



STUDY OF ANTHROPOMETRY AND ERGONOMICS OF DESK AND CHAIR DESIGN FOR ELEMENTARY SCHOOL (CASE STUDY: PUBLIC ELEMENTARY SCHOOL 008 PURNAMA)

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ABSTRACT

Desks and chairs are supporting facilities for learning activities at various school levels, especially elementary schools or mostly known as SD. The Government of Dumai City through the Education authorities provided desks and chairs for learning process. SD 008 Purnama is one of the schools that received desks and chairs as aid. However the desks and chairs provided are not ergonomic in terms of the size of desks and chairs compared to size of student's body. Somehow the un-ergonomic desks and chairs generate uncomfortable during learning and teaching process. In order to have proper anthropometry data of student of SD 008 Purnama and to be recommended to determine the size of desks and chairs ergonomically is the main purpose of this study. This study discusses the ergonomics of the design of the desks and chairs in elementary schools by using anthropometric data of students in grade 1 and 6. The research method used is quantitative research using the anthropometric approach. This research was conducted at SD 008 Purnama so that it can be used as main reference for the size desks and chairs for All elementary schools in the city of Dumai. The results of this study were the recommended Desk and chair sizes based on anthropometric data of students at SD 008 Purnama. Anthropometric data obtained were the high of desk and chair which can be raised and lowered. The high of desk was obtained 42.40 cm-67.35 cm and chair 29.22 cm-42.94 cm. However also obtained the length of desk was 64,57 cm, width 59.02 cm, the high of desk surface from below was 37.72 cm, the length of chair was 43.16 cm, the width of seat base was 36.89 cm, chair back height was 38.55 cm, chair back width was 38.55 cm and the high of footrest for desk and chair was 7.17 cm.

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I. INTRODUCTION

Desks and chairs are supporting facilities for learning activities at various school levels, especially elementary schools (SD). The proper desks and chairs will make students feeling comfort without experiencing pain or any complaints where students will spend hours in schools. Therefore proper or called ergonomic desk and chair are extremely needed. The Government of Dumai City through the Education authorities provided desks and chairs for learning process. SD 008 Purnama is one of the schools that received desks and chairs as aid, where it will be used for all students in any grades. However the desks and chairs provided are not ergonomic in terms of the size of desks and chairs compared to size of student's body.

The results of the pre-research carried out found problems with desks and chairs where the sizes did not match for several students. For instance students in grade 1, even though the desks and chairs have been set to the lowest size, students still did not get a comfortable position to study. However this problem does not only occur for grade 1 student, but for other grades also have the same problem. If the desk and chair do not meet the anthropometric requirements, then it will affect teaching and learning process because undoubtedly the students will have uncomfortable such as bone-pain due to wrong sitting positions.

This study aims to provide recommendations for the appropriate size of desks and chairs by applying anthropometric data for students at SDN 008 Purnama from grade 1 to grade 6. Anthropometric data is also applied in ablution places at SDIT ATH Thaariq-2 Dumai by Fitra, et al. in 2020. Also applied in design of motorcycle "Honda Beat" seat for children by Fitra, et al (2018) and the design of Multifunctional Narcissistic sticks by Fitra, et al in 2016. The application of anthropometric data in design is one of the basic principles of ergonomics by paying attention to human factors as users who have various limitations individually (human-centered design) (Irisdiastadi and Yassierli et al Fitra, et al, 2020).

II. LITERATURE REVIEW

A. Ergonomics

Ergonomics comes from the Latin "Ergo" which means work and "Nomos" which means natural law and also can be defined as the study of human aspects in the work environment which are reviewed from anatomy, physiology, psychology, engineering, management and design.) (Nurminto, 2008). Ergonomics is also concerned with optimization, efficiency, health, safety, and comfort at work, at home and in recreation place (Nurmianto, 2008). Ergonomics according to Iridiastadi and Yassierli (2014) is a scientific discipline that examines the limitations, strengths, and characteristics of humans, and makes use of this information in designing products, machines, facilities, environment, and even work systems, with the main objective of achieving the best work quality without ignoring the aspects of health, safety, and human comfort of its users. Several ergonomic principles that can be used as a guide for designing or criticizing a work system according to Nurmianto (2008) in Fitra, et al (2018):

1. Body posture at work is influenced by the shape, arrangement, size and placement of machines, pointing devices, how the machines operate.
2. In order to normalize the size of machines and industrial tools, the largest size must be taken as a basis and arranged in a way so that these sizes can be reduced.

