Ergonomic Risk Evaluation of Manual Material Handling in Brick Production

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Abstract. *The manual material handling (MMH) activity of making bricks causes workers to use energy throughout their body to do work so that it can pose a potential ergonomic hazard. Ergonomics hazards caused are fatigue in the muscles due to repetitive movements, poor work posture, too heavy load, inadequate tools, unsupportive environmental conditions. Complaints of Musculoskeletal disorders (MSDs) that accumulate will have a major impact on bone structure disorders and muscle disorders. The purpose of this study was to evaluate the ergonomic risks and complaints of MSDs in MMH activities using a trolley. The research method used is the risk assessment of pushing and pulling (RAPP) tool and Nordic body map (NBM). The RAPP Tool consists of 9 assessments with a rating scale of good, reasonable, poor and unacceptable. Furthermore, using the NBM which mapped 28 body parts with a rating scale of no pain, moderately ill, sick and very sick. The number of respondent is 5 workers, then the chi-square test is to test the first hypothesis, which is the relationship between the age of the workers with muscle complaints, and the second hypothesis is the relationship between years of service and complaints of workers. The results of The study contained 3 assessments of the RAPP Tool with the highest score, including floor surface, posture, and condition of the tool. The results of the NBM found that the body parts that often felt complaints were the back, waist, buttocks, left knee, right knee, left leg and right leg. The conclusion is that workers with high RAPP scores have an impact on high levels of muscle complaints so that improvements need to be made immediately to reduce ergonomic risks to workers.*

Keywords: brick worker, manual material handling, musculoskeletal disorders, RAPP tool, Nordic body map

I. INTRODUCTION

Manual material handling (MMH) activities use energy throughout the worker's body to do their work. The material handling process includes a variety of manual, semi-automatic, and automated systems that support the production process (Efthymiou & Ponis, 2019). MMH activities are one of the direct interaction activities between work aids and workers. In particular, ergonomic problems related to MMH such as the back, shoulder, and wrist pain, sprain injuries, MSDs, fatigue, and improper design (Kay et al., 2015). If material handling activities are carried out inappropriately, one of the consequences that arise is complaints of MSDs (Pancharya, 2011). Potential hazards can arise because the activities carried out are not in accordance with standards in doing work safely and correctly (Karaca, 2015). The danger of ergonomic factors is the misalignment of working environmental conditions that can cause fatigue and even disease in workers such as unsafe work activities, repetitive movements, poor work postures, too heavy loads, inadequate tools, unsupportive environmental conditions, and lack of rest time (ILO, 2013). In the industrial sector, task demands, especially MMH, require workers to work in non-ergonomic conditions to meet task demands (Basahel, 2015).

Anugrah Jaya Batako (AJB) is a business that produces brick products, loster concrete, paving blocks, tube concrete, lining culverts, sand, and other building materials. The process of making building materials in these small-medium enterprises (SMEs) has problems with MMH activities that use a large workforce. MMH

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activities carried out in these SMEs include moving, lifting, pulling, and pushing building materials such as sand, gravel, and cement as well as products produced either without tools or with assistive devices. AJB workers experience squatting while printing and the body parts that feel sore are the back, arms, and knees. Material handling activities that are carried out repeatedly, loads that are too heavy, and for a long period of time will cause disruption of bone structure and muscle fatigue (Umyati et al., 2018). Working with awkward postures for a long time and monotonous movement frequency and forceful exertion causes trauma to the body caused by the accumulation of complaints in the skeletal muscles so that workers feel pain. This is because the muscles that work perform all movements in the human body. Muscles bear a large load and monotonous movements will cause muscle tissue, tendons, and ligaments to rupture (Muslimah et al., 2006). This disease can cause disorders of MSDs (Ribeiro et al., 2017). MSDs are muscle tension injuries, inflammation, and degeneration of muscles, nerves, tendons, ligaments, joints, cartilage, and intervertebral discs (Asl et al., 2014). Workers with a vulnerable age that is more than 50 years are not allowed to be prosecuted for physical activity. Workers of vulnerable age will be at great risk of causing potential factors for injury related to MMH (Ayoub & Dempsey, 1999). MSDs occur in two ways, namely constant fatigue caused by a long duration of use of muscles and sudden injury caused by strenuous activities or unexpected movements during work (Setyanto et al., 2015). MSDs often focus on work-related risk factors, including manual lifting, repetitive hand

or arm movements, and awkward posture (Der Beek et al., 2017)..

The methods used to solve these problems are the RAPP Tool and the NBM to determine the muscle complaints experienced by workers. The RAPP Tool is a method used to help assess the main risks in pushing and pulling activities that involve manual full-body strength or other wheel aids by dragging, sliding, or rolling the load (HSE, 2016) Risk assessment can obtain the value of the magnitude of the hazard in the workplace so that it can be taken into account when taking preventive actions based on the magnitude of the hazard risk. The RAPP Tool is designed to assess the most common ergonomic risk factors such as moving loads with or without wheels (HSE, 2016). Each operation contains assessment steps as well as a description for each assessment along with the assessment score, category, and color of risk indicators. The assessment steps are in the form of a flow chart that helps identify ergonomic risks in each process assessment. The RAPP Tool can also find the level of ergonomic risk in MMH activities with the color category of risk indicators, namely green means low risk, yellow means medium risk, red means high risk and very high risk. The NBM method in the form of a questionnaire is the most commonly used to determine physical discomfort or pain, respondents filling out the questionnaire are asked to indicate whether there is discomfort in that part of the body (Bragança & Costa,, 2014).

