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Submission date: 13-Oct-2021 08:44AM (UTC+0700)
Submission ID: 1672462498
File name: 8_Proceeding_ICOEMIS_2019.pdf (2.07M)
Word count: 3569
Character count: 15705

ATLANTIS PRESS

Advances in Intelligent Systems Research, volume 173

1st International Conference on Engineering and Management in Industrial System (ICOEMIS 2019)

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Keywords: Assembly Work Station, MSEs, Musculoskeletal Disorders, REBA, Work Posture

Abstract. This research was conducted at MSEs of silver jewelry handicraft called SILVER 999. Workers in this MSEs, especially in assembly work station often experience back pain, neck pain, achy shoulders, achy hands called musculoskeletal disorders (MSDS). To reduce the risk of MSDS, ergonomic evaluation is carried out directly at this work station. Respondents in this study were all 10 workers. Data collection uses observation and filling in questionnaires. Worker posture is measured by Rapid Entire Body Assessment (REBA) method. The MSDS complaint was measured by filling out Nordic Body Map (NBM) sheets. The results obtained as much as 70% (7 people) work posture in the assembly section with a very high category and 70% (7 people) workers in this section who experience MSDS complaints with a moderate category. Non-ergonomic work postures can cause MSDS complaints. Work posture that is getting worse cause greater musculoskeletal complaints. This shows that the redesign of the assembly work station is recommended so that the work posture is more ergonomic and reduces the symptoms of MSDS.

Introduction

UKM SILVER 999 is a small enterprise in silver jewelry craft that located in Malang. This MSEs currently has 10 workers with a production capacity of 30-50 pieces per month depending on the design of the products produced. The production process is performed by handmade which requires precision and skill. In fact, production in UKM SILVER 999 is often delayed so that the specified target is not achieved. To achieve the production target, UKM SILVER 999 is required their workers to work overtime every day. The addition of working hours that imposed on workers and the position of workers in a static sitting position or standing for a long time and uncomfortable working facilities. This condition causes workers to become easily tired resulting in inconvenient condition. The lack of comfort in this work station is partly due to the dimension of working facilities that are not suitable for the worker's body size and have not been based on anthropometric aspects. Evaluation of muscle injury risk, it makes some challenges in almost MSEs where the environment does not provide certain standards yet [1]. For this reason, it is necessary to design a proper facility, in example an adjustable table, in order to make the facility design become more ergonomic so that it can support the comfort of workers in assembling silver jewelry. Also, this improvement is able to improve worker posture due to reducing muscle injuries the workers have been experienced. To identify the above problems, this research will use the Rapid Entire Body Assessment (REBA) method, where the REBA method is used to measure posture, strength of activity, coupling factors and movements associated with silver jewelry assembly activities [2]. The purpose of this research was to identify and analyze the work posture of silver jewelry assembly workers at the assembly work station with the REBA method and to design ergonomic workplaces (adjustable tables) based on anthropometric data.

Literature Review

Product Design is a way of living and creating new ideas and then communicating those ideas to others in an understandable way [3]. Work stations are spaces occupied by machines or work stations, necessary supporting equipment, and workers or contain the same set of machines, which may require more than one worker. Sometimes it is only part of the room space with workers working along the conveyor, as in assembly operations [4]. Work-Related Musculoskeletal Disorder (WMSD) or muscle injury due to work is a term that is aimed at body tissue disorders caused by poor posture and body movements, repetitive, forced and accumulated movement. In addition to those factors, WMSD can be caused by environmental influences such as vibrations, low temperatures, and others. [5]. Rapid Entire Body Assessment (REBA) is a method developed in the ergonomics field and can be used appropriately to assess the work position or posture of a worker 's neck, back, arms, wrists, and legs. In addition this method is also influenced by factor coupling, external loads supported by the body and worker activities. Assessment using the REBA method conducted by Dr. Sue Hignett and Dr. Lynn McAtamney [6] through the following stages:

Stage 1: Retrieving workers' posture data using video or photo guidance.

Stage 2: Determine the angle of the worker body part. After determining the score of each body movement, the results of the score are used to find out the A score using table A and score B using table B, by drawing / matching columns with rows according to the body movement scores that have been obtained.

Stage 3: Determining the lifted object weight, coupling, and worker activity.

Stage 4: Calculation of REBA values for the relevant posture. From the value of REBA, it can be defined as the level of risk on Muscolusceletal and actions that need to perform to reduce risk and improve work. For more details, the flow of work methods using the REBA method are shown in Figure 1.

