Assessment of exposure packaging worker and designing work methods using OCRA index in fertilizer producer company

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Abstract. Repetitive tasks carried out by packaging workers of fertilizer producer company. These task led to some complains of pain and fatigue on upper body part of the workers based on Nordic Body Maps (NBM) questionnaire. This is because the workers work continuously for eight hours per shift and no recovery period. This study aims to determine risk level of musculoskeletal disorders and break time calculation. In this study, using Occupational Repetitive Actions (OCRA) index to reduce the risk level. The samples according to expert judgement criteria are three workers (packer clamper, packer tailor and loader). The improvement in this study is designing work methods with break time calculation. This improvement shows the risk reduction on the left hand of the packer clamper from 4,2 to 3,4 and the right hand from 9,9 to 8,2. Risk reduction on the left hand of the packer tailor from 3,44 to 2,2 and the right hand from 5,7 to 2,26 while the risk level on the left hand of loader from 1,4 to 0,87 and in the right hand from 2,17 to 1,18.

1 Introduction

Packaging process in Fertilizer producer company is manually by three workers, those are packer clamper, packer tailor and loader. They worked continuously during eight hours per shift without recovery periods.

Repetitive task is the most important factor of ergonomic risk in various works. The high repetitive tasks is the activity that have cycle duration less than 30 seconds [7]. High repetitive rate occurs when more than 50% of cycle time used for the same technical activity. Short cycle does not need over movements but long cycle needs high movement. So the movements frequency is the important factor to assessing the risk for repetitive tasks.

Many activities in packaging process are pulling, pushing, raising, displacing and slue the body part repetitively. Despite small workload of the workers, this activities were done

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by poor distribution of recovery periods and lengthy working time for highly repetitive tasks. Repetitive tasks led to some complains of pain and fatigue on upper body part of the workers based on interviewed and Nordic Body Maps questionnaire. It questionnaire spreaded to 96 workers in packaging unit that got some complain about arm 94,8%, shoulder 85,4%, hand 84,4 %, calf 83,3% after doing their activity of fertilizer packing. Packing activity is the most important in production process.

Based on previous research, it discusses about decreasing musculoskeletal disorders using OCRA index and gave recommendation by increasing the condition every factor (postural factor, additional factor and recovery periods factor) so the risk level can decrease optimally [4]. Besides that, other research also used OCRA index method assessed risk and gave recommendation about unoptimal risk by gave optimal break with integer linear programming [1] [2].

In this study, method to identified repetitive task, manual and lengthy working time is Occupational Repetitive Actions (OCRA) index. It is quantitative method to identify work method in repetitive task specifically for upper limbs with consider job rotation in different task. The purpose of this study is to determine risk level in packaging activity because it is the most important process in production so it must be analized to decrease risk level of musculoskeletal disorders using

OCRA index method. Therefore, with the recommendation, it hoped that the worker can work more comfortable.

2 Methodology

2.1 Population and Sample

Populations are all the objects or subject by characteristic will be researched, Population in this study are 96 worker or all the packaging worker consists of packer clamper, packer tailor and loader in Fertilizer Producer Company.

Number of sample for this study just a worker every activity that were choosen based on expert judgement criteria. The criteria of expert judgement are: attemp to participate in risk assessment, formal educations (elementary school, junior high school and senior high school), experienced more than 15 years, have a skill in their activity and have a position as the chief.

2.2 Data Resources

Both of data resources are primary data and secondary data. Primary data is found from direct observation, in this case are fertilizer workers. Primary data that needed are video of fertilizer activities and spreading quistionnaire about lamentation of musculoskeletal disorders.

Secondary data is found from indirect observation collected from interview and management of company. Secondary data that needed are organization structure and process of fertilizer packing, number of workers, work time data and break time data.

2.3 Collecting Data

Collecting data in this study based on observation, interview and questionnaire. In this process the observation used for identifiying the problem. It was packer activities and hazards from it. The observation process used for determining of this study.

