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# The Risk Assessment of Repetitive Strain Injury (RSI) **Disorder Using Occupational Repetitive Action (OCRA) Index** Method

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Abstract. Problems that are often encountered in the workplace, especially those associated with obstacles in carrying out their work is a complaint of Repetitive Strain Injuries. Most problems frequently encountered in this workplace are associated with fatigue in carrying out their work. During the production process, the whole employees use their upper body. Results of questionnaire to workers using the method Nordic body map indicated that the complaints of pain in the left right upper arm are 93%, 93% of the right and left forearm, 93% for the left right wrist, 84% for the left right shoulder. This research uses the OCRA (Occupational Repetitive Action) method. The OCRA method is a quantitative method for the workings used in specific repetitive work. The results of this study are the types of jobs that are at high risk of recurrent strain injury, determining the major use of behavioural repetitive action behaviour (OCRA) and addressing work issues that may cause disturbance of repetitive strain injuries.

#### 1. Introduction

Repetitive Strain Injuries (RSI) is a term used to define various types of injuries to muscles, tendons, and nerves [1]Error! Reference source not found. Repetitive Strain Injuries is also known as repetitive strain injury, repetitive motion injuries, repetitive motion disorder (RMD), cumulative trauma disorder (CT), occupational overuse syndrome, overuse syndrome, regional musculoskeletal disorder). This injury is usually causing by activities, which involve repetitive movements, such as typing or clicking the mouse. RSI is also often referred to Upper Limb Disorder (ULD) as it can cause injury to the upper part of the body such as the neck, shoulders, arms, and wrists.

Most problems frequently encountered in this workplace are associated with fatigue in carrying out their work, such as RSI complaints. During the production process, the whole employees use their upper body. The 9 operators carried out repetitive activities such as picking up and lifting corn sacks into storage at workstation 1, lifting buckets of corns into the boiling drum at workstation 2, lifting containers of water into the washing machine at workstation 3, lifting corn into grinding machine at workstation 4, putting corn above the drying place at workstation 5, putting corn into the baskets of workstation 6, lifting corn from the salt operator of workstation 7, lifting corn at workstation 8, and lifting the plastics containing corn at workstation 9. On distributing the questionnaire to 14 workers using the method Nordic body map, where the results prove that the complaints of pain in the left right upper arm are 93%, 93% of the right and left forearm, 93% for the left right wrist, 84% for the left right shoulder. Based on the complaints, the operator of production section does wrong repetitive works so that he experiences Repetitive Strain Injuries complaints.



Based on the problem faced in this workplace, the most appropriate method for identifying problems is the OCRA method (Occupational Repetitive Action). The OCRA, which was discovered by Occhipinti and Colombini [2] is a quantitative method for identifying the ways of working used in repetitive work, notably on upper body movements. Afterwards, a proposal testing is conducted using OCRA Index method. It is expected that this proposal makes the operator work more comfortably and healthier. To strengthen this proposal, a previous study conducted by Kiellberg [3] is used as a reference, which discussed the comparison of six observation methods for repeated work risk assessment from consensus assessment using OCRA in Department of Health and Environmental Health, Uppsala University. Occhipinti[4], discussed the papillary assessment of repetitive movements in the upper limbs using OCRA method. Cheung [5] discussed the Occupational Repetitive Strain Injuries in Hong Kong. Camillieri [6] discussed the application of OCRA method in agriculture and food of Dept. Gesa, University of Catania Italy, Colombina, and Occhipinti [7] discussed the ergonomic evaluation tools for Physical Workload using OCRA method to evaluate risk for upper limbs, Milan Italia. Paulsen et all using OCRA and Strain Index to characterize the inter-rater reliability of two physical exposure assessment methods of the upper extremity. The OCRA Checklist interrater reliability scores were among the highest reported in the literature for semi-quantitative physical exposure assessment tools of the upper extremity. The OCRA Checklist however, required more training time and time to conduct the risk assessments compared to the SI [8][8]. The method that we propose in the following has therefore as its reference the OCRA Index because it is particularly complete and because it is used as the European standard (EN 1005-2) [9] and the international one (ISO 11228-3, [10]). In addition, as demonstrated in various researches ([11-14]), the OCRA Index provides results that are consistent with other methods, resulting in being certainly more complete.