The RAPP Tool method in Ani Umyati's research (Umyati et al., 2018) was used in mapping complaints with NBM and evaluation with the RAPP Tool on MMH activities in the

Table 1. Activities Identification at UKM AJB

No	Making Process	Activities Description
1	Concrete bricks	Making a brick concrete dough consisting of sand, cement, and water then stirred and molded with a brick mold and then left to dry in the open.
2	Loster Concretes	Making a loster concrete dough consisting of sand, cement, and water then stir and print with a loster mold after which it is left to dry in the open.
3	Short Tube Concretes	Making a short tube concrete dough consisting of sand, cement, and water then stir and print with a short tube concrete mold after which it is left to dry in the open.
4	Long Tube Concretes	Making a long tube concrete dough consisting of sand, cement, and water then stir and print with a long tube concrete mold after which it is left to dry in the open.

process of making liquid soap. The results of the study showed that the operator complained of complaints in the upper left arm, back, upper right arm, waist, buttocks, left wrist, right wrist, left thigh, right thigh, left calf, right calf, left ankle, and right ankle. The final score of the RAPP Tool is 15 with details of the working posture category's score is 6, handgrip's score is 2, and the condition of the tool's score is 3, this is the highest risk of injury in MMH activities. The NBM method in Jacky Chin's research (Chin et al., 2019) aims to identify lifting complaints by sheet metal painting operators in West Java, Indonesia using the NBM, Borg RPE, and NIOSH methods. The result of the research is that painting operators experience pain and tingling in the neck, back, and waist. Research by I Putu Prisa Jaya (Jaya & Negara, 2019) in order to analyze the working posture of tofu makers using the REBA method associated with musculoskeletal complaints using NBM. The results of this study are the tofu makers with a dynamic standing posture, in a state of motion and body posture on the back and neck that tends to bend and the repetitive hand movements cause musculoskeletal complaints, namely in the parts that experience pain. Research conducted by Indah Pratiwi (Pratiwi et al, 2018) which aims to determine the complaints of workers using NBM, the risk of working posture using the Manual Task Risk Assessment (ManTRA) method, obtained the results that the NBM questionnaire shows the complaints felt by workers, namely: waist, back, neck, shoulders, arm, and wrist. While the results of the ManTRA method are the printing work station has the highest musculoskeletal risk, the lowest risk is at the palm juice pressing work station. Research by Ade Sri Mariawati (Mariawati et al., 2017) has the aim of reducing accidents that can occur at PT Barata Indonesia and preventing work accidents that will occur. The results of this study are that the root cause of the highest potential hazard is using the Fault Tree Analysis (FTA) method on stairs that do not stand upright and one of the main causes of material hit accidents is because the stairs used are not suitable for use.

The aim of this research is to analyze and evaluate the ergonomic risk and to know the complaint that felt by the workers while doing MMH activities using one-wheeled cart using RAPP Tool and NBM. The research was conducted to find out how the conditions of the work environment in MMH activities are and what muscle complaints are felt by workers.

II. RESEARCH METHOD

Research Object

Research conducted on AJB is a business that produces brick products, loster concretes, paving blocks, tube concretes, culvert lining, sand, and other building materials. This business has been around since 2016 which is located in Mojosongo, Surakarta City. The working time is 9 hours per day in 6 days per week. The types of production of this business are make to stock and make to order.

This study involved all five workers with four types of products. The five workers are male with an age range of 28 to 50 years, the length of work ranges from 1 to 6 years and the body mass index (BMI) of workers ranges from 20 to 22. The production process at AJB is: the process of making bricks, the process of manufacture of loster concretes, the process of making short tube concretes, and the process of making long tube concretes (see Table 1). The focus is on pushing and pulling a one-wheeled trolley while working. Posture on the average worker leaning forward and bending. These activities use a lot of labor and are carried out in a frequent frequency and the load carried is quite heavy. This is coupled with the condition of the path that is passed is not comfortable for workers to pass.

Research Methods

RAPP Tool to help assess the main risks in manual pushing and pulling activities that involve full-body strength and moving loads using trolleys and other wheeled aids by dragging, sliding, and rolling the loads (HSE, 2016). The RAPP Tool data collection was carried out by observing MMH activities when workers used trolleys according to the nine assessments on the worksheet and scoring according to the description in each category. The nine

Table 2. MSDs Risk Level Classification Based on Individual NBM Score

Likert Scales	Individual Total Scores	Risk Levels	Corrective Action
1	28-49	Low	No corrective action is needed
2	50-70	Medium	Corrective action may be needed in the future
3	71-91	High	Immediate action needed
4	92-112	Very High	Comprehensive action is needed as soon as possible

