Evaluation of Worker Discomfort on Manual Palletization Activities of Bottled Water Products

Firstama Saka Adiatmaja, Guntarti Tatik Mulyati*, Didik Purwadi
Department of Agroindustrial Technology, Faculty of Agricultural Technology
Universitas Gadjah Mada, Jl. Flora No.1 Bulaksumur 55281, Indonesia.
Email: guntarti.ftp@ugm.ac.id*

Abstract

The risk of Musculoskeletal Disorders (MSDs) is one of the problems that often occurs in manual handling workers with heavy loads in repetitive work movements for a long time. One example of this movement is the manual palletization activity of Bottled Drinking Water products at PT XYZ. Initial observations showed that 18 workers felt limb discomfort while stacking cardboards of 18kg water bottles. This study aims to determine the Recommended Weight Limit (RWL) used to measure the lifting load limit for workers; Lifting Index (LI) measurement that can describe the level of safety of lifting loads.The results showed that the load limit in drinking water palletization activities exceeded RWL, while the results of the LI calculation showed that manual palletization activities of bottled drinking water had a score of 6.4 where the LI score according to the safety standards of lifting activities was 1. These results indicate that manual palletization activities are not safe for workers and are at risk of causing MSDs. This is evidenced by the results of the assessment of the level of work posture discomfort using NBM which shows the highest pain score in the lower back of the body. Furthermore, workload measurement results vary from heavy to very heavy. From all parameters measured, it can be seen that the manual palletization activity of Bottled Drinking Water products at PT XYZ is very poor. The recommendation that can be proposed is to change the work system of manual palletization activities to a mechanical or automatic system.

Keywords: *LI, MSDs, Palletizing, RWL, Workload*

1. INTRODUCTION

Ergonomics is a science that studies the relationship between humans and the environment and work equipment used to solve the problem of incompatibility between humans and work equipment (Bridger, 2003). Ergonomics aims to design equipment, technical systems, and tasks in such a way as to improve safety, health, comfort and human performance (Dul &; Weerdmeester, 2001). Ergonomic problems are closely related to the risk of work accidents caused by the wrong posture and movement of workers. One of the causes of ergonomic problems that occur in industries involving manual handling is the presence of repetitive movements carried out for a long time with a heavy load on a work system. If the work system is not immediately repaired, then workers can experience Musculoskeletal Disorders (MSDs).

MSDs is an illness caused by wrong attitudes or work positions (Ulfah et al., 2014). MSDs often result in pain in muscles, nerves, tendons, blood vessels, and ligaments. Manual work is prone to MSDs due to repeated performance and excessive use of force. In increasing production capacity, companies often increase working time without paying attention to aspects of worker ergonomics, thereby increasing the risk of workers experiencing MSDs (ulfah et al., 2014).

PT. XYZ is a company engaged in drinking water. Production Area 1 has two production lines, namely 600 ml and 1500 ml Bottled Drinking Water. In its processing, there are several stages in the production of bottled water in Production Area 1. These stages start from the preparation of raw materials (water, bottles, and cardboard), filling water into bottles, infeed cardboard raw materials, visual, and palletizing. The process of feeding cardboard, visual, and palletizing raw materials includes manual material handling because it still uses human labor as operators.

Based on preliminary research conducted using the OWAS method, the palletizing workstation on the 1500 ml production line is a work station that requires improvement because it has a score of 2 which means the work is in the rather heavy category. This work is harmful to the musculoskeletal system (work attitude affects significant tension), so future improvements are needed due to poor work posture. Workers have to bend down to put down the cardboard and do it repeatedly quickly with a fairly heavy load of 18 kg. Both infeed workstations and visual workstations have a score

of 1, meaning that work on both workstations is normal and therefore does not require repair. In addition, the 600 ml production line has the same score for all manual material handling activities. Significant differences can be seen in the weight of cardboard and the dimensions of cardboard. The difference in cardboard weight affects the palletizing process by workers. The total weight of 12 bottled waters is 18 kg with a length of 34 cm, a width of 26 cm and a height of 32 cm.

