

Chair Design Analysis Of Work To Reduce Musculoskeletal Part 1: Anthropometry Method

Nelfiyanti, Ery Diniardi, Anwar Ilmar Ramadhan

Abstract: Refilling of fire extinguishers is a key activity in PT Pinaco Utama Indonesia. In these activities, the workers doing the work manually with ergonomic postures that can cause a complaint to the musculoskeletal system. In a preliminary study, a questionnaire used Nordic Body Map is used to identify specific problems in parts of the body and using REBA (Rapid Entire Body Assessment) to determine the level of risk working posture. This preliminary study shows that workers have a lot of complaints on the part of their body with a high level of risk and very high. For that we need a tool that can reduce the complaints of the musculoskeletal system. Tools in the form of work chair. The purpose of this study was to design an ergonomic office chair and is equipped with several features to accommodate the needs and conditions in PT Pinaco Utama Indonesia. The first step of this research is to develop the expectations of the office chair features information then is poured into a design concept. Furthermore, this concept is manifested in a more specific design taking into account the anthropometric dimensions of the workers. Making the design and production cost calculation is made to perform a feasibility analysis in this research.

Index Terms: Work Chairs, Design, Nordic Body Map, REBA anthropometry

1 INTRODUCTION

PT PINACO UTAMA INDONESIA is a factory in the field of trade and services refilling fire extinguishers to be sent to various customers. In the production process includes several stages of the process of making powder / powder contents of the tube, filling powder / powder contents of the tube, storage tube into the storage table. [1-3] From the results of direct observation and interviews with workers at PT PINACO UTAMA INDONESIA, the process of making powder / powder fill tube and filling powder / powder content of the tube indicates the operator musculoskeletal complaints such as pain in the neck, back, waist, legs and calves. Based on the results of questionnaires Nordic Body Map to 4 operator recharging fire extinguishers got complaints on several body segments operator [4-5]. Of the four carriers is known that the four complained of pain in the upper neck, lower neck, upper arm, right wrist, right shoulder, back, waist, legs and feet. Based on observations, there are work postures that indicate the occurrence of muscle injury. Therefore, it is necessary to design work facility in an effort to reduce the grievances felt by the operator. [6-8] Based on the background of the problems that exist researcher wants to try out ideas improvement in research entitled "chair design work with the ergonomic aspects to reduce musculoskeletal disorders in PT PINACO UTAMA INDONESIA". This research is very important to produce an ergonomic work chair, in accordance anthropometry of workers of PT Pinaco Utama Indonesia as users. The objectives to be achieved after doing this research that resulted in an ergonomic work chair, in accordance anthropometry of workers of PT Pinaco Utama Indonesia as users.

2 RESEARCH METHOD

The data collection phase requires some kind of data regarding the activity of fire extinguisher recharging. The data collection process can be described in the following section [9]:

Documentation and interviews

Documentation obtained by shooting and working attitude in the process of refilling fire extinguisher. While the interviews were conducted to obtain information directly from the workers to the complaints and desires in the process of refilling fire extinguisher.

Questionnaires

The spread of the questionnaire aims to find complaints or discomfort felt by the workers at PT PUI during the process of refilling fire extinguisher. Questionnaires were distributed a questionnaire Nordic Body Map. Through this questionnaire is expected to know the parts of the body that is experiencing musculoskeletal complaints.

Identification of the complaint, the expectations and needs

In this stage, the interpretation of the complaint, the expectations and needs of workers of PT Pinaco Utama Indonesia will be the product concerned, which will be used as the basis for designing an ergonomic work chair. Results ergonomic work chair design is expected to meet the needs of the worker.

Anthropometric Data

In this scheme required anthropometric data used to establish the size of the design. It is intended that the resulting design can be used with good or at least closer to its characteristics. Retrieval of data obtained from the results of anthropometric measurements of workers as much as 4 people and additional data body dimensions were 36 people taken from Lab. Practical PSKE of Industrial Engineering Department of Universitas Muhammadiyah Jakarta. The anthropometric data were taken in accordance with the variables that have been determined by that High Sitting Upright (TDT), High Eye Contact (TMD), High Shoulder Sitting (TBD), High Elbow Lounge (TSD), High-popliteal (TPO), Butt popliteal (pPO), Ass To Knee (PKL), Pinggu Width (LP), Shoulder Width (LB), and

- Nelfiyanti, Department of Industrial Engineering, Faculty of Engineering, Universitas Muhammadiyah Jakarta, Indonesia.
- Ery Diniardi, Department of Mechanical Engineering, Faculty of Engineering, Universitas Muhammadiyah Jakarta, Indonesia.
- Anwar Ilmar Ramadhan, Department of Mechanical Engineering, Faculty of Engineering, Universitas Muhammadiyah Jakarta, Indonesia E-mail: anwar.ilmar@umj.ac.id

Reach Hand Future (JTD).

