Hazard identification of repetitive truck loading activities in mineral water industry

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Abstract. A good work system is one of the most important factors in the company's progress, and is the main key to success to increase productivity, company efficiency, and reduce the risk of injury. This research was carried out in a mineral water industry located in North Sumatra. The activity of loading the product to be distributed includes lifting the gallon from the conveyor to the truck. The problem faced by the company was the lack of supervision of the appointment activities, workers complained about the muscles and skeletons due to the Manual Material Handling (MMH), and because workers were also assigned to other work stations. Complaints were identified using the Standard Nordic Questionnaire, Job Strain Index, and Rapid Upper Limb Assessment. The SNQ results show that before doing work in several parts of the body it does not feel sick, but after doing the activity arises a complaint is very sick. This shows that lifting activities are the cause of complaints. The JSI score shows an index value of 12, which means that the activity enters a hazardous job. The results of the RULA score indicate that there must be action now too. To solve this problem, Participatory Ergonomics intervention methods were carried out. PE intervention is carried out on workers who aim to get input on remedial solutions needed by workers and to management for the implementation of selected solutions.

1. Introduction

A good work system is one of the most important factors in a company's progress, and is the key to success to increase productivity, company efficiency, and reduce risk injury [1]. Musculoskeletal complaints are complaints to parts of the skeletal muscles that are felt by a person ranging from very mild complaints to very sick. If the muscle receives a static load repeatedly and for a long time, it can cause complaints in the form of damage to joints, ligaments, and tendons. These complaints to damage are usually termed musculoskeletal disorders (MSDs) or injury to musculoskeletal systems [2].

MSDs are characterized by the following symptoms: pain, swelling, redness, heat, numbness or fracture of the bones and joints and stiffness, weakness or loss of coordination, the hands are difficult to move. The symptoms of MSDs above can reduce work productivity, lost work time, lead to temporary or permanent disability. Musculoskeletal fatigue and complaints can reduce performance and increase work errors due to loss of concentration and loss of working hours due to the pain suffered [3].

Standardized Nordic Questionnaire (SNQ) is a tool to recognize the source of causes for evaluating ergonomics. The SNQ questionnaire is most often used to find out the inconveniences for workers, and this questionnaire is most often used because it is standardized and neatly arranged. 28 segments of the human body will be filled with complaints by each worker [4]. Turkish version of Nordic Musculoskeletal Questionnaire can be used to investigate musculoskeletal symptoms [5]. The Persian
version of SNQ also is reliable and valid instrument to be used for the assessment of MSDS in Iranian industrial workers [6]. Job Strain Index is a method used to evaluate work on the risk of musculoskeletal disorders in the section Distal Upper Extremity (DUE) including elbows, forearms, wrists, and hands. Evaluative methods require a subjective opinion to interpret the level of risk of injury that arises [7]. Rapid Upper Limb Assessment (RULA) is a method for assessing posture, style, and movement of a work activity related to the use of the upper limb. The RULA scores for the participants’ arm/ wrist and neck/ trunk/ legs were high as they performed the manual infusion set connecting task in the nursing work than using infusion set connector tool automatically [8]. K2RULA, a semi-automatic RULA evaluation software based on the Microsoft Kinect v2 depth camera, aimed at detecting awkward postures in real-time, but also in off-line analysis [9]. Also, another research using RULA showed that the Corrected Kinect data can provide more accurate RULA grand score even under sub optimal conditions induced by the workplace environment [10].

Participatory ergonomics is a process of approach to carry out ergonomic intervention programs. Participatory Ergonomics is the active participation of employees at all levels to implement program ergonomics in the workplace to improve working environment conditions [11]. Participatory ergonomics has 4 main elements that interact with each other, consisting of employees, company managers, knowledge of ergonomics methods and the concept of job design.

Participatory ergonomics programs have been proposed as the most effective means of eliminating, or redesigning, manual tasks to reduce the incidence of occupational musculoskeletal disorders. This review assesses the evidentiary basis for this claim; describes the range of approaches that have been taken under the banner of participatory ergonomics in diverse industries; and collates the lessons learned about the implementation of such programs [12].

Participatory ergonomics programs may differ in terms of the complexity of the structures in which the activities are embedded. While a single-layer structure involving workgroup/s only might be involved, more complex structures including, for example, a second layer of “steering committee” might well oversee the activities of multiple working groups; and more layers are also possible in large multi-site organizations [13].

The study utilized a participatory ergonomics approach to examine the ergonomic hazards and reduce musculoskeletal symptoms for librarians in the East Baton Rouge Parish Main Library. A variety of research activities were conducted, including: ergonomics training and tests, observations, work environment, and health questionnaires, and focus group discussions [14].

