (SW): measured as In case of combined desk bench unit both dimensions are almost same.
4. Angle of Seat: Angle made by seating surface to horizontal.
5. Angle between Seat and Back Rest: Angle between seat plane and back rest plane measured at center.
6. Lower Edge Back Rest Height (LEBH): It is the vertical distance between lower edge of back rest and seat.
7. Upper Edge Backrest Height (UEBH): It is the vertical distance between upper edge of backrest and seat.
8. Width of Back Rest: It is the horizontal distance between two lateral edges of the back rest.
9. Desk Top Height (DH): the vertical distance from the floor to the top of rear edge of the desk.
10. Desk Top Depth (DD): the distance from the back to the front of the top surface of the desk.
11. Desk Length / Width (DW): the horizontal distance between the lateral edges of the desk.
12. Depth of Knee Zone: It is the horizontal clear distance underneath the desk top from the rear edge of desk top or front edge of seat measured at seat / knee height.
13. Depth of Tibia Zone: It is the horizontal clear distance at the bottom of the desk from the rear edge of the desk top measured at tibia / foot level.
14. Underneath Desk Height / Height of Knee Zone: the vertical distance from floor to the lowest structure point below the desk top surface at the end of knee zone.
15. Height of Tibia Zone: It is the minimum vertical distance from floor to the lowest structural point below the desk top ahead of knee zone.

III. Theory Data Analysis And Calculations

IS 4837:1990 [8] standard deals with the dimensional requirements of the chairs and tables for children in the age group of 5-17 years for use in the Indian schools. In this standard, the school desks, chairs and tables have been divided into four sizes related to four age groups of children as follows. Age: 5-6, 6-10, 10-13, 13-17 years. However, scope of the present study is limited to the students of age group of 10-16 years. Hence only two sizes of the furniture related to this age range are studied and evaluated here.

3.1: Anthropometric Data:

The measurements of stature of the boys and girls, between age group of 10-16 years, studying in standards V to X from the three schools were taken. The schools are located in Solapur city from Maharashtra State, which is urban area. Table 3.1 shows the gender wise distribution of samples from each standard. Care is taken that sample size is enough according to statistical principles.

Table 3.1: Distribution of Samples: Standard wise and Gender wise.

Standard	V	VI	VII	VIII	IX	X
No. of Boys	90	90	90	90	70	80
No. of Girls	90	90	91	89	80	32

Data analysis is done with Statistical software SPSS16 version and MS Excel. The values of mean, standard deviation (S.D.) etc. were calculated using descriptive statistics. Table 3.2 depicts this data according to age/standard and gender. All the values are given in mm. This data is also compared with that provided by IS 4838:1990. Table 3.3 shows comparison of the current data with BIS data and deviations.

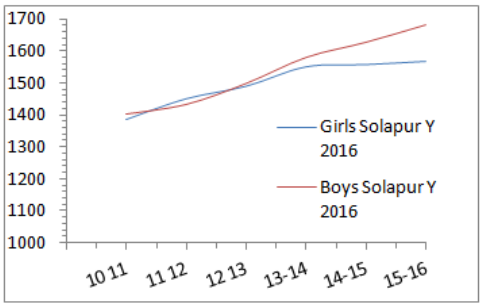
Table 3.2 : Stature of urban students - age group 10-16 years.

Sr. No	Std	Age	Girls		Boys	
			Mean	S.D.	Mean	S.D.
1	V	10-11	1384	88.48	1403	64.17
2	VI	11-12	1449	82.10	1433	76.50
3	VII	12-13	1488	84.44	1498	100.87
4	VIII	13-14	1549	68.19	1579	106.10
5	IX	14-15	1556	60.48	1626	117.82
6	X	15-16	1566	90.08	1680	96.37

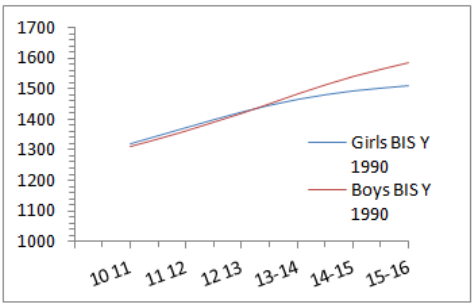
It is revealed from the table 3.2 and chart in fig.3.1 that stature goes on increasing with age. It is also seen that growth rates of statures of Girls and Boys are almost same up to the age of around 13-14, however, thereafter the growth rate of girls slows down considerably as compared to that of the boys. This behavior is in conformation with that described in IS 4838:1990[9], as seen in Fig. 3.2. This fact is also revealed in several such studies done earlier. [7], [16], [12].

