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ANALYSIS OF PHYSICAL AND MENTAL WORKLOAD OF WORKERS WITH CARDIOVASCULAR LOAD (CVL) AND BOURDON WIERSMA AT PT XYZ

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ABSTRACT

PT XYZ is a manufacturing company that produces fabricated components and machines for various heavy construction industries, but the well-known product is train components. PT XYZ has agreed to export train components to many countries so that PT XYZ has a large production target. Workers must work on requests for goods according to a predetermined date, which can cause fatigue. Based on these problems, this research was conducted to determine the value of the physical and mental workload of shift 1 and shift 2 PT XYZ workers and provide suggestions for improvement. Cardiovascular Load (CVL) and Bourdon Wiersma methods are used to identify the worker's workload. Based on the research results, it is known that the workload of shift 2 workers is heavier than shift 1 workers. This problem can be influenced by working hours at night which are less optimal for work. Improvements suggested to overcome this include increasing rest time, setting up a shift system or rolling shifts, and improving the workplace

Keywords: Bourdon Wiersma, Cardiovascular Load, Ergonomic, Workload

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1. INTRODUCTION

1.1. Sub Title for Introduction

A good and satisfying job will have an impact on the success of the company. Good performance must have factors that influence it. These factors include the workplace, working conditions, and the workload borne by the workers (Pratama, Rizqi and Hidayat, 2023). The workload can be defined as a situation where workers are faced with tasks that must be completed at a specific time (Widiastuti *et al.,* 2019). The workload is work tasks that are a source of stress, such as working quickly, producing something, and concentrating on work stress (Ali *et al.,* 2022). The burden can be in the form of physical burden and mental/cognitive load. The physical workload includes lifting, pulling, and pushing activities, while the mental workload requires accuracy, speed, and monotonous work (Simanjuntak, Oesman and Suhariyanto, 2019). The number of tasks given to workers will result in less than optimal results due to limited time and skills. A high workload will cause stress and cause employee performance to decrease (Sutisnawati and Sya'hroni, 2019). Workload analysis is carried out to learn about workload and possible obstacles that arise during work. It serves as the basis of all human resource management activities in a company because it can provide the correct measurement to determine the right workload for each worker (Arifin, 2020).

PT XYZ has three business areas: foundry, construction projects, and heavy industrial equipment. Its well-known products are train components: bogies, automatic couplers, axle boxes, knuckles, etc. PT XYZ has also agreed to export railroad components to the United States, Canada, and Mexico. This massive export gives PT XYZ a large production target so that workers are required to work on requests for goods according to a predetermined date. This massive export can cause fatigue in workers.

Fatigue arises after doing work because the human body cannot work continuously. Work-related fatigue can significantly affect worker capacity functions, impact worker performance and productivity, and increase the potential for injury at work (Wahyuni and Indriyani, 2019). Work fatigue is a state of decreased efficiency and resilience in a person at work. Fatigue refers to conditions that weaken the workforce to carry out an activity, reducing work capacity and endurance (Gaol, Camelia and Rahmiwati, 2018). Fatigue is an occupational health problem that needs special attention. Fatigue for everyone is subjective because it is related to feelings from being influenced by physical and biological factors. Fatigue is also influenced by psychological factors (Rahmawati and Afandi, 2019). Many factors can cause work fatigue, including individual characteristics, work factors such as monotonous work and workload, psychological factors, and work environment factors (Rahayu and Effendi, 2020).

PT XYZ applies a shift system in its production activities, including shift 1 from 7.30 to 15.30 and shift 2 from 15.30 to 23.30, which can also cause worker fatigue. Shift work is an employee work time system that the company or industry management officially regulates by work rules (Erwina *et al.,* 2022). Tarwaka (1999) said that 63% of workers suffer from fatigue due to the influence of work shifts which can result in work accidents (Syafar and Fiatno, 2018). The shift system can cause increased fatigue, especially during the night shift, because human life cycle patterns at night are generally used for rest. The night shift can cause irregularities in the body's biological rhythms (circadian rhythms). Circadian rhythm is a cycle that occurs at the body's chemical or functional level and adjusts the body's physiological functions to the external environment. Humans are a diurnal species. Therefore, humans have an average physiological time to sleep at night and be active during the day (Dewi Supyana, Sylviana and Eva Rakhmilla, 2019).