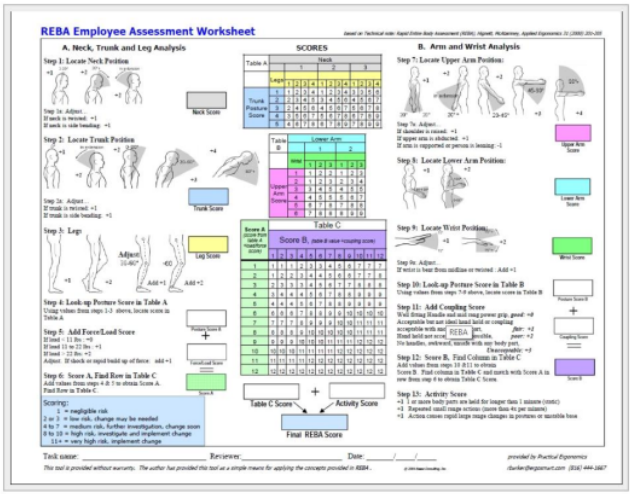

Fig. 1 REBA Calculation Steps on REBA Worksheet

Research Methodology

This research was conducted through several stages. The first stage is the formulation of the problem and the purpose of the study. Observations were carried out with the aim of finding out the problems that were being experienced by assembly line workers in the Silver UKM Silver 999. The next stage was data collection, in the form of assembly activities and questionnaires. The following step is to determine the method and problem-solving. Data processing begins with the calculation of the Nordic

Body Map. Then analyzing the body posture using the REBA method. Analysis and discussion were conducted on the body posture of the assembly workers.

A. Identification of Musculoskeletal Disorders Complaints (MSDs)
   To determine the level of complaints of workers, this research performed interviews and worksheets of Nordic Body Map (NBM) which includes 28 body parts. NBM assessment used to assess the level of complaints there are 4 categories, namely, score 1 for the level of complaints does not hurt, score 2 for the level of complaints is rather painful, score 3 for the level of pain complaints, and score 4 for the level of complaint is very sick. All scores are recorded and summed to get the final score used to determine the level of MSDs complaint risk.
B. Work Posture Data Collecting
   1. Assessment using the REBA method
   2. Measurements are made when the assembly part workers perform their work activities
   3. Measurements are made on members of the body such as the arms, forearms, wrists, back, neck, and legs.

The details flowchart of this study is shown in Figure 2.

