International Journal of Psychological Rehabilitation, Vol.24, Issue 07, 2020
`Issn: 1475-7192

The Improvement of Final Mixing Workstation Based on Recommended Weight Limit (RWL) and Workplace Ergonomics Risk Assessment (WERA) Methods

Diki Arisandi[1], Peprizal[2], Muhamad Rifqy Firdaus[3], Muhamad Rizal Prayoga[4], dan Anita Juraida[5]

Abstract - *Musculoskeletal Disorders (MSDs) are disorder that caused by accumulation of injuries or damages in musculoskeletal system due to repetitive trauma, thus forming a considerable damage with symptoms related to muscle tissues, tendons, ligaments, cartilages, nervous system, bone structures and blood vessels. The problem in this research is the work such as repeatedly moving and processing raw materials in machines, causing complaintts of pain and aches from the operator in parts of the body such as neck, hands, waist and legs. Method used in this research is the Recommended Weight Limit (RWL) and Workplace Ergonomics Risk Assessment (WERA) Methods. RWL method is a recommended load limit that can be lifted by humans without causing injury even though the work was done repetitively and in sufficiently long time, whereas WERA is a survey tool that developed for screening task in order to expose physical risk factors related to Work-related Musculoskeletal Disorders (WMSDs). The resulting score of WERA in this research is 36, where that value is deemed safe risk level (Medium), whereas the initial RWL calculation result shows that LI = 1.996 > 1, which means the risk of work of lifting raw materials into the mixer is risky so it may cause irritation in MSDs. After the repairs done using supporting tools to reduce the load of lifting raw materials into the mixer obtained RWL score of LI = 0.85 < 1, so it can be concluded that the work activity turned out safe or not at risk.*

Keywords *– Musculoskeletal Disorders, Recommended Weight Limit, Workplace Ergonomics Risk Assessment*

i. INTRODUCTION

Operator workload in production process is one of the problems that are often complainted, for example in the case of production activity done by PT Simex Pharmaceutical Indonesia. PT Simex Pharmaceutical Indonesia is a pharmaceutical company that produced around 300,000 caplets of ethical drugs, supplements, and vitamins every day. The drugs produced have to be processed through several steps, the role of operator is very important; a lot has to be done by the operator in the process of creating the drug, such as lifting and moving raw materials, running the machines, as well as various work activities that needs energy and risks that may caused Musculoskeletal Disorders (MSDs) problems due to the repetitive work activities.

According to National Institute of Occupational Safety and Health (NIOSH) in 2007, MSDs are abnormalities that caused by accumulation of injuries or damages in musculoskeletal systems due to the repetitive trauma, thus forming a

[1] Program Studi Teknik Industri, Fakultas Teknik, Universitas Widyatama,
Jl. Cikutra No. 204 A, Sukapada, Cibeunying Kidul, Bandung, Jawa Barat, Indonesia
(*diki.arisandi@widyatama.ac.id, peprizal@widyatama.ac.id, muhamad.rifqyf@widyatama.ac.id, muhamad.rizal@widyatama.ac.id, anita.juraida@widyatama.ac.id*)

Received: 10 Nov 2018 | Revised: 20 Dec 2018 | Accepted: 02 Jan 2019

considerable damage with symptoms related to muscle tissues, tendons, ligaments, cartilages, nervous systems, bone structures and blood vessels. MSDs generally not directly occurred but heaps of small and large crash injuries that accumulated continuously for a long time caused by lifting the load at work, causing injury starting from soreness, pains, aches in the limbs. The symptoms of MSDs can be described using the Nordic Body Map (NBM), through assessment of this NBM questionnaire it can be known the sore parts of the muscles with sore level ranging from pain and no pain.

