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Analysis of Work Posture and Manual Material Handling in a Flour Production Process

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ABSTRACT

The workers in UD Jaya Group, a small flour producer located in Klaten District, Central Java, Indonesia, complained of having muscle pain or musculoskeletal disorders in the calf, knee, wrist, arm, waist, shoulder, back, and neck because there were variety of activities that required the workers to perform non-ergonomic work postures. This pain resulted in a decrease of work productivity, potentially caused work accidents, and affected the health of the workers. The purpose of the research is to analyze the work postures and to reduce musculoskeletal disorders caused by the non-ergonomic work postures among UDJaya Group workers. In achieving the purpose, a post-work analysis was performed on the work postures and the manual handling processes by using the Rapid Entire Body Assessment (REBA) method and the Manual Activity Chart (MAC) Tool. Based on the REBA assessment on 18 work activities, there was 1 working activity that was classified as an action level 1, 15 working activities were classified as the action level 2, and 2 working activities were classified as the action level 3. Based on the MAC Tool assessment on 11 work activities, 10 working activities were classified as the action level 2 and 1 working activity was classified as the action level 4. The recommendations were to reduce the weight of the load, increase the number of lamps and provide aiding tools.

Key words : Manual Handling Assessment Chart Tool, Musculoskeletal Disorders, Rapid Entire Body Assessment, Work Posture

1. INTRODUCTION

The availability of flour in Indonesia is required to improve the food industrial sector that continues to grow. According to Djoni Wibowo[1] flour is a solid granule of which concentration is smooth to very fine according to its use.Flour utility varies greatly as it is used as an object of research, industrial raw materials, and household items.

Flour suppliers in Indonesia consist of large companies and small and medium enterprises (SMEs). The process of making flour in SMEs uses simple machines with a large contribution of physical activities of human labor, especially in manual material handling.

Manual material handling is the most common cause of the workers experiencing fatigue, spinal cord injuries, and waist injuries. Among several manual material handling activities, lifting operations are proven to be one of the highest causes of workers experiencing injuries [2]. The process of manual work with non-ergonomic work postures is very risky to cause musculoskeletal disorders or muscle pain [3].

Musculoskeletal discomfort is the complaints of mild to severe pain in the skeletal muscle. When muscles lift static loads repeatedly for a long time, they may damage the joints, tendons, and ligaments [4]. The health problem-related study conducted to 9482 workers in 12 districts/cities throughout Indonesia by the Ministry of Health, Republic of Indonesia, in 2006 [5] revealed that approximately 40.5% of Indonesian workers felt the health problem was strongly influenced by the type of work they performed. It is found in the study that the four most common health problems suffered by the workers were musculoskeletal disorder (16%), neurological disorders (6%), cardiovascular (8%), and ENT disorders (1.5%). Work-related Musculoskeletal Disorders (WMSDs) led to decreasing product/job quality and worker productivity as well as increasing costs [6].

Ergonomic workplace design has a focus on reducing exposure to hazards in the musculoskeletal system, including symptoms and related disorders. Therefore, the work assessment carried out manually is very important to estimate the health risks of employees and as a preventive strategy to reduce such exposure [7]. Ergonomics aims to design the workplace so that the worksite is suitable according to the needs and physical abilities of the workers, rather than physically forcing the worker's body to fit the job [8]. The application of ergonomic principles will help in improving the performance and productivity of the workers and for assisting the operator to feel safe and comfortable [9]. The working position that does not meet the application of ergonomics potentially causes musculoskeletal discomfort, muscle pain, and fatigue. Several factors such as repetitive activities, excessive muscle stretching, awkward work posture, combined causes, and secondary causes cause a person to suffer musculoskeletal disorders [4].

UD Jaya Group is a small and medium enterprise (SME) located in Klaten, Central Java, Indonesia. The company produces corn flour and palm flour. The flour production

process at UD Jaya Group uses machinery and human labor. In the company, a variety of activities requires the workers to perform work postures that are not ergonomic. The activities are dominated by manual material handling one. During the research conducted by the authors, there were 5 work stations in UD Jaya Group namely washing, grinding, drying, smoothing and packing work stations. Based on the observations at UD Jaya Group using the Nordic Body Map questionnaire, the workers complained of having muscle pain or musculoskeletal disorders in the calves, knees, wrists, arms, waist, shoulders, back, and neck. The Pain resulted in a decrease of work productivity, which potentially caused work accidents and affected the health of the workers.

