The comparison of ergonomic risk assessment results using job strain index and OCRA methods

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Abstract. Musculoskeletal Disorder (MDSs) is a real problem in terms of ergonomics. MSD is a muscle/pain disorder which is frequently undergone by operators after doing work, e.g. in the press line of a printing company. Some activities in press line are lifting books, reaching out the engine levers, and turning the engine levers. Many MSDs are undergone by operators, such as aches in the upper arms, hands, feet, and back. This is caused by excessive burdens and wrong posture when doing work. This study is aimed to compare the assessment results of operators' body posture by using OCRA and JSI methods. OCRA (Occupational Repetitive Action) Index is a method used to evaluate and analyze a job. Meanwhile, Job Strain Index (JSI) is a method used to estimate the risk of pain in the upper body. Evaluation is carried out on repetitive activities. Based on the calculation results, the OCRA values obtained are 3.35 for the right hand and 1.13 for the left hand. Meanwhile, JSI value for the right hand is 9 and the left hand is 4.5. The results of the assessment indicate that these activities are categorized as high-risk so and need to be corrected. The author's recommendation is by adding the number of operators on the press line.

1. Introduction

The Indonesian printing industry has been increasing since 2012 [1]. Printing is a mass production process of writing and images, particularly ink printed on paper using a printing machine. However, various complaints have been encountered in printing companies as almost 75% of the activities are carried out manually. The press line is a section with the highest number of complaints. Some activities carried out on these sections are lifting books, reaching out the levers, as well as turning the levers. There are many complaints from operators, ranging from aches in legs, upper arms, hands, and back.

Humans play a very important role in the production process as many locations still use human power, especially in Manual Material Handling (MMH) activities. The unergonomic Manual Material Handling activities will cause accidents during production process. Any inappropriate manual work can also result in the risk factors for musculoskeletal disorders (MSD) [2]. The Musculoskeletal disorder complaint is a kind of skeletal muscle pain, ranging from mild complaints to very severe one [3, 4]. Several observation techniques have been developed to assess MSD risk factors, namely Bulduk, et al. [5], Chander and Cavatorta [6], Kee and Karwowski [7], and Hellig et al. [8]. Chiasson, et al. [9] divide the methods of assessing MSD risk factors exposure into three categories: subjective assessment, systematic observation, and direct observation.
Occhipinti and Colombini [10] developed the occupational repetitive action (OCRA) methods to analyze workers’ exposure to tasks featuring various upper-limb injury risk factors (repetitiveness, force, awkward postures and movements, lack of recovery periods, and others, defined as “additionals”). The OCRA methods are largely based on a consensus document of the International Ergonomics Association (IEA) technical committee on musculoskeletal disorders (Colombini et al., 2001), and they generate synthetic indicators that also consider worker rotation among different tasks. The OCRA index can be predictive of the risk of upper extremity (UE) work-related musculoskeletal disorders (WMSDs) in exposed populations. The OCRA index was the first, most analytical, and most reliable method developed. It is generally used for the (re)design or in-depth analysis of workstations and tasks (Colombini et al., 1998, 2002). The OCRA checklist, based on the OCRA index, is simpler to apply and is generally recommended for the initial screening of workstations featuring repetitive tasks (Colombini et al., 2001, 2002).

It has to be added that the current OCRA method forms the basis for two technical standards currently being developed by CEN (pr EN 1005-5) and ISO (ISO DIS 11128-3). In EN 1005-5 OCRA is the method of choice. ISO 11228-3 chose OCRA as the preferred method for detailed risk assessment because it considers all the relevant risk factors, is also applicable to “multitask jobs”, and provides criteria — based on extensive epidemiological data — for forecasting the occurrence of UL-WMSD (upper limb work-related musculoskeletal disorders) in exposed working populations.

Both OCRA methods are observational and are largely designed to be used by corporate technical specialists (occupational safety and health [OSH] operators, ergonomists, time and methods analysts, production engineers), who have proven in practice to be best suited to learning and applying the methods for prevention and also for improving production processes in general.