Step research conducted as in Figure 1 below:

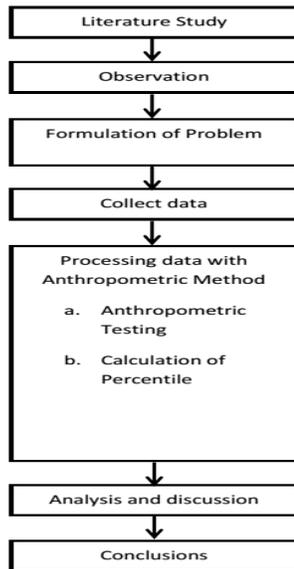


Figure 1. Flow of research conducted

3 RESULTS AND DISCUSSION

The data collection phase is obtained from direct observation of the process of filling the fire extinguisher in PT Pinaco Utama Indonesia. Then the collected data will be used as the basis for designing a tool in the form of "work chair" that is expected to be able to cope with musculoskeletal complaints experienced by these workers.

Questionnaire Results Recap NBM (Nordic Body Map)

Nordic Body Map questionnaires were given to four workers at PT Pinaco Utama Indonesia, aims to understand the complaints of the workers in the process of charging the fire extinguisher. This questionnaire Following are results of the questionnaire in Table 1:

Table 1. Questionnaire NBM (Nordic Body Map)

| No | Type of complaints body | Score Operator of 1 | | | | Score Operator of 2 | | | | Score Operator of 3 | | | | Score Operator of 4 | | | | Total Complaints | |
|----|-------------------------|---------------------|----|---|----|---------------------|----|---|----|---------------------|----|---|----|---------------------|----|---|----|------------------|----|
| | | TS | AS | S | SS | | |
| 0 | Neck top | 1 | | | | | | | | | | | | | | | | | 3 |
| 1 | Neck down | 1 | | | | 1 | | | | | | | | | | | | 1 | 4 |
| 2 | Section left shoulder | | | | 0 | | | | 0 | | | | | | | | | | 1 |
| 3 | Section right shoulder | 1 | | | | 1 | | | | 1 | | | | | | | | | 3 |
| 4 | Left upper arms | 0 | | | | 0 | | | | 0 | | | | | | | | | 0 |
| 5 | dorsally | | 2 | | | | 2 | | | | 2 | | | | | | | 2 | 8 |
| 6 | Right upper arms | | 1 | | | | 1 | | | | 1 | | | | | | | 1 | 4 |
| 7 | waist | | 2 | | | | 2 | | | | 2 | | | | | | | 2 | 8 |
| 8 | the hips | | 2 | | | | 1 | | | | 1 | | | | | | | 1 | 5 |
| 9 | buttocks | 0 | | | | 0 | | | | 0 | | | | | | | | | 0 |
| 10 | Section left elbow | 0 | | | | 0 | | | | 0 | | | | | | | | | 0 |
| 11 | Section right elbow | 0 | | | | 0 | | | | 1 | | | | | | | | | 1 |
| 12 | The left forearm | | 1 | | | | | | 0 | | | | | | | | | | 1 |
| 13 | The right forearm | | 1 | | | | 1 | | | | 1 | | | | | | | 1 | 4 |
| 14 | Section left wrist | 0 | | | | 0 | | | | 0 | | | | | | | | | 0 |
| 15 | Section right wrist | 0 | | | | | 1 | | | | 1 | | | | | | | 1 | 3 |
| 16 | The left hand part | 0 | | | | 0 | | | | 0 | | | | | | | | | 0 |
| 17 | The right hand part | | 1 | | | | 1 | | | | 1 | | | | | | | 1 | 4 |
| 18 | Part of the left thigh | | 1 | | | | | | 1 | | | | | | | | | | 2 |
| 19 | Part of the right thigh | | 1 | | | | | | 1 | | | | | | | | | | 2 |
| 20 | Left knee | 0 | | | | 0 | | | | 0 | | | | | | | | | 0 |
| 21 | Right knee | 0 | | | | 0 | | | | 0 | | | | | | | | | 0 |
| 22 | Left calf section | | 1 | | | | 1 | | | | 1 | | | | | | | | 3 |
| 23 | Right calf section | | 1 | | | | 1 | | | | 1 | | | | | | | 1 | 4 |
| 24 | | 0 | | | | 0 | | | | 0 | | | | | | | | | 0 |
| 25 | Right ankle part | 0 | | | | 0 | | | | 0 | | | | | | | | | 0 |
| 26 | Part of the left leg | 0 | | | | 0 | | | | 0 | | | | | | | | | 0 |
| 27 | Part of the right leg | 0 | | | | 0 | | | | 0 | | | | | | | | | 0 |
| | Total | | 12 | | 6 | | 10 | | 4 | | 13 | | 4 | | 7 | | 4 | | 60 |