# 2. Method

# 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:

$$Frequency = \frac{number of technical actions x 60 seconds}{cycle time (in seconds)}$$
(1)  
ATA = Frequency x The time total of *repetitive* action (2)

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.

Time proportion in one cycle = 
$$\frac{\text{Work duration in one cycle}}{\text{Cycle time}}$$
 (3)

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- Average score = Borg scale score x time proportion in one cycle(4)b.Determining posture factor and operator movement by paying attention to hand segment<br/>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.

Cycle time proportion = 
$$\frac{\text{Total Time}}{\text{Cycle Time}} \times 100 \%$$
 (5)

- d. Determining recovery period factor by classifying each working hour as 'risky' 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.
  - Cycle time Total time of doing technical action (6)

Total Micro Break Time = 
$$\frac{\text{Work Time}}{\text{Cycle Time}} x \text{ Micro Break Time}$$
 (7)

Macro Break Time + Total Micro Break Time (8)

Actual Working Time = 
$$60 \text{ minutes} - \text{Actual Break Time}$$
 (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:

$$RTA = \sum_{i=1}^{n} [CF x (Ff i x Fp i x Fc i) x Di] x Fr x Fd$$
(10)

## 2.4. Calculating OCRA Index

According to Stanton [15], 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).

$$OCRA = \frac{\text{Number of technical actions carried out in one shift ($\Sigma$ ATA)}}{\text{Number of recommended technical actions in one shift ($\Sigma$ RTA)}}$$
(11)

## 2.5. Classifying OCRA Index Calculation Results based on OCRA Index Provision

After calculating the OCRA Index, according to Stanton [15], 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
>9.0	Red-High	High-risk condition

Table 1. The classification of OCRA index result

#### **3.** Findings and Discussions

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## 3.1. Identifying the Highest Risk Occupation Type of Repetitive Strain Injury

The data obtained from 14 respondents filling the first questionnaire is processed by Nordic Body Map. After that, the data of the highest body part having complaint is obtained, namely left shoulder pain is 86%, right shoulder pain is 86%, left upper arm pain is 93%, right upper arm pain is 93%, left elbow pain is 79%, right elbow pain is 79%, left lower arm pain is 93%, right lower arm pain is 93%, left wrist pain is 93%, right wrist pain is 93%, left-hand pain is 93%, and right-hand pain is 93%. The second questionnaire, which is the identification of risky job getting repetitive strain injury at this workplace shows that the highest percentage of risky jobs causing repetitive strain injury are taking and lifting the corn sacks into storage, taking and lifting the corn sacks, lifting the buckets of corn sacks into boiling drum, lifting containers of water into drum, lifting and moving corns from boiling drum to washing grinding machine, lifting containers of water into washing grinding machine, carrying the buckets of corns to the operator of corn flattening machine, lifting the corns into grinding machine, lifting the corns while moving from grinding operator to drying place, carrying baskets to the drying containers, carrying drying containers to drying place, lifting corns, and pouring brown sugar into the machine.

#### 3.2. Determining Actual Technical Action (ATA)

To determine ATA, the first thing to do is calculating the frequency and total of repetitive work time, which is 570 minutes from the total repetitive time in one shift.

#### 3.3. The Technical Action in One Cycle

The videos recorded are playing back in slow motion. For example, on the corn washing station, the technical action for the filling process is "turning on the water tap" by using right hand, the number of technical actions is 1 as a basic operation is needed to complete the activity. The time to complete this technical action is 3 seconds. The number of technical action is 8 and the time needed for each left-hand technical action is 76 seconds, while for technical actions of 12, the time for each right-hand technical action is 87 seconds.