The methods have been applied in a wide cross-section of industries and workplaces. They target any jobs in manufacturing and the service sector that involve repetitive movements and/or efforts of the upper limbs (manufacture of mechanical components, electrical appliances, automobiles, textiles and clothing, ceramics, jewelry, meat and food processing). In Europe, it is estimated that these methods are currently used in more than 5,000 tasks that fit these categories, involving over 20,000 employees. The methods are not suitable for assessing jobs that use a keyboard and mouse, or other computerized data-entry tools.

In this study, the work posture analysis of printing operators was conducted by using direct observation. This was done to find out the specific painful part as well as give the best suggestion to reduce the complaint. This research was conducted using the Job Strain Index and Occupation Repetitive Index methods. Job Strain Index serves to evaluate the work toward the risk of musculoskeletal disorders in the upper body or Distal Upper Extremity (DUE), which is on elbows, forearms, wrists, and hands [2]. While the Occupation Repetitive Index is a quantitative method to identify the ways of workings on repetitive workers, especially those raising the risk of pain during upper body movements and repetitive activities [11, 12]. As in the journal of Hudiantoko, et al. [13] OCRA is used to improve the ways of workings in the logistics department, which has many complaints of muscles and nerves. In risk analysis, there are several methods such as OWAS, RULA, REBA, OCRA, and Checklist [14]. Some incorporations of this methods has been carried out in various studies such as Enez and Nalbantoğlu [15] who compared two results from OWAS and REBA methods for harvesting forest products, Paulsen et al. (2015) who used OCRA and strain index methods for processing cheese, and Restuputri [16] had carried out work risk assessments using the strain index method to batik workers.

2. Method
The two assessment methods evaluate four main collective risk factors based on their respective duration, Repetitiveness, Force, Awkward posture and movements, and Lack of proper recovery periods. Other "additional factors" are also considered, such as mechanical, environmental, and organizational factors for which there is evidence of causal relationship with UE WMSDs. Each identified risk factor is properly described and classified to help identify possible requirements and
preliminary preventive interventions. All factors contributing to the overall "exposure" are considered in a general and mutually integrated framework. This research was conducted in a printing company located in Malang area.

This study observed the whole work activities during printing process. The data needed include work posture, work cycle, work time data, and work duration per day. The data retrieval was done by observation and interview. Work posture data was obtained by recording, in the form of photos and videos. For analyzing, a method which assesses the work focusing on the upper body was used. Occupational Repetitive Action (OCRA) and Job Strain Index (JSI) are selected for analyzing the ergonomic risk levels in printing activities because it is considered as the most appropriate semi-quantitative comprehension method in measuring MSD risk factors for the upper body [17, 18].

2.1. Determining the highest risk occupation type of RSI
There are two stages in this research, namely Nordic Body Map questionnaire of pain complaints on entire body and Nordic Body Map questionnaire of complaints to the highest risk occupation causing Repetitive Strain Injury. The Nordic Body Map questionnaire of pain complaints on entire body is given to 14 employees of the production section, whose results are processed by accumulating the selected highest percentages of employees’ body parts. After that, the Nordic Body Map questionnaire of complaints to the highest risk occupation causing Repetitive Strain Injury will be conducted.

The questions given to respondents in Nordic Body Map questionnaire of highest risk occupation type has already had scores to be chosen. The scores used in this questionnaire is the Likert scale, in which letter A shows pain complaints, letter B shows a-few-pain complaints, and C shows no-pain complaints. The Nordic Body Map questionnaire of highest risk occupation is given to 14 employees of the production section.

