Application of Anthropometry Methods in Ergonomic Chair Redesign to Prevent Fatigue A Case Study UKM Lestari Jaya, Tulungagung

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Abstract. Small and Medium Enterprises (UKM) Lestari Jaya is one of the home industries in Pucuk Village, Tulungagung Regency that produces chips from processed cassava ingredients which are commonly called samiler. These samiler chips are produced using manual methods so that the production process still depends on workers. So far, the work chairs used for military production, especially in the printing process, are not ergonomic and cause fatigue. This work chair is said to be not ergonomic in terms of the form of the backrest that is far from the back of the worker, the size that does not fit the worker's body shape, the chair material is made of plastic and the resistance of the chair in accepting body loads. Based on data from the Nordic Body Map questionnaire distributed to workers, chairs that are not ergonomic can cause fatigue in workers. Based on the above problems, a study was carried out to redesign an ergonomic work chair with the aim of reducing the risk of fatigue in workers. The anthropometric calculation of percentiles is used to determine chair size. The data is in the form of the 95th percentile for the seat height (45 cm) so that it can be used for people who have long or short legs, the 95th percentile for the width of the seat base (44.02 cm) so that the size of the seat base is wide, the 50th percentile for the back height (56.58 cm) so that it can be used for tall and short people, the 50th percentile for the length of the seat base (44.93 cm) so that people with large and small popliteal bottoms can use this chair, and the 50th percentile for the height of the armrests (23.95 cm) to fit the average human hand size. The advantages of this chair design are that it is stronger, the size of the chair is in accordance with the worker's body size and the addition of functions, namely that the chair's height can be raised or lowered according to the worker's body size.

1. Introduction
Ergonomics is the science, art and application of technology to harmonize or balance all facilities used for activities and breaks with human capabilities and limitations both physically and mentally so that the overall quality of life becomes better (Tarwaka, 2004). Ergonomics is closely related to anthropometry in harmonizing or balancing all the facilities used in work. Because anthropometry is a natural measure of the human body both in carrying out static activities (actual size) and dynamic (adjusted to work) (Wignjosoebroto, 2003). By knowing the dimensions of the worker's body through anthropometric calculations, a design of work equipment, work stations and products can be made in accordance with the dimensions of the worker's body so that it can create work comfort, health and safety. In an industry or business, workers' comfort must be considered related to the facilities used,
workload that does not cause fatigue, and comfort when doing work. In Tulungagung to be precise, has one of the Lestari Jaya Small and Medium Enterprises (UKM) which is engaged in the snack industry, namely military production. Samiler is a cracker made from processed cassava-based ingredients that are mashed, printed, dried and fried. One of the production activities is carried out by workers sitting in a work chair, namely when making dough. So far, using chairs that are not ergonomic because they do not match the worker's body size can cause fatigue after work. Apart from not providing comfort and causing pain, the work chairs used at UKM Lestari Jaya are made of plastic material which if the body load is too heavy it will cause the lower chair support to curve so that in the long term it can also cause work accidents. The following is a picture of a sitting position in a work chair that is not ergonomic.

![Figure 1. Samiler Pressing process](image)

Source UKM Lestari Jaya

Figure 1 represent the press process carried out in a non-ergonomic chair position. An improperly designed chair leads to a sitting position which increases muscle tension and balance control leading to fatigue and discomfort. Increased muscle pressure and disturbed balance control can have an impact on worker fatigue.

2. Literature Review

Industrial ergonomics is the application of various sciences that link human performance with a work system consisting of workers, jobs, equipment and environment, workplaces and their environment.