The total score of the recapitulation of the questionnaire Nordic Body Map in Table 1 above as many as 60 complaints with a risk level of the high risk category and class actions are required immediate action.

Initial work posture

Posture assessment work conducted to determine the attitude / position work experience musculoskeletal complaints. Posture assessment work carried out by the method of REBA (Rapid Entire Body Assessment). REBA method can be used to determine which parts of the body experiencing fatigue or pain. Rate posture PT PUI workers drawn from the current posture of the process of refilling fire extinguisher consists of several processes including; the process took a powder and take the empty tube into the working area, the process took a powder and pour the contents into an empty tube until fully charged according to the charging standard size and then after the tube is fully charged, then the final step is filling nitrogen. Here are the results of the risk assessment ergonomics with REBA method, among others:

Powder-making process and the empty tube

The process of decision-making processes of powder and empty tubes is done with standing posture slightly bent with the hands reaching forward to take the powder from the powder storage shelves. The position could potentially cause a complaint to the back. The process can be seen in Table 2. with REBA results below:

Table 2. Posture powder-making process and the empty tube

| Posture of decision powder and empty tube | | | | | | | |
|---|-------|------------------|--------------------------|-------|---------------|-------------|----|
| Picture of Process | Group | Posture | Remarks | Score | Score Changes | Score Total | |
| | A | Body | Body bending 20-60° | 3 | 0 | 3 | |
| | | Neck | Neck Degree 0-20° | 1 | 1 | 2 | |
| | | Leg | Position of Normal Leg | 1 | 0 | 1 | |
| | B | Upper arm | Upper arm degree 20-45° | 2 | 0 | 2 | |
| | | Lower arm | Lower arm degree 60-100° | 1 | 0 | 1 | |
| | | wrist | Degree of 0-15° | 1 | 0 | 1 | |
| | | Load | Up load from 10 kg | 1 | 0 | 1 | |
| | | the kind of grip | the handle being | 1 | 0 | 1 | |
| | C | Activity Score | | | | | 12 |

Posture process of filling powder into an empty tube

In the process of filling powder into the empty tube until it is full, the worker standing bent. The posture can potentially cause pain in the back, neck and hands. The process can be seen in Table 3 with the results of REBA below:

Table 3. The process of retrieving and pour the powder into the empty tube

| Posture of retrieving and pour the powder into the empty tube | | | | | | | |
|---|-------|------------------|--------------------------|-------|---------------|-------------|----|
| Picture of Process | Group | Posture | Remarks | Score | Score Changes | Score Total | |
| | A | Body | Body bending 20-60° | 3 | 0 | 3 | |
| | | Neck | Neck Degree 20° | 1 | 1 | 2 | |
| | | Leg | Position of Normal Leg | 1 | 0 | 1 | |
| | B | Upper arm | Upper arm degree 20-45° | 2 | 1 | 3 | |
| | | Lower arm | Lower arm degree 60-100° | 1 | 1 | 2 | |
| | | wrist | Degree of 0-15° | 1 | 0 | 1 | |
| | | Load | Up load under of 10 kg | 0 | 0 | 0 | |
| | | the kind of grip | the handle of good | 0 | 0 | 0 | |
| | C | Activity Score | | | | | 10 |

Posture nitrogen charging process

Once the tube is fully charged then the workers perform the charging process nitrogen. Workers with a standing posture. The process can be seen in Table 4 with the results of REBA below:

Table 4. Posture nitrogen charging process

| Posture nitrogen charging process | | | | | | |
|---|-------|------------------|--------------------------|-------|---------------|-------------|
| Picture of Process | Group | Posture | Remarks | Score | Score Changes | Score Total |
|  | A | Body | Body bending 20-60° | 0 | 0 | 0 |
| | | Neck | Neck Degree 20° | 1 | 0 | 1 |
| | | Leg | Position of Normal Leg | 1 | 0 | 1 |
| | B | Upper arm | Upper arm degree 20-45° | 2 | 0 | 2 |
| | | Lower arm | Lower arm degree 60-100° | 1 | 0 | 1 |
| | | wrist | Degree of 0-15° | 1 | 0 | 1 |
| | | Load | Load under of 5 kg | 0 | 0 | 0 |
| | | the kind of grip | the handle of medium | 1 | 0 | 1 |
| | C | Activity Score | | | | 7 |

From the results of the three processes can be concluded with a recap on the scores REBA. Here are the results of recapitulation REBA score in Table 5.