2.2. Determining ATA (Actual Technical Actions)
To determine the number of technical actions, the first thing to do is replaying the research videotape on work in slow motion, in order to identify the technical actions as well as counting the number of it. The second is determining the frequency per minutes by dividing the total number of technical actions with the time used in one cycle. The third is determining the duration of repetitive work, namely the interval of repetitive work carried out by the operator during a work shift in units of minutes. The fourth is determining ATA by multiplying frequency per minute and duration of repetitive work. Therefore, the value of ATA is determined by the following formula:

\[ \text{Frequency} = \frac{\text{number of technical actions} \times 60 \text{ seconds}}{\text{cycle time (in seconds)}} \]  
\[ \text{ATA} = \text{Frequency} \times \text{the time total of repetitive action} \]

2.3. Determining RTA (Recommended Technical Actions)
To determine the value of RTA (Recommended Technical Actions), these steps are needed:

a. Determining the strength factor based on the interview with the operator using the CR-10 Borg scale.

\[ \text{Time proportion in one cycle} = \frac{\text{Work duration in one cycle}}{\text{Cycle time}} \]  
\[ \text{Average score} = \text{Borg scale score} \times \text{time proportion in one cycle} \]

b. Determining posture factor and operator movement by paying attention to hand segment movement, namely shoulder, wrist, elbow and hand grip. Then select the smallest multiplier score of the four-hand segments as the posture and movement factor score.
c. Determining additional risk factors based on direct observation. This factor is not always present in certain work situations. If additional factors do not exist, then the additional risk factor is 1.

\[
\text{Cycle time proportion} = \frac{\text{Total Time}}{\text{Cycle Time}} \times 100 \%
\]  

(5)

d. Determining recovery period factor by classifying each working hour as ‘risk’ or ‘no risk’ hour, with a reference that each ‘no risk’ hour have comparison between work time (with repetitive movements) and minimum recovery time of 5:1.

e. Determining the duration factor. The time lapse during repetitive work in one work shift matched with the criteria of duration factor determination.

\[
\text{Cycle time} - \text{Total time of doing technical action}
\]

(6)

\[
\text{Total Micro Break Time} = \frac{\text{Work Time}}{\text{Cycle Time}} \times \text{Micro Break Time}
\]

(7)

Actual Break Time =

Macro Break Time + Total Micro Break Time

(8)

Actual Working Time = 60 minutes – Actual Break Time

(9)

f. Determining RTA by multiplying constant frequency (30 actions per minute), strength factor, posture factor, additional factor, total duration, recovery period factor, and duration factor.

g. Therefore, the value of RTA is searched by the following formula:

\[
\text{RTA} = \sum_{i=1}^{n} \left( \text{CF} \times (F_i \times F_p \times F_c) \times D_i \times F_r \times F_d \right)
\]

(10)

2.4. Calculating OCRA Index

According to Stanton [12], OCRA Index is a result of comparison between the number of technical actions during the work shift and the number of recommended technical actions. Calculating OCRA Index is carried out by dividing ATA (Actual Technical Actions) by RTA (Recommended Technical Actions).

\[
\text{OCRA} = \frac{\text{Number of technical actions carried out in one shift} (\Sigma \text{ATA})}{\text{Number of recommended technical actions in one shift} (\Sigma \text{RTA})}
\]

(11)

2.5. Classifying OCRA index calculation results based on OCRA index provision

After calculating the OCRA Index, according to Stanton [12], the meaning of OCRA Index calculation results can be classified as Table 1:

| OCRA Index | Area       | Note                        |
|------------|------------|-----------------------------|
| ≤ 1.5      | Green      | Optimal                     |
| 1.6 – 2.2  | Green      | Condition can be accepted   |
| 2.3 – 3.5  | Yellow     | Condition needs to be checked or improved |
| 3.6 – 4.5  | Red-Low    | Low-risk condition          |
| 4.6 – 9.0  | Red-Medium | Medium risk condition       |
| > 9        | Red-High   | High-risk condition         |
3. Discussions

3.1. OCRA Methods

From the problem of risk factors for repetitive strain injury, the next step is to determine Actual Technical Action (ATA). Based on the results of recorded video that is played back in slow motion (slow motion). As an example of how to fill Table 2 in the technical action right hand, the number of technical actions is 1 because it requires one basic operation to complete the activity. The time to complete this technical action is 2 seconds.

