

# WORKLOAD ANALYSIS OF THE CONTAINER UNLOADING PROCESS WORKER

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## ABSTRACT

*Abstract and key words written in one column using Arial, 10pt, Italic with Justified.*

*Manual materials handling increased risk of a skeletal muscle injuries, which generally occurs due to excessive muscle contractions as a result of the heavy workload with a long duration. Unloading containers manually is a typical example of working conditions that need attention. The research aims to analyze the workload received by workers in unloading containers manually. The data analyzed were Heart Rate, Nordic Body Map Questionnaire, Rapid Entire Body Assessment (REBA), and Recommended Weight Limit (RWL). The results of the questionnaire Nordic Body Map indicates the biggest complaints from workers that is on the shoulders. Then following by wrists, hands, low back, thighs, knees, and feet. Job with high-risk workload is at job 2, job 3, and job 4. It is seen from REBA score on the job 2, job 3, and job 4 respectively 9 and 10, when the phase bend over movement and bringing cardboard. From the standpoint of energy consumption required, energy consumption is 2.71 to 3.75 kcal / min, IRHR (Increase Ratio of Heart Rate) value is 1.51 to 1.62, and the value of the CLI (Cumulative Lifting Index) > 1. Therefore we can conclude, the job should be carried out with immediate corrective action.*

*Key words: Heart Rate, Energy Consumption, Nordic Body Map, REBA, CLI*

## 1. INTRODUCTION

"CV. Citra Hannoeh" company is an importer of electronic products from China. Imported products consist of product lighting and non-lighting products, which will be delivered directly to the warehouse. The process of unloading containers divided into two processes. The first process is dismantling to 1 point, carried by 5-10 people. Whereas the second process was the transportation to the warehouse lighting or non-lighting, done by 2-5 people. This study focused on the process of the dismantling to 1 point, because it still done manually, while the transport process to the warehouse already using tools such as hand pallet. In the process of dismantling to 1 point, there is repetition process of moving the cardboard container to the warehouse floor, which is divided into a number of different job activity. Workers must climb the wooden foothold to drop the boxes at the top, and then supplied to other workers who are at the bottom. Workers who are at the bottom will arrange the cardboard on top of

trolly, then be taken to the next worker. The next worker will arrange the cardboard that will be placed on a pallet. The load must be moved by the workers is about 8 kg. With the container size 40 feet, in one container consists ± 800 cardboard boxes must be removed by workers. Posture of the worker's body is often bent to remove the cardboard, so that workers suffered a physical complaint after doing the work.

This research was conducted for analyzing the workload on the workers unloading containers to 1 point. The results of this analysis used to propose tools that can reduce the risk of injury to workers, improve posture workers, and reduce the number of workers to unloading the containers.

## 2. THEORETICAL REVIEW

### 2.1. Work Physiology

Based on the viewpoint of ergonomics, workload received by a person should be adjusted to the physical abilities, and the

limitations of human cognitive abilities. Generally, jobs are classified into two types, namely physical work (muscle) and mental work. In mental work, energy expenditure is relatively smaller than physical work (Nurmianto, 2003). Physical work causing changes in the function of organs, which can be detected through the heart rate, blood pressure, chemical composition of blood, body temperature, and oxygen consumption.

## 2.2. Physical Workload

Valuation of the workload can be done by two methods objective namely the direct assessment method and indirect assessment (Tarwaka et.al., 2004). The category of workload based on metabolism, respiration, body temperature and heart rate (Christensen, 1991). These categories can be seen in Table 1.

Table 1. Classification of workload based on metabolism, respiration, body temperature, and heart rate

Classification of workload	Oxygen Consumption (l/min)	Lungs Ventilation (l/min)	Rectal Temperature (°C)	Heart rate (beep/ment)
Light	0,5 – 1,0	11 – 20	37,5	75 – 100
Average	1,0 – 1,5	20 – 30	37,5 – 38,0	100 – 125
Heavy	1,5 – 2,0	31 – 43	38,0 – 38,5	125 – 150
Very heavy	2,0 – 2,5	43 – 56	38,5 – 39,0	150 – 175
Extremely heavy	2,5 – 4,0	60 – 100	>39	>175

To determine the energy consumption, calculated based on the value of heart rate by the following equation (Setyaningrum, 2010).

$$KE = Et - Ei \quad (1)$$

Where:

Et = energy expenditure during working (kcal/min)

Ei = energy expenditure at rest (kcal/min)

$$E = 1.80411 + 0.0229038 X + 4.71733 \times 10^{-4} X^2 \quad X = \text{heart rate (bpm)}$$

The results of energy consumption calculations determines the classification of physiological work activity (Astrand&Rodahl, 1977). The classification can be seen in Table 2.

