

Reducing Operator's Musculoskeletal Problems Using REBA, Nordic Body Map, and Karakuri

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ABSTRAK

Di Indonesia, tenaga kerja manusia masih banyak digunakan untuk memproduksi barang di pabrik. Mereka merupakan buruh dengan tingkat pendidikan dan keahlian rendah yang dengan mudah digantikan sehingga sering diabaikan oleh manajemen. Dalam pekerjaannya, para buruh sering mengeluh sakit pada bagian tubuh tertentu tetapi seringkali tidak sampai kepada manajemen pabrik. Penelitian ini dilakukan untuk menganalisa keluhan yang dialami para buruh pabrik dan berusaha mencari penyelesaian bagi masalah kesehatan yang dikeluhkan buruh. Penelitian dimulai dengan mengumpulkan pustaka, pengambilan data melalui pengukuran menggunakan kuesioner 'Nordic musculoskeletal body map' dan REBA. Data kemudian di proses menggunakan Excel dan dianalisa untuk mendapatkan solusi bagi permasalahan keluhan akibat kerja. Penelitian dilakukan di beberapa pabrik yang berbeda, seperti pabrik sepatu, pabrik kertas dan pabrik perakitan panel listrik. Keluhan sakit pada seluruh bagian tubuh para pekerja diukur dan diberi skor untuk menentukan apakah postur kerja mereka aman atau perlu diperbaiki. Berdasarkan pengukuran 'Nordic musculoskeletal body map', keluhan di bagian punggung, pinggang, tangan dan kaki banyak dikeluhkan oleh para pekerja di asembly panel listrik dan juga oleh pekerja di pabrik kertas bagian pemilahan dan inspeksi. Berdasarkan hasil pengukuran REBA, beberapa postur kerja ini dianjurkan untuk segera diubah karena beresiko dapat menimbulkan cedera di masa depan. Gerakan yang beresiko tinggi ini kemudian diubah dan diukur kembali menggunakan REBA. Beberapa postur tidak dapat diubah pengerjaannya, seperti mengangkat benda berat, atau hanya menghasilkan sedikit perubahan di skor REBA, maka alat bantu perlu digunakan untuk menggantikan kerja manusia. Beberapa prinsip dasar fisika dapat dimanfaatkan untuk membuat alat bantu tersebut, seperti meja hidrolik untuk mengangkat dan memindahkan benda berat, atau prinsip kerja karakuri untuk bagian pengepakan.

Kata kunci: Ergonomics kerja, karakuri, Nordic body map, REBA, Alat Bantu Kerja

ABSTRACT

Human labor is the most common type of worker in manufacturing plant in Indonesia. Their low education level and skills make them easy to replace. Their welfare mostly ignored by management even though complaints of pain and body discomfort released to supervisors. This research was conducted in order to analyze body postures of workers in manufacturing plant and tried to find ways to minimize future injury of these workers. Research started with literature studies, data gathering using questionnaire in Nordic body map, assessed their postures using REBA then processed using Excell. The result then analyzed to find solution for this problem. This research was conducted in several different manufacturing industries, such as packaging department in shoes manufacturing, sorting and inspection in paper industry and assembly department in electrical panel industry; since all of these industries still rely on human workers. Complaints and discomfort on their back, waist, hand and feet are common in the assembly panel workers while similar complaints also reported by workers in sorting and inspection in the pulp and paper industry. REBA findings suggest that workers postures should be immediately improved to minimize harm and prevent future injury for workers. But, even the task are redesign, some posture still poses risk, for example lifting heavy object. In this situation a support devices, such as adjustable hydraulic table, or karakuri devices should developed to assist worker accomplished tasks that require bending, twisting, reaching, or lifting heavy object.