Besides that, the literature study shows the right method to solve the problem. It was Occupational Repetitive Action to assess repetitive tasks. Interview was done to the management and packer workers about their activity to get informations to endue from the observation and spreaded questionnaire of Nordic Body Map about lamentation of musculoskeletal disorders.

2.4 Tabulation of Data

2.4.1 Determining left and right hand chart

Left and Right Hand Chart is used to establish the number of technical action in a cycle that used to establish Actual Technical Action (ATA).

2.4.2 Calculating Actual Technical Actions (ATA)

1. Determine Number of Technical Action
   The result from video of fertilizer packing is identified to know the number of technical action of every task based on right and left hand chart.
2. Determine frequency Every Minute
   Frequency is number of technical actions per unit of time (number of actions per minute).
3. Determine Net Duration of Repetitive Task Duration (in minutes) of repetitive task per shift.
4. Determine Actual Technical Action (ATA)
   The next step involves estimating the overall number of technical actions performed throughout the entire duration of the repetitive tasks. This is calculated by multiplying the frequency of action per minute by the duration (in minute) of the repetitive task [3].

$$ATA = \sum(FxD) \tag{1}$$

2.4.3 Calculating Recommended Technical Actions (RTA)

1. Assessment of Force Factor (Fo)
   Force represents the leading biomechanical effort required to perform a certain technical (or set of actions). Assessment of Force is determined by interview to the management and fertilizer packer based on expert judgement.

   The force perceived by the whole upper limb should be quantified for every technical action making up the cycle. For practical purposes, one can preliminary identify actions calling for minimal muscle involvement (Borg scale = 0/0.5).

   At a second stage, the average weighted score will be calculated for all the actions performed in the cycle, including time fractions for every action and the relative level on the Borg CR-10 scale. Table 1 proposes a model for applying the Borg scale to gather information about perceived physical exertion [3].

Table 1. Borg scale.

BORG SCALE			
Value	**Description**	**Value**	**Description**
0.5	Extremely light	6	
1	Very light	7	Very hard
2	Light	8	
3	Moderate	9	
4		10	Extremely hard (almost maximum)
5	Hard	6	

To choose the multiplier, reference must be made to the average force score weighted by the duration of the cycle. However, if the task includes technical actions requiring a level of force substantially higher than 5 on the Borg CR-10 scale or above 50% of the maximum voluntary contraction and lasting at least 10% of the cycle time, the multiplier of 0,01 will be used as Table 2 below:

Table 2. Force scores used to determine the force multiplier (FOM).

Force Level (%)	Borg Scale Scores	Force Multiplier
5	0,5	1
10	1	0,85
15	1,5	0,75
20	2	0,65
25	2,5	0,55
30	3	0,45
35	3,5	0,35
40	4	0,2
45	4,5	0,2
≥50	≥5	0,01

2. Assessment of Awkward Working Postures Factor (Po) and Stereotypy Factor (Re)
Upper limb postures are described and assessed based on a representative cycle of each repetitive task; left and right limbs must be analyzed separately. The frequency and duration of positions and/or movements are considered for the four main anatomical segments: Postures and movements of the shoulder (flexion, extension, abduction); Movements involving the elbow (arm-forearm flexion-extension, forearm pronation-supination) ; Wrist postures and movements (flexion-extension, radioulnar deviations); Hand postures and movements (mainly type of gripping).

Table 3. Awkward posture multiplier (PoM).

Score	Awkward Posture Multiplier	Score	Awkward Posture Multiplier
0	1	16	0,33
0,4	0,7	17,4	0,2533
5,4	0,6667	18,7	0,1767
6,7	0,6333	20	0,1
8	0,6	21,4	0,09
9,4	0,5667	22,7	0,08
10,7	0,5333	24	0,07
12	0,5	25,4	0,0567
13,4	0,4433	26,7	0,0433
14,7	0,3867	28	0,03

It has been reported in the literature that when identical actions are performed for more than 50% of the duration of the cycle (and thus the task) the situation (also defined as stereotypy) may pose a potential risk (i.e., high repetitiveness). Likewise, stereotypy (high repetitiveness) also occurs when technical actions featuring the frequent repetition (≥4 times a minute) of the same set of actions and postures are performed within an extremely short cycle (i.e., less than 15 min) [3]. It can be seen on Table 4.

