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Ergonomic risk and work load analysis on material handling of PT. XYZ

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Abstract. In Indonesia, some industries do manual work using human labor. Among other things is the process of raw materials handling. Likewise, this happened to PT XYZ, which has not used a tool in the material handling process. The material are steel plates and wood plates. This study aims to determine the physical complaints felt by workers, determine the workload classification, and analyze the work posture of workers. In accordance with the results of the Nordic Body Map questionnaire, there are complaints from workers, especially pain in the upper neck, pain in the left and right shoulder, pain in the left upper and right upper arm, backpain, low back pain, left and right forearm pain, left-right wrist pain, and right and left hand pain. Based on Rapid Entire Body Assessment (REBA) and Workplace Ergonomic Risk Assessment (WERA) analysis, all activities of carrying steel plates and wood plates are categorized as medium. Based on Ovako Working Posture Analysis System (OWAS), the elements of work that require immediate action are Taking Plate (Wood) and Carrying the Plate (Wood). The results of the calculation of energy consumption obtained by 5.94 kcal / minute and categorized as work heavy / heavy work (5.0 - 7.5 kcal / minute). Workers carry plates with a weight of 30 to 42 kg, while according to NIOSH Equation and Snook Table analysis the maximum load is 14.06 kg, so this is far beyond and dangerous.

Keyword: ergonomic, work load, material handling, WERA, OWAS

1. Introduction

Manual work, if not done ergonomically, can cause work accidents or what is called Over Exertion-Lifting and Carrying. Lifting and carrying loads by bending forward repeatedly causes chronic Low Back Pain [1]. That is the state of damage to body tissues due to excessive lifting load [1]. Lifting a load above 25 kg is potentially a high risk of physical injury to workers. It is advisable to form a lifting and carrying team if the load exceeds 25 kg [2]. Lifting activities that are not done properly, such as postures / positions that are not natural at work, can cause illness or injury to the spine in workers. This working condition also happens to workers in the activity of transporting iron plates and wooden plates at the XYZ Factory. Workers carry steel and wood plates using both hands from the raw material warehouse to the work station. The size of the steel plate varies, ranging from 16 kg to 42 kg. Meanwhile, the heaviest wood plate is 25 kg. These plates will be transported one by one by the number of workers ordered. A heavy burden to be lifted by the workers, so that they had complaints of pain in the waist, shoulders, neck, or hands.

Based on the above problems, an in-depth analysis of working conditions, work posture and workload is carried out. The analysis results are used as input in designing of ergonomic material



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handling tools. This tool is to facilitate the move the steel plates and wood plates so as to reduce fatigue in workers and avoid work-related diseases. This is in accordance with the purpose of ergonomics which is to maximize the design of products, tools and workplaces, in relation to integral anthropometry, so that getting a complete knowledge of the problems of human interaction with technology and its products, as well as the design of human systems can be optimal [3].

This study aims to determine physical complaints of workers by using the Nordic Body Map questionnaire to find out the part of the worker's body that feels painful before and after doing work [4]. In addition to using NBM questionnaire, worker complaints can be measured from the level of ergonomic risk with the Workplace Ergonomic Risk Assessment (WERA)[3] and Rapid Entire Body Assessment (REBA)[4][5][6]. The complaint in question is related to fatigue of musculoskeletal work (WMSDs) due to unnatural posture. Assessment of WERA [4], categorized into three categories: low (score 18–27: work acceptable), moderate (score 28–44: work needs further investigation and requires improvement), and high (score 45–54: job the observed is unacceptable, it is necessary to make immediate repairs). While the REBA assessment is categorized into five levels which can be seen in Table 1.