Table 3.3: Comparison of Statures of Urban Students with IS 4838:1990.

Standard	Age in Years	BIS Year 1990	Solapur Year 2016	Deviation %	BIS Year 1990	Solapur Year 2016	Deviation %
V	10-11	1318	1384	5	1313	1403	6.9
VI	11-12	1371	1449	5.7	1364	1433	5
VII	12-13	1422	1488	4.6	1421	1498	5.4
V-VII	10-13	1318-1422	1384-1488	5.1	1313-1421	1403-1498	5.77
VIII	13-14	1463	1549	5.9	1484	1579	6.4
IX	14-15	1491	1556	4.4	1541	1626	5.5
X	15-16	1508	1566	3.8	1586	1680	5.9
VIII-X	13-16	1463-1508	1549-1566	4.7	1484-1586	1579-1680	5.93



Fig, 3.1 Comparison of stature - Boys and Girls (Solapur)



Fig, 3.2 Comparison of stature - Boys and Girls (BIS)

The comparison of the current data with that of IS 4838:1990 is seen in Table 3.3 and Fig.3.3 and Fig. 3.4. It is seen that, there is significant deviation in the values of current stature from those given in IS 4838:1990 [9]. The values are consistently higher for all age groups as well as for both the genders. This is natural, as there is considerable time gap of almost 25 years between the two anthropometric data. This deviation may be attributed to growth in living standards as well as increased awareness about the nutrition values of the food consumed by school children, at all levels. This is also in conformation of several such studies done world over. [11] [14].

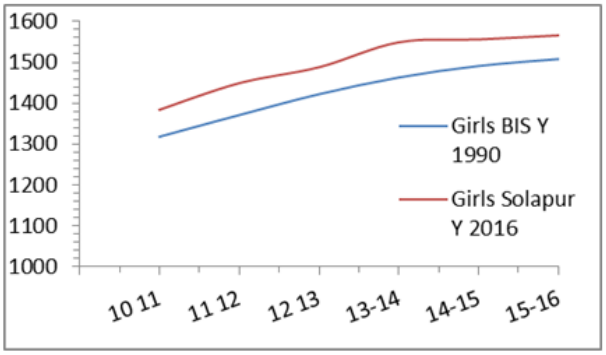
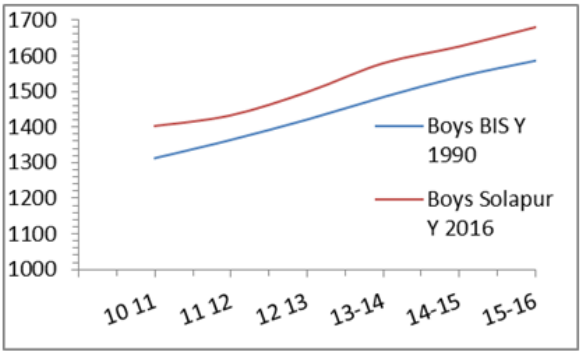


Fig.3.3 Comparison of stature - Boys and Girls (Solapur).



Fig, 3.4 Comparison of stature - Boys and Girls (BIS)

3.2 Desk Dimensions

Measurements of the various dimensions of the desks from three different schools were carried out. It was noticed that mainly dual desk i.e. combined bench and desk design is commonly used design in all the three schools. In this design, writing desk and seating bench are combined together in one fixed unit and two students share one unit. Similarly, it was found that two sizes of the desks are being used for this age group, one for standards V to VII, say size I and another, say size II, for standards VIII to X.

The measured dimensions are then compared with the standards recommended by IS 4837:1990 [8]. The anthropometric data (Standing Height – Stature) considered in IS 4838:1990 [9] for recommending the school furniture dimensions was collected during the year 1990 or prior to that. The data had been collected from different regions in India. Hence there is considerable variation between the current data from Solapur city and that provided in IS 4838:1990 [9]. Authors felt that there is a need to revise the standards of furniture to suit to the recent anthropometric measures of the local students. The analysis of this comparison shown in table 3.3 indicates that, on an average there is rise of around 5.5% in the stature values of the students compared to IS 4838:1990 [9] values. Considering this fact, the authors propose equivalent revision in the standard or expected desk dimensions. The existing values of the dimensions of the furniture from the three schools are then compared with these revised standards. Tables 3.4 and 3.5 show comparative studies of desk dimensions from different schools with IS standards, according to the two sizes (I and II). For each size from all the schools, deviations from the standards are also computed and are presented in the same tables. All dimensions are in mm.

