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Full Length Article

Anthropometric measurements for ergonomic design of students' furniture in India

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ABSTRACT

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.

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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 result 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 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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