Table 5. Summary of REBA Score

| Process | REBA Score | Risk Level | Action |
|---------|------------|------------|-------------------------------|
| 1 | 12 | Very High | As soon as possible to repair |
| 2 | 10 | High | Immediate repairs |
| 3 | 7 | Medium | required actions |

Anthropometric Data

Anthropometric data used to design ergonomic office chair. Anthropometric data obtained directly from the four workers PT PINACO UTAMA INDONESIA and there is also an additional anthropometric data of the Lab. Practical PSKE Industrial Engineering Universitas Muhammadiyah Jakarta as many as 36 people. Anthropometric data were measured for the design office chair ergonomics are 7-dimensional body, the High Sit upright (TDT), High Eye Contact (TMD), High-popliteal (TPO), Butt popliteal (PPO), Ass To Knee (PKL), Wide Hips (LP), Shoulder Width (LB), and Reach Hand Future (JTD). Here are the results of measurements of body dimensions of which are described in Table 6 below:

Table 6. Dimensional Full Body of PT PUI

| No | Body dimensions | Symbols | Measurement Results (cm) | | | |
|----|----------------------|---------|--------------------------|-------|------|-------|
| | | | Roby | Irfan | Ari | Andri |
| 1 | High Sitting Upright | TDT | 90 | 93 | 88.5 | 91.5 |
| 2 | Eye Contact High | TMD | 80 | 84 | 80.5 | 82 |
| 3 | High popliteal | Tpo | 42 | 45 | 42 | 43 |
| 4 | Butt popliteal | Tpo | 48 | 49 | 46 | 47.5 |
| 5 | Butt To Knee | PKL | 56 | 58 | 55 | 57 |
| 6 | Shoulder width | LB | 43 | 42 | 44 | 44 |
| 7 | Hands Reach Ahead | JTD | 80 | 84 | 83 | 82 |

Anthropometric Data Testing

The results of test calculations uniformity high data sitting upright, all the data is already qualified and are considered uniform uniformity, it is not necessary to test the uniformity of data again. Recapitulation of each dimension uniformity test anthropometric data is presented in Table 7:

Table 7. Uniformity Test Data Anthropometric

| No | Body dimensions | Symbols | \bar{x} | $\hat{\sigma}$ | BKA | BKB | Remarks |
|----|----------------------|---------|-----------|----------------|-------|-------|---------|
| 1 | High Sitting Upright | TDT | 88.54 | 3.16 | 98.01 | 79.07 | Uniform |
| 2 | Eye Contact High | TMD | 76.46 | 3.43 | 86.75 | 66.17 | Uniform |
| 3 | High popliteal | TPO | 43.32 | 2.32 | 50.27 | 36.37 | Uniform |
| 4 | Butt popliteal | PPO | 47.1 | 3.13 | 56.47 | 37.68 | Uniform |
| 5 | Butt To Knee | PKL | 56.27 | 3.53 | 66.87 | 45.68 | Uniform |
| 6 | Shoulder width | LB | 43.28 | 2.66 | 51.27 | 35.29 | Uniform |
| 7 | Hands Reach Ahead | JTD | 79.73 | 5.01 | 94.76 | 64.69 | Uniform |

Data observation is sufficient for meeting the requirements $N < N'$, N is the number of data observations, data retrieval is not needed anymore. The results of test calculations the adequacy of the data each anthropometric dimension are presented in Table 8 below:

