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Application of The Rapid Entire Body Assessment (REBA) Method to Improve Work Safety in The Automotive Spare Parts Industry

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Abstract. This industry consists of companies engaged in metal processing and workmanship. Companies often receive complaints from employees concerning pain or discomfort in their bodies, causing diseases such as low back pain and myalgia. The risk of accidents occurring at work is inseparable from the work done. Work-related accidents can occur due to several factors, including unsafe action. One cause of unsafe actions can be found in various unsafe work postures that workers assume. Therefore, the purpose of this study is to evaluate the posture of these workers so that it can improve their safety and health. This research was conducted by identifying occupational risks workers face and examining work performed in stamping products. The production section consists of six stations: material handling, stamping, welding, hemming, painting, and packing. The work risks run by workers have been identified using the Nordic Body Map (NBM) questionnaire and interview methods. As for the identification of the type of work carried out by evaluating work postures, the Rapid Entire Body Assessment (REBA) method has been employed. The risk level of accidents is also used for the selection of activities to be improved to minimize the level of injury risk caused by work postures that have been assumed, and in order to improve the safety and health of the workers. Improvements made are in engineering, such as manufacturing of assistive devices, and management engineering, such as providing directions that can improve the specific work posture used. Calculations are based on simulations performed with tools conducted with suggested postures by evaluation using the REBA method. Based on the results of REBA calculations, the resulting risk is lower than the one caused by the previously assumed posture, namely medium and low.

Keywords: : work posture, REBA, NBM, work safety, occupational health

INTRODUCTION

The automotive industry's development continues to increase, especially in Indonesia. According to data obtained from the Ministry of Industry, "exports of automotive components increased 13 times to 81 million components in 2017 from 6.2 million components in 2016" (Ministry of Industry, 2018). This indicates that the automotive sector's growth has increased the demand for motor vehicles.

Increased job demands will affect worker productivity, especially in the worker safety and health sector. If ignored, there will be unwanted events such as accidents or other undesirable losses that can affect the productivity of workers or the company. According to data obtained from BPJS TK by way of the *Pikiran Rakyat* newspaper, "The number of work accidents continues to show an increasing trend where there is an increase from 2017 to 2018 with reported work accident numbers reaching 123,041 cases in 2017, while throughout 2018 it amounted to 173,105 cases", according to Priono (2018), and Widianto (2019). By looking at the increasing trend of work accidents along with the increasing demand it will certainly be a warning or threat to the company, so it needs to pay attention to the health and safety conditions of workers. According to the International Labor Organization (2013), and Tarwaka, Bakri, Sudiajeng (2005), occupational safety and health can affect work productivity.

This company is engaged in processing and metalworking. Based on data obtained from the company, employees often experience discomfort that causes illness. Diseases arising from work at the company are Low Back Pain (LBP), and Myalgia. According to Ridley (2008), Bird (1990) in Sujoso (2012), the causes of work accidents are unsafe acts (85%), while the remaining 15% are caused by dangerous conditions. According to Rachmawati (2008), illnesses related to attitude and work methods are included in physiological factors that can result in work accidents. The percentage arising from musculoskeletal diseases per month compared to the average number of diseases that arise per month is 29.33%, as shown in Figure 1 below.

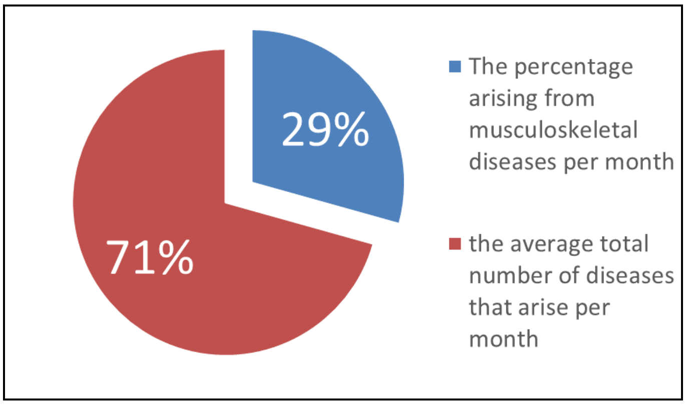

Figure 1. The percentage arising from musculoskeletal diseases per month compared to the average total number of diseases that arise per month

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The total average monthly percentage of musculoskeletal work-related diseases is 29% (blue), while the total average monthly percentage of workers who experience work-related accidents is 71% (red).