The distribution of Nordic Body Map questionnaire is given to 4 employees from 3 work stations; final mixing, caplet printing, and primary packing (striping), to know which work station is the most critical. Refer to interview result and initial observation using NBM questionnaire toward the operators, obtain results of the highest number of complaintts for Musculoskeletal Disorders was found in the final mixing process with 57% of complaintts, compared with caplet printing with 30% of complaintts, and primary packing with 13% of complaintts. It is discovered that the operators are complainting about pain and soreness on parts of the body such as neck, hands, waist and legs on work or afterwards. It happens because they have to do work such as lifting, moving, and processing raw materials in the machines repeatedly. To reduce the risk of Musculoskeletal Disorders experienced by the employees, it is necessary to have an attempt of analysis or risk assessment towards work process in the final mixing by looking at the work activities done by the workers. The assessment was done based on aspects of work assessed as the parameter in analysing work attitudes such as analysis of the employees' posture, load of work done, movement and repetitive works.

The research is focusing on 1 critical work station, which is final mixing, using 2 methods which are Recommended Weight Limit (RWL) and Workplace Ergonomics Risk Assessment (WERA). The method of Recommended Weight Limit (RWL) is a recommendation of load limit that can be lifted by humans without causing injuries even though the work was done repetitively and in sufficiently long time. Whereas the method of Workplace Ergonomics Risk Assessment (WERA) is a survey tool that developed for screening task in order to expose physical risk factors related to Work-related Musculoskeletal Disorders (WMSDs).

ii. STUDY LITERATURE

Workload is defined as the difference between the capacity or ability of the workers and the work demands they have to face [1]. Since human work is both mentally and physically, each has different level of loading. Considering the workload is really affecting the posture, we must know what method to do the lifting safely.

After knowing the correct way to lift the weight, the next thing is to consider the weight lifted, if the weight lifted excess weight recommended by International Labour Organisation (ILO). For weight lifting recommended by ILO is as follows:

- Adult Men 40 kg
- Adult Women 15-20 kg
- Men (16-18 years old) 15-20 kg
- Women (16-18 years old) 12-15 kg

That is why, NIOSH (National Institute for Occupational Safety and Health) create a formula that can be used to determine the load limit can be lifted in a lifting activity that called Recommended Weight Limit [2].

Recommended Weight Limit (RWL) is a recommendation of load limit that can be lifted by humans without causing injuries even though the work was done repetitively and in sufficiently long time.

This Recommended Weight Limit (RWL) set by NIOSH on 1991 in the United States of America. NIOSH equation applies to:

1. Load given is static weight, no additional or reduction of weight in the middle of work
2. Weights were lifted by both hands

Received: 10 Nov 2018 | Revised: 20 Dec 2018 | Accepted: 02 Jan 2019

3. Lifting or putting down the load were done in the maximum time of 8 hours
4. Lifting or putting down the load most not done when sit down or kneel
5. Workspace is not narrow

Based on the attitudes and conditions of the load lifting work system in the process of loading goods done by workers in experiments, the factors that have influence in load lifting with provision referenced by NIOSH is measured [3].

The equation to determine the recommended weight to be lifted by a worker in certain condition according to NIOSH [4] is as follows:

$$LC \times HM \times VM \times DM \times AM \times FM \times CM$$

Description:

LC: Lifting Constanta = 23 kg

HM: Horizontal Multiplier = 25/H

VM: Vertical Multiplier = 1 –0.003 [V –75]

DM: Distance Multiplier = 0.82 + 4.5/D

AM: Asymentric Multiplier = 1 –0.0032A (°)

FM: Frequency Multiplier

CM: Coupling Multiplier (handle)

Lifting Index (LI)

Lifting Index (LI) is a term that provides estimation of relative level of physical stress that associated with a specific manual lifting task. The estimated physical stress level is determined by the relationship between the weight of the load and recommended weight limit LI is defined by following equation:

$$LI = \frac{Load\ Weight}{Recommended\ Weight\ Lift\ (RWL)}$$

Workplace Ergonomics Risk Assessment (WERA) is a survey tool that developed to identify work movement and posture that caused musculoskeletal disorder (work-related MDS) [5]. WERA method determines 6 physical movement identification factor that cause Musculoskeletal Disorders which are factors of postures,

repetition, strength, vibration, contact stress, and work duration involving five main body parts (shoulders, wrists, back, neck and legs). It has assessment system and action level that give guidance for risk level and action needs to do more detailed assessment actions. This tool has been tested for reliability, validity, and usability during the development process [1-2]. Because WERA tools are pen and paper technique that can be used without any special equipment, it also can be done in any workplace without bothering the workforce [5].

