

## Ergonomic Chair Design for Musculoskeletal Disorder (MSD)

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**Abstract:** The purpose of this study was to observe the anthropometric data collected compared to the existing data. Data was determined to propose the new design of school chair. The data collection was conducted at SK Jengka Pusat 2 located in front of UiTM Jengka, Pahang and the samples were the school students. The range of ages of the samples were around 7 to 12 years old among the students who volunteer to be physically measured in this study. The samples 125 male students and 125 female students. Thirteen human body dimensions were measured: stature, shoulder breadth, chest depth, sitting height, sitting eye height, sitting shoulder height, popliteal height, sitting knee height, forearm hand length, sitting elbow height, thigh clearance, head length and hip breadth. Finally, the anthropometric data was compared to the previous study. The findings showed similarity with the existing data. Presently, designing ergonomic workstation at school becomes an important task in order to create better sitting habits for youngsters despite taking into consideration the other factors that may influence the furniture itself. This is because school children remain seated in static and poor posture throughout their lesson, usually with their chest back and neck flexed or rotated making it difficult to change the sitting habits later in adulthood.

**Keywords:** Anthropometric, Chair design, Ergonomic, MSD

### 1. Introduction

Anthropometry can be defined as a study of a human body dimension. Human body measurements are very different in sizes and builds. Another term that related to the anthropometry is also known as Kinanthropometry. It also studies of human size, shape, proportion, composition, maturation and gross function, in order to understand growth, exercise, performance and nutrition (Tsang et. al., 1998).

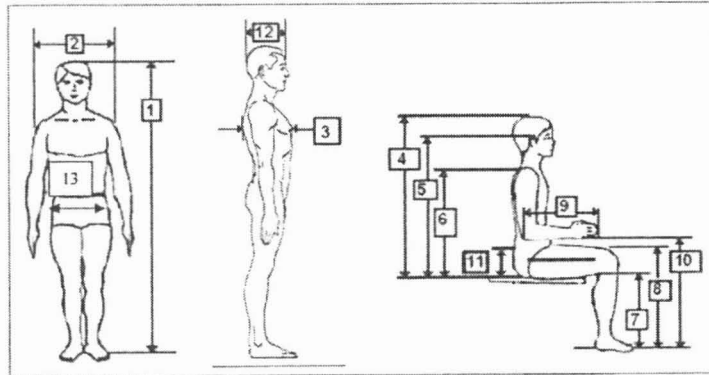
Today, designing ergonomic workstation has become very important to reduce work related musculoskeletal disorders (MSD) such as lower back pain (LBP) especially for students whether in class or laboratory. Students were using furniture like chairs and desks to achieve comfort in class. In addition, mismatch factors always happen between existing design product with the students' anthropometric dimension (Parcel et. al., 1999). Then, poor posture can effect the efficiency of performance work.

Choobineh et al. (2007) stated that high rate of shoulder problem can lead to poor posture due to high table workstations. High rate of back problems are related to the long awkward posture and lack of back system because of improper backrest while working.

Body measurements are based on age and body sizes (Kromer, 2008). The effect of unsuitable design of furniture will lead to a fatigue, lack of focus, decrease study performance; feeling sleepy in class, also feeling uncomfortable when study and the main risk is work related musculoskeletal disorder (MSD) such as lower back pain. According to Alireza et al. (2007), constraint and awkward posture can cause stress, decreased efficiency, work related musculoskeletal disorder and etc.

2. Methodology

In total, 250 students were involved in this study, which consist of 125 male and 125 female students from SK Jengka Pusat 2 located in front of UiTM Jengka, Pahang. The sample candidates were randomly chosen between the ages of 7 to 12 years old and based on their body figure. The design development is based on the anthropometric data collected from sample candidates from SK Jengka Pusat 2. Overall, there were thirteen dimensions of physical characteristics involved in this process as shown in the Figure 1. The equipment and tools used were digital caliper, measuring tape, portable height scale and one meter ruler.



- |                            |                          |
|----------------------------|--------------------------|
| 1. Stature                 | 8. Sitting Knee Height   |
| 2. Shoulder breadth        | 9. Forearm Hand Length   |
| 3. Chest Depth             | 10. Sitting Elbow Height |
| 4. Sitting Height          | 11. Thigh Clearance      |
| 5. Sitting Eye Height      | 12. Head Length          |
| 6. Sitting Shoulder Height | 13. Hip Breadth          |
| 7. Popliteal Height        |                          |

Fig. 1 Thirteen dimensions on data collection

Then, three replicates of vacant classroom chairs from primary school were measured and recorded as shown in Plate 1.