Table 2. Classification of Activities Work physiology

Classification of workload	Energy Consumption (kcal/ment)
Light	<2,5
Average	2,5 – 5,0
Heavy	5,0 – 7,5
Very heavy	7,5 – 10
Extremely heavy	>10

Heart rate to estimate the index of physical workload consists of several types (Grandjean, 2000), are:

1. Resting Heart Rate (HR Rest) is the average heart rate before work began
2. Working Heart Rate (HR Work) is the average heart rate during work

Calculation of IRHR (Increase Ratio of Heart Rate) is performed, to avoid subjectivity heart rate values were generally very influenced by personal factors, psychological and environmental. The calculation of the value of HR should be normalized in order to obtain an HR objective (Bary, 2013). Normalization of heart rate values is done by a comparison between HR and HR Work Rest. HR comparison values is called IRHR. The comparison is formulated as:

$$IRHR = HR \text{ work} / HR \text{ rest} \quad (2)$$

HR work = heart rate during work (bpm)

HR rest = heart rate before work began (bpm)

Table 3. Workload Category based on IRHR

Category	IRHR value
Light	1,00 < IRHR < 1,25
Average	1,25 < IRHR < 1,5
Heavy	1,5 < IRHR < 1,75
Very heavy	1,75 < IRHR < 2,00
Extremely heavy	2,00 < IRHR

**2.3. Nordic Body Map**

Questionnaires "Nordic Body Map" is a measuring tool to determine a personal perception of the condition of the body before and after work. The results of the questionnaire will show the body parts that had complaints of pain. By viewing and analyzing the map of the body, the type and level of muscle complaint perceived by workers can be estimated (Tarwaka et.al, 2004). This questionnaire describes the human body, which is divided into 9 main parts: the neck, shoulders, upper back, elbows, lower back, wrists/hands, hips/buttocks, knees and feet.

**2.4. REBA (Rapid Entire Body Assesment)**

"Rapid Entire Body Assessment (REBA)" is a method developed by Dr.Sue Hignett and Dr. Lynn Mc Atamney in ergonomics are used to quickly assess the posture of the neck, back, arms, wrists, and legs of a worker (Adi, 2008). A score be greater if the posture of the body parts are getting away with their natural position.

Table 4. REBA Score and Risk Level

Motion level	REBA score	Risk Level	Action
0	0	Negligible	None necessary
1	2-3	Low	Maybe necessary
2	4-7	Medium	Necessary
3	8-10	High	Necessary soon
4	11-15	Very High	Necessary NOW

**2.5. RWL (Recommended Weight Limit)**

NIOSH (National Institute of Occupational Safety and Health) recommend the loading equation or "lifting equation". The output is Recommended Weight Limit (RWL), which is the loading conditions without risk of injury, especially injury on Back Pain. Injuries caused by loading on Back Pain experienced by normal workers repeatedly within a certain time period. There are 2 kinds of

calculations Recommended Weight Limit/ RWL (Niebel&Freivalds, 1999), are:

1. *Single task lifting job analysis*, a method that is used for the calculation of RWL on condition of non-recurring appointment and appointment distance does not change either vertically or horizontally.

$$RWL = Lc \times HM \times VM \times DM \times AM \times FM \times CM \tag{3}$$

Lifting index is an index used to analyze the deviation between the load received against recommendation load, based on RWL calculation. Lifting index provides estimates of levels of workload accepted by the operator caused during the lifting process. LI derived from the relationship between the lifted loads (L) with RWL

$$Lifting\ Index = Lifted\ Loads / RWL \tag{4}$$

If the result of LI calculation of more than 1, then the lifting activity is not recommended to carried, because it can lead to work-related injuries.

2. *Multi task lifting job analysis* is a method used for the calculation of RWL and LI on the conditions of the repeated appointment and arbitrary appointment distance both vertically and horizontally

$$FIRWL = LC \times HM \times VM \times DM \times AM \times CM \tag{5}$$

$$STRWL = FIRWL \times FM \tag{6}$$

$$FILI = L / FIRWL \tag{7}$$

$$STLI = L / STRWL \tag{8}$$

$$CLI = STLI + \sum \Delta LI \tag{9}$$

$$\sum \Delta LI = FILI_2 \left( \left( \frac{1}{FM_{1+2}} \right) - \left( \frac{1}{FM_1} \right) \right) +$$

$$FILI_3 \left( \left( \frac{1}{FM_{1+2+3}} \right) + \left( \frac{1}{FM_{1+2}} \right) \right) \tag{10}$$

If the result of LI calculation of more than 1, then the lifting activity is not recommended to carried, because it can lead to work-related injuries.