#### 3.4. Frequency

Based on the work duration observation of corn washing operator, it is obtained that the average cycle time is 1.45 minutes or 87 seconds. While the calculation of cycles number for right hand and left hands is similar to the technical actions calculation, so that the frequency per minute can be calculated as follows:

Based on equation 1, where:

Frequency Right Hand	$=\frac{12 \times 60 \text{ seconds}}{87}$	= 8.28 actions/minute
Frequency Left Hand	$=\frac{8 \times 60 \text{ seconds}}{87}$	= 5.52 actions/minute

#### 3.5. Actual Technical Action (ATA)

After calculating the frequency, the next step is to determine ATA by multiplying the frequency by the total time of repetitive work done during 570 minutes of corn washing operator's work duration. Therefore, the number of actual technical actions can be calculated as follow: Based on equation 2, where:

ATA Right Hand	= 8.28 actions/minute x 570 minutes	=4720 actions
ATA Left Hand	= 5.52 actions/minute x 570 minutes	= 2992 actions

## 3.6. The Determination of Recommended Technical Action (RTA)

To find the value of RTA (Recommended Technical Actions), there are 7 calculation step needed

#### 3.7. Strength Factor

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The released power is estimated using a scale proposed by Borg (scale CR-10 Borg). The example calculation is turning on tap water at a corn washing workstation:

## 3.7.1 Right Hand.

The example calculation is turning on tap water at a corn washing workstation: Based on equation 3, where = 3/87 = 0.0345Based on equation 4, where =  $0.3 \times 0.0345 = 0.0103$ The total average score of right hand Borg scale is 3.1138, then the strength factor (Ff) can be calculated as follow: Borg Scale =  $3 \rightarrow Ff = 0.45$ Borg Scale =  $3.5 \rightarrow Ff = 0.35$ Borg Scale =  $3.1138 \rightarrow Ff = 0.35 + (3.5-3.1138)/(3.5-3)x(0.45-0.35) = 0.4272$ 

# 3.7.2 Left Hand.

Based on equation 3, where = 15/87 = 0.1724Based on equation 4, where =  $6 \ge 0.1724 = 1.0345$ The total average score of left hand Borg scale is 3.0149, then the strength factor (Ff) can be calculated as follow: Borg Scale =  $3 \rightarrow Ff = 0.45$ Borg Scale =  $3.5 \rightarrow Ff = 0.35$ Borg Scale =  $3.0149 \rightarrow Ff = 0.35 + (3.5-3.0149)/(3.5-3) \ge 0.447$ 

## 3.8. Posture Factor

The assessment of posture and movement is concentrated in every single segment of the upper body (shoulder, elbow, wrist, and type of grip) and is associated with the time of the movement. The posture assessment is only performed on dangerous movements, for example for the right hand and left hand. The body factor value is 0.5 for the right hand and left hand for the corn washing station.

## 3.9. Additional Risk Factor

After calculating the posture factor, the next is calculating additional risk factors. It is an important factor to be taken into account but is not always present. The additional risk factors existed when the right and left hand are working are:

1. Vibration from the engine

2. Slippery object surface

Based on equation 5, where  $= 43/87 \times 100 \% = 49.425 \%$ 

As the proportion of cycle times is between 25% -50%, the additional factor score (Fc) is 0.95 for the right hand.

Based on equation 5, where  $= 35/87 \times 100 \% = 40.229 \%$ 

Because the proportion of cycle times is between 25% -50%, the additional factor score (Fc) is 0.95 for the left hand

## 3.10. Recovery Period Factor

After counting the additional factor, the next step is calculating the recovery period, which is the time use by one or more hand to stay in idle or rest position. The distribution of working time and macro break time can be seen in Table 2.