B. Anthropometry

Anthropometry is one part that supports Ergonomics, especially in designing equipment based on Ergonomic principles. The term Anthropometry comes from the word "Anthropos" which means human and "Metricos" which means size. Anthropometry is a science that deals with aspects of human physical size (Iridiastadi and Yassierli, 2014) in Fitra, et al, (2018). Anthropometric data is clearly needed so that the design of a product can be adjusted according to the person who will operate it. The required body size is not difficult to obtain from individual measurements (Nurmianto, 2008). The application of anthropometric data using percentiles where percentile is a value that states that a certain percentage of a group of people whose dimensions are equal to or lower than that value. For example: 95% of population is equal to or lower than 95 percentile, 5% of population is equal to or lower than 5 percentile according to Iridiastadi and Yassierli (2014).

III. RESEARCH METHODOLOGY

The research was conducted at Elementary School (SD) 008 Purnama, Dumai. The population in this study were all grade 1 and grade 6 students at Elementary School (SD) 008 Purnama for the 2019/2020 academic year. The initial step of the research was carried out with a preliminary study in the form of direct observation of students to determine the incompatibility between desks and chairs with the dimensions of the student's body. Then, the researcher observed and analyzed the dimensions of the student's body in relation to tables and chairs. Furthermore, measured the anthropometry of the student's body and the results of the measurement were used to determine the size of each desk and chair dimension. Desk and chair sizes are obtained

from the percentile of each dimension. The application of the anthropometric approach in this study was to determine each ergonomic dimension for the size of the desk and chairs needed for SD 008 Purnama. Finally, redesign the size of desk and chairs according to the anthropometric measurements obtained.

IV. RESULTS AND DISCUSSION

The results of data collection that have been carried out are convenient with described phases in the research methodology. The dimensions measured consist of shoulder height, shoulder width, forward hand reach, height of elbow in sitting position, popliteal height, hip width, thigh thickness, ankle height and upper arm length. For each dimension measured can be seen in figures 1 to 5.

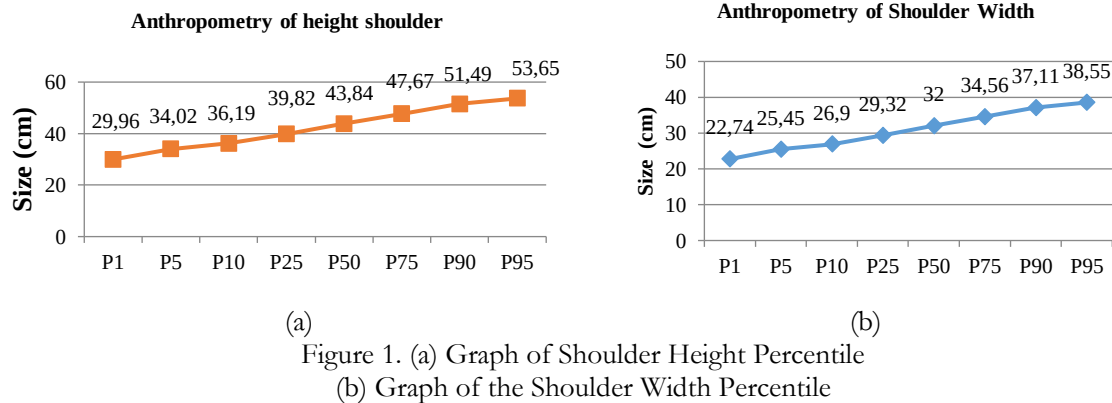


Figure 1 (a) shows the graph of the calculation of the shoulder height percentile dimension of SD 008 Purnama students which is used to determine the chair back height using the P50 percentile, which is 43.84 cm so that students with the smallest and largest shoulder height can sit with

entire back position. Whereas Figure 1 (b) shows the graph of the calculation of the width percentile dimensions to determine the width of the seat back using the P95 percentile, which is 38.55 cm so that the students with the largest shoulder width can be supported as a whole.