**3. RESEARCH METHOD**

This research starts with field studies to determine the worker complaints. The next step is collecting data of the workers include age, weight, height, as well as work experience. Data of the job observed are

working posture, displacement distance, heart rate of workers during rest and at work. The next step is data processing which includes the calculation of energy consumption, IRHR, REBA and RWL. Based on the analysis, carried out the design concept of tools. Then performed simulation and validation of the concept, and the final stages is the conclusion.

**4. RESULT AND DISCUSSION**



**4.1. Data Collecting**



The workload measurement conducted to 6 workers unloading containers with four different work activities. Initial data collection conducted by distributing questionnaires. Initial data collected are age, weight, height, and work experience of unloading containers workers that can be seen in Table 5. Thereafter, 4 different work activities of unloading containers are described in Table 6.

Table 5. Preliminary Data Collection Workers

Job	Worker	Age (years)	Weight (kg)	Height (cm)	Work Experience (years, months)
1	A (Debi Rakasiwi)	25	60	165	7 years and 1 month
2	B (Suryanto)	26	65	170	1 year
3	C (Aldi Okta.R)	24	66	170	2 years and 1 month
	D (Katib)	25	62	160	5 years and 3 months
4	E (M.Sakam.A)	22	70	170	9 months
	F (Komarudin)	20	60	165	6 months

Table 6. Work activities of unloading containers

Job	Documentation	Activity
1		Workers were in container, remove the goods that have been arranged in the container to be given to workers in work activities 2
2		Workers were in the container, receive the goods given by the worker in the work activity 1, then arranged them on a trolley

Job	Documentation	Activity
3		Workers were in the container, carrying the trolley to the door, and then unloaded at the container door
4		Workers were outside container, taking goods that have been placed at the door of container and then arranged them on a pallet that will be carried by the warehouse workers to be brought into the warehouse.

**4.2. Nordic Body Map Questionnaire**

Workers at cardboard unloading was given interviewed by questions about the complaints of the muscular system. The survey was conducted before and after the work is completed. The results compared and the biggest complaint is felt in the shoulders. Then following by wrists, hands, low back, thighs, knees, and feet.

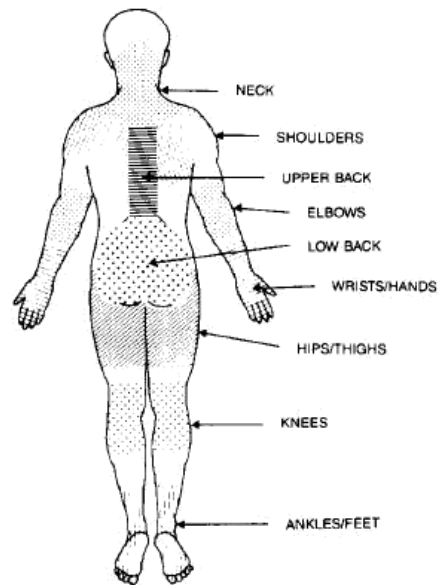


Figure 1. Body parts of Nordic Body Map (Kuorinka et.al., 1987)

**4.3. Workload Analysis Based On Heart Rate**

The results of the questionnaire Nordic Body Map indicates complaints from workers that is on the shoulders, upper arms, forearms, wrists, hands, back, buttocks, thighs, calves, knees, and feet.

The measurement the workload by measuring the heart rate conducted using the Heart Rate Monitor (HRM). This

instrument automatically programmed, so that workers can record his heart rate every second to determine the level of the workload received by workers. Measurements were performed by 2 times, during working with 15-minute and at 5 minutes rest for each worker. Based on heart rate data, it can be seen energy consumption and IRHR for each worker who can be seen in Table 7.