Table 3.4: Desk dimensions: Comparative Study - Size I – Standards - V-VII.

Desk Dimensions	**Expected value as per IS 4837:1990**	**Revised value for increased Height**	**Existing Values**			**Deviation School A**	**Deviation School B**	**Deviation School C**
			School A	**School B**	**School C**			
Seat Height (SH)	340+3	360+3	467	410	390	+107-110	+47-50	+27-30
Seat Depth (SD)	320-340	340-360	255	260	250	-(85-105)	-(80-100)	-(90-110)
Seat width (SW)	620+	655+	934	830	744	+279	+175	+89
Angle of Seat	0-4	0-4	0	0	0	0	0	0
Angle Between Seat and Back Rest	95-100	95-100	90	90	90	-5 to -10	-5 to -10	-5 to -10
Lower Edge Back Rest Height (LEBH)	140-150	150-160	118	182	94	-(32-42)	+22-32	-(56-66)
Upper Edge Backrest Height (UEBH)	280-310	295-325	338	345	330	+13-43	+20-50	+5-35
Width of Back Rest	500	530	934	830	747	+404	+300	+217
Desk Top Height (DH)	580+3	615+3	739	640	630	+121-124	+22-25	+12-15
Desk Top Depth (DD)	450	450	347	300	323	-103	-150	-127
Desk Length / Width (DW)	1050	1110	934	830	747	-176	-280	-363
Depth of Knee Zone	300	315	489	391	327	$+174_{OK}$	$+76_{OK}$	$+12_{OK}$
Depth of Tibia Zone	400	420	489	391	487	$+69_{OK}$	-29_{LESS}	$+67_{OK}$
Underneath Desk Height / Height of Knee Zone	520	550	701	620	467	$+151_{OK}$	$+70_{OK}$	-83_{LESS}
Height of Tibia Zone	300	315	701	620	467	$+386_{OK}$	$+305_{OK}$	$+152_{OK}$

Table 3.5: Desk dimensions: Comparative Study - Size II – Standards – VII-X.

Desk Dimensions	**Expected value as per BIS**	**Revised value**	**Existing value**			**Deviation School A**	**Deviation School B**	**Deviation School C**
			School A	**School B**	**School C**			
Seat Height (SH)	380+3	400+3	468	465	465	+68-71	+62-65	+62-65
Seat Depth (SD)	350-370	370-390	258	275	257	-(72-92)	-(55-75)	-(73-93)
Seat width (SW)	760+	800+	1060	910	805	+260 OK	+110 OK	+5 OK
Angle of Seat	0-4	0-4	0	0	0	0	0	0
Angle Between Seat and Backrest	95-100	95-100	90	90	90	-(5-10)	-(5-10)	-(5-10)
Lower Edge Backrest Height (LEBH)	150-160	160-170	100	130	115	-(60-70)	-(30-40)	-(45-55)
Upper Edge Backrest Height (UEBH)	310-330	345-365	312	320	305	-(33-53)	-(25-45)	-(40-60)
Width of Backrest	560	590	1060	910	805	+470	+380	+215
Desk Top Height (DH)	640+3	675+3	750	705	715	+97-100	+27-30	+37-40
Desk Top Depth (DD)	450	475	395	322	323	-80	-153	-152
Desk Length / Width (DW)	1050	1110	1060	910	805	-50	-200	-305
Depth of Knee Zone	350	370	133	235	271	-237	-135	-79
Depth of Tibia Zone	450	475	497	410	473	+22	-65	-2
Underneath Desk Height / Height of Knee Zone	580	610	560	585	580	-50	-25	-30
Height of Tibia Zone	300	315	560	585	580	+245	+270	+265

In the above tables, colour code is used for distinguishing the deviations as follows. Green colour background is used to indicate safe values, while red colour represents the deviations far higher from expected values. Analysis of the table shows that in case of Size II desk, almost 11 dimensions out of 15 deviate highly from the expected values and are in unsafe zone, for all the three schools, while, only in case of 4 dimensions, the deviations are relatively low and are in safe zone. For size I, 6 dimensions are in safe zone, while 9 dimensions are in unsafe zone for all the schools. To evaluate the degree of deviations further, a new concept of EQAI[1] is developed by the authors for the first time in the ergonomic evaluation of furniture, which is discussed in the following paragraphs.