Table 4. Stereotypy multiplier (ReM).

High Stereotypy : Score 4		Stereotypy Multiplier
A1	Cycle Time >80%	0,7
A2	Cycle Time <8 seconds	
Medium Stereotypy: Score 2		Stereotypy Multiplier
B1	Cycle Time >50%	0,85
B2	Cycle Time <15 seconds	

3. Identification of Additional Risk Factor (Ad) This step is done based on direct observation (e.g., operating vibration tools, extreme pecision in positioning objects, jerky or forceful movements etc),. This factor is not always exists. If there is no additional factor, so the value is 1.

Table 5. Additional risk factor and multiplier.

Scores for Additional Risk Factor	0-3	4-7	8-11	12-15	≥16
Additional Multiplier	1	0,95	0,90	0,85	0,80

4. Assessment of Recovery Period (Rc)

A recovery period is the time within a shift during which the upper limbs are substantially inactive (i.e., the limbs are not performing any technical actions). Risk exists if there are no recovery periods or if they are too short or poorly distributed. Ratio of Work to Recovery (from 5:1 to 6:1 (8-10 min) Score = 0; From 7:1 to 11:1 (5-7 min) Score = 0,5; Over 11:1 (less than 5 min) Score = 1.

Table 6. Elements for determining recovery period multiplier (RcM).

No. of Hour without Adequate Recovery (hours)	Corresponding Recovery Multiplier	No. of Hour without Adequate Recovery (hours)	Corresponding Recovery Multiplier
<0,5	1	4	0,60
1	0,90	4,5	0,52
1,5	0,85	5	0,45
2	0,80	5,5	0,3
2,5	0,75	6	0,25
3	0,70	6,5	0,17
3,5	0,6	>7	0,10

5. Determine of Work Duration Factor (Du)

Work Duration is total of work time in a shift then classify with criteria to determine duration multiplier.

Table 7. Duration multiplier (DuM).

Duration of Repetitive Task (min)	Duration Multiplier	Duration of Repetitive Task (min)	Duration Multiplier
<121	2,0	301-360	1,2
121-180	1,7	361-420	1,1
181-240	1,5	421-480	1,0
241-300	1,3	>480	0,5

6. Calculating Recommended Technical Action (RTA)

RTA is calculated by multiplying the constant frequency (CF=30 actions per minutes), force factor, awkward working postures and stereotypy, additional risk factor, recovery period, work duration factor and total work duration in a shift [3]. Once the score for each risk factor has been calculated, the relevant multiplier is then identified for each individual risk factor. If there are no problems, the multiplier will be one and the recommended number of actions will not change. The level of risk increases, the multiplier will proportionally approach zero, thus reduces the number of RTA. The lower the number of RTA, the higher the final risk index.

$$RTA = \sum_{=1}[CF\ (FoM \times PoM \times ReM \times AdM)D\ ]\ (RcM \times DuM) \quad (2)$$

2.4.4 Model for calculating Occupational Repetitive Actions (OCRA) index

The OCRA index is a particularly useful for those involved in designing the content and duration of work cycles. The index will help them to monitor and manage not just productivity but also risk levels, the likelihood of occupational diseases and disorders.

The Occupational Repetitive Actions (OCRA) is a method that can be used to know the presence of upper limb work-related musculoskeletal disorders (UL-WMSD) risk for workers employed in high repeatability manual tasks [5]. These tasks often require many factors (high frequency of actions, awkward postures and movements of the upper limbs, excessive use of force, of recovery periods, duration, etc.), which are jointly analyzed in the method. The result is a syntethic index (the OCRA index) which is representative of the attained level of risk based on Handbook Of Human Factors And Ergonomics Methods, 2005 [8] shown on Table 8.