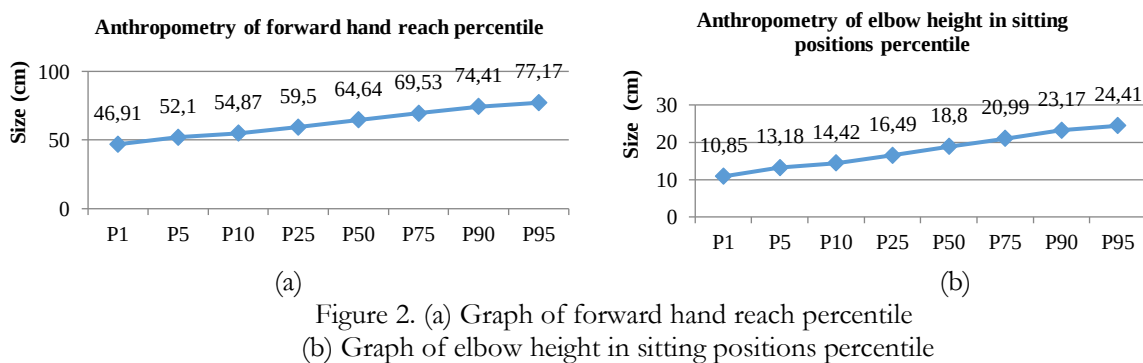


Figure 2 (a) is a graph of the calculation of the forward hand reach percentile dimensions to determine the width of the desk using the P5 percentile, which is 52.10 cm so that the students

with the smallest forward hand reach can still reach anything at the end of the desk easily and within their range. Figure 2 (b) is a graph of the calculation of the dimensions of the height of

elbow in sitting position percentile to determine the desk height using the P5 and P95 percentiles, namely 13.18 cm and 24.41 cm so that students

with high and low elbow in sitting position can put their hands on the desk comfortably

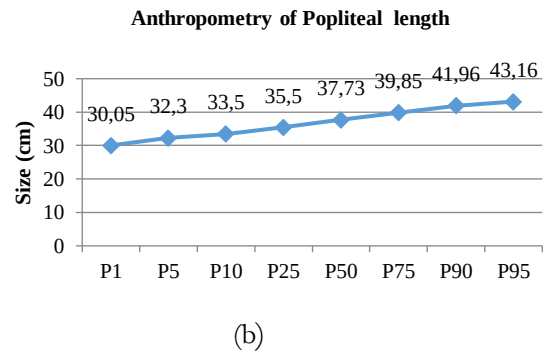
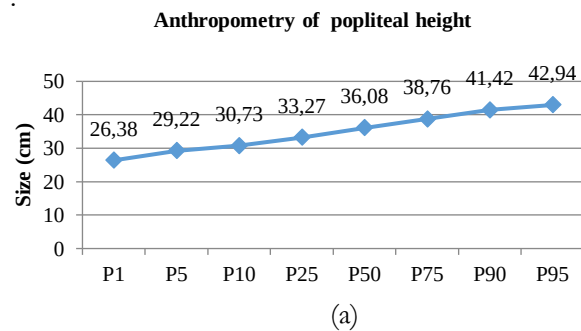


Figure 3. (a) Graph of Popliteal height percentile (b) Graph of Popliteal length percentile

Figure 3 (a) is a graph of the calculation the popliteal height percentile dimension for chair height using the P5 and P95 percentiles, which is 29.22 cm and 42.94 cm so that students with the largest and smallest popliteal heights can touch the ground as a whole. Whereas Figure 3 (b) is a

graph of the calculation of the popliteal length percentile dimension for the width of the seat base using the P95 percentile, namely 43.16 cm so that students with the largest popliteal length can sit comfortably because do not need to sit with their legs hanging off.