Several studies related to work posture assessment in order to reduce musculoskeletal discomfort have been conducted in small and medium enterprises (SMEs) in Indonesia. These include those on the paving and bricks manufacturing process [10] and on metal casting process [11]. However, there are only a few studies that consider manual material handling assessment in small and medium enterprises as the main factor that causes musculoskeletal discomfort among the workers. The study is conducted to analyze the working postures and the manual material handling processes using Rapid Entire Body Assessment (REBA) and Manual Activity Chart (MAC) Tool. The objective of the study is to analyze the work postures and manual material handling in flour production process among UD Jaya Group workers to reduce musculoskeletal disorders caused by the non-ergonomic work postures.

2. LITERATURE REVIEW

2.1 Ergonomic

The implementation of the ergonomics principle in the design of work systems can create a balance between the task's demands and the worker's characteristics. This can also provide the worker's safety, increase the worker's productivity, and give job satisfaction and the worker's physical and mental well-being [12]. The mining company in Russia started to apply ergonomics to enhance the worker’s safety as human error has been a key factor in coal industrial accidents [13]. A study on ergonomics intervention by Esmaeilzadeh and associates [14] showed that after over 6 months of ergonomics intervention, the intensity, duration, and frequency of work-related upper extremity musculoskeletal disorders (WUEMSDs) symptoms among computer workers decreased significantly.

2.2 Manual material handling (MMH)

Manual material handling (MMH) includes the activity of handling, moving, lifting, and carrying materials with the absence of mechanical tools [15]. The object’s weight is an important factor but other factors are at risk of causing injury to the workers, such as the frequency of carrying out the manual handling activities, the location of objects when picking up or putting down the objects, the distance of carrying the objects, bending, and others. The manual material handling activities that are designed with the appropriate principles can improve work performance and reduce incidents, costs, and accidents, while the manual material handling activities that are designed incorrectly can cause musculoskeletal disorders [16]. Having done research in the rice mill industry, Astuti [17] reported that the workers in the industry experienced musculoskeletal discomfort on the neck, shoulders, arms, wrist, thigh, and knee due to unnatural work posture on the manual material handling process.

2.3 Musculoskeletal Disorders (MSDs)

In Grandjean's opinion [4], musculoskeletal discomforts are complaints of pain felt by workers in the skeletal muscle area. Musculoskeletal disorders include a wide range of inflammatory conditions and a decrease in muscle function, peripheral nerves, tendons, joints, ligaments, and supporting blood vessels [18]. Many human tasks have the possibility of causing musculoskeletal disorders among the workers in some various fields related to their tasks. Some of the tasks include reaching, lifting, carrying/ transporting, repetitive movements, maintenance, climbing, working in the same position continuously (sitting or standing), and others [19]. Musculoskeletal disorders are common among workers in various fields, such as nurses in hospitals [20], construction workers [21], and office workers [22]. Recent study results showed MSDs are the main contributors of productivity loss [23], long-lasting disability [24], and functional impairment [25].

3. METHODOLOGY

The study was conducted on the flour production process of washing, milling, drying, smoothing and packing work stations at UD Jaya Group located in Klaten, Central Java, Indonesia. The sample of this research is workers who have worked for more than 3 years in a particular work station. This study identifies work postures using the Rapid Entire Body Assessment (REBA) method and evaluates manual material handling using the Manual Handling Assessment Chart (MAC Tool) method.

The Manual Handling Assessment Chart (MAC Tool) method has a number of variables to be considered, namely coupling, load/ frequency, body posture, environmental factors, the state of the floor surface, carrying distance, obstacles on the route, also communication and co-ordination between the workers [26]. REBA method needs some variables to be considered, namely posture (trunk, neck, upper arms, legs, lower arms, wrist), coupling, and load [27].