Keywords: Ergonomics, Karakuri, Nordic body map, REBA, Support device

1. Introduction

Human workers still crucial in most of manufacturing industries in Indonesia, particularly in assembly line, manual handling, sorting and inspection of finished product. Most of these task need human operator to bend, twisting, reach object higher than human height, or lifting heavy object. These awkward posture, if not properly done, can lead to discomfort or pain. Repetitively doing a task with these awkward posture pose higher risk of injury, such as musculoskeletal disorder. Musculoskeletal disorder or MSDs are injuries and disorders that affect musculoskeletal system, i.e. muscles, tendons, ligaments, nerves, discs, blood vessels, in relation with human body's movement. The most common musculoskeletal disorder are carpal tunnel syndrome (CTS), tendonitis, muscle/tendon strain.

There are many risk factors for musculoskeletal disorders, such as force, posture, repetition job, and duration of task that may lead to musculoskeletal problems. In manufacturing industry, which its job is simplified and repetitive, musculoskeletal problems are the common complaints. Researchers presented many statistics that indicate back problem as a major cost to many industries [3], meaning that health issues of its workers are important to deal with in the first place to prevent major problems in the future.

This research was trying to reveal the problem that emerge amongst worker in manufacturing plant. Several manufacturing plant, such as pulp and paper, shoes, and electrical panel, were observed and studied in order to mapping the worker's complaints. This mapping was important to for researchers reveal the relation between task, body posture, and the risk of injury and then find ways of how to minimize the risk and improve the performance of the worker.

Each manufacturing plant has its own production process that requires workers to do their job. Different job means different posture. Based on different postures and complaints, assessment of pain or discomfort should be recorded and analyzed, then preventive measure should be taken to minimize the musculoskeletal disorder risk among these workers. In order to gain the overall pictures of these problems, workers from three different manufacturing industries will be observed, measured and analyzed.

2. Research Methodology

This study use descriptive approach to describe the respondent characteristics in working postures and health problem associated with the task. In descriptive study, observation is important to give overall picture of the problem face by researcher. Interview was conducted to gather more information to support the first data, such as interview to supervisor or else. The working posture and its impact to human health would be collected using Nordic body map and rapid entire body assessment or REBA.

The respondents of this research were the workers from shoes manufactuirng plant, pulp and paper, and electric panel industry. The purpose of this research to gather as much information as possible in order to develop library of harmful worker's posture and how to minimize the risk of injury in the future.

Nordic body map is a set of statements that relate 28 parts of skeletal muscles with the associated pain start from neck, upper limb, lower limb to toe [9]. This assessment was needed to map the pain or discomfort that was complained by worker.

Rapid entire body assessment, or REBA is a set of worksheet that divided into two segments that covers neck, trunk, and leg, then arm and wrist. This segmenting ensures that any awkward or constrained postures of the neck, trunk or legs which might influence the postures of the arms and wrist are included in the assessment. For each particular task, scoring was made on both section then calculated to measure the risk of each posture that was being analyzed [8].

The data then processed using Excell to find the pattern that will be presented by table, or chart, then were analyzed to develop improvement. If the REBA score were high then the current task should be change as soon as possible. In some cases, redesign task is impossible, then support devices will be proposed to assist human task.

The idea of developing support devices will be using karakuri mechanisms, that require no electrical energy. Eegonomics guidelines, such as the ideal position of working table for light work, precision or heavy work, will be used as a design criteria. Karakuri mechanism will use physic law, such as mechanical movement using pulley, hydraulic or pneumatic.

3. Result and Discussions

There were several manufacturing plants observed for this research, but the analysis and discussion will be focused on pulp and paper industri, shoe manufacturing, and voltage-transformer electrical panel assembly. Observation was done to record the worker's postures. Questionnaire was distributed to collect information of discomforts experience by these workers, then the pain was mapping using Nordic body map and worker postures were assessed using REBA. The findings will be discussed in the next section.

Electrical Transformer Industry

PT. EIS is a multinational electrical digital manufacturing that operates in Cikarang, Cibitung, and Batam, that rely on human operators in assembling electrical voltage transformer. This voltage transformer weigh around 30 kgs and operator's task will be put wires on the voltage transformer, move this transformer to panel assembly, lifting voltage transformer to table, then assembly 3 different voltage transformers into its panel, as shown in figure 1.