3.3 School Desk Ergonomic Quality Assessment Index (EQAI):

The authors herewith propose a new methodology to assess the school desks from ergonomic point of view. This concept is relatively new. The ergonomic risk assessment tools such as RULA, REBA are deciding risk levels for different positions of the human body and are assigning some score. A similar attempt is being done by the authors with slightly different context. Ramy Harik and Jana Fattouh [18] have proposed an Ergonomic Classroom Assessment (ECA) index. Our concept is similar, however, is restricted specifically to school desks, rather than the entire classroom. Care is taken that scientific and logical bases are provided while designing this methodology. While developing this index, following process is proposed. At first, list of different ergonomic desk design parameters is determined on the basis of ergonomic parameters considered by BIS as per IS 4837:1990. [8] Secondly, weightages are assigned to these parameters, according to their importance. These weightages are decided logically on the basis of literature review and considering possible health hazards due to noncompliance of a particular parameter. In the next step, scores of 0, 1, 2 etc. are allotted to the values of each parameter depending upon its deviation from the standard expected value. For this allocation, values recommended by IS 4837:1990 [8] are taken as standard, after doing certain corrections, according to changes in the anthropometric data. Following table (Table 3.6) illustrates the weightages and scores according to deviation level.

Table 3.6: Weights and Assessment Score/Risk Level Assigned To Desk Parameters

Sr No	Desk parameter	Weight Assigned	Deviation From Standard and Corresponding Assessment Score / Risk Level			
			0 - No	1 - Low	2 - Medium	3 - High
1	Seat Height (SH)	3	-5% to +5%	-15% to -5% +5% to +15%	-25% to -15% +15% to +25%	>-25% or >+25%
2	Seat Depth (SD)	2	-5% to +5%	-15% to -5% +5% to +15%	-25% to -15% +15% to +25%	>-25% or >+25%
3	Seat width (SW)	2	-10% to 0%	-20% to -10%	-30% to -20%	>-30%
4	Angle of Seat	1	-5% to +5%	-15% to -5% +5% to +15%	-25% to -15% +15% to +25%	>-25% or >+25%
5	Angle Between Seat and Back Rest	1	-5% to +5%	-15% to -5% +5% to +15%	-25% to -15% +15% to +25%	>-25% or >+25%

6	Lower Edge Back Rest Height (LEBH)	1	-5% to +5%	-15% to -5% +5% to +15%	-25% to -15% +15% to +25%	>-25% or >+25%
7	Upper Edge Back Rest Height (UEBH)	2	-5% to +5%	-15% to -5% +5% to +15%	-25% to -15% +15% to +25%	>-25% or >+25%
8	Width of Back Rest	1	-10% to 0%	-20% to -10%	-30% to -20%	>-30%
9	Desk Top Height (DH)	3	-5% to +5%	-10% to -5% +5% to +10%	-15% to -10% +10% to +20%	>-20% or >+20%
10	Desk Top Depth (DD)	1	-15% to 0%	-20% to -15% 0% to + 10%	-25% to -20% +10% to +20%	>-20% or >+20%
11	Desk Length / Width (DW)	2	< -5%	-10% to -5%	-15% to -10%	>-20%
12	Depth of Knee Zone	1	< -5%	-10% to -5%	-15% to -10%	>-20%
13	Depth of Tibia Zone	1	< -5%	-10% to -5%	-15% to -10%	>-20%
14	Underneath Desk / Knee Zone - Height	2	< -5%	-10% to -5%	-15% to -10%	>-20%
15	Height of Tibia Zone	1	< -5%	-10% to -5%	-15% to -10%	>-20%

Rationale behind Assignment of Weight and Assessment Score:

On the basis of literature review it is found that, Seat Height and Desk Top Height are most important dimensions. Even IS 4837:1990 [8] has considered these 2 dimensions as most important. Hence maximum weight (3) is assigned to these two dimensions they are, are Seat Height (SH) and Desk Top Height (DH). It was further revealed that, maximum authors have considered additional five parameters while doing ergonomic evaluation of the school desks, these are Seat Depth, Back Rest Height, Seat Width, Desk Width and Desk Underneath Height. Hence weight of 2 is assigned to them. Remaining parameters considered in IS 4837:1990 [8] are given the lower weightage of 1.

The factors considered while assigning the score to different parameters are discussed below.