There were 18 work postures that were assessed using REBA and 11 manual material handling activities that were evaluated using MAC Tool. If a work activity has a REBA score of more than 7 (classified as Action class 3) or a MAC score of more than 12 (classified as Action class 3) then the work activity will get recommendations for improvement. The improvement recommendations are given by considering the ergonomics approach to improve the work posture of the workers by re-designing the work station or by providing

assistive devices. The improvement recommendation data were subsequently transferred to a mannequin in CATIA software, then the ergonomic intervention data will be assessed using REBA and MAC Tool to compare the risk level of before and after the improvement.

3.1 Rapid Entire Body Assessment (REBA)

The first step to collect the data was by recording the work activity using a camera. This was followed by measuring the angular dimension using Corel Draw X7 Software. The work activity was then assessed using Rapid Entire Body Assessment Method. The assessment of work posture by the REBA method in the research has several stages. The first stage is to assess the worker's posture on the trunk, legs, and neck to get the score of 'table A'. The second step is to get a 'score A' by summing up the load score and the score of 'table A'. In the third stage, the working posture of the lower arms, upper arms, and wrist was assessed and was carried out to obtain a 'table B' value. The fourth stage is to obtain the 'score B' by summing up the coupling score to the value of the 'table B'. In the fifth stage, a meeting point from the 'score A' and 'score B' was recorded in 'table C'. Furthermore, summing up the value of 'table C' and the activity scores was performed to get the 'score C'. The final step is to determine the level of risk from the work postures based on the 'score C'. The classification of work posture assessment by the REBA method [27] can be seen in Table 1.

Table 1: Work Posture Assessment by the REBA Method

REBA Score	Risk Level	Action Level	Level
1	Negligible	0	None necessary
2-3	Low	1	May be necessary
4-7	Medium	2	Necessary
8-10	High	3	Necessary soon
>11	Very High	4	Necessary Now

3.2 Manual Handling Assessment Chart Tool (MAC Tool)

The MAC tool helps the researcher in assessing the most common risk factors in lifting and lowering, the carrying process and team handling. This tool was developed to identify high-risk manual handling. The MAC tool will direct the researcher to the factors that need to be modified to control risk [26]. Regarding the application of the MAC tool in this research, all the manual material handling processes were recorded using a camera; the illuminance and noise data were recorded using an environmental tester; the temperature data was collected using a thermometer; the distance data was obtained using a metric tape measure; and the load data was acquired using a scale.

What follows are stages of evaluating the manual material handling process using the MAC tool method [28].

a. Identify the variables of manual material handling activities following the type of operation (lifting, carrying or team handling).
b. Categorize the score of each variable following the color band (color classification) so that the score of each variable is obtained.
c. Sum up the entire variable score to get the MAC score.
d. Using Table 2 of risk classification, determine the risk level of the manual material handling process based on MAC scores.

Table 2: Determination of the risk level and reforming actions in the MAC method

MAC Final Score	Reforming Action	Action Class
0-4	No action demanded	1
5-12	Action demanded in the near future	2
13-20	Action demanded shortly	3
21-31	Action demanded immediately	4

4. RESULTS AND DISCUSSION

4.1 Rapid Entire Body Assessment

In the process of making flour in UD Jaya Group, 18 work activities were assessed using the Rapid Entire Body Assessment method. The results of the Rapid Entire Body Assessment are presented in Table 3.

Based on Table 3, there was one work activity that falls into the action level 1, namely sweeping the flour activity at the drying work station. It means the work activity was classified as having a low-risk level and the activity might require improvements in the future.

There are 15 work activities falling into the action level 2 category. The activities are those of pouring raw materials, cleaning the flour and putting materials into sacks, all of which are carried out at the washing work station; smoothing the material with a shovel, moving the material to the grinding machine, inserting the milled material into the sack and transporting the sack to the cart, all of which are performed at the grinding work station; unloading sacks from carts and putting dry flour into sacks, two of which are done at the drying work station; moving flour sacks, taking the flour, and pouring flour on a milling machine, all of which are carried out at the smoothing work station; and activities carried out at the packing work station, namely the activities of taking the flour, pouring the flour into the sack and moving the sack of flour. All of these work activities had a moderate risk level and necessary improvements in the future are needed.