Table 1. REBA score and level of MSDs Risk [7]

REBA Score	Risk Level	Action Level	Action
1	Negligible risk	0	No action required
2-3	Low risk	1	Change may be needed
4-7	Medium risk	2	Further investigation, change soon
8-10	High risk	3	Investigate and implement change
11-15	Very high risk	4	Implement change

In addition, there are also OWAS methods to evaluate and analyze uncomfortable work attitudes and result in musculoskeletal injuries[8][9][10]. Besides analyzing body posture, measurement of heart rate before and after work is also done. This measurement is to determine energy consumption during work [11][12][13]. Furthermore, the workload calculation is carried out by the Kamkalan method to measure the amount of energy consumption[14]. To provide recommendations on workloads that can be safely lifted by workers for various job variables using NIOSH Lifting Equation [15][16] and snook table [17][18][19], with this method it will be known that the workload should be allowed to be manually lifted.

2. Methods

This research was conducted at PT. XYZ, a company that produces various types of furniture. The main raw material used are wood and steel. Research focused on material handling processes. The dimensions of wood and steel handled are quite large and heavy. Handling process is done manually. The study began with the provision of the Nordic Body Map questionnaire, a questionnaire to determine the subjective complaints of workers. Next is observation and analysis of work posture. The methods used are REBA, WERA and OWAS. Workload was analyzed by measuring heart rate. Calculation of workload using Kamalanan Formula. Results of all the analysis concludes that the condition of the workload and ergonomic risks of working system. This study resulted in recommendations to improve the work system for increased comfort and productivity

3. Result and Discussion

Data were collected by distributing questionnaires to workers at PT. XYZ. The results of the general questionnaire can be seen in Table 2 below.

Table 2. Summary of General Questionnaire

No	Question item	Results
1	Sex	male
2	Age	45 – 55 years
3	Weight	60 – 65 kg
4	Height	160-170 cm
5	Marriage status	married
6	Work duration	5-8 hours
7	Plate weight	5 – 45 kg
8	The amount of material carried in 1 car	100 – 150 pcs
9	Work experience	> 5 years
10	Frequent activities	stand
11	Complaints	Pain in arms, shoulders, waist, back
12	Suggestion	Provided handling tools

Furthermore, an analysis of the body parts that experienced the greatest physical complaints from the Nordic Body Map questionnaire was carried out. The results can be seen in Table 3 and marked in yellow.

Table 3. Analysis of physical complaints from the Nordic Body Map questionnaire

No	Rank of Physical Complaints	Causes
1	Pain in the upper neck	The position of the neck of the worker who must bow his head repeatedly when taking a wooden plate and lifting it.
2	Pain in the left and right shoulder	The process of lifting a steel plate and wood plate carried by placing it on the left or right shoulder repeatedly makes a complaint in this section.
3	Pain in the left upper and right upper arm	Position of the left upper arm and right upper arm that clamp the steel plate and wooden plate repeatedly during the process of transporting the material.
4	Back pain	Workers bend over and over when picking up wooden plates placed vertically on the warehouse floor causing the back of the worker to hurt.
5	Low back pain	Workers must take down and bring a wooden plate by transporting it from the raw material warehouse to the work station repeatedly causing complaints in this section.
6	Left and right forearm pain	The process of carrying a wooden plate and steel plate by holding it in the forearm left or right when taken.
7	Left-right wrist pain, right and left hand pain	The process of carrying an iron plate and wooden plate involves a lot of wrists and hands. The wrist and hand are used to hold the plate so as not to fall when taken from the raw material warehouse to the work station.



After obtaining the results of the analysis of the causes of physical complaints felt by workers, then the next is to do REBA and WERA analysis to determine the score when the worker moves the plates manually. The job position analyzed is when taking a plate, carrying the plate, and putting down the plate. The position of transporting plates can be seen in Figure 1 and Figure 2.