Figure 1. Operator's tasks in assembly voltage transformer

The voltage transformer, that was assembled by four workers, were observed and recorded, then assessed using REBA and Nordic body map. Table 1 shows that back pain, waist, and lower arm pain are the most common complaints from these workers. Lifting and fastening tasks showed the highest risk and require changes immediately. Lifting heavy transformer (weights around 30 kgs) from floor to working table requires the muscle to produce energy for the spine and hand muscles to hold the heavy equipment and produce more energy instantly to do the lifting task. When this task was done repetitively, muscle fatigue will be accumulated and if the fatigue reach the peak, the muscle will release the tension or fail to produce energy to hold the posture and injury will happen.

Fastening task, as seen in figure 1, poses high risk since the worker should bend their back and maintain this position for long period of time to fasten the wire and also fasten the transformer into its frame. During doing this task, the muscle will compressed and tight in order to hold the posture. Back and waist pain were the result of this task cause by muscle fatigue.

Table 1. Top result measurements using Nordic Body Map and REBA

Body parts	Nordic Body Map	Task	REBA score
Back	pain	Wiring	7 – medium – change soon
Waist	pain	Assembly frame	6 - medium
Lower waist	pain	Lifting	9 – high – investigate and implement change
Lower arm - left	pain	Assembly steel pin	8 - high
Lower arm - right	pain	Attached transformer	7 - medium
Lower limb	Light pain	Fastening	9 – high – investigate and implement change

Based on these findings (table 1), all the tasks associated with the assembly of voltage transformer poses medium to high risk that need to be changed soon. Lifting heavy transformer requires exertion of energy to moving heavy object form lower position to a table, and it is the primary cause of back-related injury [4]. In this case, redesigning task to minimize risk was not possible since the object was very heavy and the possibility to cause back injury was huge. The solution, the lifting heavy transformer should be done by supporting device is a must. Hydraulic table can be an alternative to do the lifting task and it will discuss later in '*Developing Ergonomic Intervention*'.

Pulp and Paper Manufacturing

The other manufacturing company that was observed was PT. IkPP that produces pulp and paper such as photocopy papers, colored paper, art paper, corrugated paper, and others. Before these papers were cut, it should be inspected and sorted. These were done manually by female workers. The workers should sort piles of papers,

inspect defect paper and count into hundreds of papers. The height of this pile sometimes higher than a worker herself and after counting and sorting the paper height become very low, and the workers need to squat down to sort the remaining papers, as shown in figure 2.



Figure 2. Extreme postures in sorting and inspection process at paper manufacturing plant

Extreme position of these female workers while sorting and inspecting pile of papers were observed, assessed using REBA score, and using Nordic body map to collect the pain they complained. The summary of all the workers' posture, were presented in table 2, shows medium to very high risk that should be change as soon as possible to prevent future injury.

Table 2. REBA score and Nordic Body Map result for paper workers

Body parts	Nordic Body Map	Task	REBA score
Neck	pain	High level sorting	9 – high risk
Shoulder	pain	Sorting with bending	10 – 11 – very high risk
Upper arms	pain	Sorting with squatting	12 – 14 – very high risk
Back and waist	pain	Sorting with sitting	14 – very high risk
Wrists	pain	Sorting with kneeling	11 – very high risk
Calves and ankle	pain	Standing sorting	6 – medium risk

Sorting task showed higher score compare to lifting heavy transformer in electrical transformer industry, means that these tasks should be changed as soon as possible. Even standing sorting impose medium risk to these workers. These result indicated that sorting paper from high pile to lower pile actually put a lot of strain and pressure to body muscle. How the workers do sorting task should be redesign that does not require the workers to tip-toe and looked up to sort the high pile of paper, or squat down or sitting to inspect and sort low pile of paper. Tip-toe, squat, or kneeling posture can be avoided only with the support of hydraulic table that will be lower or higher based on the weight on that table.