Table 3. Workers Identity Data

Worker	Product Manufacturing	Age (Year(s))	Years of Service (Year(s))	IMT
1	Brick	28	1	20,9 (normal)
2	Brick	42	5	22,7 (normal)
3	Loster Concrete	29	1	21,8 (normal
4	Short Tube Concrete	38	5	22,8 (normal)
5	Long Tube Concrete	50	6	22,6 (normal)

Table 4. RAPP Tool Score Recapitulation for AJB Workers

Number	Valuation	Worker 1	Worker 2	Worker 3	Worker 4	Worker 5
1	Type of Tool and Mass of Load	G (0)	A (2)	G (0)	G (0)	G (0)
2	Posture	A (3)	A (3)	A (3)	A (3)	A (3)
3	Handgrip	G (0)	G (0)	G (0)	G (0)	G (0)
4	Work Pattern	G (0)	A (1)	G (0)	A (1)	G (0)
5	Movement Distance	A (1)	A (1)	A (1)	A (1)	A (1)
6	Tool Condition	A (2)	A (2)	A (2)	A (2)	A (2)
7	Floor Surface	R (4)	R (4)	R (4)	R (4)	R (4)
8	Route Obstacle	A (2)	A (2)	A (2)	A (2)	G (0)
9	Other Factor	G (0)	G (0)	A (1)	G (0)	G (0)
	Total Individual Score	**12**	**15**	**13**	**13**	**10**

assessments used predetermined criteria so that the adjustments were adjusted to the conditions that existed in MMH activities with the criteria that became the standard for the RAPP Tool method (Umyati et al., 2018). The RAPP Tool evaluation includes nine assessment scores, namely: (1) evaluation related to the type of tool and the weight of the load with 5 category descriptions (low G/0, medium A/2, high R/4, very high R/8, unacceptable /P) , (2) evaluation of work posture with 3 category descriptions (good G/0, reasonable A/3, poor R/6), (3) evaluation of hand grip strength with 3 category descriptions (good G/0, reasonable A/1, poor R/2), (4) evaluation of work patterns with 3 category descriptions (good G/0, reasonable A/1, poor R/3), (5) movement distance with 3 category descriptions (short G/0, medium A /1, long R/3, (6) equipment condition with 3 category descriptions (good G/0, reasonable A/2, poor R/4), (7) floor surface condition with 3 category descriptions (good G/0, reasonable A/1, poor R/4), (8) path and route barriers with 3 category descriptions (good G/0, reasonable A/2, poor R/3), and (9) other factors with 3 category descriptions (none G/0, one A/1, two or more R/2). Each assessment score consists of a description of the category that shows the category score, scale, and color of the risk indicator. The risk indicator colors are (1) green with a score of low, good, short, and none, (2) orange with a score of medium, reasonable, and one (3) red with a score of high, very high, poor, long, and two or more, (4) purple color with a score of the category unacceptable (HSE, 2016).

Identification of other factors, including: unstable equipment or load, the load is large and

obstructs the worker's view of where they are moving, the equipment or load is sharp, hot, or potentially damaged to the touch, poor lighting conditions, extreme hot or cold temperatures or high humidity, winds, or other strong air movements, personal protective equipment or clothing makes using the tool more difficult (HSE, 2016).

Assessment identified by giving a score on the RAPP Tool worksheet according to the description of the brick making activity. After all the assessments have been carried out, you can see which assessments are in the safe and dangerous categories and actions that must be taken immediately. Each assessment of the RAPP Tool according to the Health and Safety Executive (HSE, 2016) is presented in a safe category to a very risky category which can be seen in the resulting score.

The NBM method can see which muscles are experiencing discomfort and the level of discomfort ranges from mild pain to very painful (Chin et al., 2019). The NBM is in the form of a questionnaire that is most commonly used to determine physical discomfort and pain. Workers filling out the questionnaire were asked to indicate whether there was discomfort in that body part (Bragança & Costa, 2014). This NBM method maps 28 body parts with 4 rating scales, namely: not sick with a score of 1, slightly sick with a score of 2, sick with a score of 3, and very sick with a score of 4. This method produces a total score of complaints felt by workers and then categorized in the NBM complaint scale. The process of filling out the questionnaire is carried out directly by interviewing workers about which body muscles experience aches and pains, or another way by showing directly according to what is listed in the NBM questionnaire (Tarwaka et al., 2004). The results of the checks on the NBM worksheet are done by summing the scores of each individual and analyzing which MSDs risk level classification belongs to based on complaints that are felt to work, see Table 2. The next step is statistical data processing using SPSS version 23.0, namely the chi-square test. This study does not use the normality test, because the respondent's data is a population. The chi-

square test is a nonparametric statistical analysis used to determine the relationship between variables in the form of nominal or ordinal frequency data. The result of the chi-square test is the relationship between the age of workers and years of service on MSDs complaints obtained from NBM. The data used in this chi-square test is the age of the worker, the period of service, and the total score of muscle complaints of each individual. The first statement is determined as the initial hypothesis (H0): there is no relationship between the age of the workers with muscle complaints, for the claim hypothesis (H1): there is a relationship between the age of the workers and muscle complaints. The second statement was determined as the initial hypothesis (H0): there was no relationship between tenure with muscle complaints, for the claim hypothesis (H1): there was a relationship between tenure and muscle complaints.