iii. METHODOLOGY

This research consists of several types of data collections which were Nordic Body Map (NBM) questionnaire to know the level of Musculoskeletal Disorders (MSDs) complaintts experienced by the workers, description of work posture, work duration, and the frequency of the worker in performing the work activities. In this research consists of 2 (two) stages of data processing, namely the stage of calculating load limit of raw materials lifted by the worker into the mixer machine using the Recommended Weight Lift (RWL) method, and the stage of analysing work posture in lifting raw materials to the mixer machine using Workplace Ergonomics Risk Assessment (WERA) method.

iv. RESULTS

A. Nordic Body Map (NBM)

Nordic Body Map (NBM) is a questionnaire to know complaints experienced by the operators. Questionnaire was done to 4 employees in 3 work stations to determine the most critical work station, which were final mixing, caplet

Received: 10 Nov 2018 | Revised: 20 Dec 2018 | Accepted: 02 Jan 2019

printing, and primary packing (striping) work stations. Through this NBM questionnaire assessment it can be discovered the parts of the muscles experiencing complaint with complaint level ranging from no pain and pain. Referring to the interview result and initial observation using NBM questionnaire towards the employees, it is discovered that the employees are complainting about pain and soreness on parts of the body such as neck, hands, waist and legs on work or afterwards. This happens because they have to do their work such as lifting heavy raw materials repeatedly, moving, and processing them in the machines repeatedly. The recapitulation result of the Nordic Body Map questionnaire given to employees can be seen in Table 1.

Table 1 Nordic Body Map Recapitulation

NO	LOCATION	RECAPITULATION			PERCENTAGE%		
		WORKING STATION			WORKING STATION		
		Final Mixing	Caplet Printing	Primary Packaging	Final Mixng	Caplet Printing	Primary Packaging
0	Pain/Stiffness in the upper neck	3	3	1	75	75	25
1	Pain/Stiffness in the lower neck	0	0	0	0	0	0
2	Pain in the left shoulder	4	1	0	100	25	0
3	Pain in the right sloulder	4	4	0	100	100	0
4	Pain in the left arm	4	1	1	100	25	25
5	Pain in the back	4	3	4	100	75	100
6	Pain in the right upper arm	4	4	1	100	100	25
7	Pain in the waist	4	4	0	100	100	0
8	Pain in the buttock	1	0	0	25	0	0
9	Pain in the bottom	0	0	1	0	0	25
10	Pain in the left elbow	0	0	0	0	0	0
11	Pain in the right elbow	0	0	0	0	0	0
12	Pain in the left lower arm	4	0	0	100	0	0
13	Pain in the right lower arm	4	2	0	100	50	0
14	Pain in the left wirst	1	0	0	25	0	0
15	Pain in the right wirst	1	1	0	25	25	0
16	Pain in the left hand	4	0	0	100	0	0
17	Pain in the right hand	4	1	0	100	25	0
18	Pain in the left thigh	4	0	0	100	0	0
19	Pain in the right thigh	4	0	0	100	0	0
20	Pain in the left knee	0	0	0	0	0	0
21	Pain in the right knee	0	0	0	0	0	0
22	Pain in the left calf	4	4	3	100	100	75
23	Pain in the right calf	4	4	3	100	100	75
24	Pain in the left ankle	0	0	0	0	0	0
25	Pain in the right ankle	0	0	0	0	0	0
26	Pain in the left foot	0	0	0	0	0	0
27	Pain in the right foot	0	0	0	0	0	0
Total		62	32	14	57%	30%	13%

Based on the table above it can be concluded that from 3 work stations, the highest number of employees have Musculoskeletal Disorders complaint is at the final mixing work station with 57% of complaints, compared with the other work stations such as printing with only 30% of complaints and primary packing with 13% of complaints. Thus this research is focusing on 1 work station that is most critical, which is final mixing.

B. Recommended Weight Lift (RWL)

Data of final raw material weight in the final mixing process.