The study revealed the processes and implementation of a participatory ergonomics program among eldercare workers. The findings can be transferred to workers, workplaces, health and safety professionals, and researchers to improve future participatory ergonomics programs [15]. Also, the need to analyze the process and strategies that led to senior managers’ commitment during a decision-making intervention in a subcontracting context [16].

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2. Method and equipment
This research was conducted in mineral water industry located in Sumatera Utara. This research is a study of the analysis of work and activities that are part of case study research, using focus in one company. The object under study is worker complaints, daily activities at the appointment station and the company as the production control holder. To get a repair solution, a complaint must be identified using SNQ, and work risk assessment with JSI and RULA. The SNQ questionnaire has 4 levels of scale, worth not being sick to being very sick, which are assessed with numbers 0 to 3. In SNQ, RULA, JSI, and FGD, data was collected from 6 workers in truck loading activities. Whether, result of the identification and analysis was presented to production manager. Conduct a PE intervention process against the operator using the FGD which aims to get the proposed improvements that will be realized. Block Diagram for this research can be seen in Figure 1.
Focus Group Discussion (FGD) is a form of data collection through group interviews and group discussions. To get a more accurate understanding, it may be defined as a method and technique in gathering qualitative data where a group of people discuss a particular problem or topic guided by a facilitator or moderator [17]. In this study, FGD was conducted in 2 stages. First, FGD is conducted with workers with the aim of obtaining input for proposed improvements. Then the results will be submitted to the FGD with management to decide which proposals will be implemented.

3. Results and discussions
3.1. Worker complaints assessment
MSDs of workers were obtained using the SNQ questionnaire and interviews with 6 manual bottle handling workers. Fill out the questionnaire twice, before doing the work and after doing the work. The results of the SNQ questionnaire showed that before doing the work workers 1, 5 and 6 complained of pain in the body segment no. 5. In segments 0 and 7, all workers complain of being sick while in other body segments, complaints from workers complain that they are not sick. SNQ, which was given after completion of the work, showed an increase in the level of employee complaints, even in segment 0, all workers complained of being very sick. The recapitulation of SNQ scores before and after work carrying out appointment activities can be seen in Table 1.

![Figure 1. Block diagram for hazard identification.](image-url)
| Segment | Worker 1 | Worker 2 | Worker 3 | Worker 4 | Worker 5 | Worker 6 |
|---------|----------|----------|----------|----------|----------|----------|
|         | before   | after    | before   | after    | before   | after    | before   | after    | before   | after    | before   | after    | before   | after    |
| 0       | 1        | 3        | 1        | 3        | 1        | 3        | 1        | 3        | 1        | 3        | 1        | 3        | 1        | 3        |
| 1       | 1        | 3        | 1        | 3        | 1        | 3        | 0        | 3        | 1        | 3        | 1        | 2        |
| 2       | 1        | 2        | 1        | 3        | 1        | 3        | 0        | 3        | 1        | 3        | 0        | 1        |
| 3       | 1        | 2        | 1        | 2        | 1        | 3        | 0        | 3        | 1        | 2        | 0        | 3        |
| 4       | 1        | 2        | 1        | 2        | 1        | 2        | 1        | 3        | 1        | 3        | 0        | 1        |
| 5       | 2        | 3        | 1        | 3        | 1        | 3        | 0        | 3        | 2        | 3        | 2        | 3        |
| 6       | 0        | 2        | 1        | 3        | 1        | 2        | 1        | 3        | 0        | 2        | 0        | 2        |
| 7       | 1        | 2        | 2        | 3        | 1        | 2        | 1        | 2        | 1        | 3        | 1        | 3        |
| 8       | 0        | 1        | 0        | 1        | 0        | 2        | 0        | 1        | 0        | 1        | 0        | 1        |
| 9       | 0        | 1        | 0        | 1        | 0        | 2        | 0        | 1        | 0        | 1        | 0        | 1        |
| 10      | 0        | 1        | 0        | 2        | 0        | 2        | 0        | 1        | 0        | 1        | 0        | 2        |
| 11      | 0        | 1        | 1        | 2        | 0        | 2        | 0        | 1        | 0        | 1        | 0        | 2        |
| 12      | 1        | 2        | 1        | 2        | 0        | 2        | 0        | 1        | 1        | 2        | 0        | 2        |
| 13      | 1        | 1        | 1        | 2        | 1        | 2        | 0        | 1        | 1        | 2        | 0        | 1        |
| 14      | 1        | 2        | 1        | 1        | 0        | 2        | 0        | 1        | 1        | 2        | 0        | 2        |
| 15      | 1        | 1        | 1        | 2        | 1        | 2        | 0        | 1        | 1        | 1        | 0        | 2        |
| 16      | 0        | 2        | 0        | 1        | 0        | 2        | 0        | 1        | 0        | 0        | 0        | 1        |
| 17      | 0        | 2        | 0        | 2        | 0        | 2        | 0        | 1        | 0        | 0        | 0        | 1        |
| 18      | 0        | 0        | 0        | 2        | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 0        |
| 19      | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 0        |
| 20      | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 0        |
| 21      | 1        | 1        | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 1        | 2        | 0        |
| 22      | 0        | 1        | 0        | 0        | 0        | 1        | 0        | 0        | 0        | 1        | 0        | 0        |
| 23      | 0        | 2        | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 2        | 0        | 0        |
| 24      | 0        | 1        | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 2        | 0        | 0        |
| 25      | 0        | 1        | 0        | 2        | 0        | 1        | 1        | 2        | 0        | 2        | 1        | 1        |
| 26      | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 0        |
| 27      | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 1        |