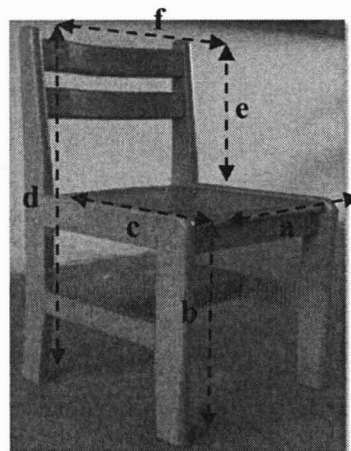


Plate 1. The dimensions of chair that are measured

All the data collected were analyzed by using SPSS software and Microsoft Office Excel 2007. After that, the new chair design concept was determined based on the candidates anthropometric

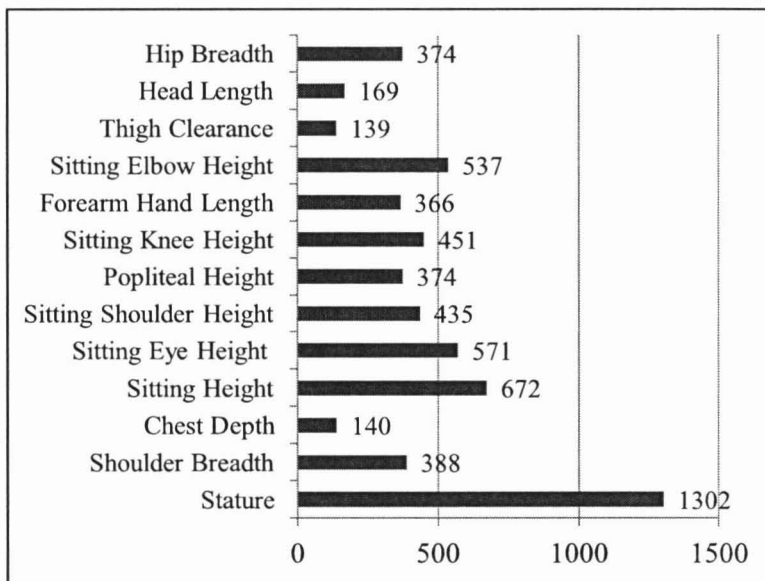
data and current chair measurements. Design process proceeded by using Google Sketch-Up Pro software.

**3. Results And Discussions**

Table 1 shows mean, standard deviation (SD), and percentile data of SK Jengka Pusat 2 students analysed from the anthropometric data gathered. Mean for sitting knee height was 434.780 mm and standard deviation of 40.127 mm. Popliteal height mean was 374.112 mm and 35.212 mm for standard deviation. Furthermore, stature shows the highest value with 1302.384 mm for mean and standard deviation of 107.927 mm because it has variation in stature value.

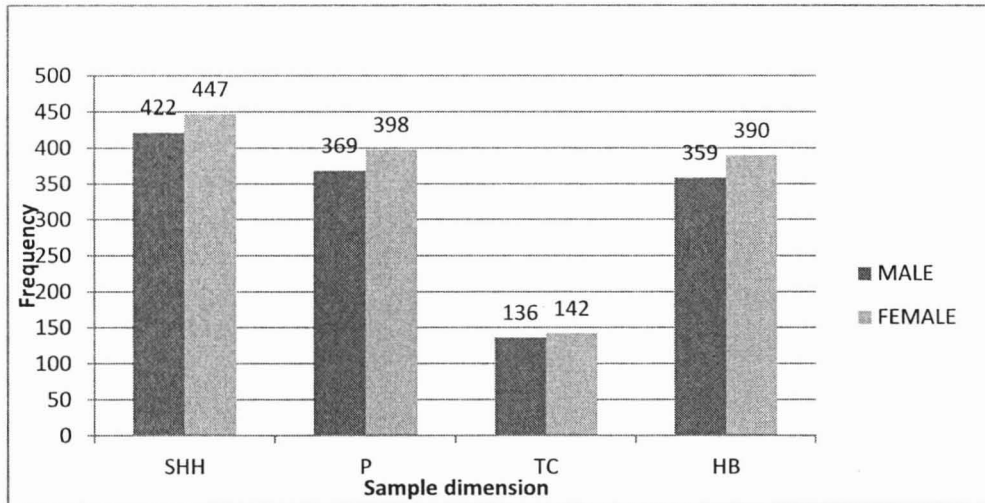
**Table 1.** Anthropometric data for male and female students (units are in mm)