There are 2 work activities falling into the action level 3 category, namely the activity of moving the sack to the grinding work station carried out at the washing work station and the activity of spreading flour at the drying work station. These activities had a high level of risk and, therefore, immediate improvements were needed.

Table 3: Recapitulation of REBA Assessment

Work station	Work Activities	REBA Score	Risk Level	Action Level	Action
Washing	Pouring raw materials	5	Medium	2	Necessary
	Cleaning the flour	7	Medium	2	Necessary
	Putting the materials into sack	4	Medium	2	Necessary
	Moving the sack to the grinding work station	10	High	3	Necessary Soon
Grinding	Smoothing the material with a shovel	6	Medium	2	Necessary
	Moving the material to the grinding machine	6	Medium	2	Necessary
	Inserting the milled material into the sack	4	Medium	2	Necessary
	Transporting the sack to the cart	5	Medium	2	Necessary
Drying	Unloading the sacks from the cart	6	Medium	2	Necessary
	Spreading the flour	9	High	3	Necessary Soon
	Sweeping the flour	2	Low	1	May Be Necessary
	Putting the dry flour in a sack	7	Medium	2	Necessary
Smoothing	Moving the sack of flour	5	Medium	2	Necessary
	Taking the flour	6	Medium	2	Necessary
	Pouring flour into a milling machine	6	Medium	2	Necessary
Packing	Taking the flour	6	Medium	2	Necessary
	Pouring the flour into the sack	4	Medium	2	Necessary
	Moving the sack of flour	5	Medium	2	Necessary

Table 4: Recapitulation of MAC *Tool* Assessment Results

Work station	Work Activities	Score MAC	Action Reform	Action Class
Washing	Cleaning the flour	12	Action demanded in the near future	2
	Putting the materials into the sack	9	Action demanded in the near future	2
	Moving the sack to the grinding work station	22	Action demanded immediately	4
Grinding	Moving the material to the grinding machine	11	Action demanded in the near future	2
	Inserting the milledd material into the sack	7	Action demanded in the near future	2
	Transporting the sack to the cart	9	Action demanded in the near future	2
Drying	Unloading the sacks from the cart	12	Action demanded in the near future	2
	Putting the dry flour in a sack	10	Action demanded in the near future	2
	Putting the sack on the cart	11	Action demanded in the near future	2
Smoothing	Transfering the flour to a milling machine	11	Action demanded in the near future	2
Packing	Moving the flour into the sack	12	Action demanded in the near future	2

4.2 The Assessment of Manual Handling Assessment Chart (MAC Tool)

In the process of making flour in UD Jaya Group, 11 work activities were assessed using the MAC Tool method. The MAC Tool assessment results are presented in Table 4.

Based on Table 4, there are 10 work activities classified as action level 2, namely cleaning the flour and putting the materials into a sack, two of which are carried out at the washing work station; moving the material to the grinding machine, inserting the milled material into the sack and transporting the sack to the cart, all of which take place at the grinding work station; unloading the sacks from the cart, putting the dry flour into the sacks, and putting the sacks onto the cart, all of which are performed at the drying work station; transferring flour to a milling machine taking place at the smoothing work station; and moving flour into the sack carried out at the packing work station.

4.3 The Improvement Recommendations

Based on the results of the assessment of the work posture with the Rapid Entire Body Assessment method and the results of the manual material handling assessment using the MAC Tool method, it is found that there were 2 work activities having a high level of risk (see Table 5). As a consequence, the workers experienced musculoskeletal discomfort. To avoid musculoskeletal discomfort and to reduce the level of risk, improvements are needed. The following paragraphs outline the recommended improvements.

Table 5: WorkActivities Which Given the Improvement

No	Work Activities	REBA Score	MAC Score
1	Moving the sack to the grinding work station	10	22
2	Spreading the flour	9	-

a.The Activity of Moving the Sack to the Grinding Work Station

The following are recommendations for improvement in the activity of moving sacks to the grinding work station

1) Reducing the weight of the sack

The weight of the sack moved by the worker is 40 kg. The weight is considered unsafe based on the MAC Tool method. It is recommended to reduce the weight of the transferred sack to 18 kg, quite safe weight. Jacob et al reported that a heavy unit increased the handling duration and muscular fatigue in the parlor milking workers, therefore workload reduction was achieved by not using a milking cluster that exceeds 2.4 kg [29].