Shoe Manufacturing

PT. AP is a footwear manufacturing company located in Tangerang, using labor intensive (employ more than 15,000 people) for most of the production process started from cutting, sewing, assembly to packaging. In this facility, observation had been done in several production areas, started form cutting raw materials, sewing, glueing until assembly into a shoe and then go into packaging area.

Assessment of workers' postures using rapid entire body assessment or REBA. Then, Ovako working posture assessment or OWAS were used to assess the workers' postures. The scores of all the workers' posture observed then summarized, as shown in table 3.

As expected, bending and twisting showed medium risk and might be harmful to the workers [4]. But, reaching while bending has higher score than bending itself. Other posture, that is lifting higher than worker's head, showed to high risk and indicated as harmful. It means that these posture should be changed to minimize the risk of work-related musculoskeletal disorder (WMSD) in the future [3]. Task that require lifting object higher than worker's head was impossible to change without the help of equipment. The worker need assistance to lift the object high to maintain safe posture and karakuri then would be developed as a solution for this problem.

Table 3. OWAS and REBA scores for workers posture at shoe manufacturing

No	Posture		OWAS score		REBA score
1	Bending	2	Might be harmful	5-6	Medium risk
2	Reaching while bending	2	Might be harmful	8	Medium risk
3	Twisting	2	Might be harmful	7	Medium risk
4	Lifting higher than head	3	Harmful posture	9	High risk

Developing Ergonomic Interventions

Ergonomic intervention should be done when the human workers are involved. Karakuri, as the art of creating machine without an external power source [11], considered as one alternative solution for ergonomic problem faced in this research. Amanu's research on motion study [1] showed that several movements, even if the motion has already redesigned as safe as possible, still pose harmful impact for the worker as long as the task requires bending, twisting, lifting, and reaching. The objective of developing karakuri device in this research is to substitute the harmful posture of worker, so the worker able to maintain safe posture while the karakuri do its job.

Developing karakuri should be based on ergonomic guidelines, such as the height of working table for heavy work, light work, or precision work, in order to develop device that safe for human workers. Karakuri device was developed as a substitute for tasks related to twisting, bending, reaching, and lifting; using basic physic law such as hydraulic, pneumatic, gravitational power, puley, and else.

Karakuri level lifter, as shown in figure 3. (a), can be used in manual handling and also sorting and inspection department in pulp and paper industry. The idea of this karakuri mechanism is to make the working object in ideal position for operator to work [3]. In inspection and sorting department, the position of paper that need to be sorted should be in ideal height, so the worker could maintain the straight neck posture and easy for finger to inspect and sort the papers, follow the guideline as shown in figure 3 (b). The design of karakuri lifter table should fit the size of paper with using puley mechanism to make the paper on the right position for worker to sort and inspect.

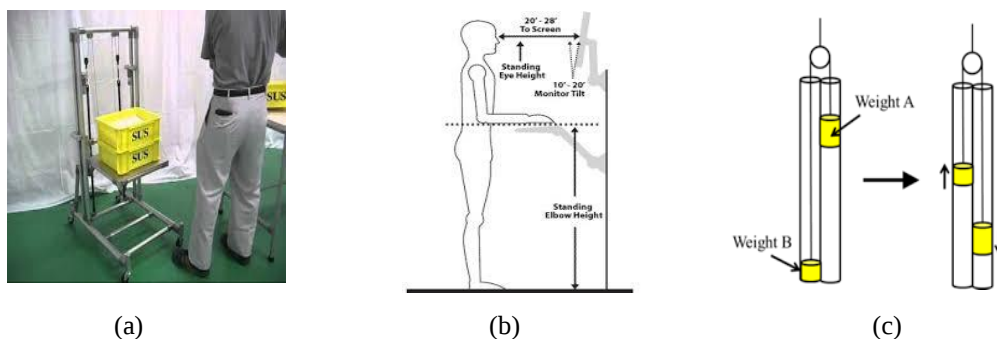


Figure 3. Karakuri level lifter (a), standing operator (b), and counter-weight puley system (c)