Dimensions	Mean	SD	5th % tile	95th %tile
Stature	1302.384	107.927	1124.304	1480.464
Shoulder Breadth	388.008	50.832	304.135	471.881
Chest Depth	139.532	38.082	76.697	202.367
Sitting Height	672.308	55.778	580.274	764.342
Sitting Eye Height	570.908	56.608	477.505	664.311
Sitting Shoulder Height	434.780	58.755	337.834	531.726
Popliteal Height	374.112	35.212	316.012	432.212
Sitting Knee Height	450.616	40.127	384.406	516.826
Forearm Hand Length	366.300	35.489	307.743	424.857
Sitting Elbow Height	537.388	57.531	442.461	632.314
Thigh Clearance	138.812	33.072	84.243	193.381
Head Length	169.337	10.914	151.329	187.345
Hip Breadth	374.476	55.594	282.745	466.206



**Fig. 2** Graph of mean for male and female anthropometric data

Figure 3 refers to the mean of female physical dimension shows the higher value compared to male physical dimension. In childhood stage, it is normal to have a slightly bigger body shape for female than male because female undergoes rapid growth at this stage (Lao J., 2012). Due to the early puberty, girls that tend to be shorter since birth until six years old could grow higher than boys when they turn twelve years old (Yeats, 1997).



Notes: SHH: Sitting shoulder height, P: Popliteal, TC: Thigh clearance, HB: Hip breadth.

**Fig. 3** Comparison of anthropometric measurements mean between male and female

Summary of analysis of variance for SK Jengka Pusat 2 is as shown in Table 2 where there are highly significant values for stature, shoulder breadth, chest dept, sitting height, sitting eye height, forearm hand length, head length and hip breadth. This means the physical measurement between male and female students has variations. The ANOVA of students thigh clearance was not significant because there is no variation in the measurement value.

Furthermore, Sk Jengka Pusat 2 have two different types of classroom chairs where the first type was meant for standard one until standard three students in age range of seven to nine years old while the second type is meant for standard four to standard six students, ten to twelve years old. Both types differ in chair dimensions but same design. Since all students seated on the same chair for an average of more than one hour in school lesson, based on the observations, the existing chair seems comfortable and ergonomic, but in some part the chair dimensions does not follow the anthropometrics measurements of the students. Thus, Table 3 below shows the unequal measurement of the existing chair with student’s anthropometrics measurements.

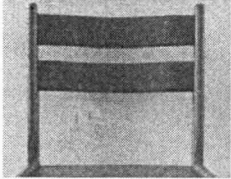
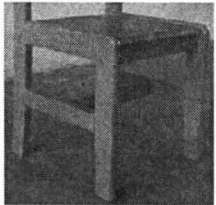
**Table 2.** Analysis of variance for male and female students.

Dimensions	df	Sig.
Stature	1	.000 <sup>HS</sup>
Shoulder Breadth	1	.000 <sup>HS</sup>
Chest Depth	1	.000 <sup>HS</sup>
Sitting Height	1	.000 <sup>HS</sup>
Sitting Eye Height	1	.000 <sup>HS</sup>
Sitting Shoulder Height	1	.001 <sup>HS</sup>
Popliteal Height	1	.014 <sup>S</sup>

Sitting Knee Height	1	.001 <sup>HS</sup>
Forearm Hand Length	1	.000 <sup>HS</sup>
Sitting Elbow Height	1	.052 <sup>S</sup>
Thigh Clearance	1	.196 <sup>NS</sup>
Head Length	1	.000 <sup>HS</sup>
Hip Breadth	1	.000 <sup>HS</sup>

Notes: df: degree of freedom, sig: significant, significant\*, highly significant\*\*, not significant<sup>NS</sup>

**Table 3.** Unequal measurement of the existing chair with student’s anthropometrics measurements

	Description	Picture
Backrest and thigh clearance	Two-piece component, only support the upper back of body whereas the student’s lower back has no support at all.	
Chair leg and popliteal height	The current dimension of the chair leg quite tall compared to the student’s popliteal height average figure.	

The new adjustment values shown in Table 4 were set by considering several anthropometric measurements that directly related to the chair dimensions which are sitting shoulder height, popliteal height, thigh clearance and hip breadth.

**Table 4.** The adjustment of school chair

Dimensions	Current Measurement (mm)	Ergonomic measurement (mm)	Final measurement (mm)
Chair seat length	345-390	270 - 480	375
Height of chair leg	360-390	327 - 468	356 – 392
Chair seat width	345-392	300 - 425	363
Chair height	680-700	421 - 724	600 – 724
Backrest height	300-320	325 - 540	325 – 350
Backrest length	335-380	297 - 492	395

An adjustment is made to the current chair, so it matches the students anthropometrics measurement and are more comfortable and ergonomic to school children. Plate 2 until Plate 4 show the proposed design of classroom chair meant for students aged between seven to twelve years old. The new design is provided with a backrest that is adjustable up to seventy millimeters. As for the leg of the chair, a spring was use so that the chair's height is modifiable to the height of the student. The dimensions of the chair follow the final measurement mentioned in Table 4. Each of the adjustable dimensions set takes into consideration of the ergonomic scale of the school students and the physical characteristics of the students involved in this research.