Table 2. The details of every hand movement activities

| Left Hand            | Action   | Time | Right Hand            | Action   | Time |
|----------------------|----------|------|-----------------------|----------|------|
| Reaching the books (A1) | 1        | 2    | Reaching the books    | 1        | 2    |
| Holding the books (A2)   | 1        | 1    | Holding the books     | 1        | 1    |
| Lifting the books (A3)    | 1        | 2    | Lifting the books     | 1        | 2    |
| Putting the books (A4)    | 1        | 1    | Putting the books     | 1        | 1    |
| Arranging the books (A5)  | 1        | 13   | Arranging the books   | 1        | 13   |
| Taking the engine control (A6) | 1   | 8    | Organizing the books  | 1        | 8    |
| Holding the control handle (A7) | 1 | 3    | Turning the engine    | 1        | 5    |
| Turning the engine (A8)    | 1        | 2    | Delay                 | 0        | 0    |
| Delay (A9)                | 0        | 0    | Reaching the levers   | 1        | 5    |
| Taking the cut paper (A10)| 1       | 2    | Taking the cut paper  | 1        | 2    |
| Reaching the engine control (A11)| 1 | 1    | Reaching the engine control | 1 | 1 |
| Holding the engine control (A12) | 1 | 2    | Turning the engine control | 1 | 2 |
| Reaching the books (A13)  | 1        | 1    | Delay                 | 0        | 0    |
| Taking the results (A14)  | 1        | 5    | Taking the results    | 1        | 5    |
| Arranging the stacks of books (A15) | 1 | 13    | Arranging the stacks | 1        | 13   |
| Cycle time                | 14       | 56   | Cycle time            | 13       | 60   |

\[ Freq_{Right\ Hand} = \frac{13 \times 60 \text{ seconds}}{60} = 13 \text{ actions/minutes} \]

Therefore, the frequency in performing operators’ duties for the right hand is 13 actions/minutes and the left hand is 14 actions/minutes (using Equation (1)). After calculating the frequency, the next step is to calculate the ATA by multiplying the results of the frequency calculation with the total work time of the repetitive work duration so that the number of actual technical actions can be calculated using Equation (2) as follows:

\[ \text{ATA}_{Right\ Hand} = 13 \text{ actions/minutes} \times 460 \text{ minutes} = 5980 \text{ actions} \]

Therefore, the ATA value in performing operators’ duties for the right hand is 5980 actions and the left hand is 6440 actions in one working shift (Table 3). After that, we search the value of force factor (FF).
Table 3. The details of right and left hand activities based on strength factor weighting classification

| Activities | Right Hand | Left Hand |
|------------|------------|-----------|
|            | Time (seconds) | Score of Borg Scale | Time proportion in one cycle | Average Score | Time (seconds) | Score of Borg Scale | Time proportion in one cycle | Average Score |
| A1         | 2           | 0.3        | 0.0333          | 0.01         | 2             | 0.3        | 0.0333          | 0.01         |
| A2         | 1           | 0.3        | 0.0167          | 0.005        | 1             | 0.3        | 0.0167          | 0.005        |
| A3         | 2           | 3          | 0.0333          | 0.1          | 2             | 3          | 0.0333          | 0.1          |
| A4         | 1           | 1          | 0.0167          | 0.0167       | 1             | 1          | 0.0167          | 0.0167       |
| A5         | 13          | 0.5        | 0.2167          | 0.1083       | 13            | 0.5        | 0.2167          | 0.1083       |
| A6         | 8           | 0.5        | 0.1333          | 0.0667       | 8             | 0.3        | 0.1333          | 0.04         |
| A7         | 5           | 4          | 0.0833          | 0.3333       | 3             | 0.3        | 0.05            | 0.015        |
| A8         | 0           | 0          | 0               | 0            | 2             | 0          | 0.0333          | 0.1333       |
| A9         | 5           | 0.3        | 0.0833          | 0.025        | 0             | 0          | 0               | 0            |
| A10        | 2           | 0.3        | 0.0333          | 0.01         | 2             | 0.3        | 0.0333          | 0.01         |
| A11        | 1           | 0.3        | 0.0167          | 0.005        | 1             | 0.3        | 0.0167          | 0.005        |
| A12        | 2           | 4          | 0.0333          | 0.1333       | 2             | 0.3        | 0.0333          | 0.01         |
| A13        | 0           | 0          | 0               | 0            | 1             | 0.3        | 0.0167          | 0.005        |
| A14        | 5           | 0.7        | 0.0833          | 0.0583       | 5             | 0.7        | 0.0833          | 0.0583       |
| A15        | 13          | 0.5        | 0.2167          | 0.1083       | 13            | 0.5        | 0.2167          | 0.1083       |
| **TOTAL**  | **60**      |            | **0.8133**      | **56**       | **60**        |            | **0.625**      | **9625**     |