Table 8. Test Anthropometric Data Sufficiency

| No | Body dimensions | Symbols | \bar{x} | $\hat{\sigma}$ | N' | N | Remarks |
|----|----------------------|---------|-----------|----------------|----|----|---------|
| 1 | High Sitting Upright | TDT | 88.54 | 3.16 | 2 | 40 | Enough |
| 2 | Eye Contact High | TMD | 76.46 | 3.43 | 3 | 40 | Enough |
| 3 | High popliteal | TPO | 43.32 | 2.32 | 5 | 40 | Enough |
| 4 | Butt popliteal | PPO | 47.1 | 3.13 | 7 | 40 | Enough |
| 5 | Butt To Knee | PKL | 56.27 | 3.53 | 6 | 40 | Enough |
| 6 | Shoulder width | LB | 43.28 | 2.66 | 6 | 40 | Enough |
| 7 | Hands Reach Ahead | JTD | 79.73 | 5.01 | 6 | 40 | Enough |

Percentile is a value that indicates a certain percentage of people who have sizes at or below that value. At this stage it is used percentiles 5 and 95, Here is the recapitulation of percentile calculations are presented in Table 9. below:

Table 9. Data percentile anthropometry

| No | Body Dimensions | Symbols | Percentil (%) | Size (cm) |
|----|----------------------|---------|---------------|-----------|
| 1 | High Sitting Upright | TDT | 95 | 93.73 |
| 2 | Eye Contact High | TMD | 50 | 76.46 |
| 3 | High popliteal | TPO | 95 | 47.13 |
| 4 | Butt popliteal | PPO | 5 | 42 |
| 5 | Butt To Knee | PKL | 5 | 50.47 |
| 6 | Shoulder width | LB | 95 | 47.66 |
| 7 | Hands Reach Ahead | JTD | 50 | 76.46 |

4 CONCLUSION

From the results of this study provide the following conclusions:

1. Based on the identification using REBA after designing a decline in the level of risk. For the powder-making process has a score of 12 with a very high level of risk into a score of 5 with moderate risk level, to the process of filling the tube has a score of 10 with a high level of risk into a score of 3 with a low risk level and for nitrogen charging process no change in score.
2. The results of the design workbench refers to workers anthropometric data, body dimensions and percentiles are used for the design is the TDT (High sitting upright) with the 95% percentile, TMD (seated eye height) with a percentile of 50%, TPO (popliteal height) with a percentile 5%, pPO (butt popliteal) with

5% percentile, PKL (buttock to knee) with 5% percentile, LB (Shoulder Width) with a percentile of 95%, and JTD (Reach arms forward) with 5% percentile.

ACKNOWLEDMENT

The author would like to thank the Institute for Research and Community Services of Universitas Muhammadiyah Jakarta, which has provided research grants to develop in 2016.

REFERENCES

- [1] D. M. Pardede, A. R. Matondang, L. N. Huda, 2013, Analysis Chair Ergonomic Design Work Employee in PT. YYY, Journal of Industrial Engineering Universitas Sumatra Utara Vol 8, No. 2, Desember 2013 pp. 14-18
- [2] D. R. Permana, I. Wahyuni, 2010, Freshness value difference Squad Stretching Before and After Giving Mc. Kenzie Extension on Women Workers packers Jamu PT. X Semarang, Journal of Media Kesehatan Masyarakat Indonesia., Vol. 9 No. 1, April 2010, 18-26
- [3] Tarwaka, 2013, Industrial Ergonomics, Harapan Press, Solo
- [4] T. F. Maulana, Sugiharto, Anizar, 2013, Proposed Improvement Work Facilities In Cutting Station To Reduce Musculoskeletal Complaints in CV. XYZ, Journal of Industrial Engineering Universitas Sumatra Utara Vol 1, No.2, Maret 2013 pp. 59-63
- [5] W. Susihono, E. Rubiati, 2012, Repair Work Method Based on Rapid Upper Limb Assessment (RULA) On Construction and Fabrication Company, Journal of Industrial Spektrum 2012, Vol. 10, No. 2, pp. 101-110
- [6] S. Wingjosoebroto, 2000, Ergonomics and Time Motion Study (Analysis Techniques to Increase Work Productivity), Guna Widya, Second Edition, Jakarta
- [7] W. Susihono, W. Prasetyo, 2012, Posture Repair Work To Reduce Musculoskeletal Complaints With OWAS Method Approach (Case Study at UD. Rizki Ragin Jaya - Cilegon City), Journal of Industrial Spektrum 2012, Vol. 10, No. 1, pp. 1-107
- [8] K. N. Sundari, 2011, Work Attitude The Cause Musculoskeletal Complaints And Increase Workload In Shape Artisan Ceramics, Journal of Ilmiah Teknik Industri, Vol. 10, No. 1, Juni 2011, pp. 42-47
- [9] E. Nurmianto, 1996, Ergonomics, Concepts and Applications. First Edition. Guna Widya. Jakarta