Fault Tree Analysis (FTA) is an analysis tool that converts problems into graphs to find the root cause of problems in a system. FTA consists of two basic types, namely: events and logic events. Event notation consists of basic events, intermediate events, developed events, and symbol transfers. While the event logic notation consists of AND gates and OR gates. This symbol combination is used to describe the cause of the problem (HSE, 2016). The FTA in this study is to identify the causes of ergonomic risk in MMH activities using trolleys at AJB.

III. Result and Discussion

AJB workers consists of five workers and makes four product types (look at Table 3). MMH's activities are in the form of pushing and pulling using tools in the form of a one-wheeled trolley used to move building materials and production products, namely: gravel, sand, cement, brick, paving blocks, loster concretes, and tube concretes. Based on the results of the RAPP Tool data collection, a recapitulation of worker scores is carried out which can be seen in Table 4.

Based on the results of the RAPP Tool in Table 4, the first assessment score is the type of tool and the load period, the score for the

Medium A/2 category in orange color occurs in worker 2 with a description of the 50 kg to 100 kg load weight category. While the other four workers with a score of the Low G/0 category in green with a description of the weight category of the load less than 50 kg with safe conditions. The second assessment score is the posture score, where the five workers get a Reasonable A/3 category score in orange with a description of the body category that tends to go forward, the torso feels bent or twisted, the hands are below the height of the hips. The third assessment score is hand grip, where the five workers get a green Good G/0 score with a description that there is a grip area that allows a comfortable grip to pull or a full hand grip that is comfortable to push. The fourth assessment score is the work pattern where the score in the category Good G/0 is green for worker 1, worker 3, and worker 5 with a description of the non-repetitive job category (less than five transfers per minute) and the work rate is determined by the worker, the score category is Reasonable A/1 in orange in worker 2 and worker 4 with the job category description repetitive, but there are opportunities for rest or recovery through formal and informal breaks or job rotation. The fifth assessment score is the displacement distance where the Medium A/1 category score is orange for the five workers with a description of the displacement distance

Table 5. Recapitulation of NBM Results for Brick Maker

Number	Complaint Type	Pain Level				Total Score
		NS (1)	SS (2)	S (3)	VS (4)	
0	Pain/stiffness in the upper neck	3	2	0	0	7
1	Pain/stiffness in the lower neck	3	2	0	0	7
2	Pain in left shoulder	1	1	1	2	14
3	Pain in right shoulder	1	1	1	2	14
4	Pain in left upper arm	2	3	0	0	8
5	Pain in the back	0	0	0	5	20
6	Pain in right upper arm	2	3	0	0	8
7	Pain in the waist	0	0	0	5	20
8	Pain in the buttocks	0	0	3	2	17
9	Pain in the ass	0	0	5	0	15
10	Pain in left elbow	0	2	2	1	14
11	Pain in right elbow	0	2	2	1	14
12	Pain in left forearm	1	2	2	0	11
13	Pain in right forearm	1	2	2	0	11
14	Pain in left wrist	0	3	2	0	12
15	Pain in right wrist	0	3	2	0	12
16	Pain in left hand	1	1	3	0	12
17	Pain in right hand	1	1	3	0	12
18	Pain in left thigh	2	3	0	0	8
19	Pain in right thigh	2	3	0	0	8
20	Pain in left knee	0	0	1	4	19
21	Pain in right knee	0	0	1	4	19
22	Pain in left calf	0	2	2	1	14
23	Pain in right calf	0	2	2	1	14
24	Pain in left ankle	0	3	2	0	12
25	Pain in right ankle	0	3	2	0	12
26	Pain in left leg	0	1	2	2	16
27	Pain in right leg	0	1	2	2	16
	Total	20	46	42	32	

Explanation: NS = Not Sick (1), SS = Slightly Sick (2), S = Sick (3), VS = Very Sick (4)

between 10 meters and 30 meters. The sixth assessment score is the condition of the equipment with a reasonable A/2 category score in orange color for the five workers with a description that maintenance only occurs when problems arise and the equipment is in reasonable repair condition. The seventh assessment score is the floor surface where the floor surface category scores where the Poor R/4 category score is red for the five workers with a description of contaminated (wet or debris in some areas), steep slope (slope of more than 5°), soft ground or not stable (gravel, sand, mud) and very poor condition (severe damage). The eighth assessment score is the route barrier where the score in the category Good G/0 is green in worker 5 with a description of no obstacles and the Reasonable category score A/2 is orange in worker 1, worker 2, worker 3, and worker 4 where the description contains one obstacle. but no stairs or steep incline. The ninth assessment score is another factor where the score of the None G/0 category is green in worker 1, worker 2, worker 4, and worker 5 where there are no other factors that influence. Category One A/1 orange color for worker 3 where the other factor is the unstable load when the trolley contains products whose shape makes the trolley unbalanced.

Based on the results of the recapitulation of the RAPP Tool, it can be seen that the total score is 63 for the five workers. The assessment with the highest score of 20 is contaminated floor surface, steep slope, and unstable ground surface. This is most often felt by workers and is included in the hazard category. The next order of assessment is a posture score of 15, equipment condition of 10, route barrier of 8, displacement distance of 5, weight of load, and work pattern of 2, other factors of 1, and handgrip of 0.

