Application of Anthropometry to Overcome Musculoskeletal Problems

Meri Andriani1*, Muhammad Thaib Hasan1, Nazaruddin2 and Nina Fahriana3
1Department of Industrial Engineering, Universitas Samudra, Langsa, Indonesia
2Department of Mechanical Engineering, Universitas Samudra, Langsa, Indonesia
3Department of Civil Engineering, Universitas Samudra, Langsa, Indonesia

* meri_tind@unsam.ac.id

Abstract The results of interviews from field observations, operators feel uncomfortable working because of lifting weights. Applying anthropometry in designing the tool, so Musculoskeletal Disorders (MSDS) can be avoided is the goal of the study. The research method used is Rapid Entire Body Assessment (REBA) method to find out the overall risk factor for body disorder, anthropometry method and percentile used to design the equipment. The results showed that for eight days the operator got a score of 6 ie to take immediate action, body dimensions used to design the trolley tool is 4 dimensions of the arm forward, elbow height, knee height and long arm. The conclusion of the research is trolley design is done to solve the problem of MSDS operator to work ergonomically. The dimension used is the future hand coverage dimension using Percentile 5 (P5) is worth 75.53 cm, standing elbow height using 95% (P95) worth of 109.02 cm, standing knee height using 95 Percentile (P95) worth 48.88 cm and long forearm using 50th percentile (P50) is worth 27.38 cm.

1. Introduction
A good working system from before is a goal to be achieved by the manufacturing industry [1]. Work system consists of human, material, equipment/facility, and work environment.

Humans as the center of the system work basically in addition to acting as a system planner work, as well as the executor and the controller always interact with the system. Humans as a source of labor are still dominant in carrying out the production process, especially recurrent activities that cause ergonomic hazards, such as tense posture and prolonged repetitive motions can cause musculoskeletal disorders (MSDS) [2]. Musculoskeletal disorders are a condition that the muscles experience the burden of either silent or repetitive activity over a sufficiently long period of time that causes damage to the joints, ligaments, and tendons [3]. This disorder is caused by the interaction of different risk factors generated by several factors, which can be categorized into individual, psychosocial and physical factors [4]. Musculoskeletal can be prevented by applying ergonomics in every job.

Ergonomics is concerned with human interaction and other system elements, as well as optimizing human wellbeing and overall system performance [5].

The object of research is the operator who brought the dough crackers. The operator in carrying the cracker dough is still manually bringing some dough trays full of batter crackers to be dried, and done repetitively. The results of the interview, the operator complained of pain in some parts of the body, identified as an inconvenience in the work. Work discomfort causes the operator to experience fatigue.
and the operator is not working optimally. If done continuously will cause musculoskeletal disorders (MSDS).

The object of research is the operator who brought the dough crackers. The operator in carrying the cracker dough still manually is bringing some dough trays full of dough crackers to be dried without using tools/facilities that can lighten the workload of the operator. The operator brings the cracker dough very much with the weight of ± 20 kg and the distance between the cracker and the drying place outside the factory is ± 10 meters, the action is repetitive. The work posture of the operator at work appears to be bent and difficulty carrying the dough. Manual removal by repeat operators can cause musculoskeletal disorders. Interview results, the operator feels tired and ill on the limbs, this is identified as an inconvenience to the job. Operator inconvenience is proven by using pulse measurement. The pulse rate is measured at the time of the operator before it begins lifting the dough by 80 beats/min, but after lifting the batter repeatedly the operator pulse increases to 120 beats/min. Work discomfort causes operators to quickly experience fatigue, fatigue is a commonly reported complaint among the general working population and can be seen as an imbalance between job demands and the ability of workers or the capacity to perform work [6].

The objective of the study was to apply anthropometry in designing the tool, so Musculoskeletal Disorders (MSDS) can be avoided.

2. Method
The term ergonomy or commonly known as human factors began to be triggered in 1949, but the activities related to it have appeared tens of years before [7]. Ergonomic considerations help operators work comfortably and increase productivity.

2.1. Rapid Entire Body Assessment
Sue Higgett and Lynn McAtamney developed REBA that was used to assess the worker's posture, the force employed, the type of labor movement [8]. REBA tools can be used for rapid assessment of the whole body as an evaluation of musculoskeletal loads due to posture, repetition, and style. REBA also evaluates work or tasks that can expose workers to whole-body disorders (wrists, upper and lower arms, neck, trunk, and legs). In the REBA tool, all parts of the body are classified into two known groups of scores A and B. Group A consists of the neck, legs, and trunk; and group B consists of the forearms, upper arms, and wrists. The results of scores A and B are scored C. Finally, REBA scores are calculated by adding C to "ACTIVITY score" [9].

2.2. Anthropometry
Anthropometry is used to adjust the dimensions of the tool/machine and workplace to the human dimension. Where anthropometric data does not exist, it can lead to negative consequences for human and product conformity or workplace [10], for example, a study conducted by [11], found in the process of pulverizing the dough crackers, the operator is too bowed so that they complain of back pain. Their complaints identified the inconvenience at work.