Strength Factor (Ff) 0.906 0.9625

The released power is estimated by a scale proposed by Borg (scale CR-10 Borg) as in the table above. The example of calculations using Equation (3) and (4) in arranging the stacks is:

\[
\text{Time proportion in one cycle} = \frac{13}{60} = 0.2167 \\
\text{Average score} = 0.5 \times 0.2167 = 0.1083
\]

The next step is calculating Posture Factor (Fp). In the right hand, there are 15 steps to work. At action number 3, there is 2 point for shoulder movement abduction 45° - 80°, 2 point for elbow movement flexion-extension more than 60°, 2 point for wrist movement radial deviation more than 15°, 2 point for kind of grips. Action number 7 spend 5 second, there are 5 point for shoulder movement, 5 point for elbow movement, 5 point for wrist movement extension more than 45° and 5 point for kind of grips. Action number 12 spend 2 second. The point of A12 are 2 point for shoulder movement abduction 45°-80°, elbow movement flexion-extension more than 60°, wrist movement extension more than 45°, and the last is 2 point for kind of grips. After that we calculate the percentage of that posture. After percentage, we score from segment risk and all of that posture’s score is 1 (for right hand left hand)

The next is Additional Risk Factor (Fc). Additional factors are important to take into account but they are not always present. The existed additional risk factors is vibration. The risk from vibration for right hand is 9 and left hand is 4. So the proportion of cycle time for right hand is 15 % and left hand is 6.67 %. As the proportion of cycle time is between 0 % - 50 %, and then the score of additional factors (Fc) is 0.95. The next is Recovery Period Factor (Fr). Below is the example of how to determine the actual working time and break time in the first hour (Table 4):
Table 4. Determination of the actual working and break time.

| Hour | Actual Break Time (minute) | Actual Working Time (minute) | Risk Value | Actual Break Time (minute) | Actual Working Time (minute) | Risk Value |
|------|----------------------------|-----------------------------|------------|----------------------------|----------------------------|------------|
| I    | 8.67                       | 51.33                       | 0          | 5.00                       | 55.00                      | 1          |
| II   | 4.00                       | 56.00                       | 1          | 0.00                       | 60.00                      | 1          |
| III  | 4.00                       | 56.00                       | 1          | 0.00                       | 60.00                      | 1          |
| IV   | 4.00                       | 56.00                       | 1          | 0.00                       | 60.00                      | 1          |
| V    | 60.00                      | 0.00                        | 0          | 60.00                      | 0.00                       | 0          |
| VI   | 4.00                       | 56.00                       | 1          | 0.00                       | 60.00                      | 1          |
| VII  | 4.00                       | 56.00                       | 1          | 0.00                       | 60.00                      | 1          |
| VIII | 13.33                      | 46.67                       | 0          | 10.00                      | 50.00                      | 0          |
| IX   | 8.67                       | 51.33                       | 0          | 5.00                       | 55.00                      | 1          |

If the comparison between the actual working time and the actual break time is ranged from 5:1 to 6:1 or below 5:1, then the risk value is 0. If the ratio is between 7:1 and 11:1, then the risk value is 0.5. If the ratio is greater than 11:1, then the risk value is 1. For example, in the first hour of the right hand, the ratio is 55 minutes : 5 minutes or 11:1. Therefore, the risk value in the first hour is 1. After that, each risk is added up to know the value of Fr. For the left hand, the risk number is 5 so that the value of Fr is 0.45, while for the right hand, the number of the risk is 7 so the value of Fr is 0.15.

After that, we calculate Duration Factor (Fd). The duration of repetitive work is 460 minutes. As the duration of repetitive work is between 421 to 480 minutes, then the duration factor (Fd) is 0.5 for the right and left hand.