The results of the preliminary questionnaire revealed that 27.8% of workers were aged 18-27 years and 72.2% were aged 28-37 years. As many as 100% of workers feel sick after work. A total of 77.8% of workers' pain was slightly reduced after rest and 22.2% of workers' pain was greatly reduced after rest. As many as 100% of workers stated that palletizing workstations are not in accordance with the wishes of the workers because they are not ergonomic and not in accordance with the wishes of the workers. As many as 100% of workers state that work aids are needed to help the palletizing process and there is a problem that is less ergonomic work position. This study aims to determine the Recommended Weight Limit (RWL) used to measure the lifting load limit for workers; Lifting Index (LI) measurement that can describe the level of safety of lifting loads.

2. MATERIALS AND METHODS

The object to be studied in this study is palletizing workstation workers. Things observed in this study were lifting loads and work posture when placing cardboard. This research was conducted at PT. XYZ which is located at Jl. Cokro-Wangen, Klaten.

The study began in December 2019 to February 2020. The tools used in this study include preliminary questionnaires, posture assessment using the OWAS method, Recommended Weight Limit assessment, NBM questionnaire, Borg RPE scale questionnaire, and SPSS software.

RWL assessment aims to obtain lifting load limits for workers. The Revised NIOSH Lifting Equation is based on the assumption that manual material handling activities do not require significant energy expenditure, especially when performing repetitive lifting work. This lifting activity is limited to only moving 1-2 steps with a very short moving time. RWL is calculated using the formula (Waters et al., 1993)

$$RWL = LC \times HM \times VM \times DM \times AM \times FM \times CM \quad (1)$$

With a multiplier factor

Multiple rs		Metric
LC	Load constant	23 kg
HM	Horizontal multiplier	(25/HOUR)
DM	Vertical multiplier	(1 – 0.003|V – 75|)
AM	Distance multiplier	(0.82 + 4.5/s)
FM	Asymmetric multiplier	(1 – 0.0032 A)
CENTIMETRE	Frequency multiplier	Table
	Clutch multiplier	Varies from 0.9 (ugly) to 1.0 (good)

RWL is used to calculate the Lifting Index which describes the level of physical stress which is the ratio of the weight of the load lifted to the lifting limit of the load. The largest LI value is 1 which means the size of the load lifted is equal to the recommended load weight

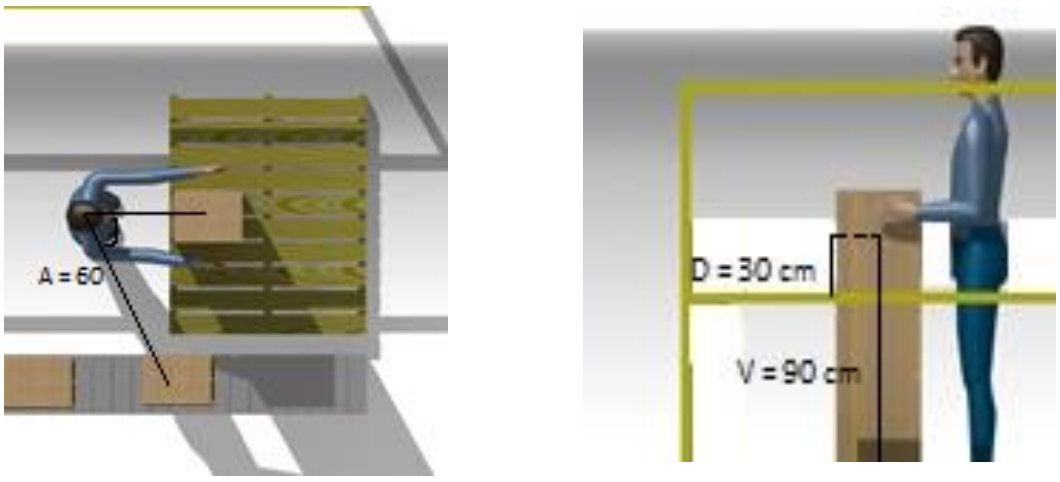
$$LI = \frac{Load\ weight}{RWL} \quad (2)$$

After obtaining results that prove that the work posture of workers is at high risk, proceed with measuring the discomfort of workers' work posture using the NBM questionnaire. Workers' fatigue levels are measured based on heart rate. The design is made based on the assessment that has been done. The results of data processing are used as a reference to develop work system engineering.

3. RESULTS AND DISCUSSION

3.1. Recommended Weight Limit

The National Institute for Occupational Safety and Health (NIOSH) devised a formula that can be used to determine the limit on the amount of weight lifted in lifting activities called the Recommended Weight Limit (RWL). Figure 1 shows (a) the position of the worker when retrieving the cabinet from the conveyor, (b) the position of the worker when placing the cabinet on a pallet (Kroemer, 1994).