Received: 10 Nov 2018 | Revised: 20 Dec 2018 | Accepted: 02 Jan 2019

Table 2 Raw Material Weight Data

No	Raw Material	Weight (kg)	Total Containers
1	*Astasanthin 2,5%*	48 kg	2
2	*MCC PH 102*	91,8 kg	3
3	*Sodium Starch Glycolate*	6 kg	1
4	*Plasdone K 29/30/32*	1,5 kg	
5	*Collodial Silicon Dioxide*	1,5 kg	
6	*Magnesium Stearate*	0,204 kg	
7	*Selohvita C*	0,996 kg	
Total :		**150 kg**	**6**

Note: If the weight of raw material > 25 kg then it is assumed 1 container is 25 kg, and if the weight of raw material < 25 kg then it can be combined with other raw material that weighted < 25 kg. So the operator frequency to put raw material into the drum mixer machine is 6 times.

Recommended Weight Lift (RWL) and Lifting Index (LI)

Picture 1 Initial Position **Picture 2** End Position

Table 3 Position Activity

RWL	Early	End
LC	23	23
H	10	12
V	5	5
D	214	214
A	40°	40°
F	6	6
C	*Poor*	*Poor*

Recommended Weight Lift (**RWL**) and Lifting Index (**LI**) Calculations

1. Initial Recommended Weight Lift (**RWL**)

RWL = LC x HM x VM x DM x AM x FM x CM

RWL = 23 x 2.5 x 0.792 x 0.841 x 0.872 x 0.50 x 0.90

RWL = 15.029 kg

Lifting Index (**LI**) Calculation;

Initial Lifting Index = $\frac{Load\ Weight}{Recommended\ Weight\ Lift}$

Received: 10 Nov 2018 | Revised: 20 Dec 2018 | Accepted: 02 Jan 2019

$= \frac{25}{15.029} = 1.663$

Because LI = 1.663 > 1, then that activity or work contains back injury risk.

2. End Recommended Weight Lift (**RWL**)

RWL = LC x HM x VM x DM x AM x FM x CM

RWL = 23 x 2.5 x 0.792 x 0.841 x 0.872 x 0.50 x 0.90

RWL = 12.522 kg

Lifting Index (**LI**) Calculation;

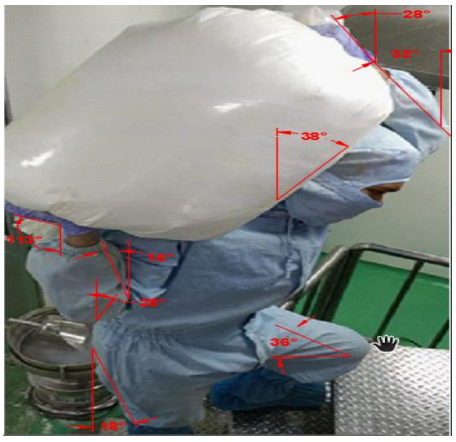
Initial Lifting Index = $\frac{Load\ Weight}{Recommended\ Weight\ Lift}$

$= \frac{25}{12.522} = 1.996$

Because LI = 1.996 > 1, then that activity or work contains back bone injury risk.

C. Workplace Ergonomics Risk Assessment (WERA)

Workplace Ergonomics Risk Assessment is a survey tool that developed for screening task in order to expose physical risk factors related to Work-related Musculoskeletal Disorders (WMSDs). Based on the result of data processing using WERA method it was discovered that for activity of lifting raw materials on final mixing work station shows that the risk level obtained is medium level. Following is the WERA method assessment analysis.



Picture 3 Raw Material Lifting Activity

Table 4 Recapitulation of WERA Measurement at Medium Level

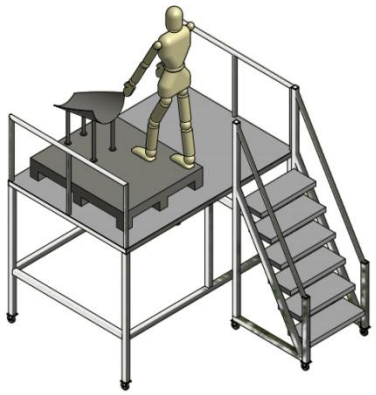
Received: 10 Nov 2018 | Revised: 20 Dec 2018 | Accepted: 02 Jan 2019