Seat Height (SH): Higher SH causes increased pressure on underneath portion of thighs, as the leg support is reduced. When legs are completely hanging, then, the entire body weight comes on buttocks and thighs. This position comes approximately when deviation of SH is exceeding 25% of the standard value, which causes high risk. Similarly, as SH decreases, Knee flexion increases causing lifting of thighs from seat and load on buttocks increases. Contact area with seat goes on reducing and consequently pressure goes on increasing.

Seat Depth (SD): As SD decreases, unsupported length of thighs goes on increasing, which reduces the contact area of buttock and thighs for transferring the body weight. While, increasing SD reduces the underneath knee clearance required for its flexion.

Seat Width (SW): As SW decreases below standard, space for support of hips and thighs reduces in lateral direction causing discomfort. While higher value of SW will be favourable for increasing comfort in sitting and movement.

Angle of Seat: Recommended value is 0 – 4 degrees. Lesser angle than 0 means forward tilt which is acceptable to certain degree beyond that it causes sliding action and becomes uncomfortable. While larger backward tilt causes awkward position for writing as well as for leaning forward during listening activity.

Angle between Seat and Backrest: Recommended value is 95-100. Smaller angle does not provide comfort for resting position, while greater angle will not provide support to back.

Lower Edge Back Rest (LEBR): Measured from seat surface, higher value does not provide enough back support to fifth lumbar, while lower value will not provide sufficient buttock clearance.

Upper Edge Back Rest (UEBR): Measured from seat plane, higher value will not allow free shoulder movement, while lower value will not provide necessary back support.

Backrest Width (BRW): Lower values will be uncomfortable, as no enough support to back will be available in lateral direction. However, higher values are favourable because of extended support.

Desk Top Height (DH): Higher values than the standard will cause higher flexion of elbows and awkward position for writing, while lower values will not provide support to elbows and will lead to more forward bending of body, causing uncomfortable posture.

Desk Top Depth (DH): Higher values than standard will cause undue stretching of arm and hand or forward bending of body to reach up to front end of desk top. Lower values will not provide enough space for keeping study material such as books, notebooks etc.

Desk Top Length / Width (DW): Lower than standard value will cause discomfort, as support to elbows, especially for writing position will be inadequate. However, higher value is preferable as that will increase comfort, as more space will be available for the movement of elbows as well as for placing the study material.

Depth of Knee Zone and of Tibia Zone: Lower values will restrict the horizontal movement of knee, leg and foot. However higher values are preferred as they will provide enough space for free movement of leg and foot, similarly stretching of leg will be possible.

Table 3.7: EQAI Score for School Desks from the Three Schools - Size I

Desk parameter	Weight Assigned	SCHOOL A			SCHOOL B			SCHOOL C		
		% Deviation	Risk Score	Weighted score	% Deviation	Risk Score	Weighted score	% Deviation	Risk Score	Weighted score
Seat Height (SH)	3	30	3	9	13	1	3	8	1	3
Seat Depth (SD)	2	-25	3	6	-24	2	4	-26	3	6
Seat width (SW)	2	43	0	0	27	0	0	14	0	0
Angle of Seat	1	0	0	0	0	0	0	0	0	0
Angle Between Seat and Back Rest	1	-5	1	1	-5	1	1	-5	1	1
Lower Edge Back Rest (LEBR)	1	-21	2	2	15	2	2	-37	3	3
Upper Edge Back Rest (UEBR)	2	4	0	0	7	1	2	2	0	0
Back Rest Width (BRW)	1	76	0	0	57	0	0	41	0	0
Desk Top Height (DH)	3	20	2	6	4	0	0	2	0	0
Desk Top Depth (DD)	1	-23	2	2	-33	3	3	-28	3	3
Desk Length / Width (DW)	2	-15	2	4	-25	3	6	-33	3	6
Depth of Knee Zone	1	55	0	0	24	0	0	4	0	0
Depth of Tibia Zone	1	17	0	0	-7	1	1	16	2	2
Underneath Desk / Knee Zone - Height	2	27	0	0	13	0	0	-15	2	2
Height of Tibia Zone	1	102	0	0	97	0	0	48	0	0
Max score	72			30			22			26

Height of Knee Zone and of Tibia Zone: Lower values will restrict the vertical movement of knee, leg and foot. However, higher values are preferred as they will provide enough space for free movement of leg and foot.