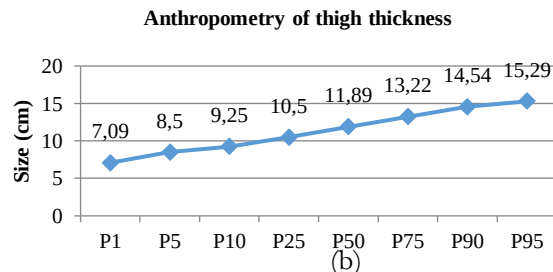
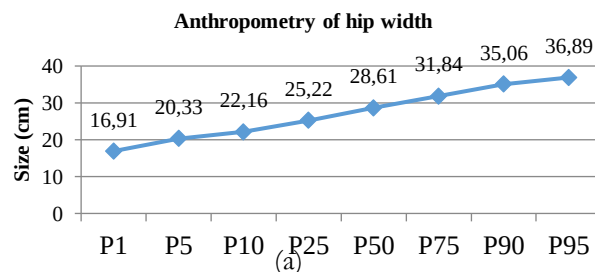


Figure 4. (a) Graph of hip width percentile (b) Graph of thigh thickness percentile

Figure 4 (a) is a graph of calculation of the hip width percentile dimensions for the width of the chair base using the P95 percentile, which is 36.89 cm so that the students with the largest hip width can be accommodated as a whole. Whereas Figure (b) is the result of the calculation of the

thigh thickness percentile dimension which is used to determine the height of the lower desk surface using the P5 percentile, which is 8.5 cm so that students with the largest thigh thickness puts their feet under the desk where their knees will be not bended.

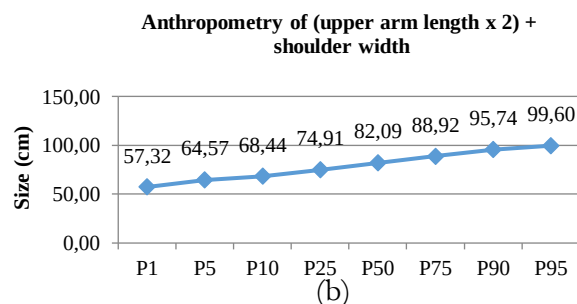
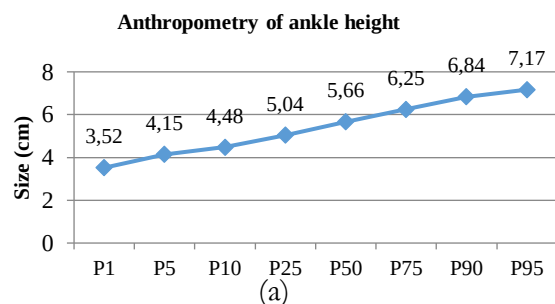


Figure 5. (a) Graph of ankle height percentile (b) Graph of (upper arm lengthx2) + shoulder width percentile

Figure 5 (a) is a graph of the calculation of the percentile dimensions for the ankle height which is used to determine the height of the desk and chair footrests using the P95 percentile which is 7.17 cm so that students with the greatest ankle

height can put their feet comfortably. However Figure 5 (b) is a graph of the calculation of the percentile dimension (upper arm length x 2) + shoulder width which is used to determine the length of the desk using the P5 percentile, which

is 64.57 cm so that students with large extended arms can put their hands on the table with comfortable and also considering the size of the classroom which is only 7 m x 8 m, if the large percentile is used then classroom to be narrow.

From the results of calculating the anthropometric data that had been calculated

using percentiles, then redesigned the size of the desks and chairs based on existing products using prototypes. The prototype is build to compare the actual desk and chair sizes also doing improvement in the adjustable system. The variables of ergonomic redesign of desks and chairs based on the anthropometric dimensions can be seen in Table 1.