2) Adding the lights in the washing work station

The washing work station has illuminance level of 123.1 Lux. The minimum illuminance level for manual and continuous work based on the Minister of Health's decision No. 1405 / MENKES / SK / X1 / 2002 is 200 lux. Therefore the lighting in the washing work station is considered not good. The level of the lighting can be improved by adding a few lights in the washing work station to improve the illuminance uniformity since it will decrease the risk of musculoskeletal disorder [30]. In a study by Aaras et al. [30], the workplace was given a new lighting system which increases the illuminance level from 300 lux to above 600 lux. The result shown that there was a significant decrease of neck, back and shoulder pain.

3) Moving the sack with the trolley tools

The activity of moving a sack to the grinding work station is not safe in terms of work posture or manual material handling. In this activity, the worker lifted the sack on his back without any tools. This caused the worker's back to bend when moving the sack. To reduce the level of risk in this activity, it is recommended that a tool such as a trolley will make it easier for workers to move the sack to the grinding work station. The process of moving the sack by using a trolley is considered to be more effective because in one cycle it can load 3 sacks, while the process of manually moving a sack can only move one sack. The proposed trolley has a medium size, thus the workers do not handle excessive loads. The trolley design recommendation is shown in Figure 1. Hasalkar et al [31] evaluated the process of topdressing fertilizer with the traditional method and the use of improved trolley. Their result highlighted that the use of the improved trolley reduces the percentage of the workers complaining about the musculoskeletal discomfort by 75%, 91.42%, 47.83%, 68.85% and 72.72% in the upper arm, shoulder joints, low back, knees, and wrist, respectively.

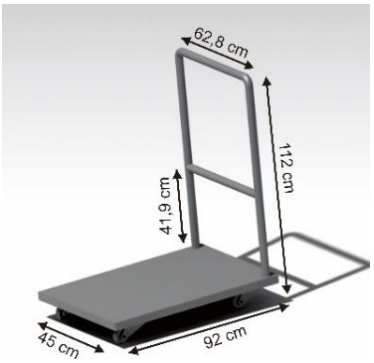

Figure 1: Trolley Design

Figure 2 provides a comparison between the process of moving the sacks before and after the intervention.

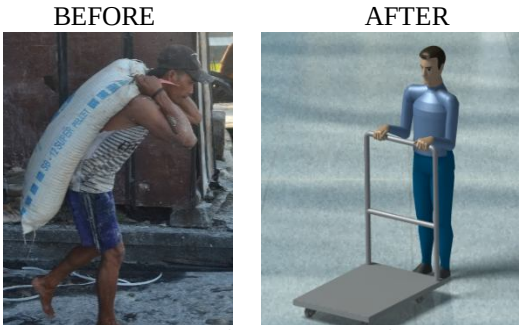

Figure 2: Comparison of the Activities of Moving Sacks

b. Spreading Flour Activity

The activity of spreading flour is considered unsafe in terms of work posture. This activity is carried out by the workers without assistive devices. In this case, the workers were squatting while spread the flour using their hands. To reduce the level of risk in this activity, it is recommended to use a tool that will be able to spread the flour properly. The tool design proposed in this paper is shown in Figure 3. The recommended tool will enable the workers to spreading the flour with less risk and reduce non-ergonomic work postures such as bending and squatting down. The tool will change the work posture of the workers to standing which is generally a preferred posture. This was in agreement with a study conducted by Gallagher [32] which found that the squatting posture is the least stable one compared to the other restricted postures while the standing posture appeared to be the highest psychophysically acceptable posture for loads compared to the other work postures.