LITERATURE

LBP and Myalgia are occupational diseases that form a category of skeletal disorders or Musculoskeletal Disorders (MSDs). Musculoskeletal Disorders (MSDs) are injuries and disorders of the soft tissues (muscles, tendons, ligaments, joints, and cartilage) and the nervous system due to muscles receiving repetitive static loads over long periods (OSHAcademy, 2018). Myalgia is a musculoskeletal disorder characterized by muscle pain, causing them to feel heavy and stiff, as well as cramps, muscle aches, and leg cramps (Tomaszewski et al., 2011). LBP is a musculoskeletal disorder in the lower back part caused by various diseases and improper or harmful body activity (Tarwaka et al., 2005). Based on the Australian Standard (established in 1990), illnesses related to work posture are included in work-related accidents.

Based on the preliminary observations and interviews conducted, both diseases are caused by the positions assumed mainly by workers in a standing position, which involves the bending or raising of one foot on the work platform. One example can be found at a delivery station that carries out material handling activities, as illustrated in Figure 2. The findings of Grandjean (1993), Anis and McConville (1996), Waters Putz-Anderson (1996); and Manuaba (2000) in Tarwaka, Bakri, Sudiajeng (2005) show that unnatural work attitudes cause the position of body parts to move away from the natural position, for example, the movement of a raised hand and back that is excessively bent.

Figure 2. Operator's Work Position at the Delivery Section

The farther the body's position from the center of gravity of the body, the higher the risk of skeletal muscle complaints. Therefore, a work posture analysis method is needed to improve worker safety and health.

The methods to be employed include distributing the Nordic Body Map (NBM) and REBA (Rapid Entire Body Assessment) questionnaires. According to Tarwaka, et al. (2005), analyzing the body map (NBM) can estimate the type and level of skeletal muscle complaints of the workers. According to Corlett and McAtamney (1988), NBM is a body map to determine the part(s) of muscles that are experiencing pain leading to complaints and the level of skeletal muscle pain felt by workers so that the type and level of skeletal muscle pain leading to complaints by workers can be estimated (Tarwaka et al., 2005).

According to Sari, Anwar, and Suryoputro (2018), the process carried out in the assessment using the NBM questionnaire includes (1) Filling out the NBM questionnaire based on body parts and the level of pain felt, (2) Assessing the values (weighting) based on the level of pain felt in the various body parts, (3) Calculation of the total value/weight obtained, (4) The conversion of total values into the level of risk of work performed. The NBM questionnaire sheet used is a questionnaire obtained from Setyanto et al. (2015). The results of the NBM are carried out to identify jobs from the individual or worker's point of view. When workers misjudge the level of pain experienced, this can lead to occupational risks that may arise in the future. Therefore, an objective analysis is needed to show whether the work done is safe or not to avoid subjectivity.

The method used in objectively evaluating work postures is the REBA method. The REBA method or Rapid Entire Body Assessment is used to analyze workers' posture from the researcher’s angle to examine the work-related risks in terms of work by assessing a body's posture at work (Hignett McAtamney, 2000). According to Budiman and Setyaningrum (2006) Kurniawati (2009), Nurliah (2012), and Saptadi and Wijanarko (2008), there are 6 main steps in using the REBA method, namely (1) observing tasks, (2) selecting postures for assessment, (3) giving scores to postures, (4) processing the scores, (5) determining the REBA value or REBA final score, and (6) converting REBA values to the level of action concerning the urgency for control measures. According to Hignett and McAtamney (2000), Wijanarko (2008), and Nurliah (2012), REBA can be used to study ergonomic factors in the workplace if ergonomic work assessments identify that further postural analysis is needed and under certain conditions, namely (1) The whole body being used (2) Static, dynamic posture, speed of change, or unstable posture (3) Frequent or rare handling of loads (4) Modification of workplaces, equipment, training, or behavior of workers who work ignoring risks are also monitored.