(a) (b)

Figure 1. (a) the position of the worker looking up when retrieving the cabinet; (b) side view of the worker's position when lifting the cabinet

RWL calculation requires data when picking up products from the origin area and data when products are placed in the destination area. In company XYZ the initial data is data when cardboard arrives using a conveyor. The original RWL is the weight of cardboard that is recommended to be lifted in the initial area where the goods arrive for pickup and forwarding to the destination area. Destination RWL is the recommended cardboard weight value to be lifted at the destination position.

When a worker lifts an 18 kg cardboard without a handle, the worker will hold cabinets at the bottom and back. The coupling value is 0.9 (C = 0.9). When picking up cabinets, the worker's posture stands upright, the horizontal distance of the hands to the midpoint of the body (Ho = 60 cm), the vertical height of the conveyor from the V floor (Vo = 90 cm), the height of the cabinet (D = 34 cm), the worker faces towards the closet (Ao = 00).

When placing on a pallet (destination area) the worker must bend his body because the height of the pallet is only 25 cm from the floor (Vd = 25) by turning his body to the right by 600 (AD = 60). Given that workers must arrange cabinets on pallets, the destination RWL must also be calculated. Cabinet lifting is carried out 5-8 times per minute with a working time of 1-2 hours then a break (FM =). These numbers are then fed into the multiplier factor formula in the RWL formula. RWL assessment is performed on the stack closest to the body to obtain the lowest Lifting Index (LI) value. An illustration of the arrangement of cardboards is shown in Figure 2 which shows the posture of workers when placing cardboard on pallets. Figure 3 illustrates when workers arrange cabinets in piles on pallets.

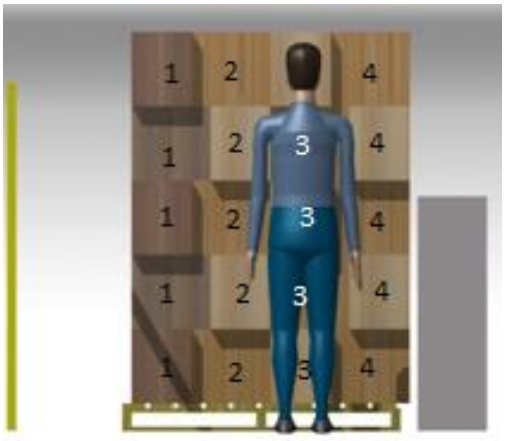


Figure 2. Cardboard Arrangement Illustration

Figure 3. Illustration of the arrangement of cabinets on pallets
(Source: secoptot.com/ergonomic-consultation)

Using the RWL and LI formulas in equations 1 and 2, the original RWL obtained is 2.8 kg and the destination RWL obtained is 2.7. The original RWL value of 2.8 kg indicates that the recommended load weight for workers working between 2-8 hours a day, moving cabinets without handles at a height of 90 cm with a lifting frequency of 5 cabinets/min is 2.8 kg. Given that the actual weight of the moved cabinet is 18 kg, the Lifting Index value is 6.4. This value is very large compared to the value of secure LI 1. The higher the LI value, the greater the risk by workers (Waters et al., 1993).

For destination RWL, the value is smaller than the original RWL. This is because at the destination RWL (placing the cabinet on the pallet) the worker rotates the body 60 degrees and the difference between the height of the pallet and the standard height of 75 cm is very large (75-25=50). This is not an ergonomic posture when workers place and arrange cabinets on pallets. The RWL results show a very serious value, that it is difficult to find solutions administratively. in their research did not find an ideal position that could reduce the LI to 1. Therefore, the recommendation given is to add bench and rolling track at the end of the conveyor belt (Umami et al., 2014).

According to the Regulation of the Minister of Manpower of the Republic of Indonesia, the threshold value of manual lifting by male workers is 20 kg if lifted at elbow level with objects raised close to the body. The activity of lifting the cardboard at an intensity of five to eight times per minute requires a 50% reduction in weight limits. Tarwaka (2004) explains that prevention of MSDs can be done with administrative control or Engineering control (Anonim, 2018). Administrative control at PT XYZ for lifting loads is lifted 5-8 times per minute, so that the recommended lifting load is only half of the total load. However, this cannot be done. Although this lifting activity is allowed only 1-2 steps with

a very short movement time, it does not help. Technical control can be carried out if the results of administrative control are not optimal. The use of mechanical or automatic equipment is highly recommended to overcome this problem (Waters et al., 1993).