Nordic Body Map

Analysis of muscle complaints with NBM was carried out on all workers in AJB. The results of filling out the NBM worksheets for all workers can be seen in Table 5. The calculation of the NBM score is by multiplying the number of workers who experience complaints by the rating scale. For example, for pain/stiffness in the upper neck, there are 3 workers who have NS and 2 workers have SS, then the NS scale rating is 1 times 3 workers. The SS scale rating is 2 times 2, so the number is 7 as the total score.

Based on the recapitulation of the results of the NBM in Table 5, it can be seen that the total tick of all workers for the level of pain is not sick at 20, slightly sick at 46, sick at 42 and very sick at 32. The population is 5 people and used as respondents so that the results of the NBM are the individual scores analyzed. Based on this, it can be said that with the NBM method, it is known that workers are dominated by feeling a bit sick and sick. The body parts with the highest scores are: back, waist, buttocks, left knee, right knee, left leg and right leg. This is in accordance with research by Snook (Snook, 1978) who reported that field studies showed that a quarter of the industrial tasks examined accounted for less than 75% of the workforce, but these occupations accounted for half of back injuries. The results of Umyati's research (Umyati et al., 2018) that workers feel complaints in the upper left arm, back, upper right arm, waist, left buttocks, wrist, right wrist, left thigh, right thigh and left calf. There is a difference because the

Table 6. Classification of Individual NBM Score Results

Worker	Individual Score	MSDs Risk Level	Corrective Action
1	66	Medium (50-70)	Action may be needed in the future
2	81	High (71-91)	Immediate action needed
3	62	Medium (50-70)	Action may be needed in the future
4	72	High (71-91)	Immediate action needed
5	85	High (71-91)	Immediate action needed

tools observed are different from this study, namely tools with tricycles. Next, the individual NBM score categories were classified according to the MSDs risk level classification based on the individual NBM scores in Table 6.

Based on the results in Table 6, it can be seen that workers 1 and 3 are classified as moderate risk level for MSDs where corrective action may be needed in the future. While workers 2, 4 and 5 are classified as high risk of MSDs where corrective action is needed immediately to reduce the risk of injury to workers in the long term.

Chi Square Test

The Chi-Square test was conducted to determine the relationship between age and work period to muscle complaints scores. Table 7 and Table 8 show the distribution of age and years of service of brick-making workers in AJB.

Table 7. Worker Age Distribution

Age (Year)	Frequency (n)	Percentage (%)
<35	2	40
>35	3	60
Total	5	100

Tabel 8. Worker Working Period Distribution

Working Period (Year)	Frequency (n)	Percentage (%)
<5	2	40
>5	3	60
Total	5	100

Table 7 and Table 8 show the distribution of workers age and years of service where 60% are over 35 years old and have more than 35 years of service.

The relationship between the age of workers and years of service with muscle complaints can be proven by the chi square test using SPSS software version 23.0 at a 95% confidence level.

Hypothesis of Relationship between Worker Age and Muscle Complaint

H_0: There is no relationship between the age of workers with MSDs muscle complaints

H_1: There is a relationship between the age of workers with MSDs muscle complaints
Decision making basis:

1. If the 2-tailed significance value <0.05, it means that H0 is rejected and H1 is accepted

2. If the 2-tailed significance value> 0.05, it means that H0 is accepted and H1 is rejected

Based on the results of the Chi-Square test in Table 9, it can be seen that the Pearson Chi-Square value on the 2-sided asym.sig is 0.025. Because the value of asym.sig 2 tailed is 0.025 < 0.05, then based on the decision-making basis that has been determined, it can be concluded that H0 is rejected and H1 is accepted so that it can be interpreted that there is a relationship between the age of workers and MSDs muscle complaints. This can also mean that age affects the muscle complaints felt by workers.

Hypothesis of the Relationship between Work Period and Muscle Complaints

H_0: There is no relationship between the working period of workers with MSDs muscle complaints

H_1: There is a relationship between the working period of workers with MSDs muscle complaints
Decision making basis:

1. If the 2-tailed significance value <0.05, it means that H0 is rejected and H1 is accepted

2. If the 2-tailed significance value> 0.05, it means that H0 is accepted and H1 is rejected

Based on the results of the Chi-Square test in Table 10, it can be seen that the Pearson Chi-Square value on the 2-sided asym.sig is 0.025. Because the value of asym.sig 2 tailed is 0.025 > 0.05, then based on the basis of the decision-making that has been determined, it can be concluded that H0 is rejected and H1 is accepted so that it can be interpreted that there is a relationship between the working period of workers and MSDs muscle complaints. This can also be interpreted that the length of the working period affects the muscle complaints felt by workers.