Based on these considerations, research has been conducted to determine the risk of injury caused by ergonomic factors by applying the REBA and NBM methods so that suggestions for improvements can be provided that will later improve occupational health and safety (OHS, referred to in Indonesian as K3).

METHOD

This study consists of evaluating the initial work posture and proposing improvements to work that needed improvement in this company. This research has been conducted at six stations: the material handling, stamping, welding, hemming, painting, and packing stations. The number of workers at each station can be seen in Table 1 below.

Table 1. Station Description and Number of Respondents taken at each station

Station	Activity	Total Number of Respondents
Material Handling	Moving Goods	4
Stamping	Moving items from the stamping station	8
	Operation of Stamping Machines	
Welding	Moving items at the welding station	4
	Operation of welding machines	
Hemming	Moving Goods	4
	Operating Hemming machines	
Painting	Painting Process	3
Painting (Material Handling)	Process of Moving Goods	4
Packing	Pre-packing Process	
	Wrapping Process using cardboard boxes	4
	Process of Moving Goods to the Cardboard Box Distribution Desk	

The research procedure carried out can be seen in Figure 3. The initial step is to describe the station and the activities carried out at the station concerned. The next step is to explain the production process that is carried out. The initial work posture evaluation is conducted by conducting interviews and filling in the Nordic Body Map (NBM) questionnaire taken from each station to identify tasks from the individual's or worker's side. Evaluation is also made of the work carried out by identifying the work posture using the Rapid Entire Body Assessment (REBA) method. The results obtained are stations or specific tasks that require improvement. The REBA assessment in this research has employed the REBA Assessment Form designed by Hignett & McAtamney, 2000 in Middlesworth 2014 and Ergo-plus, 2012.

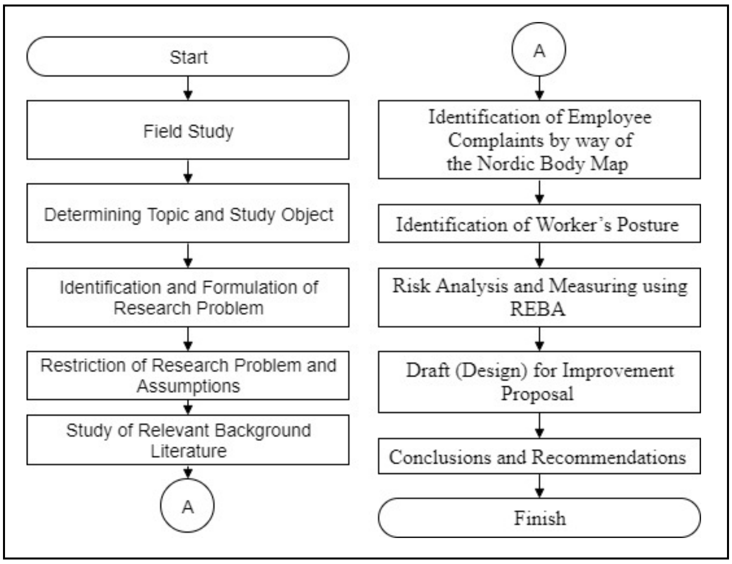

Figure 3. Research Flow Chart

Proposed improvements are the engineering and management methods for tasks requiring improvement. In engineering methods, engineering is used for making tools, and improving work posture. Knowledge or direction concerning the work posture will be carried out in management engineering methods, such as the maximum load workers can carry. The evaluation carried out on the proposed improvement is to evaluate the work posture with the REBA method, in which the work posture is visualized by simulation using a 3D model. This 3D model simulates workers using tools made or only by improving the posture used. This 3D model simulation uses *SolidWorks* software.

DISCUSSION

The production process is carried out to produce stamping products at six stations: stamping, welding, hemming, painting, packing, and delivery. The flow of the production process can be seen in Figure 4 below.

Based on the number of respondents determined in Table 1, the next step is to assess the work carried out based on the Nordic Body Map (NBM) method. This assessment has been conducted using the NBM questionnaire. The results obtained from NBM assessments are occupational risks,as seen in Table 2.