Anthropometry is a science of measurement and the art of applications that define the physical geometry, mass properties and the power capabilities of the human body [12]. In industry, anthropometry is needed in the design of machinery, tools, and work environments to improve welfare, health, comfort, and security. The importance of matching anthropometry data to workers in the design of tools and workplaces [13]. Anthropometric dimensions vary across gender, race, and age [14]. Procedures that can be followed in the application of anthropometric data in the design process, [15]:

a. Determine the user population of product design or workstation. Different people in the age group will have different physical characteristics and needs, as well as for gender, race, ethnic group, civilian or military groups.

b. Determine the body dimensions that are thought to be important in design.

c. Select the percentage of the population to accommodate in design.
d. For each body dimension, determine the relevant percentile value.
e. Give leeway to existing data if needed.
f. Use simulators to test the design. The designers need to evaluate whether the design is appropriate or not.

2.3. Statistic test
The statistical test was performed after obtaining anthropometric dimension data which included data uniformity test and data adequacy test. Test data uniformity serves to minimize the existing variant by removing extreme data. The first step in the uniformity test is the calculation of the mean and standard deviation to know the upper and lower control limits. Test data adequacy serves to determine whether the data obtained is sufficient to be processed. Test data adequacy in advance determine the degrees of freedom $s = 0.05$ and 95% confidence level with $k = 2$, meaning that the average of the measurement data allowed to deviate by 5% of the actual average of 95% [16].

3. Result
3.1. Identify MSDS using REBA
The study was conducted for eight days with the same operator. Determination of the operator is done from 10 operators by taking the operator approaching the average time in completing the activity. Operators are measured and assessed for eight days under the guidance of the REBA method. Assessment results are listed in Table 1.

| Score A | Score B | Table C | Value action level | Risk level | Action |
|---------|---------|---------|-------------------|------------|--------|
| 6       | 6       | 9       | 3                 | High       | Soon   |
| 6       | 4       | 8       | 3                 | High       | Soon   |
| 3       | 5       | 6       | 2                 | Medium     | Need   |
| 6       | 6       | 9       | 2                 | Medium     | Need   |
| 5       | 6       | 9       | 3                 | High       | Soon   |
| 6       | 6       | 8       | 3                 | High       | Soon   |

It can be seen in Table 1 that the level of risk to the operator is identified as high for six working days so that the action is done immediately, while for 2 working days the operator is identified the medium risk level so that the action needs.

3.2. Implementation of Anthropometry for designing tools
In anthropometry, the data used is the data operator field aged 17 years and over. Data collected amounted to 8 people of male sex. Operators are measured using an anthropometric martin (manual measurement) on a portable basis. Measurements use 2 assistants who have experience in anthropometry measurement at the time of the ergonomics practice. The data taken is accurately measured twice for each individual dimension. The anthropometric dimension used is the range of the front arm, the height of the standing elbow, the height of the knee standing, and the length of the forearm, shown in Fig.
1. The range of the front arm
2. The height of the standing elbow
3. The height of the knee standing
4. The length of the forearm

Figure 1. Anthropometric Dimensions

Figure 1 is an anthropometric data used to design the tool [12] ie the ergonomic trolley. The anthropometric dimensions used and their usefulness in the trolley design are the range of the forehands for the width of the trolley, the height of the elbows standing for the height of the trolley handle, the knee height stands for the trolley height and the length of the forearm for the height of the trolley handle to the trolley height. The percentile can be determined after obtaining the data adequacy test and the data uniformity test (statistical test) of each dimension, in table 2.

| No. | Dimension                        | Mean | P5  | P50 | P95 |
|-----|----------------------------------|------|-----|-----|-----|
| 1.  | The range of the front arm       | 76.75| 0.74| 75.53| 76.75|
| 2.  | The height of the standing elbow | 107.50| 0.93| 105.58| 107.50|
| 3.  | The height of the knee standing  | 47.38| 0.92| 45.87| 47.38|
| 4.  | The length of the forearm         | 27.38| 0.74| 26.15| 27.38|

In table 2 there are four dimensions that are used to design the trolley, one of which the dimension of the range of the front arm with percentile 50 is worth 76.75.

4. Discussion
The operator's anthropometric data as a basis for designing an ergonomic trolley is to look at the suitability between the operator's body dimensions and the trolley. Percentiles for each dimension are different, such as the dimensions of forward arm range using the 5th percentile on the grounds that short-handed operators can reach the tip of the width of the trolley, the height of the elbows standing using the 95th percentile on the grounds that the operator having a large body does not bend when carrying the trolley, the height of the knee stands using the 95th percentile for the same reason as the height of the elbow standing, the dimension of the forearm length using the 50th percentile with the reason that the short and medium-sized operator is not too difficult indeed the trolley handle. The ergonomically designed device in figure 2.

| Design | Standard Operating Process |
|--------|-----------------------------|
|        | The operator brings the cracker dough by pushing the trolley to the drying place. |

Figure 2. Ergonomic design tool
5. Conclusion
Based on the research can be concluded: Trolley design is done to overcome the problem of MSDS operator to work ergonomically. The four dimensions used are the future hand coverage dimension using Percentile 5 (P5) is 75.53 cm, height of elbow standing using 95 Percentile (P95) is 109.02 cm, standing knee height using Percentile 95 (P95) worth 48.88 cm and the length of the forearm using 50th percentile (P50) is worth 27.38 cm.

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