3.2. Worker Muscle Pain

The Nordic Body Map (NBM) is a questionnaire filled out by workers to assess muscle pain experienced while working (Wilson and Corlett, 1995). Fifteen worker limbs were self-assessed by assigning a score of 1 for limbs that felt no pain, a score of 2 for slight pain, a score of 3 for pain and a score of 4 for very high pain. The questionnaire is filled out before and after palletizing. All workers do not feel any pain before work. Figure 4 shows the number of scores for each limb for 18 workers. The highest score indicates the limb feels the most pain for all workers. The three highest scores were leg numbers 7,8,9 which means that the lower back is the most followed by pain in the left hand and right hand.

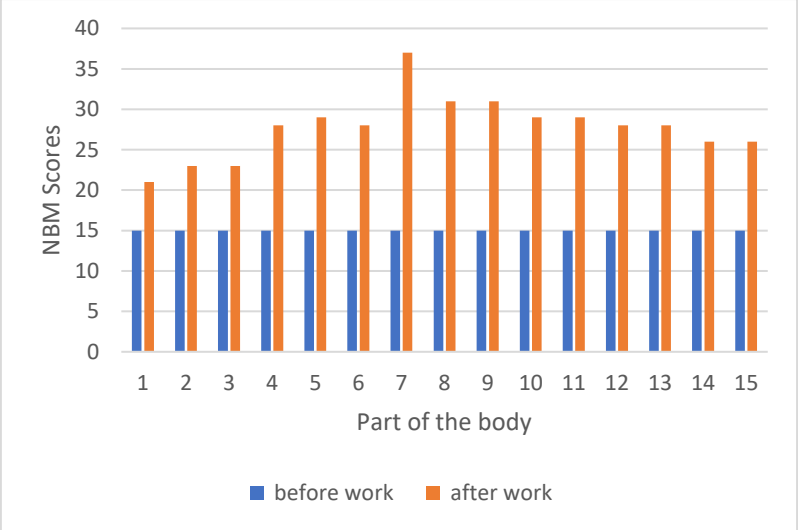


Figure 4. Discomfort Scores Before (blue) and After Work (red)

Based on Figure 4, it can be seen that the highest score is part number 7, which is low back pain (LBP). The lower back is used to support weight when bending over to place a cardboard on the first stack and experiencing tension when standing on tiptoe to place the cupboard on the fifth pile. Bridger (2003) states that awkward postures and repetitive work can lead to reduced blood supply, lactic acid accumulation, and stress on muscles. Based on the discomfort of limb number 7, improvements are needed for the work design to reduce or eliminate the discomfort experienced by workers.

3.3. Worker Workload Tier

Heart rate measurement using the Borg scale shows results as in Table 1 (Borg, 1982) mentions the category of workload level, which in the assessment is selected based on the worker's perception of the level of fatigue he feels (Table 1).

Table 1. Borg Scale and Pulse Score Measurement Results

Not	Worker	Age (year)	*Rating*	Pulse Rate Score (pulse rate/min)	*Business Perception*
1.	W1	28	14	140	*It's a bit difficult*
2.	W2	32	14	140	*It's a bit difficult*
3.	W3	26	14	140	*It's a bit difficult*
4.	W4	24	13	130	*It's a bit difficult*
5.	W5	34	14	140	*It's a bit difficult*
6.	W6	29	14	140	*It's a bit difficult*
7.	W7	35	15	150	*Hard*
8.	W8	34	15	150	*Hard*
9.	W9	30	14	140	*It's a bit difficult*
10.	W10	37	15	150	*Hard*
11.	W11	27	14	140	*It's a bit difficult*
12.	W12	32	14	140	*It's a bit difficult*
13.	W13	29	14	140	*It's a bit difficult*
14.	W14	26	14	140	*It's a bit difficult*
15.	W15	32	14	140	*It's a bit difficult*
16.	W16	34	14	140	*It's a bit difficult*
17.	W17	28	14	140	*It's a bit difficult*
18.	W18	24	13	130	*It's a bit difficult*

Heart rate measurements using the Borg scale show results as shown in Table 1. This showed that 18 workers felt very tired which was supported by a high heart rate indicating a very high workload (Kroemer et al, 1997).