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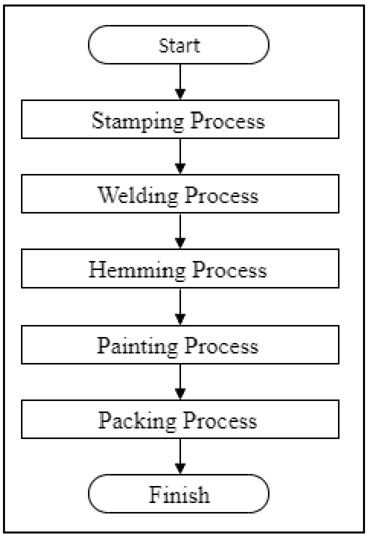

Figure 4. Flow of the Production Process

Table 2. Risk Level Results from Assessment using the NBM Questionnaire Method

No.	Station	Activity	NBM Risk
1	*Material Handling*	Moving Goods	Medium
2	*Stamping*	Moving items from the stamping station	Medium
3		Using the stamping machine	
4	*Welding*	Moving goods at the welding station	Low
5		Using the welding machine	
7	*Hemming*	Moving items at the hemming station	Low
8		Operating the hemming machine	
9	*Painting*	Painting Process	Medium
10		Process of moving items at the painting section	
11	*Packing*	*Pre-packing process*	Low
12		Wrapping process using cardboard boxes	
13		Process of moving items at the cardboard distribution desk	

Other information obtained from the NBM results consists of the level of pain based on body parts at all stations. This is accomplished by sorting out the parts of the body that attain the most minor score to the most significant score. This can be seen in Figure 5. Based on this figure, the elements that can be taken are the five most extensive body parts that suffer the highest level of pain, namely the right hand, right knee, hip, waist, and back. The hip, waist, and back of the body experience a level of pain of 2-2.9 on a scale of 4, which shows the scale "rather painful" in the NBM questionnaire. This indicates that the interviews and observations conducted give the same results, i.e., LBP and myalgia.

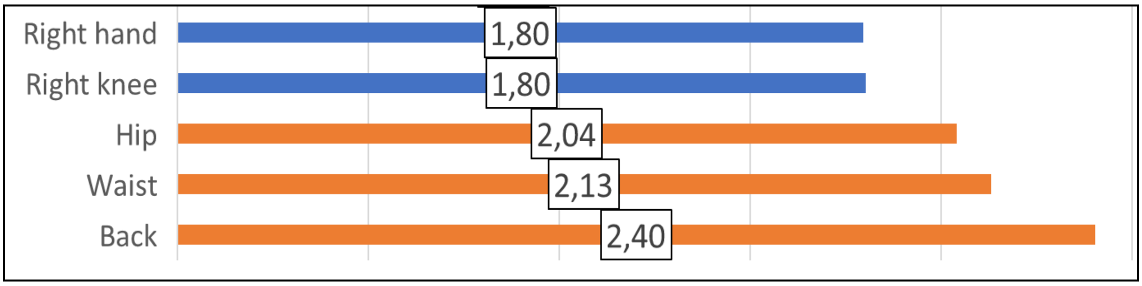

Figure 5. Top 5 body parts based on the level of pain from the results of NBM featuring (from top to bottom: the Right Hand, Right Knee, Hip, Waist, and Back)

After an assessment derived from the worker's side, an assessment is made of the task performed by evaluating work postures using the REBA method. The following is an example of providing the specific angles of the worker's posture at a material handling station, as seen in Figure 5. The posture will be assessed later using the REBA worksheet that has been created based on Hignett and McAtamney (2000).

Figure 6. Angles of Worker A.'s Posture in Moving Activities at the Material Handling Station

The assessment will be based on the respondents described in Table 1. The results obtained will be processed to provide a level of risk that can represent the station under scrutiny. Table 4 summarizes the recapitulation results from the initial posture evaluation for all stations using the REBA method.

Tables 4 and 2 show the results of the initial posture evaluation for all stations using the REBA and NBM methods. These results indicate that several tasks require improvement as they carry risks ranging from moderate (medium) to very high. Stations with risks ranging from negligible to low, i.e., welding and hemming, will not need any improvement.