Given these problems, a study was conducted using the Bourdon Wiersma method to measure and analyze the workload of workers in the production department in shift 1 and shift 2 at workshop 1. This method was chosen because it can objectively measure work fatigue to evaluate concentration, work speed in monotonous tasks, and thorough work (Amri, Hahury and Fandi Marsulan, 2022). While

research using the Cardiovascular Load (CVL) method is a measurement using a pulse oximeter to calculate the pulse. The heart rate is used to estimate the physical workload index, which consists of the resting heart rate, working heart rate, and the difference in heart rate (Sari, Ramadani and Fahriati, 2022). The author chose this method because the user of the work pulse (pulse during physical work) to assess the severity of the workload has several advantages. Besides being easy, fast, and inexpensive, it does not require expensive tools, and the results are reliable. Besides, it does not interfere with the work process or hurt the examined person. The sensitivity of the pulse to changes in the body's loadings is relatively high (Vivi Putri, 2020). This study aims to measure production employees' workload and provide solutions to reduce work fatigue levels at PT. XYZ.

2. METHODS

This quantitative research is conducted by measuring workers' physical and mental workload, pulse vibration and calculating the proportion of CVL and the time taken by doing the Bourdon Wiersma test.

2.1 Object of Research

The object studied for this study was 30 workers in workshop 1 (the minimum number of samples in statistics). The subjects studied included 15 workers each shift, with 3 people in pattern core making, 3 in pattern molding making, 3 in grinding, 3 for assembly, and 3 for welding.

2.2 Research Methodology

Based on the source, the data in the study were divided into two, namely primary and secondary data. Primary data is data in verbal form or words spoken orally or behavior carried out by subjects that can be trusted (Beno, Silen and Yanti, 2022). This study's primary data was obtained from direct field research by interviewing workers and production managers. Meanwhile, research-related documents obtain secondary data from literature or companies (Wahyulistiani *et al.*, 2022). In this study, secondary data were obtained from companies and literature used as a reference for the research.

2.3 Data Analysis Technique

These are the following steps for the research:

1) Collecting data
   The data collected includes the worker's pulse, the worker's weight, the worker's age, and the results of the Bourdon Wiersma test.
2) Calculation of physical load
a. Pulse rate calculation
b. Oxygen consumption calculation
c. Energy consumption calculation
3) Calculation of the percentage of Cardiovascular Load (CVL)
   Pulse measurement using the Cardiovascular Load (CVL) method calculates the % Cardiovascular Load (CVL) value with the following formula.

$$\%\ \text{CVL} = \frac{100\ x\ (Working\ HR - Resting\ HR}{Maximum\ HR - Resting\ HR} \quad ....(1)$$

   Where the resting heart rate is the average pulse before work starts, the working heart rate is the average heart rate during work, and the maximum heart rate is (220 – age) for men and (200 – age) for women (Hasibuan, Munte and Lubis, 2021).
   Where from the results of the calculation of %CVL is then compared with the classification that has been set in the table.

Table 1. %CVL Classification

Percentage Range	Classification
< 30%	Fatigue does not occur
30% - <60%	Repair needed
60% - <80%	Improvement required
80% - <100%	Work in a short time
100%	Not allowed to work

   Source: (Purbasari and Purnomo, 2019)
4) Calculation of the results of the Bourdon Wiersma test
a. The researcher accompanied the test work.
   In working on this test, the researcher calculated the time needed by workers to complete the test.
b. Speed variable calculation
   The data obtained will be calculated on how fast each worker is.

c. Calculation of accuracy variable
   Classify the number of objects skipped, crossed-out errors, and total overall errors from the tests given to workers.
d. Calculation of the constant variable
   Calculation of constants to find out whether the worker is experiencing fatigue or not.
e. Classification of Bourdon Wiersma test results
   Summarizes the results of the Bourdon Wiersma test by displaying the value and Weighted Score (WS) and the group of each variable (Aryanny and Baitil, 2021).