Definition of Anthropometry

Anthropometry comes from the words anthropos and metricos. Anthropos means human and metricos means measure. Anthropometry is the measurement of the human body naturally both in carrying out static activities (actual size) and dynamic (adjusted to work). Anthropometry is a science that deals with the measurement of dimensions and other characteristics of the human body such as volume, center of gravity and mass of human body segments[1]. The size of the human body varies widely, depending on age, sex, race, occupation and period from time to time. Measuring the dimensions of the human body is the most important part of anthropometry because it will be the basic data for preparing the design of various equipment, machines, processes and workplaces. We often find several industries in Indonesia that the design of work equipment and work stations is not in accordance with the dimensions of the worker's body[2]. For example, industrial display designs that are difficult for operators to read. Another example is the operator doing work where the workpiece is on the floor, so the operator performs activities with a bent work attitude or sitting in a short chair[3]. This work attitude will cause premature fatigue and even injury to the spine and cervical spine. Another case we often encounter is the design of classroom equipment for Elementary Schools (SD), where the design of tables and chairs for grades one to six has the same size. This condition makes students in grades one to grade three who have body dimensions smaller than grade four to grade six students will feel uncomfortable in following lessons. Several studies related to the design of elementary school desks and chairs have been carried out. The research carried out is in the form of proposed designs and implementation of ergonomics-based designs to reduce musculoskeletal complaints. However, the results of research has not received a positive response from stakeholders, so we often encounter table and chair designs that are not in accordance with the dimensions of the elementary school student body[4] , [5]. Today the application
of anthropometric data does not only concern the characteristics of the equipment, equipment and everything used in carrying out work activities, but also the design of work stations. In order for the design of work stations to be comfortable to use for activities, it is necessary to carefully consider including the use of anthropometric data[6]. The design of a work station requires knowledge of the range limits of the human body, known as the normal working area and the maximum working area.

2.1. Anthropometric Calculations
There are several anthropometric calculations that need to be done in data processing

2.2. Data Normality
The data normality test aims to determine whether the collected data follows a normal distribution. Normality testing will direct advanced statistical techniques to be used for decision-making tests, Data normality tests were carried out using the Shapiro-Wilk analytical test method. The Shapiro-Wilk test

\[ \bar{X} = \frac{\sum X_i}{n} \]  

(1)

method is used when the sample size is small (\( \leq 50 \))[7], [8]

\[ N' = \frac{K}{5} \left[ \frac{\sqrt{N \left( \sum X_j^2 \right)} - (\sum X_j)^2}{\sum X_j} \right] \]  

(2)

One of the factors that affect occupational health is related to ergonomics or work attitudes such as repetitive work and non-ergonomic positions. Apart from that the hours of activity are Nordic Body Map, One of the tools used to determine the description of Musculoskeletal Disorders is the Nordic Body Map questionnaire. Nordic Body Map is a questionnaire in the form of a body map containing data on the body parts complained by workers. The Nordic Body Map questionnaire is the most frequently used questionnaire to find out workers’ discomfort, and this questionnaire is most often used because it is standardized and neatly structured[9].

3. Results and Discussion

3.1. Data Collection
The data collection stage is the stage where the researcher will look for the data needed to be processed. The data collected by researchers are data on the production process identification of the work chair used and the sitting position of the worker using the old work chair, At this stage the researcher will process the data that has been taken at the data collection stage. The data obtained will be a measure used in designing a work chair through anthropometric data processing. The data normality test is used to determine whether the data in a group or variable based on the test is normal or not. Data is said to be normal with a failure rate of 5% or 0.05 using SPSS software[10], [11]. That is, if the data with a significance \( \geq 0.05 \) is normal data, while if the significance is \( \leq 0.05 \) then the data is considered abnormal and must take data again. There are two types of normality tests, namely the first Kolmogorov for large samples \( \geq 50 \) data[12], [13], [14]. Then the second is Shapiro for small samples \( \leq 50 \) data. In this study, because the data were below 50, the Shapiro normality test was used. The calculation results can be seen in table 1.
Table 1. Results of the data normality test calculation

| Tests of Normality | Kolmogorov-Smirnova | Shapiro-Wilk |
|--------------------|----------------------|--------------|
|                    | Statistic | Df | Sig. | Statistic | df | Sig. |
| Tpo                | .137      | 40 | .056 | .960      | 40 | .163 |
| LP                 | .126      | 40 | .111 | .950      | 40 | .079 |
| TSP                | .112      | 40 | .200* | .945      | 40 | .051 |
| Ppo                | .108      | 40 | .200* | .969      | 40 | .333 |
| TSD                | .107      | 40 | .200* | .970      | 40 | .350 |