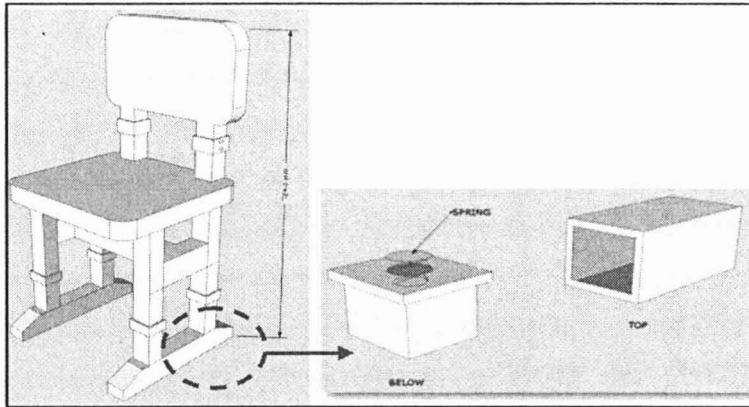


Plate 2. Classroom adjustable chair design

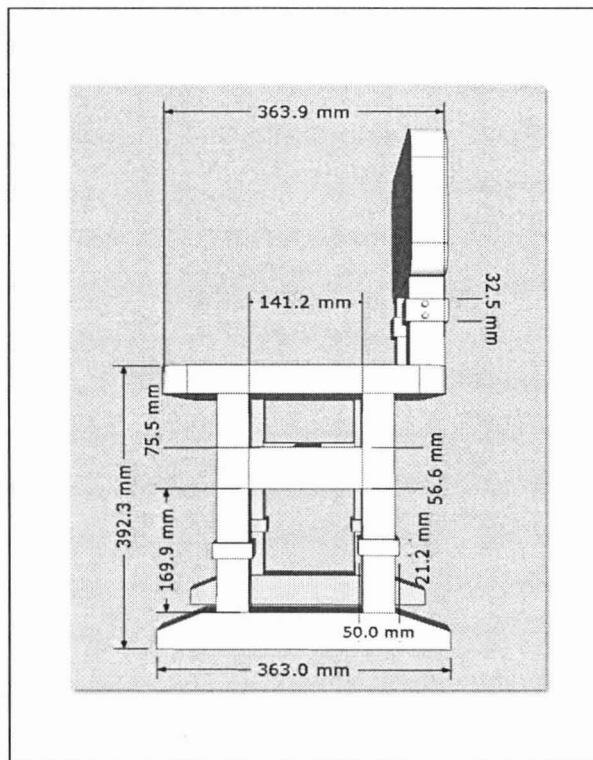
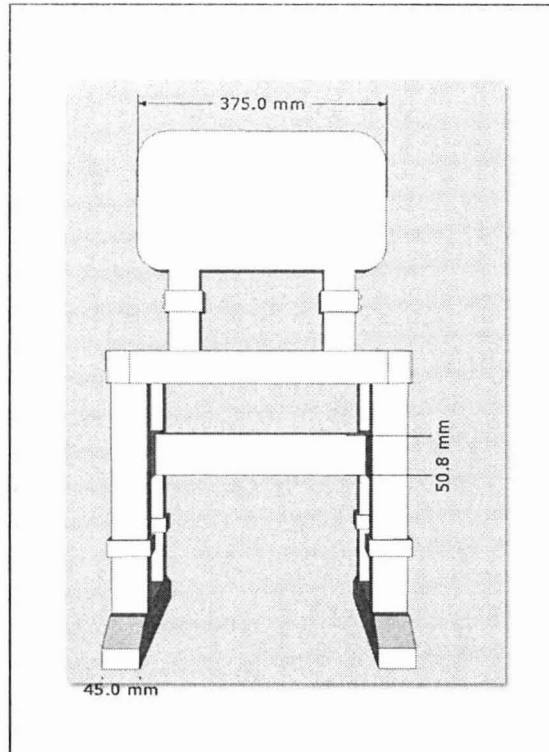


Plate 3. Side view of the adjustable chair



**Plate 4.** Front view of the adjustable chair

#### 4. Conclusion

A new design of an adjustable classroom chair was fit to be used in the classroom as the chair could be adjusted according to the students' physical characteristics. The dimensions of the chair take into consideration of the sitting shoulder height, popliteal height, thigh clearance and hip breadth measurement of the students. Thus, less muscular disorder problem will occur because students practiced proper sitting habits.

#### 5. Acknowledgements

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