Therefore, the tasks selected for improvement can be seen in Table 3.

Table 3. Tasks Selected Based on REBA and NBM Results

Station	Activity	REBA Risk	NBM Risk
Material Handling	Moving Goods	High	Medium
Stamping	Moving items from the stamping station	Very High	Medium
	Using the stamping machine	High	
Painting	Process of moving items at the painting section	Very High	Medium
Packing	*Packing process using cardboard boxes*	High	Low
	Process of moving items to the cardboard box distribution desk	Very High	

The work carries a level of risk described in Table 4 and Table 2 due to several factors, namely, the activities carried out by workers involve an unsafe posture characterized by bending and heavy object loads. This is indicated by worker complaints obtained from interviews and NBM questionnaires. Complaints experienced are pain in the body, particularly in the back, waist, and hips. Therefore, tasks that carry risks (ranging from moderate to very high) require improvement in engineering, namely the manufacture of assistive devices and management engineering by providing some guidance that can help workers reduce injuries while doing their work.

Peter Vi (2000) in Tarwaka, Bakri, Sudiajeng (2005) proposed improvements to be made include engineering and management engineering. These proposed improvements can be seen in Table 5. The proposed improvement is an evaluation of work posture using REBA once again so that it can compare the results of the initial conditions with the final conditions.

Table 4. Recapitulation of REBA Results at All Stations

No.	Station	Activity	Final Score Group A	Final Score Group B	Final Score REBA	Risk	Action/ Measure to be taken
1	*Material Handling*	Moving Goods	8	3	10	High	Required soon
2	*Stamping*	Moving items from the stamping station	9	5	12	Very High	Required this instant
3		Operating the stamping machine	7	4	9	High	Required soon
4	*Welding*	Moving items to the welding station	1	2	1	Negligible	Not required
5		Operating the welding machine	2	1	2	Low	Possibly required
7	*Hemming*	Operating the hemming machine	1	2	2	Low	Possibly required
8		Operating the hemming machine	1	2	2	low	Possibly required
9	*Painting*	Painting Process	1	1	3	low	Possibly required
10		Process of moving items at the painting section	9	3	11	Very High	Required this instant
11	*Packing*	Pre-packing process	2	1	3	low	Possibly required
12		Packing process using boxes	6	4	9	high	Required soon
13		Process of moving items at the cardboard box distribution desk	7	5	9	high	Required soon
Average			5	3	6	medium	Required
Maximum			9	5	12	Very High	Required this instant
Minimum			1	1	1	Negligible	Not required

Table 5. Proposals Provided at Each Station

Station	Activity	Proposal/Suggestion
Material Handling	Moving Goods	Use a *Trolley* with a base (storage tray) whose height can be adjusted
Stamping	Moving items from the stamping station	Make a printing part that can easily be reached
	Using the stamping machine	Use a button that can be adapted
		Improve the posture used
Painting	Process of moving items at the painting section	Use a vertical trolley with an appropriate height
Packing	Packing process using cardboard boxes	Posture improvement
	Process of moving goods to the cardboard box distribution desk	Improve posture and suggest the goods had better be carried by two workers

One example of providing a proposal can be seen in the material handling section, namely in moving goods at the material handling station, as seen in Figure 6. In this case, the proposal used data from Indonesian Anthropometry from the ages of 23 to 47 years old (Indonesian Anthropometry, 2018). According to Sutalaksana, Anggawisastra, Tjakraatmadja (2006) in Tarwaka, Bakri, and Sudiajeng (2005), standing is an alert attitude both physically and mentally so that work activities are carried out faster, with more strength, and more thoroughly. According to Pulat (1992) and Clark (1996) in Tarwaka, Bakri, Sudiajeng (2005), there are several considerations about work that is best done in a standing position, including:

(1) No space available for feet and knees;
(2) Workers must hold heavy objects (more than 4.5 kg);
(3) Workers often reach up, down and sideways;
(4) Workers often do the job by pressing down and
(5) Jobs that require high mobility.