Table 11 shows that, worker 1 needs to make improvements to posture, movement distance, equipment condition, route barriers and especially immediate repairs on the floor surface

Table 9. Output of SPSS version 23.0 Chi-Square Test Relationship between Age and Muscle Complaints

Chi-Square Tests					
	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	5,000ᵃ	1	0,025		

Table 10. Output of SPSS version 23.0 Chi Square Test Relationship between Working Period and Muscle Complaints

Chi-Square Tests					
	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	5,000ᵃ	1	0,025		

Tabel 11. Risk Analysis using the RAPP Tool

Worker	Making Process	Evaluation Result
1	Concrete Brick	Slightly Risky category on the RAPP Tool method with moderate MSDs complaints
2	Concrete Brick	Dangerous category on RAPP Tool and NBM method
3	Loster Concrete	Quite Risky category on the RAPP Tool method with moderate MSDs complaints
4	Short Concrete Tube	Quite Risky category on the RAPP Tool method with high MSDs complaints
5	Long Concrete Tube	Quite Risky category on the RAPP Tool method with high MSDs complaints

so that the MSDs complaints of workers in the medium category can be reduced to the low category. Workers 2 need to make improvements to the type of tool and the mass of the load, posture, work pattern, distance of movement, equipment condition, route barriers and especially immediate repairs on the floor surface so that the MSDs complaints of workers with high categories can gradually decrease to low categories accompanied by preventive measures and regular maintenance. Workers 3 need to make improvements to posture, movement distance, equipment conditions, route barriers, unstable load factors and especially immediate repairs on the floor surface so that the MSDs complaints of workers with moderate categories can be reduced to low categories.

Workers 4 need to make improvements to their posture, work patterns, movement distances, equipment conditions, route barriers, and especially immediate repairs to the floor surface so that the MSDs complaints of workers with high categories can be gradually reduced to low categories accompanied by preventive and periodic maintenance actions. Workers 5 need to make improvements to the type of tool and the mass of the load, posture, work patterns,

movement distances, equipment conditions, route barriers and especially immediate repairs on the floor surface so that the MSDs complaints of workers with high categories can be gradually reduced to low categories accompanied by preventive action and periodic maintenance.

In Table 4, it can be seen that the cause of the high RAPP tool score is because the floor surface variable is a control variable that interferes with the use of non-standard shoes (Argubi-Wollesen et al., 2017). Meanwhile, adjustment of posture and direction of hand and foot strength to compensate for the reduced level of foot friction (Boocock et al., 2006). The posture variable is also the cause of the high RAPP tool score. The postures formed by workers are different because the size of the work equipment is also different so that the results of the tensile force are also different (Chen et al., 2021). Additionally, the ideal grip position is around hip to shoulder height and depends on the strain factor (Argubi-Wollesen et al., 2017). The displacement distance of objects also affects the total score of the RAPP Tool, a study where the displacement distance affects the results of the biomechanics assessment (Saputra et al., 2021). Meanwhile, developed a toolkit based on a
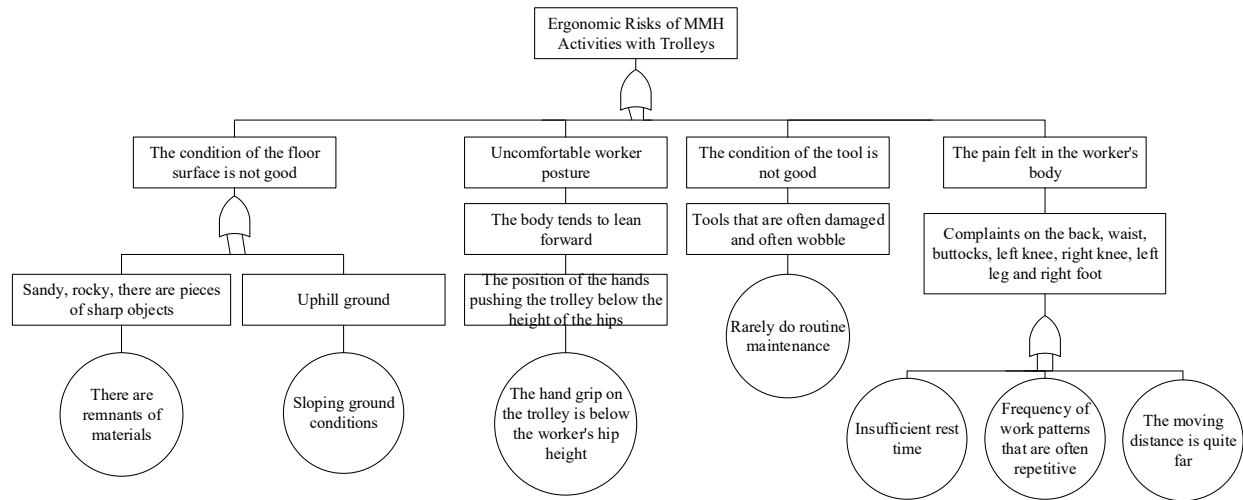
Figure 1. FTA Diagram on brick-making workers

collaborative platform to prevent MSDs and be able to improve and maintain healthy and safe working conditions (Zhang, 2012).

Based on the analysis, it was found that several assessments needed to be improved, especially on the floor surface, posture, equipment condition, displacement distance and route barriers. These improvements have an impact on the level of MSDs complaints felt by workers will be reduced so that workers are comfortable in their activities with a safe work environment.

Identifying the Root of the Problem with the FTA Method

FTA method is used to identify the causes of ergonomic risks for MMH activities using trolleys on AJB as shown in Figure 1.