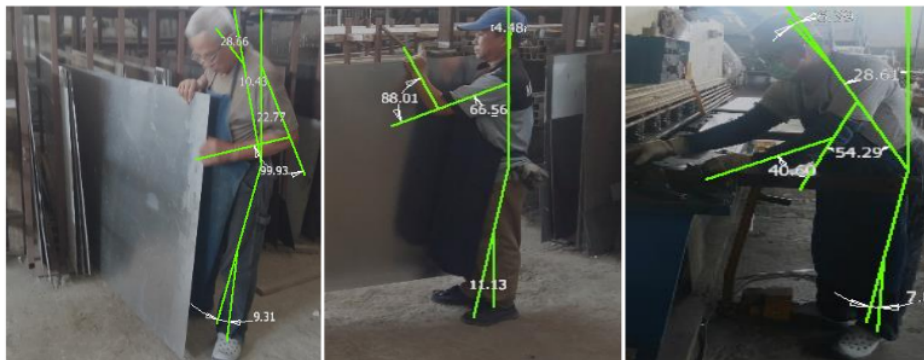


Figure 1. The process of carrying steel plates



Figure 2. Process for carrying wood plates

6 From Figure 1 and Figure 2, the calculation of REBA and WERA scores is then performed. Calculation results are shown in Table 4 and Table 5.

Table 4. REBA score for each activity

No	Activity	REBA Score For Steel Plates	REBA score For Wood Plates
1	Taking Plate	4	5
2	Carrying the Plate	5	5
3	Putting down the Plate	6	5

Table 5. WERA score for each activity

No	Aktivitas	WERA Score For Steel Plates	WERA score For Wood Plates
1	Taking Plate	35	33
2	Carrying the Plate	31	32
3	Putting down the Plat	29	29

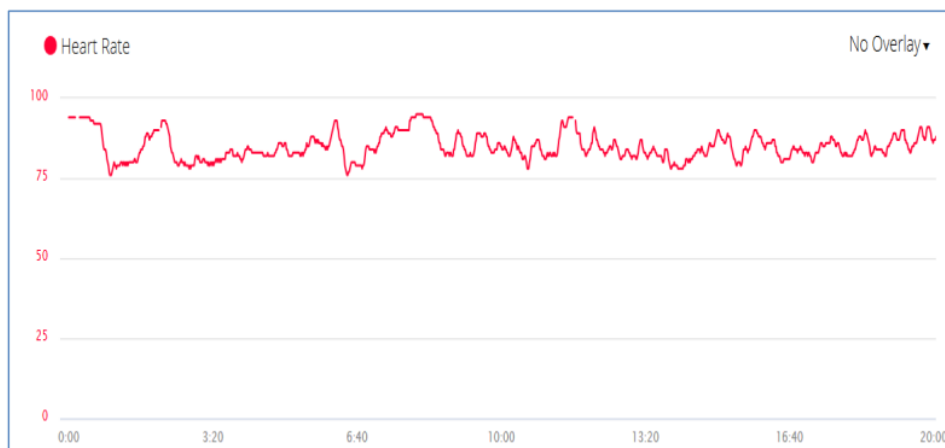
Based on REBA and WERA analysis, all activities of transporting steel plates and wood plates are categorized as medium risk. This means that the working conditions are further investigation, change soon, thus minimizing the risk of injury.

Furthermore, an OWAS method is analyzed to find out whether it is necessary to take corrective action or not. The results of the OWAS analysis are shown in Table 6.

Table 6. Risk Score Using the OWAS Method

Working Element	Score	Category	Action
Taking Plate (Steel)	1123	1	Not necessary
Carrying the Plate (Steel)	1273	1	Not necessary
Putting down the Plate (Steel)	2121	2	Need improvement in the future
Taking Plate (Wood)	2122	2	Need improvement as soon as possible
Carrying the Plate (Wood)	2172	3	Need improvement as soon as possible
Putting down the Plate (Wood)	1121	1	Not necessary

Next, measurement of heart rate, using Heart Rate Monitor (HRM). Heart rate measurement was done during work and at rest. Graphs of heart rate measurement can be seen in Figure 3 and Figure 4.