Table 2. Workload categories by heart rate frequency

Workload Categories	Heart rate frequency (beat/minute)
Very light	Less than 75
Light	75 – 100
Quite heavy	100 – 125
Heavy	125 – 150
Very heavy	150 – 175
Extreme	More than 175

(Kroemer et al, 1997).

The results showed that the work system at PT XYZ palletization workstations must be improved. The main cause of ergonomic problems that occur is that the cardboard that must be lifted by workers is too heavy. Changing the packaging to contain 6 packages weighing 9 kg is not possible. This problem is exacerbated by a fairly high lifting frequency of 5-8 cardboards / minute and the accumulation of cardboard on pallets is quite high. The impact felt by workers is feeling very tired and pain in the lower back (Low Back Pain). Work system administration improvements cannot be done at PT XYZ. Changes in manual labor systems to mechanical or automatic work systems.

4. CONCLUSION

Workers in the palletizing work station of PT XYS feel uncomfortable and hope that the work system will be improved. The results of the workload level assessment show that the workload is very heavy, there is pain in the lower back which indicates Low Back Pain. The calculation of the lifting load limit shows that lifting 12 bottles @ 1,500 ml in an 18 kg cabinet is beyond the safe lifting limit. The recommendation for the pelletizing work system to be ergonomic is to change the work system from manual to mechanical or automatic.

REFERENCE

Anonymous. 2018. Manual Handling Guidelines in the Workplace 2018. Department of Occupational Safety and Health. https://www.dosh.gov.my/index.php/competent-person-form/occupational-health/regulation/guidelines/ergonomic/2959-guidelines-for-manual-handling-at-workplace-2018/file

Borg, G. V. 1982. psychophysical_bases_of_perceived_exertion. Medicine and Science in Sport and Power, 14(5), 377–381.

BPJS Employment. 2018. Number of Work Accident Cases in 2001-2017 downloaded in isafetymagazine.com

Bridger, R.S. 1995. Instructors for Ergonomics. Mc-Graw Hill. Singapore. doi: 10.4324/9780203426135.

Caputo, F.D. and Marzano, A. 2006. Ergonomic optimization of work cells of manufacturing systems in a virtual environment. Acta Polytechnica, 56(5), pp. 21-27. doi: 10.14311/872.

Della, T. L., Farras, M. F., Hamid, A. N., and Suryoputo. M. R. 2019. Evaluation of Work System Design on REBA Output of Bottled Water Appointment Based on Material Handling Manual Principles in IDEC National Seminars and Conferences.

DOSH, Malaysia. 2018. Guidline for Manual Material Handling at Work 2018. 1-90. http://www.dosh.gov.my/index.php/en/competent-person-form/occupational-health/guidelines/ergonomic/2959-guidelines-for-m

Dul, J., and Weerdmeester, B. 2001. Ergonomics for Beginners: Quick reference guide, second edition.

Kroemer, KHE 1994. How to Design Ergonomics for Ease &; Efficiency: Prentice Hall. p. 514.

Kroemer, K.H.E., Kroemer, H.J., and Kroemer-Elbert, K.E. 1997. Engineering Physics: Human Factors Basis / Ergonomics third edition. International. Thomson Publishing Company, USA.

Suma'mur, P. K. 1996. Higeine Company and Work Safety. Jakarta: Mount Agung.

Tarwaka, S. H., Sholichul., and Sudiajeng, L. 2004. Ergonomics for Safety, Occupational Health, and Productivity. Surakarta: UNIBA Press.

Ulfah, N., Harwanti, S., and Nurcahyo, P. J., 2014. Work Attitudes and Risk of Musculoskeletal Disorders in Laundry Workers. doi: 10.21109/kesmas.v0i0.371

Umami, M., Dwi, A., Hadi, R., and Agustina, F. 2014. Ergonomic Evaluation of Manual Material Handling Activities in Production Parts in CV. GMS, Base, 65-70. doi: 10.26593/jrsi.v3i2.1298

Waters, T. R., Putz-Anderson, V., Garg, A., and Good, L.J. 1993. Revised NIOSH equation for manual lifting task design and evaluation. Ergonomics, 36(7), 749 - 776. doi: 10.1080/00140139308967940