Based on Figure 1, that the identification of the root cause of the problem is the ergonomic risk of MMH activities using trolleys. The main causes are uneven floor surface conditions, uncomfortable worker postures, poor equipment conditions, and pain felt in the workers' bodies. Based on these problems, each problem was identified using the FTA method so that the root of the problem was found, namely the presence of remnants of material, sloping ground conditions, handrails on the trolley under the workers' hips, routine maintenance is rarely

carried out, insufficient rest time, frequency repetitive work and long distances.

The solution that can be an alternative is to make a roof on the area where workers pass, this refers to the RAPP Tool's assessment, namely the temperature and wind gust factors so that workers do not overheat or get wet by rain and reduce complaints by workers. Bringing the material location closer to an area with a flat surface and protected from rain, this refers to the RAPP Tool's assessment, namely the distance factor, floor surface conditions and route barriers so that the path is shorter, dry, flat, and clean with no gravel passed by workers and reduce the pain felt by workers, especially in the legs. Making road access safe by making further incline trajectories, this refers to the RAPP Tool's assessment, namely the floor surface condition factor and the route obstacle factor so that it doesn't feel heavy when pushing the trolley and reduces fatigue. Perform routine checks and schedule preventive repairs on the trolley, this refers to the RAPP Tool's assessment of the condition of the trolley for optimal equipment conditions and safe use. Calling on workers to use safe clothing and personal protective equipment for the safety of workers, this refers to the NBM assessment to create safe and protected working conditions from things that pose a danger. A tool that is comfortable to use by adjusting the position of the handle for the hand located above

the waist so that the body becomes firm, this refers to the RAPP Tool's assessment of the hand grip factor so that it is expected that the position of the hand grip on the tool is above the worker's hip and the worker is in a straight body position will reduce the risk of complaints on the workers' bodies.

IV. CONCLUSION

Based on research that has been carried out using the RAPP Tool method, it can be seen that workers with the highest ergonomic risk are worker 2 with a score of 15, worker 3 and worker 4 with a score of 13 each, worker 1 with a score of 12, and worker 5 with a score of 10. RAPP Assessment Tool that has the highest number of scores is the floor surface with a score of 20, posture with a score of 15, and the condition of the tool with a score of 10. Based on research conducted using the NBM method, the body parts that are often felt to have complaints are the back, waist, buttocks, left knee, right knee, left leg and right foot. In workers 1 and 3, the level of risk of MSDs complaints was moderate, while workers 2, 4, and 5 had a high level of risk for MSDs. Solutions that can be applied are making a roof over the area where workers pass, bringing the material place closer to an area with a flat surface and protected from rain, making a further incline path so that it doesn't feel heavy when pushing the trolley, conducting routine checks and schedules for preventive repairs on trolleys, as well as urging workers to use safe clothing and personal protective equipment, as well as assistive devices that are comfortable to use.

REFERENCES

Argubi-Wollesen, A., Wollesen, B., Leitner, M., & Mattes, M. (2017). "Human Body Mechanics of Pushing and Pulling: Analyzing the Factors of Task-related Strain on the Musculoskeletal System," *Saf. Health Work, 8* (1), pp. 11–18. doi: 10.1016/j.shaw.2016.07.003.

Asl, S.B., Naeini, H.S., Ensaniat, L.S., Khorshidian, R., & Alipour, S. (2014). "Injury Prevention among Construction Workers: A Case Study on Iranian Steel Bar Bending Workers," *Int. J. Ind. Manuf. Eng., 8* (8), pp. 467–470.

Ayoub, M. & Dempsey, P.G. (1999). "The Psychophysical Approach to Manual Materials Handling Task Design," *Ergonomics, 1* (42), pp. 17–31. doi: 10.1080/001401399185775.

Basahel, A.M. (2015). "Investigation of Work-related Musculoskeletal Disorders (MSDs) in Warehouse Workers in Saudi Arabia," *Procedia Manuf., 3* (Ahfe), pp. 4643–4649, 2015, doi: 10.1016/j.promfg.2015.07.551.

Boocock, M.G., Haslam, R.A., Lemon, P., & Thorpe, S. (2006). "Initial force and postural adaptations when pushing and pulling on floor surfaces with good and reduced resistance to slipping," *Ergonomics, 49* (9), pp. 801–821. doi: 10.1080/00140130600562876.

Bragança, S., & Costa, E. (2014). "Risk Assessment of Musculoskeletal Disorders in an Electronic Components Company," *Int. J. Biomed. Biol. Eng., 8* (6), pp. 354–357.

Chen, Y.L., Ho, T.K., & Chen, K. L. (2021). "Maximum strength levels for pulling and pushing handleless cartons in warehousing tasks," *Ergonomics, 64* (9), pp. 1174–1182. doi: 10.1080/00140139.2021.1924406.

Chin, J., Herlina, Iridiastadi, H., Shu-chiang, L., & Persada, S.F. (2019). "Workload Analysis by Using Nordic Body Map , Borg RPE and NIOSH Manual Lifting Equation Analyses : a Case Study in Sheet Metal Industry," *J. Phys. Conf. Ser., 1424*, pp. 1–6, doi: 10.1088/1742-6596/1424/1/012047.