No.	Physic Risk Factor		Risk Level			Score
			Low	Medium	High	
1	Shoulder	Posture			√	5
		Repetition		√		
2	Wrist	Posture			√	4
		Repetition	√			
3	Back	Posture			√	4
		Repetition	√			
4	Neck	Posture			√	5
		Repetition		√		
5	Leg	Posture			√	5
6	Forceful	Lifting the load			√	6
7	Vibration	Using of vibration tool		√		3
8	Contact Stree	Using tool handle or wearing hand gloves	√			2
9	Task duration	Task (hr/day)	√			2
Total Score						36

According to the total score in table 4 shows that the lifting activity in final mixing process do not need further examination since the risk level is still in medium stage or still in safe limit.

D. Designing Supporting Tool

Analysis for overall result of Recommended Weight List (RWL) and Lifting Index (LI) required changes to the work processes, those changes must be done to reduce the workload that may cause Musculoskeletal Disorders. The design provided is in the form of three supporting tools to facilitate the process of lifting the material to the mixer machine. The results are improvements in platform ladder, additional transfer plates, and lifter. Pictures and descriptions for each lifting tools designs can be seen in Picture 4.



Picture 4 Raw Material Lifting Supporting Tools

Transfer plates are supporting tools that used to help the operator in putting raw materials into the mixer. The plates are made of SUS 316. Previously the transfer plate was raised to the top of platform ladder using a lifter, so that it can reduce the weight of raw material lifted by workers and reduce the frequency from 6 times to 1 time to lift the raw material to the Platform Ladder. After the operator lifted raw material over the plat cone, the raw materials will slide into the mixer. Platform ladder is the supporting tools that used by the operator to go to plat cone which will put the raw material into the mixer.

I. ANALYSIS

Received: 10 Nov 2018 | Revised: 20 Dec 2018 | Accepted: 02 Jan 2019

The final score result from Workplace Ergonomics Risk Assessment (WERA) method towards the lifting work is 36 and considered into the medium level, it shows that the operator's work condition must be examined further and changes are needed, which in line with the result of research by Siswanto et al where the WERA method from the operator having a final score of 37 considered in the medium level action category and changes needed [11]. Then Alias N et al said, identification and analysis result shows that every work stations have score ranging from 32 to 36. That score range shows that all parts of production have a medium risk level so further investigation and improvement in the work system are needed [10]. While the Recommended Weight Lift (RWL) and Lifting Index (LI) calculation result shows that LI result 1.996 this means the worker's risk in lifting the raw materials into the mixer can be risky and may cause trouble to Musculoskeletal Disorders (MSDs). Because the actual weight load is over the recommended weight with the level of Lifting Index (LI) > 1 can cause MSDs [9]. Therefore, in this stage improvement is needed.

v. CONCLUSION

Based on the research result using Recommended Weight Lift (RWL) and Lifting Index (LI) methods show that improvement is needed in the stage of lifting raw materials into the mixer by workers, thus designing tools to help reduce the weight of raw materials and worker's frequency to load the raw materials into the mixer. After the improvement is done in this stage, it obtained result of Lifting Index (LI) value of 0.85. As the Lifting Index (LI) result 0.85 < 1 then it can be concluded that the work activity after improved is safe or the work activity do not carry the risk of back bone injuries.

vi. REFERENCE

[1] H. Astianto, "Pengaruh Stres Kerja dan Beban Kerja Terhadap Kineja Karyawan Kinerja Karyawan PDAM Surabaya," *Jurnal Ilmu dan Riset Manahemen,* vol. 3, 2014.

[2] K. Kroemer, K. Kroemer and K. Kroemer , Ergonomic : How to Design for Ease and Efficiency, New Jersey: Prentince Hall International, Inc., 1994.

[3] E. Nurminato, Ergonomi :Konsep Dasar dan Aplikasinya, Jakarta: Guna Widya, 1991.

[4] T. a. P.-A. V. Waters, Manual Material Handling, Edited by Battacharya, A. & McGlothlin, New York: Marcel Dekker Inc,, 1996.

[5] M. Rahman, Rani and M. Rohani, Investigation of work-related musculoskeletal disorders in wall plastering jobs within the construction industry, 2012.