Fable 2.	Time and	macro	break	time	schedule	in	one	day	for	operato	rs
----------	----------	-------	-------	------	----------	----	-----	-----	-----	---------	----

55 min	60 min	60 min	60 min	60 min	Lunch Break	50 min	60 min	60 min	50 min	55 min
Ι	II	III	IV	V	VI	VII	VIII	IX	Х	XI
D 1		< 1								

Based on equation 6, where

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Micro Break Time Right Hand = 87 seconds - 87 seconds = 0 seconds Micro Break Time Left Hand = 87 seconds - 76 seconds = 11 seconds Based on equation 7, where Total Micro Break Time Right Hand =  $55/87 \ge 0$  minute Total Micro Break Time Left Hand =  $55/87 \times 11 = 6.95$  minutes Based on equation 8, where Actual Break Time Right Hand = 5 minutes + 0 minute = 5 minutesActual Break Time Left Hand = 5 minutes + 6.95 minutes = 11.95 minutesBased on equation 9, where: Actual Working Time Right Hand = 60 minutes - 5 minutes = 55 minutes Actual Working Time Left Hand = 60 minutes - 11.95 minutes = 48.05 minutes

If the comparison between actual working time and actual break time is ranged from 5:1 to 6:1 or below 5:1, then the risk is 0. If the ratio is 7:1 to 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 50.18:9.82 minutes or 5.11: 1. Therefore, the risk value in the first hour is zero.

**Table 3.** Actual work time and break time schedule for operators

**Total Micro** Actual Break Actual Working Macro

Hour	Working Time	Break	Break Time (minute)		Time (1	ninute)	Time (	(minute)	
	(minute)	(minute)	Left	Right	Left	Right	Left	Right	<b>Risk Value</b>
		` <i>`</i>	Hand	Hand	Hand	Hand	Hand	Hand	
Ι	55.00	5.00	6.95	0.00	11.95	5.00	48.05	55.00	0.50
II	60.00	0.00	7.59	0.00	7.59	0.00	52.41	60.00	0.00
III	60.00	0.00	7.59	0.00	7.59	0.00	52.41	60.00	0.00
IV	60.00	0.00	7.59	0.00	7.59	0.00	52.41	60,00	0.00
V	60.00	0.00	7.59	0.00	7.59	0.00	52.41	60.00	0.00
VI	0.00	60.00	000	0.00	60.00	60.00	0.00	0.00	0.50
VII	50.00	10.00	6.32	0.00	16.32	10.00	43.68	50.00	0.50
VIII	60.00	0.00	7.59	0.00	7.59	0.00	52.41	60.00	0.00
IX	60.00	0.00	7.59	0.00	7.59	0.00	52.41	60.00	0.00
Х	50.00	10.00	6.32	0.00	16.32	10.00	43.68	50.00	0.50
XI	55.00	5.00	6.95	0.00	11.95	5.00	48.05	55.00	0.50

The risk value, in terms of lack of recovery period, is 1 for the left hand. As the risk value of lack of recovery period is zero, the recovery factor (Fr) is 1 for the left hand and the risk value in terms of lack of recovery period is 0.8 for the right hand. As the risk value of lack of the recovery period is 0, the recovery factor (Fr) is 2.5 for the right hand. It can be seen in table 3, which presents the lack of recovery period risk value and recovery period factor (Fr). The comparison calculation example of the actual break time ratio with the actual working time of the 1st hour of the right hand is 55: 5 is 11 and 11.00: 1 is 1, as shown in Table 4.

## 3.11. Duration Factor

The duration of repetitive work is 570 minutes. As the duration of repetitive work > 480 minutes, then the duration factor (fd) is 0.5 for the right and left hand. The calculation method is by looking at the repetitive work duration and duration factor (fd) table.