Height measurements employ the Indonesian Anthropometry method. According to Wignjosoebroto (2003), Anthropometry is a science that deals with the measurement of the dimensions of the human body. Sanders and McCormick (1987); Pheasant and Haslegrave (2015), and Pulat (1992) in Tarwaka, Bakri, and Sudiajeng (2005) divide up the application of Ergonomics concerning Anthropometry into two main divisions, namely Ergonomics dealing with labor, machinery and other supporting facilities and work environment, and Ergonomics dealing with the characteristics of factory products that relate to consumers or users of the product.

The proposal is to provide a trolley whose foundation is adjusted to human height and is based on Indonesian anthropometry. The results can be seen in Figure 7. The Trolley table used is designed to have a maximum height of the 95th percentile at an elbow height of 1097.3 mm or approximately 1100 mm. The use of a trolley table that can be adjusted in height is intended for use by certain workers. The length of the handle used is the 50th percentile of the elbow height, which is 1040 mm because most workers can use it. The reason for providing this trolley table is to eliminate the bending motion to reduce the risk of LBP injury.

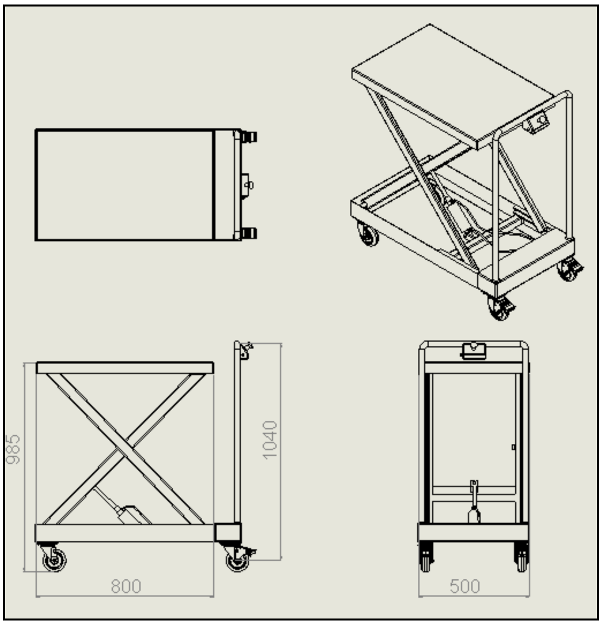

Figure 7. Dimensions of Trolley Proposal

Subsequently, this proposal is simulated using a 3D model, which is simulated using Solidworks software. Figure 8 shows an example of a 3D model simulation of moving goods.

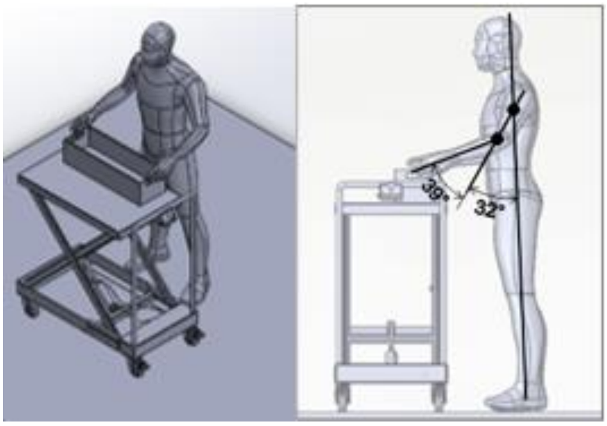

Figure 8. Simulation of Proposed Improvements in Moving Goods at the Material Handling Station

This proposal is subsequently re-evaluated using the REBA method. Table 6 shows the REBA results for proposals given for each activity. Table 7 shows the results obtained from evaluating the proposed work posture using the REBA method. Table 6 illustrates the improvements made before and after using REBA. The table shows a decrease in risk levels from high to low.