[6] Mas'idah, "Analisa Manuall Material Handling (MMH) dengan Menggunakan Metode Biomekanika Untuk Mengidnetifikasi Resiko Cidera Tulang Belakang (Musculoskeletal Diosorder) (Studi Kasus Pada Buruh Pengangkat Beras di Pasar Jebor Demak)," vol. 47, 2009.

[7] A. N. Bintang and S. K. Dewi, "Analisis Postur Kerja Menggunakan Metode OWAS dan RULA (Studi Kasus di PT PG Tjoekir)," *Jurnal teknik Industri,* vol. 18, pp. 43-54, 2017.

[8] S. Wignjosoebroto, Ergonomi Studi Gerak dan Waktu, Surabaya: Guna Widya, 2003.

[9] N. Aliafari, O. R. Pertiwi, M. T. Anugerah and A. D. Sari, "Analisis Eksposur Kerja pada Lini Produksi Batik Menggunakan Metode Workplace Ergonomic Risk Assesment," *Seminar dan Konferensı Nasional IEDC,* pp. 2576-6429, 2018.

[10] Siswanto, P. Pusporini and E. Ismiyah, "Analisis Postur Kerja Operator Sablon Karung dengan Metode RULA dan WERA," Teknik Industri Universitas Muhammadiyah Gresik, Gresik, 2018.

Received: 10 Nov 2018 | Revised: 20 Dec 2018 | Accepted: 02 Jan 2019

[11] Shahu. R, The NIOSH Lifting Equation for Manual Lifting and Its Application, J Ergonomics, 2016.

[12] M. Hossain, A. Aftab, M. Al Imam, I. Mahmud, I. Chowdury, R. Kabir and M. Sarker, "Prevelance of Work realted musculosketal disorders (WMDS) and Ergonomic Risk Assesmenr Among Ready Made Garment Workers of Bangladesh," *Jurnal Pane,* pp. 1-18, 2018.

[13] A. A. S. D.K, "Determination if Musculokeletal Disorder (MSDs) Complaints Level With Nordic Body Body Map (NBM)," *IOP Conferense Series: Material Science and Engineering,* 2019.

[14] L. Punnet and D. Wegman, "Work-Related Musculoskeletal Disorder: The Epidemiologic Evidence and The Debate," *Journal of Electromyography and Kinesiology 14,* pp. 13-23, 2014.

[15] R. Setiyowati, "Analisis Postur Kerja Dengan Menggunakan Metode Workplace Ergonomic Risk Assessment (WERA) dan Novel Ergonomic Postural Assessment (NERPA) Pada Pekerja Batik," *Universitas Muhammadiyah Surakarta,* 2017.

[16] A. Juraida, M. Sunyoto, I. Ratnasari and N. Nisfiani, "Identification of Muscle Fatique Using Rapid Upper Limb Assessment (RULA) in Motorcycle Washing Activities," *International Journal of Advance Science and Technology,* vol. 28, pp. 8-11, 2019.

[17] A. Noor , M. Rubel, J. Akram, M. Shohel Parvez and S. Saha, "Analysis of RWL and Designing Safe Load for The Workers to Reduce Lifting Related Injury in a Bangladeshi Brick Industry: A Case Study," *Iternational Journal of Scientific & Engineering Research,* vol. 4, 2013.

[18] E. Muslimah, I. Pratiwi and F. Rafsanjani, "Analisis Manual Material Handling," *Jurnal Ilmiah Teknik Industri,* vol. 5, pp. 53-60, 2006.

[19] N. Aliafari, O. Pertiwi, M. Anugerah and A. Sari, "Analisis Eksposur Kerja Pada Lini Produksi Batik Menggunakan Metode Workplace Ergonomic Risk Assesment," *Seminar dan Konferensi Nasional IEDC,* 2009.

[20] Siswanto, P. Pusporini and E. Ismiyah, "Analisis Postur Kerja Operator Sablon Karung dengan Metode RULA dan WERA," *Gresik: Teknik Industri Universitas Muhammadiyah Gresik,* 2018.

Received: 10 Nov 2018 | Revised: 20 Dec 2018 | Accepted: 02 Jan 2019