#### 3.12. Recommended Technical Action (RTA)

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The calculation	result of RTA multiplier factor can be seen in Table 5.
Based on equati	on 10, where:
RTA Right Hand	= 30 Actions/minutes x 0.4272 x 0.5 x 0.95 x 570 minutes x 0.8 x 0.5
RTALAN	= 1,38/.9/ actions = 30 Actions/minutes x 0.447 x 0.33 x 0.95 x 570 minutes x 1 x 0.5
ICITY Left Hand	= 307  Retrons minutes x 0.447 x 0.55 x 0.75 x 570 minutes x 1 x 0.5 = 1.198.15 actions

**Table 4.** The comparison of risk values determination in recovery time lacking for corn washing operators

Compari	son of Left	Comparison of			
Hand		Right Ha	ind		
4.019	1.000	11.000	1.000		
6.909	1.000	0.000	0.000		
6.909	1.000	0.000	0.000		
6.909	1.000	0.000	0.000		
6.909	1.000	0.000	0.000		
0.000	1.000	0.000	1.000		
2.676	1.000	5.000	1.000		
6.909	1.000	0.000	0.000		
6.909	1.000	0.000	0.000		
2.676	1.000	5.000	1.000		
4.019	1.000	11.000	1.000		

**Table 5.** RTA Multiplier Factor of operator

<b>Multiplier Factor</b>	Left Hand	Right Hand
CF	30 Action/minute	30 Action/minute
Ff	0.447	0.427
Fp	0.330	0.500
Fc	0.950	0.950
D	570 minute	570 minute
Fr	1.000	0.800
Fd	0.500	0.500

*3.13. Determining the Risk Occurrence Level Using Occupational Repetitive Action (OCRA) Index Method* 

In calculating risk occurrence level, the previous data has been obtained, namely ATA and RTA calculation data, which are used to calculate the level of risk occurrence. The calculation of OCRA Index is based on equation 11, where:

OCRA Index Right Hand =  $(4720 \text{ actions})/(1,387.97 \text{ actions}) = 3.4 \approx 4$ OCRA Index Left Hand =  $(2992 \text{ actions})/(1,198.15 \text{ actions}) = 2.49 \approx 3$ 

#### 3.14. Classifying the OCRA index Calculation Result

Next is to classify the previous OCRA index calculations. The right hand OCRA Index is 4 (between 3.6 to 4.5), then it belongs to Red-Low area which indicates the low-risk condition. Left hand OCRA Index is 3 (between 2.3 to 3.5), then it is included in Yellow area which indicates that the condition needs to be checked or improved. The OCRA Index calculation results can be classified as presented in Table 6.

Table 6. The cclassification of OCRA Index Calculation Result

Movement Body Part	OCRA Index	Area	Note
Right hand	4	Red-Low	Low-risk condition
Left hand	3	Yellow	The condition needs to be checked or improved

Based on the OCRA *Index* calculation result, it can be concluded that the right-hand work method needs to be ergonomically designed, while the left hand is already  $\leq 3.5$ .

#### 4. Conclusion

Based on the study, it can be concluded that there are 13 highest risk occupations of getting repetitive strain injury on 9 operators. Based on the calculation results in data processing, it is found that righthand OCRA Index factor at the corn washing station is 4 (Red-Low) and the left hand is 3 (Yellow). At the corn boiling station, the right hand OCRA Index is 19 (Red-High) and left hand is 9 (Red-Medium). At the corn lime washing station, the right hand OCRA Index is 19 (Red-High) and the left hand is 8 (Red-Medium). At the corn piping station, both right hand and left hand OCRA Index are 1 (Green). At the corn drying station, both right hand and left hand OCRA Index are nine (Red-Medium). At the salt station, the right hand OCRA Index is 3 (Yellow) and the left hand is 2 (Green). At the salted corn drying station, the right hand OCRA Index is 11 (Red-High) and the left hand is 10 (Red-High). At the frying station, the right hand OCRA Index is 4 (Red-Low) and the left hand is 2 (Green). At the seasoning station, the right hand OCRA Index is 5 (Red-Medium) and the left hand is 19 (Red-High). The proposed improvements to work problems causing repetitive strains are the loads lifting exceeded rules should be assisted by machine such as forklifts, adding oven machines for corn drying, frying machines and automatic washing, changing the working hours of this workplace into 11 hours/day with a total lunch break of 1 hour, must be changed according to government regulations, namely 1 working shift for 8 hours and 1 hour for lunch breaks, as well as changing the dangerous posture position in order to prevent injury.

#### **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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