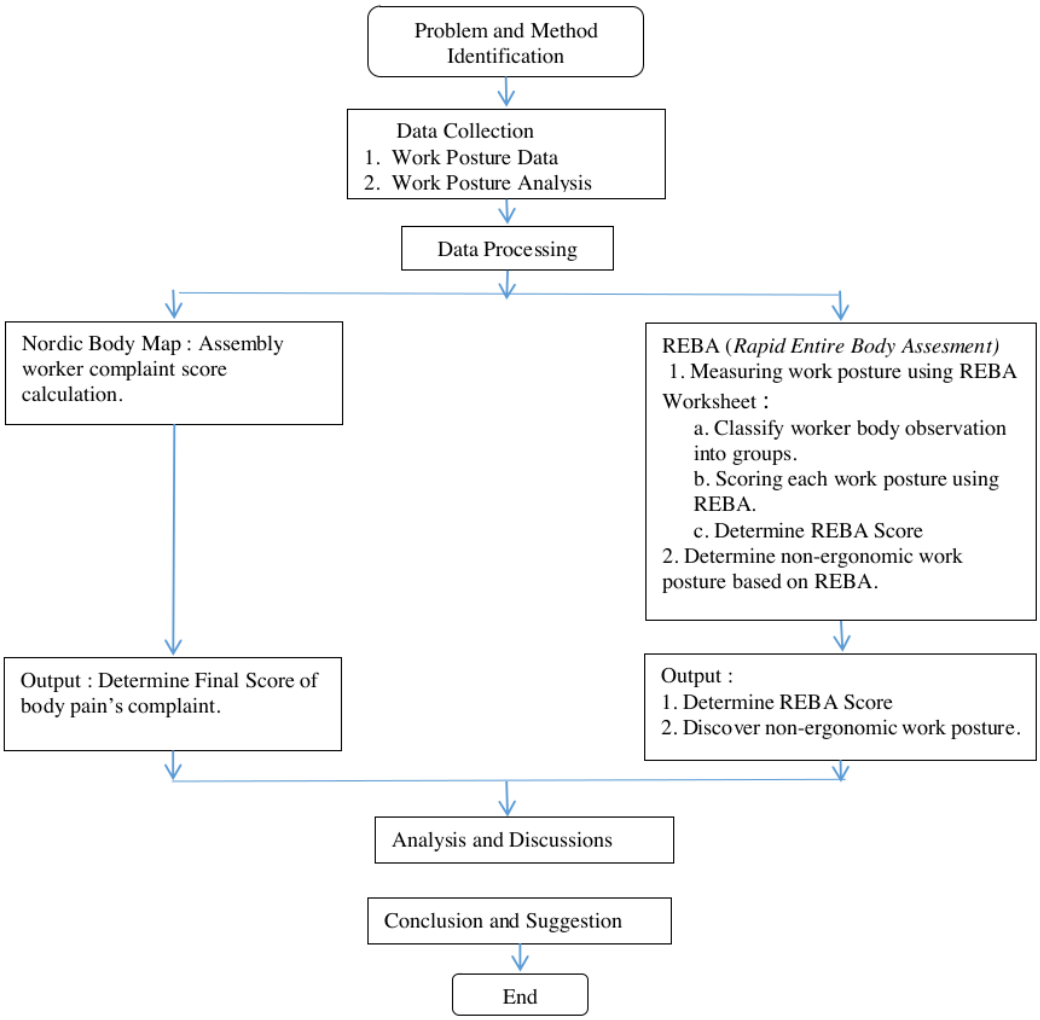

Fig. 2 Research Flowchart

Result and Discussion

Nordic Body Map

In this research, Nordic Body Map is conducted by using a questionnaire filled by 10 workers in assembly department of UKM Silver 999. The result of questionnaire recapitulation is shown in Table 1.

Table 1. Musculoskeletal Disorders Complaint Distribution Position on Assembly Workers.

No	Pain Position	Respondent										Pain Score
		1	2	3	4	5	6	7	8	9	10	
1	Upper Neck	1	1	1	2	2	2	2	2	2	2	17
2	Lower Neck	1	1	1	2	2	2	2	2	2	1	16
3	Left Shoulder	1	1	1	2	2	2	2	2	1	1	15
4	Right Shoulder	1	1	1	2	2	2	2	2	2	1	16
5	Upper Left Arm	1	1	1	2	2	1	2	2	2	1	15
6	Back	1	1	1	2	2	2	2	2	2	2	17
7	Right Upper Arm	1	1	1	2	2	2	1	2	2	2	16
8	Waist	1	1	1	2	2	2	2	2	2	2	17
9	Buttock	1	1	1	2	2	2	2	2	1	1	15
10	Bottom	1	1	1	2	2	2	2	2	1	1	15
11	Left Elbow	1	1	1	2	2	2	2	1	1	1	14
12	Right Elbow	1	1	1	2	2	2	2	1	1	1	14
13	Left Lower Arm	1	1	1	2	2	1	2	2	2	2	16
14	Right Lower Arm	1	1	1	2	2	2	2	1	1	1	14
15	Left Wrist	1	1	1	2	2	2	2	2	1	1	15
16	Right Wrist	1	1	1	2	2	2	2	2	2	2	17
17	Left Hand	1	1	1	2	2	1	2	2	2	2	16
18	Right Hand	1	1	1	2	2	1	2	2	2	2	16
19	Left Thigh	1	1	1	2	2	1	2	1	1	1	13
20	Right Thigh	1	1	1	2	2	1	2	2	2	1	15
21	Left Knee	1	1	1	2	2	1	2	2	2	1	15
22	Right Knee	1	1	1	2	2	1	2	2	2	2	16
23	Left Calf	1	1	1	2	2	1	1	2	2	2	15
24	Right Calf	1	1	1	2	2	1	1	2	2	2	15
25	Left Ankle	1	1	1	2	2	1	1	2	2	2	15
26	Right Ankle	1	1	1	2	2	1	1	2	2	2	15
27	Left Foot	1	1	1	2	2	1	1	1	2	2	14
28	Right Foot	1	1	1	2	2	1	1	1	2	2	14
	Individual Score	28	28	28	56	56	42	49	50	48	43	428

From Table 1, the final score of the complaint is quite painful in some parts of the worker's body. It can be seen that the most pain complaint by workers is on the upper neck, back, waist and right wrist. There were 7 respondents who showed the highest score, and 3 respondents had below scores below. Then the results of the questionnaire were processed into four categories, namely not sick, quite sick, sick and very sick, that shown in Table 2.

Table 2. Classified Musculoskeletal Disorders Complaint Distribution Position on Assembly Workers.

