Design of Adjustable Desks and Chairs for University Classrooms Suitable For Students of Jadavpur University, India

Kashif Md, Bhattacharya Amrita and *Banerjee Debamalya
Production Engineering Department, Jadavpur University,
Kolkata- 700 032. India.
*Email: debmalya_banerjee@yahoo.co.uk

ABSTRACT

This paper demonstrates how adjustability of classroom desks and chairs can help to accommodate students of different body sizes. The first part of the paper deals with REBA analysis, used for ergonomic evaluation where very high final scores in the range of 8-10 were obtained. This indicates a high risk level and demands for investigation and further implementation for changes. A sample of 20 students consisting of 16 males and 4 females, of U.G. students of Production Engineering Department of Jadavpur University, was inspected for REBA analysis. Since attending to lectures on a desk is a sedentary job which is predominantly a long-cycle repetitive task, the injuries primarily involved the back and the neck. The second part of the paper suggests a suitable design for the desks and chairs with appropriate dimensions taking into consideration the anthropometric measurements of 48 students (41 males and 7 females) of Production Engineering department of Jadavpur University, Kolkata. This work will aid in mitigating Work Related Musculoskeletal Disorders (WMSDs) of students of India.

Key words: REBA, classroom chair-desk, students, posture, WMSDs

INTRODUCTION

One of the basic philosophy of ergonomics is to design workstations that are comfortable, convenient and productive to work at. Ideally workstations should be designed to fit both the body and the mind of the worker. By the use of anthropometric design principles it is possible for a variety of students to find physical comfort at a classroom. On the other hand, by not taking into consideration these physical requirements, one may create bad work postures, which lead to fatigue, loss of productivity and sometimes injury. Here, the anthropometric design motto has been applied that is "Let the small person reach and let the tall person fit." The aim of this design is to satisfy as large a population as possible. This cannot be achieved only by using the mean values of the appropriate anthropometric dimensions. Adjustability should also be provided to cater to wide variability of certain critical dimensions.

MATERIALS AND METHODS

REBA Analysis of the existing classroom sitting arrangement

Source of data: A random sample of 20 students consisting of 16 males and 4 females of U.G. students of Production Engineering Department of Jadavpur University, was inspected for REBA Analysis (Fig. 1).

Method followed: Pictures of all the subjects were clicked by using a "Nikon D3100" DSLR camera in three different angles- front, right and top view. These were then analysed using a computer application "Ergo Fellow" by FBF SISTEMAS to ascribe REBA scores.

Fig 1: Right, front and top view of a subject for REBA analysis

Anthropometric data collection

Source of data: Anthropometric measurements of randomly selected 48 U.G. students (41 males and 7 females) of Production Engineering department of Jadavpur University, Kolkata were recorded to arrive at the dimensions of the chair and desks suitable for them.

Method: It is not economically feasible to accommodate the extremes (minority) and the majority of students taking into consideration the design constraints, so, the intention is to design the reach distances for small (5^{th} percentile of the population) individuals, whereas clearance dimension are designed for large (95^{th} percentile of the population) individuals. Since the design is for both male and female students, the seating arrangement has been designed for 5^{th} percentile female and 95^{th} percentile male. After collecting sample data, they were analysed using a statistical computer application "Minitab" to find the 95% confidence interval of means of pertinent dimensions.

RESULTS

REBA analysis results

Table 1: REBA scores

S. No.	Sex	Score A	Score B	GRAND SCORE	S. No.	Sex	Score A	Score B	GRAND SCORE
1	M	7	4	10	11	M	7	4	10
2	M	8	3	10	12	M	7	3	9
3	M	6	2	8	13	M	7	3	9
4	M	6	3	8	14	M	8	4	11
5	M	7	4	10	15	M	6	2	8
6	M	7	4	10	16	M	7	2	9
7	M	8	3	10	17	F	7	3	9
8	M	6	3	8	18	F	7	4	10
9	M	6	2	8	19	F	7	4	10
10	M	8	2	10	20	F	7	4	10

Very high final scores in the range of 8-10 indicate a high risk level and demands for investigation and further implementation of changes.

Anthropometric measurements of the subjects

Table 2: Relevant anthropometric dimensions of sample

Parameter	95% confidence interval for mean (cm)	Parameter	95% confidence interval for mean (cm)
Popliteal depth	40.44 - 42.96	Sitting elbow height	22.64 - 24.26
Hip breadth	30.03 – 32.33	Elbow to elbow breadth	41.54 - 43.79
Buttock popliteal depth	44.81 - 46.60	Thigh clearance	13.55 – 14.90

DISCUSSIONS

Proposed chair dimensions for the U.G. students

Seat height

Seat heights are measured after loading the seat with the British Standard seat plate and compression weights, which simulate the Compression resulting from a person sitting on the seat (BS EN 527-1:2011) [1]. The anthropometric dimension which forms the basis for this dimension is the popliteal height. Appropriate heel height should also be added to this. While heel heights vary with fashion, Stephen Pheasant recommends adding 25mm for men and 45mm for women [2]. Thus seat height should be adjustable between: (40.44+2.5) cm – (42.96+4.5) cm = 42.94cm – 47.46cm

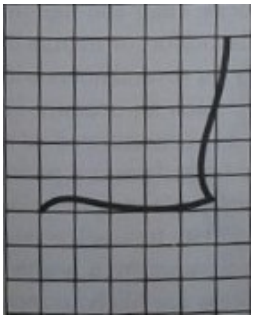

Fig 2: Seat profile

Seat width

On the basis of hip breadth, seat width should be adjustable between 30.03cm to 32.33 cm.