After we know all the indicator value, the next step is recommended technical Action (RTA). The RTA values are obtained by multiplying all indicators (CF, Ff, Fp, Fc, D, Fr, and Fd). CF value is 30 actions/minutes. The RTA Value for right hand is 1781.6 actions and left hand is 5678.3 actions. After that we calculate Occupational Repetitive Action (OCRA). The value of OCRA Index from ATA value divided by RTA value. OCRA Index for right hand is 3.356 and left hand is 1.13

3.2. JSI Method
The first step is calculate the Intensity of Exertion (IE). This is an estimated strength needed to do a task at a time. Based on the analysis, researchers find that this activities are considered quite heavy as operators have to move books and pull the lever manually. Therefore, the IE value is 3.

The second steps is Duration of Exertion (DE). The percentage of DE is obtained from amount of energy use multiplied by 100 divided by total time of observation. The percentage of DE is 85.18 % its mean the DE Multiplier value is 3.

The next step is Effort per Minutes (EM). EM is the amount of energy expended by workers in one minute. EM is obtained amount of energy use divided by total time of observation. The value amount of energy use for the right hand is 429.33.total time of observation is 540. So the value of EM for right hand is 0.851. Therefore, the EM Multiplier value is 0.5

The next step is Hand/Wrist Posture (HWP). Hand/wrist posture is an estimation of relative hand and wrist position to the neutral position. Based on the analysis, the operator's left hand is straight which means that the position is very good, with HWP value of 1. Meanwhile, the right hand forms an angle of 50° which means the position is bad, with the HWP value of 2.

After that is Speed of Work (SW). The speed of work is an estimation of how fast a worker is doing the job. Based on the observation, the operators working normally, which is categorized as Fair, the value is 1 in SW table. This factor shows the duration of the task per day as well as the total time it was done in one day. As these activities are carried out for 460 minutes or equivalent to 7 hours 40
minutes, so the DD value is 1. So Job Strain Index (JSI) is obtained by multiplying IE, DE, EM, HWP, SW, and DD. The value of JSI for right hand is 9 and the left hand is 4.5.

4. Conclusion
In this case study of the printing field, researchers take objects in the process of pressing paper and cutting. At this work station, the operators work manually by standing within 8 working hours. Based on the interview, there were several complaints undergone after work, e.g. in back, shoulders, neck, and hands. The OCRA and JSI methods are carried out to analyze the workload of operators and to find out whether it is dangerous.

Based on the OCRA method, the right hand gets a value of 3.3564 which means it is in the yellow area. This situation needs to be checked or improved again. While the left hand got an OCRA value of 1.1341 which means it is in the green area so that the activities are considered optimal. The OCRA index for right hand is bigger than left hand. Because the value of Ff and Fr right hand is smaller than left hand. This is due to the lowest recovery time for right hand compared to let hand. This cause the RTA value for right hand lower than left hand. Where, RTA is inversely proportional to the OCRA Index.

The results of the analysis using JSI method show that the value of the right hand is 9. It means that the right hand has entered Hazardous area which needs to be analyzed as soon as possible. Whereas the JSI value of the left hand is 4.5. It entered uncertain area which means that the activities do are not at risk of injury. This is due to the value of HWP for right hand bigger than left hand. HWP is an indicator that explains hand and wrist posture. Its mean that posture for right hand is worse than left hand. Right hand forms a 50° position which means the position is bad. That position can cause work accidents.

Based on the comparison of the two analyzed methods, it is found that the right hand does need to be repaired immediately because of its great risk. It is particularly the activity of turning the engine lever to cut the paper together as well as the distance between the lever and machine table which is considered to be too high. Whereas the left hand activities are considered good and optimal.

List of Notations
1, n = Tasks displaying repetitive movements of upper limbs which carried out during a shift.
CF = Constant frequency = 30 action/minute
Ff = Strength factor
Fp = Posture factor
Fc = Additional factor
D = Total duration of each work with repetitive movement
Fr = Lack of recovery time factor
Fd = Duration factor

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