Table 6. Recapitulation of REBA Results for Proposals

No	Station	Activity	Final REBA Score Group A	Final REBA Score Group B	Final REBA Score	Risk
1	*Material Handling*	Moving Goods	3	2	3	*low*
2	*Stamping*	Moving items from the stamping station	2	4	4	*medium*
3		Using the stamping machine	1	2	2	*low*
4	*Painting*	Process of moving items at the painting section	3	5	5	*medium*
5	Packing	Process of packing into boxes	2	2	2	*low*
6		Process of moving items to the cardboard box distribution desk	2	2	3	*low*

Table 7. Evaluation of Proposed Improvements Provided at Each Station by way of the REBA Method

Station	Activity	REBA Risk beforehand	REBA Risk afterwards
Material Handling	Moving Goods	*Very High*	*Low*
Stamping	Moving items from the stamping station	*Very High*	*Medium*
	Using stamping machines	*high*	*Low*
Painting	Process of moving items from the painting section	*Very High*	*Medium*
Packing	Process of packing with cardboard boxes	*high*	*Low*
	Process of moving items to the distribution desk for cardboard boxes	*Very High*	*Low*

Another proposal that can be used is the use of standing chairs that can support workers while performing activities in a standing position, as can be seen in Figure 9. This proposal is also expected to change standing work positions to be dynamic. The selection of dynamic work designs is based on a table according to Helander (1995), and in Tarwaka, Bakri, and Sudiajeng (2005), there is a table for selecting work positions that must be adjusted to the type of work performed. According to Das and Sengupta (1996), Clark (2012), and Pulat (1992) in Tarwaka, Bakri, and Sudiajeng (2005), the sitting-standing position is the best one to assume is more desirable than merely sitting or standing.

This is because it allows workers to change work positions to reduce muscle fatigue due to forced attitude in one exclusive work position. The sitting-standing position (widely tested in the industry) has a bio-mechanical advantage where the pressure on the spine and waist is 30% lower compared to the continuous sitting or standing position.

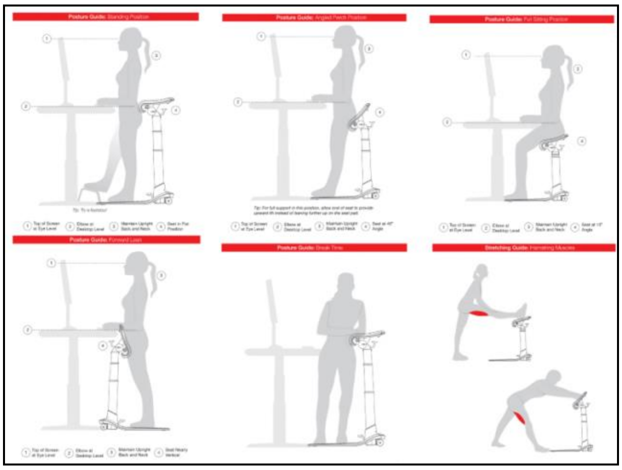

Figure 9. Simulation of Proposed Standing Chair Improvement (Ergoimpact, 2019)

The advantage of this standing chair is the dynamic attitude that can improve workers' health, especially for work postures, and reduce skeletal muscle disorders affecting the back and feet due to the position assumed all day long, namely standing. According to Tarwaka, Bakri, and Sudiajeng (2005), the implementation of sit-and-stand work in the laundry industry can significantly increase work productivity, especially in the case of skeletal muscle disorders (around 25%), and increase work productivity by almost 85%. Some positions that can be used are standing, leaning, and sitting, which can improve or maintain the lumbar posture (Ergoimpact (2019)).

CONCLUSION

Based on the observations and research conducted, several conclusions can be drawn based on the formulation of the problems made at the outset.

(1) Almost all activities carry a high risk that requires improvement, except at welding and hemming stations. This is indicated by worker complaints obtained from the results of interviews and NBM questionnaires. Complaints indicate pain in the body, specifically affecting the back, waist, and hips. This is because the activities carried

out by workers involve an insecure posture marked by bending and heavy object loads.

(2) Proposed improvements for activities that carry a moderate to high level of risk. The results are improving the workstation, adding tools, improving posture, and knowledge of the work done to reduce the risk of injury to workers. Based on the evaluation of proposals conducted by the REBA method, the results obtained are thriving where the work-related risk in terms of posture decreases from moderate to very high to low to moderate.

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