Table 8. Risk classification.

Index Value	Risk Classification
≤ 1,5	Optimal
1,6 – 2,2	Acceptable
2,3 – 3,5	Uncertain or very low
3,6 – 4,5	Light
4,6 – 9,0	Medium
> 9	High

The OCRA index is produced by the ratio of the actual number of ATA (derived from tasks with repetitive movements) actually performed in a shift to the corresponding number of specially RTA. In other words [3]:

$$OCRA = \frac{ATA}{RTA} \tag{3}$$

3 Result and Discussion

3.1 Actual Technical Actions (ATA)

It based on collecting data in every packaging worker, then calculate OCRA index. First step is calculate Actual Technical Actions (ATA) of packer clamper, packer tailor and loader. In collecting data process, net durations were 410 minutes in a shift every task and total cycle were 3563 cycles then time cycle = 7 seconds. This cycle time is found by divide net duration in a shift with total cycle in a shift.

Table 9. ATA calculations every task.

Operator		Σ Technical Actions	Frequency (actions per minutes)	ATA (actions per shift)
Packer Clamper	Right hand	6	51,4	21074
	Left hand	5	42,9	17589
Packer Tailor	Right hand	5	42,9	17589
	Left hand	4	34,3	14063
Loader	Right hand	3	25,7	10537
	Left hand	2	17,1	7011

Total number of technical actions of left hand is lower than right hand in every task shown on Table 9. This is because the right hand is more actively working than the left hand, so ATA of right hand is also larger than left hand.

3.2 Recommended Technical Actions (RTA)

Next step is calculate Recommended Technical Actions (RTA) of packer clamper, packer tailor and loader.

Table 11 refer to RTA calculation of packer tailor. Constant frequency is absolutely 30 actions per minute. Average of borg scale in right hand is 0,83 then force multiplier is 0,95 whereas in left hand is 0,66 then force multiplier is 0,9. Stereotypy factor in packer tailor is done repetitively in a cycle 83,7% with duration 5,86 seconds for right and left hand then the score is 4 (high stereotypy) and stereotypy factor is 0,7. Assessment of awkward posture just for dangerous movement then choose the highest score of the movement (shoulder = 12,9) so posture factor is 0,48. Additional risk on packer tailor is vibration of machine in right hand with proportion of cycle time is 16,9% then additional risk factor is 0,80 whereas no additional risk in left hand then give score 1. The risk value for left hand is 0 and right hand is 1 then recovery periods factor are 1 for left hand and 0,9 for right hand. This score is got from comparing work time with break time. Net duration of this task is 410 minutes then duration factor is 1,1. This can be seen on Table 10.

Table 10. RTA calculation of packer tailor.

Factor **Multiplier**	**Left Hand**	**Right Hand**
CF	30 act/min	30 act/min
FoM	0,9	0,95
PoM	0,48	0,48
ReM	0,7	0,7
AdM	1	0,8
RcM	1	0.9
DuM	1,1	1,1
D	410 min	410 min
RTA	4091,47 technical actions	3109,52 technical actions

Besides that, the RTA calculation of packer clamper can be seen on Table 11. Average score of right hand is 1,64 then force multiplier is 0,68 and the left hand of this task is 0,78 because average score is 1,13. This is because the worker is more actively using right hand. Stereotypy factor in packer clamper is done repetitively in a cycle 96,6% with duration 6,76 seconds for right and left hand then the score is 4 (high stereotypy) and stereotypy factor is 0,7. High score of posture factor of packer clamper is shoulder movements in right hand and pinch grip in left hand. Position of right hand of shoulder movement is Flexion/Abduction $>80^0$.The vibration of machine belong to additional risk factor in this task just on right hand when packer tailor pushing the cutting knob. Recovery period is found from ratio of work time and break time. The left hand is (< 5:1) and the right hand is (over 11). Duration multiplier of this task is 1,1 because net duration of work is 410 minutes.