Seat depth

The pertinent anthropometric dimension to consider for this is the buttock to popliteal length. Thus seat depth should be adjustable between 44.81cm to 46.60cm.

Shape of backrest

Khan M. I. in his book 'Industrial Ergonomics', after testing and voting moulded seat shells of different profiles, has suggested the profile as depicted in 'Fig 2'.

Backrest Angle

The backrest angle should be adjustable to ensure that good lumbar support is available, and that working posture can be varied. Standards suggest backrest angle to be adjustable from 10^0 to 30^0 to the vertical [4].

Armrests

The armrests should be made of soft material. It's height from the seat, determined by sitting elbow height, and should be adjustable between 22.64cm to 24.26cm from the seat. The width between armrests, determined by elbow to elbow breadth, should be adjustable between 41.54cm to 43.79cm.

Desk

Height of the top surface

The height of the writing surface, as determined by the seat height and sitting elbow height, should be adjustable between: (42.94+22.64) cm to (47.46+24.26) cm = 65.58 to 71.72cm.

Thickness of table

To accommodate thighs there should be a clearance below the lower surface of the table. If we consider the worst case scenario the thickness should not be more than (65.13 – 47.46 – 14.90) cm i.e. less than 2.77 cm.

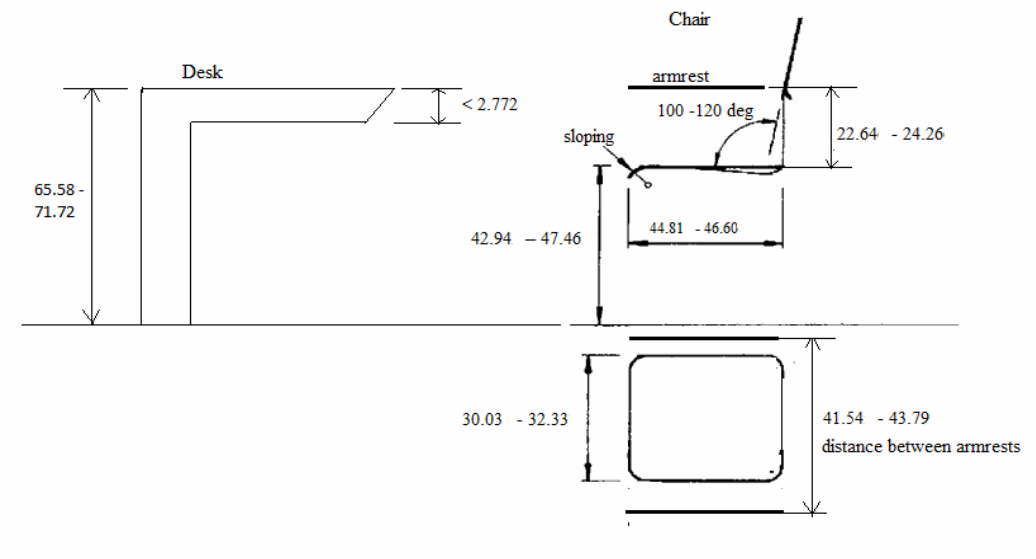

Fig 3: Proposed Chair-desk dimensions (in centimetre)

FUTURE SCOPE

Scope of improvement of the work

Sometimes it's difficult to illustrate a work situation using only an Anthropometric model. Anthropometric measures are static, and in the real world there are many dynamic elements. Students reach for accessories and swing around in the chair. To evaluate the dynamic aspects of a workstation appropriately one may construct a full-scale mock-up out of cardboard or Styrofoam. This should not take more than a couple of hours. The task is, to have people of different sizes, testing out the workstation by moving their body and simulating their work. Full-scale mock-up may identify some features of the workstation that need to be redesigned

Other applications

The same methodology, with little variation, can be used to ergonomically design bus-seat, computer work stations etc. Apart from the standard measurements of chairs and bus-seats, we can also go for designing based on strength by considering the load on the chairs or seats.

CONCLUSION

We hope, this work will aid in mitigating Work Related Musculoskeletal Disorders (WMSDs) of students of India. However, users are the ones who know most about their tasks and they should have every opportunity to advice on potential problems. In many cases there is little to choose between different products because of contradictory nature of the ergonomic and cost criteria, and then users should be given the opportunity to make the final decision.

STATEMENT OF RELEVANCE

In college class-rooms, students have to sit all day long while attending to lectures. Although sitting requires less physical effort than standing or walking, it still puts a lot of stress on the lumbar area. The selection of a suitable chair is a critical step in preventing health problems for people working in a sitting position.

REFERENCES

1. Ergonomic Principles and Checklists for the Selection of Office Furniture and Equipment (1991). http://www.safeworkaustralia.gov.au/sites/SWA/about/Publications/Documents/31/ErgonomicPrinciplesChecklistsForOfficeFurniture_1991_PDF.pdf , as on 8th October, 2013 at 1600 hours IST
2. PHEASANT S. (1986). Body space, Anthropometry, Ergonomics and Design. *London: Taylor and Francis Ltd*.
3. KHAN M I. (2010). *Industrial Ergonomics: 1st ed.* PHI Learning Private Limited, New Delhi - 110001.
4. Shibata N., Maeda S. (2010). Determination of backrest inclination based on biodynamic response study for prevention of low back pain. *Human Engineering and Risk Management Research Group, National Institute of Occupational Safety and Health, 6-21-1, Nagao, Tama-ku, Kawasaki, 214-8585, Japan*.