Der Beek, A.J.V., Dennerlein, J.T., Huysmans, M.A., Mathiassen, S.E., Burdorf, A., van Mechelen, W., van Dieën, J.H., Frings-Dresen, M., Holtermann, A., Janwantanakul, P., van der Molen, H.F., Rempel, D., Straker, L., Walker-Bone, K., Coenen, P. (2017). "A Research Framework for the Development and Implementation of Interventions Preventing Work-Related Musculoskeletal Disorders," *Scand. J. Work. Environ. Heal., 43* (6), pp. 526–539, doi: 10.5271/sjweh.3671.

Efthymiou, O.K., & Ponis, S.T. (2019). "Current Status of Industry 4.0 in Material Handling Automation and In-house Logistics," *Int. J. Ind. Manuf. Eng., 13* (10), 1370–1374.

HSE, "*Risk assessment of pushing and pulling (RAPP) tool, Health & Safety Executive (HSE)*, UK.," pp. 1–15, 2016.

ILO (International Labour Organization), (2013) *Keselamatan dan Kesehatan Kerja Sarana untuk Produktivitas*, Modul Lima. Jakarta: International Labour Office.

Jaya, I.P.P., & Negara, N.L.G.A.M. (2019). "Analisis Sikap Kerja Menggunakan Rapid Entire Body Assessment dengan Keluhan Muskuloskeletal menggunakan Nordic Body Map pada Pekerja Pembuat Tahu di

Desa Tonja Denpasar Utara," *Bali Heal. J., 3* (2), pp. S1–S9, 2019.

Karaca, N.G. (2015). "Examining Occupational Health and Safety Inspection and Supervision in Turkey by Comparison to EU Countries," *Int. J. Ind. Manuf. Eng., 9* (3), pp. 880–883.

Mariawati, A.S., Umyati, A., & Andiyani, F. (2017). "Analisis Penerapan Keselamatan Kerja Menggunakan Metode Hazard Identification Risk Assessment (HIRA) Dengan Pendekatan Fault Tree Anlysis (FTA)," *J. Ind. Serv., 3* (1), pp. 293–300, 2017.

Muslimah, E., Pratiwi, I., & Rafsanjani, F. (2006). "Analisis Manual Material Handling Menggunakan Niosh Equation," *Jurnal Ilmiah Teknik Industri, 5* (2), pp. 53–60, 2006, doi: https://doi.org/10.23917/jiti.v5i2.1566.

Pancharya, A. (2011). "Improvements in Material Handling: A Case Study of Cement Manufacturing Plant," *Int. J. Ind. Manuf. Eng., 5* (3), pp. 589–593.

Pratiwi, I., Afifuddin, M., Djunaidi, M., & Suranto, 2018. "Analisis Postur Kerja Dengan Metode Manual Task Risk Assessment (ManTRA) Pada Pembuatan Mie Sohun," *Jurnal Ilmiah Teknik Industri, 17* (1), pp. 71–82. doi: 10.23917/jiti.v17i1.6423.

Ray, P.K., Parida, R., & Saha, E. (2015) "Status Survey of Occupational Risk Factors of Manual Material Handling Tasks at a Construction Site in India," *Procedia Manuf., 3* (Ahfe), pp. 6579–6586, 2015, doi: 10.1016/j.promfg.2015.07.279.

Ribeiro, T., Serranheira, F., & Loureiro, H. (2017). "Work Related Musculoskeletal Disorders in Primary Health Care Nurses," *Appl. Nurs. Res., 33*, pp. 72–77. doi: 10.1016/j.apnr.2016.09.003.

Setyanto, N.W., Efranto, R.Y., Lukodono, R.P., & Dirawidya, A. (2015). "Ergonomics Analysis in the Scarfing Process by OWAS , NIOSH a nd Nordic Body Map's Method at Slab Steel Plant's Division," *Int. J. Innov. Res. Sci. Eng. Tech., 4* (3), pp. 1086–1093. doi: 10.15680/IJIRSET.2015.0403060.

Snook, S.H. (1978). "The Ergonomics Society The Society's Lecture 1978. The Design Of Manual Handling Task," *Ergonomics, 21* (12), pp. 963–985., doi: 10.1080/00140137808931804.

Tarwaka, Sudiajeng, L., & Solichul, B.H. (2004). *Ergonomi Untuk Keselamatan, Kesehatan Kerja dan Produktivitas.*

Umyati, A., Widianto, A., Lady, L. & Mariawati, A.S. (2018). "*Evaluasi Aktivitas Manual Material Handling dengan Metode Risk Assessment in Pushing and Pulling (RAPP),*" in Proceding Seminar Nasional Teknik Industri, 2018, p. ER-13.

Saputra, A.A., Wahyudin, & Nugraha, A.E. (2021) "Evaluasi Aktivitas Manual Material Handling Dengan Menggunakan Metode Biomekanika Kerja Pada Pengangkatan Thiner di Bagian Warehouse," *J. Sist. Tek. Ind., 23* (2), pp. 233–244, 2021, doi: 10.32734/jsti.v23i2.6273.

Zhang, B. (2012). "Development of Toolkits for Hazard Identification, Risk Assessment and Prevention of Work-Related Musculoskeletal Disorders based on a Collaborative Platform," *J. Ergon., 02* (04). doi: 10.4172/2165-7556.1000108.