Karakuri lifter table should be carefully design since the huge size of paper and heavy pile of paper. The weight of pulley and balast used for karakuri mechanism should be carefully calculated in order to make the lifter table move according to paper weight. The opening for the worker inspect and sorting, and opening for easy transferring paper from sorting table to the other, should be carefully design. The principle of this lifter table will be in low position while the heavy pile of paper were put to inspect, then the table will go higher as the paper weight become lower. This lifter karakuri table make the worker able to maintain the safe position and posture while doing this job, means no reaching or tip-toeing, kneeling or squatting. If the position of paper still too high for the worker, additional adjusted bench is required. This adjusted bench for the worker to stand on it so she can do sorting and inspection in a safe level. It also use hydraulic mechanism, so the worker will be able to adjust the height using her foot.

Lifting heavy transformer shold be avoided completely, so redesign task was not necessary. Lifting heavy transformer will be done by hydraulic table as shown in figure 4 (a). This table use hydraulic mechanism to lowering and heightening according to the need of operator, using lever that can be operated by foot. This

hydraulic table has function to lift transformer from palet to the ideas position for operator put wire on this transformer.

Three heavy transformers need to be put into its frame. Lifting and moving heavy transformer into its frame should be done by support tool. In this case, dual spring desk will assist the operator to move the transformer, adjust it, and then put into its place inside the frame. Dual spring desk is a better choice for this job, since the weight of this transformer is 30 kgs, to ensure safety.



(a)



(b)

Figure 4. Hydraulic table (a), dual gas spring desk (b)

Karakuri mechanism is a promising device to assist human to complete the task that require bending, twisting, lifting, reaching, and other harmful pose for human. Karakuri has been applied in many manufacturing plant, such as Toyota [11]. The development of karakuri become a promising solution for ergonomic problem in work area whereas human are needed to finish the task. Karakuri also an economic solution, no electrical energy and save energy compare to automation or robotic technology.

Conclusion and Further Research

Workers' posture from shoe manufacturing, pulp and paper manufacturing, and electrical transformer industry have been observed and analyzed using Nordic body map, REBA and OWAS [1, 12]. The results showed that operator movements in doing their jobs pose high and harmful risk varied from neck, shoulder, upper limb, wrist, lower limb until calves and ankle, but most of the problem around back, neck, and waist.

Redesigning the movement using motion study was necessary to minimize the health impact on the workers. But based on Amanu [1], Aldoreno [2], and Neyla [12] some task still pose harmful risk to worker and precaution should be taken to avoid the harmful impact on workers. The task like reaching object higher than head, lifting heavy object, or kneeling while doing a task, even when these task has been redesainnging, the harmful risk still there. For these particular task need supporting device to assist operator. Karakuri is the best option since it is use basic physic principle to make karakuri work.

Inspection and sorting will be more comfortable if the pile of paper were put on karakuri lifter table, the worker standing on adjustable hydraulic bench to adjust the worker position while inspecting high pile of paper. The purpose of this karakuri lifter table is to make the work object on the right position for the worker to sort and inspect, so reaching, bending, tip-toeing, kneeling, and squatting is not necessary.

Lifting heavy object is harmful to the workers and it should be avoided using hydraulic table. This table also assist the workers to move heavy transformer after wiring to its frame. Dual gas spring desk was useful to assist the workers to move transformer and place it into its frame. Using dual spring desk is better option rather than single spring desk for safety purpose, since the transformer is heavy.

Karakuri mechanism is a promising support devices to do harmful human tasks, such as twisting, bending, lifting, and reaching. Karakuri also preferable since it use mechanical or gravitational energy to move the device. Karakuri is energy saving. Careful design and calculation with regard to ergonomics, will make karakuri the best option to assist human accomplish task in manufacturing plant with lower cost compare to robot.

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