**Figure 3.** Heart Rate Graph (at rest)

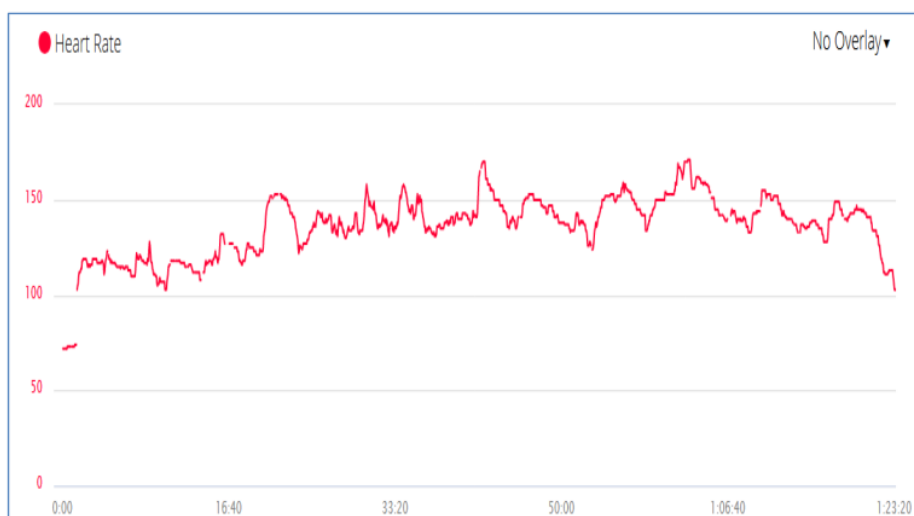


Figure 4. Heart Rate Graph (during work)

Calculation of workload using the equation stated by Kamkalanan as follows:

$$\begin{aligned}
 MWR &= -1967 + 8,58HR + 25,1HT + 4,5A - 7,47RHR + 67,8G \\
 &= -1967 + 8,58 \times 136 + 25,1 \times 66,92 + 4,5 \times 48 - 7,47 \times 91 + 67,8 \times 0 \\
 &= 415,802 \text{ watt} = 5,94 \text{ kcal/min}
 \end{aligned}$$

The results of the calculation of energy consumption obtained by 5.94 kcal / minute and categorized as heavy work (5.0 - 7.5 kcal / minute).

Activities of lifting, lowering and carrying steel plates and wooden plates were analyzed with NIOSH Lifting Equation and Snook Table. The results are shown in table 7 below.

Table 7. NIOSH Lifting Equation, Snook Table Carrying and Snook Table Lifting/ Lowering

Analysis	Results
NIOSH Lifting Equation	34,01 lbs = 15,34 kg
Snook Table Carrying	31 lbs = 14,06 kg
Snook Table Lifting/lowering	22 lbs = 9,97 kg

Based on the NIOSH Lifting and Snook Table analysis, it can be seen that the maximum load limit allowed to carry a steel plate or wooden plate is 14.06 kg, while the lifting or lowering of a steel plate or wooden plate is 9.97 kg. However, workers at the XYZ Plant lift or lower steel plates up to 42 kg or wooden plates up to 30 kg. This exceeds the maximum load limit for lift / lower activity, so it can cause physical complaints to workers.

4. Conclusion

In accordance with the results of the Nordic Body Map questionnaire, there are complaints from workers, especially pain in the upper neck, pain in the left and right shoulder, Pain in the left upper and right upper arm, back pain, low back pain, Left and right forearm pain, and left-right wrist pain, right and left hand pain. Based on REBA and WERA analysis, all activities of transporting steel plates and

wood plates are categorized as medium. This means that it has a high level of risk and changes are needed to reduce the risk of physical complaints to workers. Based on OWAS analysis, the elements of work that require immediate action are Taking Plate (Wood) and Carrying the Plate (Wood). The results of the calculation of energy consumption obtained by 5.94 kcal / minute and categorized as work heavy / heavy work (5.0 - 7.5 kcal / minute). Workers transport plates with a weight of 30 to 42 kg, while according to NIOSH Equation and Snook Table analysis the maximum load is 14.06 kg, so this is far beyond and dangerous.

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