Table 11. RTA calculation of packer clamper.

Factor Multiplier	Left Hand	Right Hand
CF	30 act/min	30 act/min
FoM	0,78	0,68
PoM	0,66	0,46
ReM	0,7	0,7
AdM	1	0,8
RcM	1	0.9
DuM	1,1	1,1
D	410 min	410 min
RTA	42108,8 technical actions	2133,02 technical actions

Table 12 shows the RTA calculation of loader. Net duration in this task same with packer tailor and packer clamper. Average of borg scale in left hand is 1,62 then force multiplier is 0,67 whereas in right hand is 1,96 then force multiplier is 0,74. Stereotypy factor in loader is done repetitively in a cycle 62,3% with duration 4,36 seconds for right and left hand then the score is 2 (medium stereotypy) and stereotypy factor is 0,85. This is different with packer clamper and packer tailor because cycle time is shorter. High score of

posture factor of loader is shoulder movements (Abduction 45^0 - 80^0) in right and left hand. This is because loader raise the bag contain of fertilizer (50kg) manually. There is no vibration additional factor in this task because the loader uncontact directly to the machine.

Table 12. RTA calculation of loader.

Factor Multiplier	Left Hand	Right Hand
CF	30 act/min	30 act/min
FoM	0,67	0,74
PoM	0,6616	0,6616
ReM	0,85	0,85
AdM	1	1
RcM	1	0.9
DuM	1,1	1,1
D	410 min	410 min
RTA	5097,85 technical actions	5067,415 technical actions

RTA is calculated by equation 2. The value recommended by the OCRA method for FoM, PoM, AdM, RcM is 1. According to all calculation of RTA, shows that some of these factors are still not appropriate and need improvement.

3.3 Occupational Repetitive Actions (OCRA) index

After that, compared ATA and RTA so OCRA index will be identified as shown on Table 13 below.

Table 13. OCRA index result.

Operator	OCRA Index	
	Left Hand	Right Hand
Packer Clamper	4,2	9,9
Packer Tailor	3,44	5,7
Loader	1,4	2,17

According to the result above, the OCRA index result on right hand of packer clamper is 9,9 (high risk) and the left hand is 4,2 (light risk). While the risk classification on right hand of packer tailor is 5,7 (medium risk) and the left hand is 3,44 (uncertain or very low risk). Besides that, the OCRA index result of loader on right hand is 2,17 (acceptable risk) and the left hand is 1,4 (optimal risk). On the other words, it still needs improvement on every task because the optimum risk only on left hand of loader.

Some factor caused unoptimal risk is kind of task and work system applied. Kind of work is classified in high repetitive. This establishes with short time cycle (7 seconds) each task of operator so they attemp to work until 8 times work cycle. Besides that, posture factor can be repaired each task. Another factor is about break schedule only a hour. The

lower the number of RTA then the higher the final risk index. Therefor improvement process can be done by improving each condition factor of RTA.

3.4 Improvement Process

Ergonomics can be applied as job design in an organization, for example: the determination of recess, schedule of work shift, and others [6]. Things that affect the work system as the cause of risk level of OCRA index is the working time and work procedures applied. Each job has the rest time is only 1 hour ie at 12:00 to 13:00 o'clock and no recovery time in eight hours per shift.

Australian Health and Safety Commission explained that work period more than 60 minutes with repetitive without recovery period were unacceptable. Ratio between work time (repetitive movements) and recovery time at least 5:1. Other declaration from ACGIH about hand working suggested that allowed pause the working at least one time per hour. By conquer two declaration then found optimal recovery time distribution that were 50 minutes work and 10 minutes break as Figure 1.

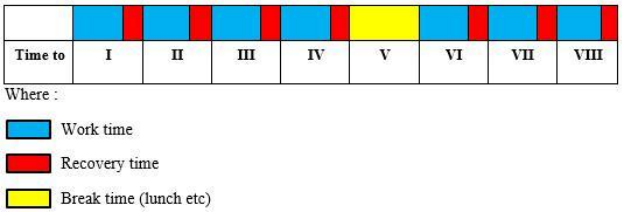

Fig. 1. Optimal recovery time.