Table 1. Recapitulation of SNQ scores before and after performing work.
By recapitulating the above table, conditions can be obtained that describe the activities before and after the truck loading is carried out for a certain period as shown in Figure 2. From the results of the recapitulation as it can be seen that complaints occur after workers carry out transport activities.

3.2. Job risk assessment

Job risk assessment uses JSI and RULA. Valuation using JSI collects data from 6 task variables consisting of business intensity, namely estimation of effort used to do a job, duration of business which shows how long it takes the worker to carry out work activities, effort per minute which is the amount of labor per minute or frequency of work per minute, hand/wrist position, work speed, and duration of work per day which is the total time of work performed per day. The results of the work risk assessment using JSI show a value of 12, namely observed work is dangerous. Job risk assessment uses RULA by collecting data on each worker at the transport station. The worker posture can be seen in Figure 3.

Worker activities are divided into three main activity elements, namely when the worker holds the gallon, moves the gallon, and puts the gallon. Recapitulation score RULA can be seen in Table 2. Table 2 shows that almost all elements of work in transport activities need action soon.
### Table 2. Recapitulation of RULA posture score elements.

| Respondent | Holding | Moving | Putting |
|------------|---------|--------|---------|
|            | Score   | Act    | Score   | Act                   |
| Workers 1  | 2       | Take some time | 7 | Action now | 6 | Action in the near future |
| Workers 2  | 6       | Action in the near future | 7 | Action now | 7 | Action now |
| Workers 3  | 2       | Take some time | 7 | Action now | 7 | Action now |
| Workers 4  | 5       | Action in the near future | 7 | Action now | 6 | Action in the near future |
| Workers 5  | 2       | Take some time | 6 | Action in the near future | 6 | Action in the near future |
| Workers 6  | 6       | Action in the near future | 7 | Action now | 7 | Action now |

After scoring the elements using JSI and RULA, the result brought to the management to ensure there are high risks that need to be improved immediately. In order to obtain participatory ergonomics proposals, it is necessary to communicate the proposals with workers through FGDs.

### 3.3. Participatory ergonomics interventions

The search for remedial solutions is carried out by involving workers and management with discussion methods. The discussion method chosen was the Focus Group Discussion (FGD). The first PE intervention was carried out to workers by bringing proposed solution material, then discussed through the FGD so that the proposed improvements were better. The stages of FGD with workers are as follows:

a. Explain the results of the identification of complaints and work risks. Explain to the worker the impact if the activity continues.

b. After workers know the risks of work activities, then workers are allowed to express their opinions. The responses obtained were:

   1) Workers suggested that the posture they did, though sometimes uncomfortable, was a movement that they were reflexing because they did not know how to handling properly.
   2) Workers want a clear Job description.
   3) Workers also want the location of drinking water dispensers close to the transport station and if possible electrolyte drinks are provided to restore stamina.
   4) Workers said that working hours of more than 3 hours were too tiring and suggested additional work teams, so that when 3 teams worked there was one team that was standing by.

The results of the FGD summarized the proposed improvements in the form of:

1) Improve work method
2) Standard job description
3) Limitation working time up to 3 hours
4) Additional 1 working team
5) Provide electrolyte drinks
6) Good appointment procedure

The results of the FGD with workers will be used as material for the FGD with management. Improvements will be made depending on the results of an agreement and applicability from the FGD with management.

4. Conclusions
Problems at the transport station are complaints of pain in the body, poor work posture, lack of supervision, and lack of standard work procedures. PE interventions in the form of FGDs to workers resulted in some proposed improvements that became material for the FGD with the management. There are improve work method, standard job description, limitation working time up to 3 hours, additional 1 working team, provide electrolyte drinks, and good appointment procedure. In the next step an FGD will be carried out with the management to decide which proposals will be implemented and carry out a reevaluation after the implementation.

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