3. FINDINGS AND DISCUSSION

The following is data processing from the data that has been collected.

3.1 Calculation of worker's physical load

The physiological approach in Ergonomics focuses on measuring the energy consumed, metabolic needs, the performance of body functions, and its components in designing work (Nina Saparina Yuliani *et al.*, 2021). Pulse can be used as an indicator to determine the severity of a person's burden. The average pulse rate in adults is 60-100 beats/minute. At the same time, the abnormal pulse is 100 times/minute (Harioputro *et al.*, 2018).

The following is a table of workload categories related to the condition of the human body.

Table 2. Workload Category

Workload Category	Oxygen Consumption (l/min)	Energy Consumption (Kkal/min)	Pulse Rate (beats/min)
Very Light	0,25-0,3	<2,5	<60
Light	0,5-1,0	2,5-5	75-100
Moderate	1,0-1,5	5-7,5	100-125
Heavy	1,5-2,0	7,5-10	125-150
Very Heavy	2,0-2,5	10-12,5	150-175
Extremely Heavy	>25,0	>12,5	>175

Source: (Hutabarat Yulianus, 2017)

Table 3 shows the recapitulation results of calculating the heart rate, oxygen consumption, and energy consumption of shift 1 workers.

Table 3. Heart rate, oxygen consumption, and energy consumption data of shift 1 workers

No.	Worker	Maximum Pulse Rate (beats/min)	Working Pulse (beats/min)	Oxygen Consumption (l/min)	Energy Consumption (Kkal/min)
1	Worker 1	185	36	1,031	2,317
2	Worker 2	189	44	1,148	3,164
3	Worker 3	191	52	1,553	4,009
4	Worker 4	185	49	1,178	3,339
5	Worker 5	188	39,5	1,083	2,887
6	Worker 6	192	60	1,333	4,541
7	Worker 7	193	60,5	1,28	4,764
8	Worker 8	189	58	1,508	4,663
9	Worker 9	192	41	1,135	3,064
10	Worker 10	189	48,5	1,304	3,728
11	Worker 11	193	58	1,218	4,526
12	Worker 12	186	38	1,188	2,464
13	Worker 13	188	43	1,334	3,011
14	Worker 14	184	46	1,03	3,004
15	Worker 15	194	55,5	1,239	4,475
Average		189,2	48,6	1,237	3,597

Source: Data processing

Table 4 below shows the recapitulation results of calculating the heart rate, oxygen consumption, and energy consumption of shift 2 workers who work from 15.30 to 23.30.

Table 4. Heart rate, oxygen consumption, and energy consumption data of shift 1 workers

No.	Worker	Maximum Pulse Rate (beats/min)	Working Pulse (beats/min)	Oxygen Consumption (l/min)	Energy Consumption (Kkal/min)
1	Worker 16	190	53,5	1,261	4,137
2	Worker 17	192	61,5	1,414	5,017
3	Worker 18	190	44,5	1,269	3,399
4	Worker 19	183	62	1,254	4,517
5	Worker 20	185	52	1,438	4,083
6	Worker 21	191	51	1,233	3,908
7	Worker 22	192	61	1,367	5,077
8	Worker 23	184	56	1,359	4,185
9	Worker 24	190	49,5	1,522	3,828
10	Worker 25	188	47	1,277	3,668
11	Worker 26	185	58	1,345	4,226
12	Worker 27	185	41	1,277	2,987
13	Worker 28	192	52	1,354	4,205
14	Worker 29	192	64	1,649	5,206
15	Worker 30	185	46,5	1,263	3,223
Average		188,27	53,5	1,3521	4,111

Source: Data processing

3.2 Cardiovascular Load (CVL)

After knowing the workers' heart rate data, the Cardiovascular Load (CVL) percentage was calculated for shift 1 and 2 workers. Table 5 below shows the results of calculating the percentage of workers' Cardiovascular Load.