No	Body Parts	Percentage of Worker Questionnaire							
		No Pain		Mild		Nagging Pain		Unbearable Pain	
		No. Of Worker	%	No. Of Worker	%	No. Of Worker	%	No. Of Worker	%
1	Pain/stiff on the Upper Neck	3	30%	7	70%	0	0%	0	0%
2	Pain on Lower Neck	4	40%	6	60%	0	0%	0	0%
3	Pain on Left Shoulder	5	50%	5	50%	0	0%	0	0%
4	Pain on Right Shoulder	4	40%	6	60%	0	0%	0	0%
5	Pain on Left Upper Arm	5	50%	5	50%	0	0%	0	0%
6	Pain on Back	3	30%	7	70%	0	0%	0	0%
7	Pain on Right Upper Arm	4	40%	6	60%	0	0%	0	0%
8	Pain on Waist	3	30%	7	70%	0	0%	0	0%
9	Pain on Buttock	5	50%	5	50%	0	0%	0	0%
10	Pain on Bottom	5	50%	5	50%	0	0%	0	0%
11	Pain on Left Elbow	6	60%	4	40%	0	0%	0	0%
12	Pain on Right Elbow	6	60%	4	40%	0	0%	0	0%
13	Pain on Left Lower Arm	4	40%	6	60%	0	0%	0	0%
14	Pain on Right Lower Arm	6	60%	4	40%	0	0%	0	0%
15	Pain on Left Wrist	5	50%	5	50%	0	0%	0	0%
16	Pain on Right Wrist	3	30%	7	70%	0	0%	0	0%
17	Pain on Left Hand	4	40%	6	60%	0	0%	0	0%
18	Pain on Right Hand	4	40%	6	60%	0	0%	0	0%
19	Pain on Left Thigh	6	60%	4	40%	0	0%	0	0%
20	Pain on Right Thigh	5	50%	5	50%	0	0%	0	0%
21	Pain on Left Knee	5	50%	5	50%	0	0%	0	0%
22	Painon Right Knee	4	40%	6	60%	0	0%	0	0%
23	Pain on Left Calf	5	50%	5	50%	0	0%	0	0%
24	Pain on Right Calf	5	50%	5	50%	0	0%	0	0%
25	Pain on Left Ankle	5	50%	5	50%	0	0%	0	0%
26	Pain on Right Ankle	5	50%	5	50%	0	0%	0	0%
27	Pain on Left Foot	6	60%	4	40%	0	0%	0	0%
28	Pain on Right Foot	6	60%	4	40%	0	0%	0	0%

Table 2 present the percentage of pain complaints felt by assembly line workers. The results of the Nordic Body Map questionnaire showed that scores with a mild pain category were 70% in the upper neck, back, waist and right wrist. From complaints that are felt by workers, possibility will decrease their work productivity. The percentage of complaints felt by workers will increase if the activity that performs continuously and for a long time period.

REBA Method

Respondent body posture assessment on working position was conducted using Rapid Entire Body Assessment (REBA) method. This method is a quite keen method in evaluating the risk of posture, especially in the musculoskeletal system. Body segment classification was also performed in this method, body segments will be coded individually and evaluate all parts of the body both upper limbs and body, neck and legs. Assessment with this method uses the steps in Figure 1. The final results obtained are the level of risk of injury in determining the required corrective action.

Table 3. Risk Distribution of Assembly Worker Based on REBA

Risk Level	Frequency (n)	Percentage
Medium	3	30 %
High	7	70 %
Very High	0	0 %
Total	10	100%

According to Table 3, it shown that 70% of respondents have a high level of risk, and 30% have a medium level of risk. The following illustration is an example of valuation in determining the risk level of work position performed on workers. The example of high risk with a REBA final score of 8-10 illustrated in Figure 3.

Fig. 3 Worker with High Risk of REBA

Based on the REBA calculation in figure 3, it can be analyzed that the movement in the body position forward 0 ° -20 ° is given a score of 2, because the body position is bent then a change score of 1 is added, to score the body in the score 3. Position of the neck at > 20 ° towards the front so that it gets a score of 2 with the addition of a change score of 1 because the position is bent then the neck score is obtained 3. The foot score is 1 because the leg is well supported. It is shown that the respondent sat with both legs bent > 60 ° then added a change score of 2 then the total score on the foot was 3. The results obtained from the assessment of body, neck, and legs were then converted into Group A and produced a score of 7. In the upper arm a score was obtained 2 because the position of the arm supporting the weight of the arm is given a change score of -1. The total score of the upper arm is 1. The position of the forearm is scored 2 because it is in the position of the forearm towards the front < 60 ° or > 100 °.