Table 7. Energy Consumption and IRHR

Worker	Work Heart Rate (bpm)	Rest Heart Rate (bpm)	Et	Ei	Energy Consumption (kcal/min)	EC Classification	IRHR	IRHR Classification
1A	111	74	5.07	2.69	2.38	Light	1.50	Average
2B	114	72	5.32	2.6	2.72	Average	1.58	Heavy
3C	117	74	5.58	2.69	2.89	Average	1.58	Heavy
3D	116	77	5.49	2.84	2.66	Average	1.51	Heavy
4E	131	83	6.9	3.15	3.75	Average	1.58	Heavy
4F	126	78	6.41	2.89	3.52	Average	1.62	Heavy

Based on calculations of energy consumption and IRHR, worker classification 1A is light and moderate work. While the classification 2B workers un to 4F workers are in the category of medium and heavy work. The difference of the job category between by energy consumption and IRHR occurs because IRHR calculation compares with the workers themselves each based on weight, height, and age. So the calculation IRHR is better than calculations based on energy consumption.

means that immediate corrective action is required.

**4.4. Rapid Entire Body Assesment**

Assessment is based on documentation of the posture of workers, divided into several phases of working motion. REBA assessment results can be seen in Table 8.

Based on the recapitulation of the value of REBA, it can be seen that there are a high risk level scores high that occurred on the job 2B phases of motion REBA 2, job 3C phases of motion REBA 2, job 3D phases of motion REBA 3, job 4E phases of motion REBA 2 and REBA 3 , as well as job 4F of motion REBA 3, which is when workers put cardboard with a bent position and carrying cardboard pallet. This high level of risk

Table 8. REBA Assesment Value

Motion level	REBA score	Risk Level	Action
Job 1A			
REBA 1	6	Medium	Necessary
REBA 2	7	Medium	Necessary
REBA 3	5	Medium	Necessary
Job 2B			
REBA 1	5	Medium	Necessary
REBA 2	10	High	Necessary soon
Job 3C			
REBA 1	4	Medium	Necessary
REBA 2	10	High	Necessary soon
Job 3D			
REBA 1	6	Medium	Necessary
REBA 2	6	Medium	Necessary
REBA 3	9	High	Necessary soon
Job 4E			
REBA 1	6	Medium	Necessary
REBA 2	6	High	Necessary soon
REBA 3	9	High	Necessary soon
Job 4F			
REBA 1	7	Medium	Necessary
REBA 2	6	Medium	Necessary
REBA 3	10	High	Necessary soon

**4.5. Recommended Weight Limit (RWL)**

Having done the calculations of REBA, then performed calculations to determine the value of RWL and LI of the job with high and weight category ie Job 2, Job 3 and Job 4. Based on data collection and calculation of RWL results, CLI values obtained are shown in Table 9.

Table 9. CLI Values

CLI for Job Destination 2				
STLI 1	Δ FILI 2			CLI
	FILI 2 (1/FM1+2 -1/FMI)			
1.3637	0.9402	1.38889	1.19048	1.55025
CLI for Job Destination 3				
STLI 1	Δ FILI 2			CLI
	FILI 2 (1/FM1+2 -1/FMI)			
1.37776	1.08057	1.38889	1.19048	1.59215
CLI for Job Destination 3				
STLI 1	Δ FILI 2			CLI
	FILI 2 (1/FM1+2 -1/FMI)			
1.22716	0.83221	1.38889	1.19048	1.39228
CLI for Job Destination 4				
STLI 1	Δ FILI 2			CLI
	FILI 2 (1/FM1+2 -1/FMI)			
1.49984	0.67986	2.85714	1.38889	2.49805
CLI for Job Destination 4				
STLI 1	Δ FILI 2			CLI
	FILI 2 (1/FM1+2 -1/FMI)			
1.28035	0.78629	2.85714	1.19048	2.43483

Based on the results of the RWL calculation, the RWL value of job position origin 2 has a value of 10 kg and 12 kg as well as the value of LI <1, means that the workload for this job is recommended. While the RWL results of job 2 (destination), 3 and 4 has a RWL value <8 kg and generate value CLI > 1, it means that the workload for the job 2 (destination), 3, and 4 are not recommended, because it can lead to the risk of injury on posture workers.

**5. CONCLUSION**

The results of the questionnaire Nordic Body Map indicates the biggest complaints from workers that is on the shoulders. Then following by wrists, hands, low back, thighs, knees, and feet. Work with high-risk workload is at job 2, job 3, and job 4. It is

seen from REBA score on the job 2, job 3, and job 4 respectively 9 and 10, when the phase bend over movement and bringing cardboard. From the standpoint of energy consumption required, energy consumption is 2.71 to 3.75 kcal / min, IRHR value is 1.51 to 1.62, and the value of the CLI >1. Therefore we can conclude, the work should be carried out with immediate corrective action.

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