Table 6: Recapitulation of the REBA Assessment Results Before and After Improvement

Work Activities	REBA score		Decrease	
	Before Improvement	After Improvement	Score	Percentage (%)
Moving the sack to the grinding work station	10	4	6	60
Spreading the flour	9	2	7	77.8

Table 7: Recapitulation of MAC Assessment Results Before and After Improvement

Work Activities	MAC score		Decrease	
	Before Improvement	After Improvement	Score	Percentage (%)
Moving the sack to the grinding work station	22	8	14	63.6

Figure 3: The Tool Design

A comparison between the process of moving the sacks before and after the intervention is available in Figure 4.

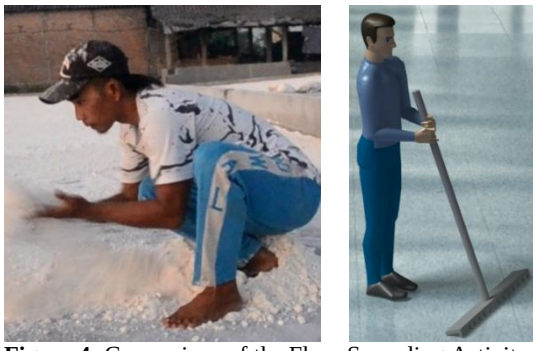

Figure 4: Comparison of the Flour Spreading Activity

4.4 The Improvement Results

Re-assessment was conducted on the proposed improvements using the REBA and MAC methods. Table 6 and Table 7 provide the recapitulation of the reassessment simulation results.

Based on Table 6, the risk levels of all work activities have decreased after the interventions. The work activity of moving the sack to the grinding work station before and after the improvement has a REBA score of 10 (classified as action level 3 with high risk), and of 4, respectively. The results of the improvement showed a significant reduction on the risk by 60%. The work activity of spreading flour before the improvement had the REBA score of 9 (classified as the action level 3 with high risk). After the improvement, this activity had the REBA score of 2, meaning that this work activity was classified as action level 1 with a low-risk level. The results of improvement showed a risk reduction of 77.8%. This study is in agreement with that conducted by Suhardi et al. on applying a new tool to improve the work posture among the furniture industry workers [33]. In their study, a reduction of risk level from a high-risk level (REBA score of 9 to 10) to a low-risk level (REBA score of 2 to 3) was resulted.

Table 7 consolidates the results related to the activity of moving the sack to the grinding work station.The activity had the MAC score of 22 before the improvement, meaning that immediate improvements were required (which classified as action class 4). After the improvement,the same activity had the MAC score of 8, a low level of risk activity. The results of the improvement showed a significant reduction on the risk equalling 63.6%.

Overall, the results of this study indicate that the ergonomic interventions successfully reduced the risk of musculoskeletal disorders among workers in UD Jaya Grup. These findings are consistent with a recent study [34] which depicted that designing a new tool as an ergonomic intervention reduced the risk of being afflicted by musculoskeletal disorders caused by manual material handling in the tile industry.

5. CONCLUSION

Based on the results of research and analysis of the data that has been presented, it can be concluded as follows:

a.The results of the assessment of work posture using the Rapid Entire Body Assessment (REBA) method in 18 work activities of flour production process obtained 1 work activity belonged to the action level 1 (low-risk level)

category, 15 work activities belonged to the action level 2 category (level medium risk) and there were 2 work activities classified in the action level 3 category (high-risk level).

b. The results of the manual material handling assessment using the Manual Handling Assessment Chart (MAC Tool) method in 11 work activities of flour production process obtained 10 work activities classified as the action class 2 meaning that these work activities need improvements in the future and there was 1 work activity classified as the action class 4 meaning that the work activities need an immediate improvement.

c. Based on the assessment of work postures, there were 2 work activities that had a high risk of causing musculoskeletal disorder, namely the activity of moving sacks to the grinding work station and the activity of spreading flour. Based on the manual material handling assessment, there was one work activity that had a high risk of causing musculoskeletal disorder, that was the activity of moving the sack to the grinding work station.

d. The improvement recommendations for the activity of moving the sack to the grinding station were reducing the weight of the transferred load, adding lights at the washing work station and moving the load with trolley. The improvement recommendation for the activity of spreading the flour were using a tool as shown in Figure 3.

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