Table 3.8: EQAI Score For School Desks From The Three Schools - Size II

Desk parameter	Weight Assigned	SCHOOL A			SCHOOL B			SCHOOL C		
		% Deviation	Risk Score	Weighted score	% Deviation	Risk Score	Weighted score	% Deviation	Risk Score	Weighted score
Seat Height (SH)	3	17	2	6	16	2	6	16	2	6
Seat Depth (SD)	2	-19	2	4	-15	2	4	-20	2	4
Seat width (SW)	2	33	0	0	14	0	0	1	0	0
Angle of Seat	1	0	0	0	0	0	0	0	0	0
Angle Between Seat and Back Rest	1	-5	1	1	-5	1	1	-5	1	1
Lower Edge Back Rest (LEBR)	1	-38	3	3	-19	2	2	-28	3	3
Upper Edge Back Rest (UEBR)	2	-10	1	2	-8	1	2	-12	1	2
Back Rest Width (BRW)	1	78	0	0	64	0	0	36	0	0
Desk Top Height (DH)	3	14	1	3	4	0	0	5	1	3
Desk Top Depth (DD)	1	-17	2	2	-32	3	3	-32	3	3
Desk Length / Width (DW)	2	-5	1	2	-18	2	4	-27	3	6
Depth of Knee Zone	1	-64	3	3	-36	3	3	-21	2	2
Depth of Tibia Zone	1	5	0	0	-14	1	1	0	0	0
Underneath Desk / Knee Zone - Height	2	-8	1	2	-4	0	0	-5	0	0
Height of Tibia Zone	1	78	0	0	86	0	0	84	0	0
Total EQAI Score	Maximum-72			28			26			30

Evaluation of Ergonomic Quality Assessment Index (EQAI):

The total maximum possible assessment score of the school desks, as per tables 3.7 and 3.8 is 72 which is worst possible case, while, least score of 0, represents best ergonomic design as per the IS 4837:1990. Here the authors propose to develop an ergonomic risk scale as follows. **1**. Satisfactory or no risk – EQAI score 0-9. **2**. Unsatisfactory or Low risk – EQAI score 10-18, **3**. Risky- Medium Risk - EQAI score 19-27**. 4**. Critical – High Risk – EQAI score 28-36. **5**. Dangerous – Very High Risk – EQAI score > 36. Corresponding deviations from zero score and proposed actions are presented in the following table – Table 3.9

It is seen that, for size I, the school desks from school A are in the critical zone, while those from school B and C lie in the risky zone. Similarly, for size II, the school desks from school B lie in the risky zone, while those from school A and C fall in the critical zone. It implies that there is urgent need to replace the existing furniture in all the schools by ergonomically designed furniture which adheres to IS 4837:1990 [8] standards and suits to the anthropometric measurements of the students.

Table 3.9: EQAI Score: Evaluation and Interpretation

Sr No	EQAI Score	Deviation from Ideal 0 Score	Risk Level	Proposed Action
1	0-9	@ 12.5%	Satisfactory - No Risk	Monitor Individual Allocation.
2	10-18	@ 12.5% -25%	Unsatisfactory – Low Risk	Monitor Individual Posture for stress level.
3	19-27	@ 25% - 37.5%	Risky – Medium Risk	Requires immediate attention and modification.
4	28-36	@ 37.5% -50 %	Critical – High Risk	Change the furniture as soon as possible.
5	>36	>50%	Dangerous – Very High Risk	Unacceptable. Stop usage.

Although, the study was carried out only in three schools, considering the in general negligence towards the ergonomic aspects, situation in other schools will be no different, the authors believe. The concept

of ergonomic quality assessment index proposed by the authors is relatively new one and needs further investigation and development. Also, this index is based on BIS standards right now, which can be based on more scientific basis, considering ergonomic evaluation of the desk dimensions with reference to concerned anthropometric dimensions of the students.

The authors conclude, therefore, that there is widespread unawareness about the ergonomic aspects of the furniture, especially school furniture and also about the BIS standards. Considering the huge population of school children in India, the problems of health could be detrimental to the development of the nation as a whole. Hence authors suggest that there is necessity to educate all Indians, especially school teachers and management in the area of ergonomics. Similarly, there is need of measurement and making available the anthropometric data of local students region wise. In India, very few such studies have been carried out in different regions. Again, there is a need to conduct such studies periodically. Such data should be provided to the school furniture manufacturers and they be encouraged to manufacture the furniture with ergonomic design considerations and with specifications adhering to BIS standards.

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