Tabel 1. Comparison of size between Actual design to redesign

No.	Items	Actual design		redesign	
		Min	Maks	Min	Maks
1.	Chair height	37 cm	46 cm	29,22 cm	42,94 cm
2.	Chair width	41 cm		36,89 cm	
3.	Chair Length	35 cm		41,16 cm	
4.	Seat back height	36 cm		43,84 cm	
5.	Seat back width	42 cm		38,55 cm	
6.	Desk height	59 cm	77 cm	42,40 cm	67,35 cm
7.	Desk length	60 cm		64,57 cm	
8.	Desk width	45 cm		52,10 cm	
9.	Desk height from under	42 cm		37,72 cm	
10.	footrest height	14 cm		7,17 cm	

Table 1 is a comparison between the actual desk and chair sizes with the redesigned size. It can be seen some significant differences between the dimensions of the actual desks and chairs with the redesigned. The results of the redesign of desks and chairs carried out in this study are desks and chairs with an adjustable concept combined with one piece that is simpler and more flexible than the existing desks and chairs before. In this case,

the height of the desks and chairs can be increased and decreased according to the user's body dimensions based on the maximum size (max) and minimum size (min) of the redesigned desks and chairs. This is because there are too large differences in the dimensions of the student's body from one another. A detailed comparison picture can be seen in Figure 6 and Figure 7.

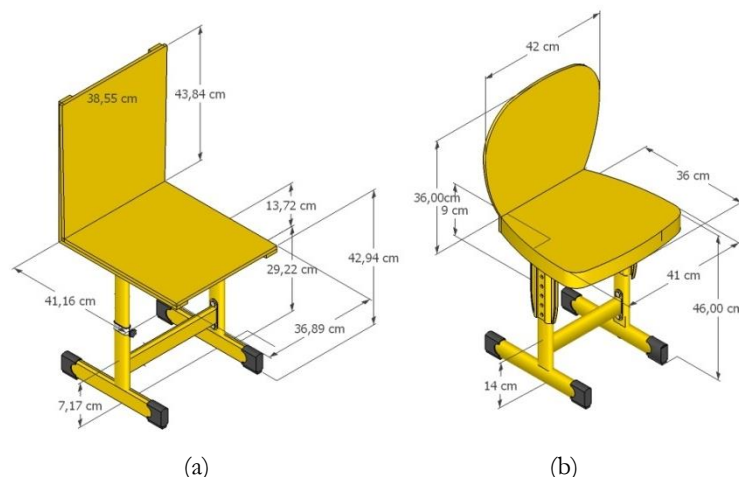


Figure 6. (a) Redesign chairs dan (b) Actual chairs

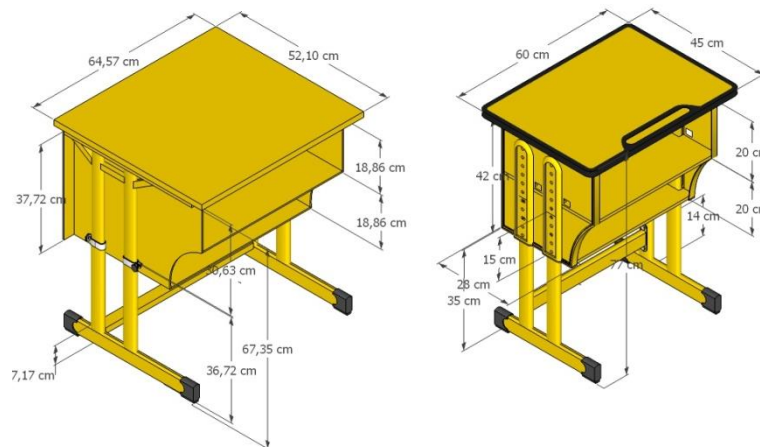


Figure 7. (a) Redesign Desk (b) Actual Desk

V. CONCLUSION

Based on the analysis that has been conducted, it can be concluded that the desks and chairs in SD 008 Purnama are not ergonomic in terms of anthropometry. Then this study has obtained the proper size of desk and chairs using anthropometric approach. The results were the high of desk and chair which can be raised and lowered. The high of desk was obtained 42.40 cm-67.35 cm and chair 29.22 cm-42.94 cm. However also obtained the length of desk was 64.57 cm, width 59.02 cm, the high of desk surface from below was 37.72 cm, the length of chair was 43.16 cm, the width of seat base was 36.89 cm, chair back height was 38.55 cm, chair back width was 38.55 cm and the high of footrest for desk and chair was 7.17 cm. However these all sizes can be applied and also referenced by government to produce desks and chair in further so that the learning and teaching activities can more be maximized and also can reduce negative impact for students.

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