* This is a lower bound of the true significance.
a. Lilliefors Significance Correction

The next test is to find out whether the data obtained is in a controlled state or not. Data that is within the specified control limits, namely Upper Control Limit and Lower Control Limit can be said to be in a controlled state, on the other hand, if the data is outside the Upper Control Limit and Lower Control Limit, then the data is said to be uncontrolled. Data that is in an uncontrolled state will be discarded and then tested again for uniformity until there are no more data that are outside the Upper Control Limit and Lower Control Limit.

Table 2. Results

| No | Description | SD (δ) | BA | BB |
|----|-------------|--------|----|----|
| 1  | Tpo         | 3.986  | 45.148 | 29.202 |
| 2  | LP          | 2.957  | 44.139 | 32.311 |
| 3  | TSP         | 2.908  | 63.391 | 50.759 |
| 4  | Ppo         | 3.846  | 52.616 | 37.234 |
| 5  | TSD         | 2.688  | 29.237 | 18.573 |

3.2. Percentile

The percentile data is used to determine the size of the chair that will be made according to anthropometric data calculations. Percentile shows the simulated average person data in percentage form. For example, the 95-th percentile will indicate 95% of the population will be at or below that measure; whereas the 5-th percentile will show 5% of the population will be at or below that measure. In anthropometry, the 95-year number represents the "largest" human size and the 5-th percentile represents the "smallest" size[15].

TPo
Percentil 5 = \( X - 1.645\delta \)
= 37.175 – 1.645 (3,986435)
= 30,61731
Percentil 50 = 37,175
Percentil 95 = \( X - 1.96\delta \)
= 37,175 + 1.96 (3,986435)
= 44,98841

LP
Percentil 5 = \( X - 1.645\delta \)
Percentil 50 = 38,225
Percentil 95 = $X - 1.96\delta$

$= 38,225 + 1.96(2,956848)$

$= 44,02042$

of all percentile calculations can be seen in table 3

### Table 3. Percentile Calculation

| Chair Dimensions | Anthropometric data used | Percentil (cm) | Percentil data used |
|------------------|--------------------------|----------------|---------------------|
|                  |                          | P5  | P50  | P95  |                  |
| Chair Height     | Tpo                      | 30,62 | 37,18 | 45 | P95 = 45 |
| Chair base weight| LP                       | 33,36 | 38,23 | 44,02 | P95 = 44,02 |
| Back Heigt       | TSP                      | 51,79 | 56,58 | 62,27 | P50 = 56,58 |
| Chair Base Length| Ppo                      | 38,60 | 44,93 | 52,46 | P50 = 44,93 |
| Armest Height    | TSD                      | 19,53 | 23,95 | 29,22 | P50 = 23,95 |

### 3.3. Chair Design

At this stage the researcher will redesign an ergonomic work chair to replace the old work chair based on body anthropometric calculations which are then used as a measure for the proposed work chair design in Figure 2. the data used are as follows

#### 3.3.1. The seat height is 45 cm. This size is in accordance with anthropometric calculations so that it can be used for people who have long or short legs.

#### 3.3.2. The width of the chair base is 44.5 cm. This size is in accordance with anthropometric calculations so that the seat size of the chair is wide.

#### 3.3.3. The height of the backrest is 56.59. This size is in accordance with anthropometric calculations so that people with tall and short body sizes can use this chair.

#### 3.3.4. The length of the base is 44.93 cm. This size is in accordance with anthropometric calculations so that people with large and small popliteal bottoms can use this chair.

#### 3.3.5. The height of the armrests is 23.95 cm. This measure is in accordance with the anthropometric calculation of the average arm size of a person.
Figure 2. The proposed framework design of chair

Figure 3. Proposed work chair design

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