The wrist has a score of 2 because of the wrist position > 15 ° up and down. With the addition of the change score because the wrist turns away from the middle side then a score of 1 is added, so the wrist score is 3. The results of the assessment of the forearm, forearm, and wrist are converted into Group B with a score of 3. Scores obtained from Group A is added with a score of 0 for loads lifted < 5 kg. The score becomes 7. Group B score is added with a score for the type of grip count to 1 because it is a moderate grip which means the handgrip is acceptable but not ideal, score B becomes 4. A score and B score then converted into table C produces a score of 8, then added with a score of type of muscle activity of 1 because one or more body parts are in a static state so that the final REBA score becomes

9 which is classified as a high-risk level and it requires immediate work posture corrections so as to minimize and prevent higher musculoskeletal complaints to workers.

Based on the results of data processing and analysis on assembly line workers, out of 10 respondents, 70% of respondents were classified as high risk, so posture improvement measures were needed. Therefore there is a need for alternative work station assembly parts that are in accordance with the worker anthropometry, which can provide convenience.

Assembly Work Station Improvement Plan

According to the results of data processing and analysis, there is a proposal for an assembly table with the anthropometric approach of the Indonesian people. The proposal given is specifically in the assembly table because current chairs used by workers have provided convenience. The design of this ergonomic table dimension based on the anthropometry of the human body, which aims to create a sense of convenience and easiness in the interaction between workers and the table. In addition, the table is equipped with a lighting system that is tailored to the needs of workers where the design of the proposed lamp support frame is adjustable. To make it easier for workers to reach the toolbox, the proposed design is a table frame made with a magnetic system so that the range of workers reach can be adjusted for each worker. The proposed design and specification of this assembly workstation are shown in Table 4 and Fig. 4.

Table 4. Table Percentile and Anthropometric

No	Table Specification	Body Dimension	Percentile	Reason (Description)
1	Table Height	Body Height While Sitting	95	In order to provide convenience for tall workers avoiding too bent position.
2	Drawer Height	Elbow Height while sitting + groin height	50	In order to make workers more convenient.
3	Table Width	Hand reach	95	As operational factor in order to fit the population.
4	Lamp Frame	-	-	Adjustable Design
5	Tool Box	-	-	Magnetic System design in order to reach distance adjustable to each worker need.
6	Tool Box Frame	-	-	Designed with Magnetic System to place idle toolbox hooked up. This frame position is adjustable.

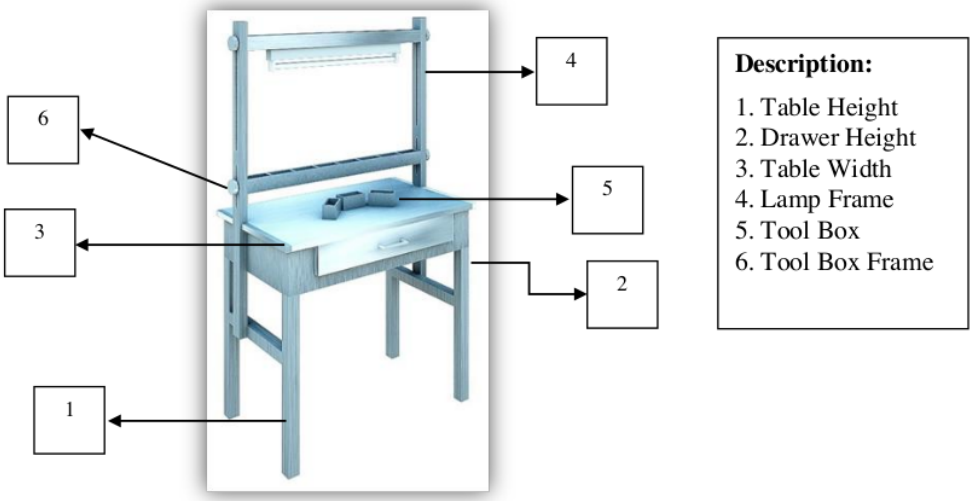

Fig. 4. Assembly Table Design

Conclusions

The conclusions that can be drawn from this research are :

1. From the assessment of workers work posture in the assembly section using the Nordic Body Map questionnaire, workers who experienced complaints were quite sick in the neck, back, waist and right wrist area by 70 % and non-sick workers by 30 %.
2. Based on the calculation of the REBA method results obtained are 70 % of workers in work activities at the assembly work station get a score of 9 which is a high risk category.

Acknowledgements

This work was funded by the "Penelitian Terapan Unggulan Perguruan Tinggi" Project 2019, Ministry of Research, Technology and Higher Education of the Republic of Indonesia.

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