By using that recovery time, the net duration of each task to 350 minutes. Besides that, improved awkward posture could be done in packer clamper and packer tailor from pinch grip to narrow grip. Another awkward posture is about shoulder movement. It can be change to optimal corner to reduce risk level except technical actions in packer tailor (pushing the cutting knop) and in packer clamper (pushing the hooper knop) because the knop is permanent on the machine. This improvement attemped to decrease OCRA index value or reducing the risk level.

For knowing this suggestion better than before, then re-calculate OCRA index based on factors that improved. Calculation was finished if the result of OCRA index is lower than before improvement. Below is OCRA index value after imrovement shown on Table 14.

Table 14. OCRA index result after improvement.

Operator	OCRA Index	
	Left Hand	Right Hand
Packer Clamper	3,4	8,2
Packer Tailor	2,2	2,26
Loader	0,87	1,18

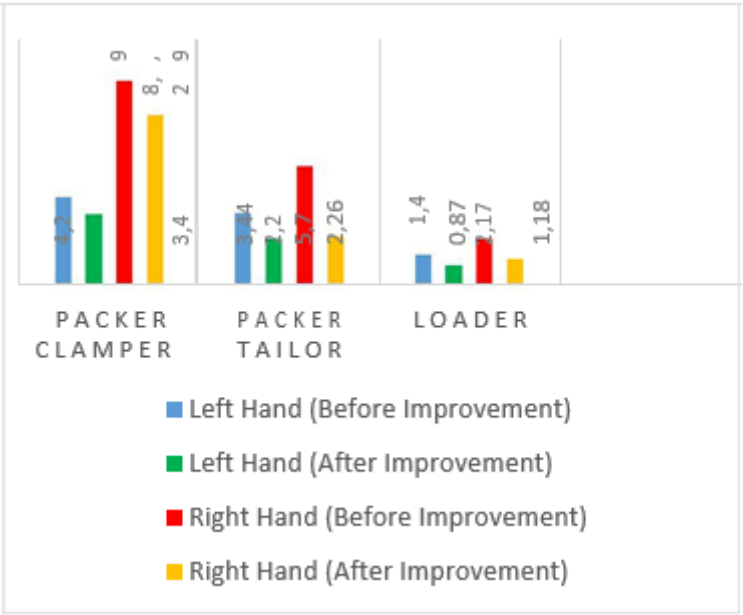

Fig. 2. Comparison of OCRA before and after improvement.

A decrease of the OCRA index value on the left hand of packer clamper is 3,4 and the right hand becomes 8,2 from the previous 4,2 on the left hand and 9,9 on the right hand. The decrease of the OCRA index in the left hand of the packer tailor is 2,2 and the right hand becomes 2,26 from the previous 3,44 on the left hand and 5,7 on the right hand. While the value of OCRA index on the left hand of loader is 0,87 and on the right hand is 1,18 from the previous 1,4 on the left hand and 2,17 on the right hand. Thus, the proposed improvement of working methods may reduce the risk level. The results of this study are expected to assist companies in evaluating the work system to reduce the risk of injury and fatigue caused by the work system applied.

4 Conclusion

Based on the result on the discussion above, The Authors propose at finding the optimal break in work environments that has characteristics high repetitive, low load manual tasks with high frequency of repetition. Workload risk and acceptability are evaluated by the OCRA method. The OCRA-based model were conquer two declaration between Australian Health and Safety Commission and ACGIH then found optimal recovery time distribution were 50 minutes work and 10 minutes break and improving each condition factor of RTA. This can reduce risk level on fertilizer packer. The reducing risk level on the right and left hand of the loader become optimal (no risk), the right and left hand of the packer tailor are acceptable risk and risk classification on packer clamper of left hand is uncertain or very low risk and right hand is medium.

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