Table 5. Percentage of worker's Cardiovascular Load (CVL)

No.	Shift	Worker	%CVL	No.	Shift	Worker	%CVL
1	Shift 1	Worker 1	32,58	1	Shift 2	Worker 16	48,42
2		Worker 2	39,82	2		Worker 17	54,91
3		Worker 3	46,85	3		Worker 18	41,59
4		Worker 4	43,36	4		Worker 19	55,11
5		Worker 5	37,26	5		Worker 20	50,24
6		Worker 6	51,06	6		Worker 21	45,95
7		Worker 7	52,38	7		Worker 22	55,45
8		Worker 8	53,46	8		Worker 23	51,61
9		Worker 9	37,61	9		Worker 24	45,62
10		Worker 10	45,12	10		Worker 25	44,98
11		Worker 11	50,43	11		Worker 26	51,56
12		Worker 12	33,93	12		Worker 27	39,42
13		Worker 13	38,74	13		Worker 28	48,15
14		Worker 14	40,53	14		Worker 29	56,39
15		Worker 15	49,55	15		Worker 30	42,08
Average			43,51	Average			48,77

Source: Data processing

The highest percentage of Cardiovascular Load (CVL) in shift 1 was owned by worker 6 at 51.06%, while in shift 2 the highest percentage of Cardiovascular Load (CVL) was owned by worker 29 at 56.39%. The average percentage in shift 1 is 43.51%, and shift 2 is 48.77%.

3.2 Bourdon Wiersma Test

Table 6 shows the results of calculating the Bourdon Wiersma test scores for shift 1 and 2 workers.

Table 6. Calculation results of the Bourdon Wiersma test for shift workers 1

No.	Worker	Speed	Accuracy	Constant
1	Worker 1	14,4	14	4,72
2	Worker 2	13,4	17	5,68
3	Worker 3	15,32	12	4,66
4	Worker 4	13,88	13	4,79
5	Worker 5	18	11	3
6	Worker 6	14,88	14	3,15
7	Worker 7	15	12	4,67
8	Worker 8	11,52	15	11,76
9	Worker 9	14,56	17	3,99
10	Worker 10	16,84	13	3,76
11	Worker 11	18,6	10	12
12	Worker 12	14	15	2,851
13	Worker 13	14	16	2,85
14	Worker 14	4,4	13	2,22
15	Worker 15	14,72	14	3,73
Average		14,9	13,73	4,92

Source: Data processing

From the calculation results, the average value of the Bourdon Wiersma test on the speed variable is 14,9 (doubtful), the accuracy variable is 13,73 (uncertain), and the constant variable is 4,92 (sufficient).

Table 7 below shows the results of calculating the Bourdon Wiersma test scores for shift 2.

Table 7. Calculation results of the Bourdon Wiersma test for shift workers 2

No.	Worker	Speed	Accuracy	Constant
1	Worker 16	16,6	12	7,46
2	Worker 17	13,64	11	3,94
No.	Worker	Speed	Accuracy	Constant
3	Worker 18	14,64	14	5,31
4	Worker 19	19,28	19	3,58
5	Worker 20	19,6	16	2,85
6	Worker 21	15	12	3,73
7	Worker 22	12,84	15	5,24
8	Worker 23	18,76	19	2,58
9	Worker 24	14,28	13	4,97
10	Worker 25	14,16	15	4,19
11	Worker 26	16,16	16	2,68
12	Worker 27	18,72	20	3,58
13	Worker 28	13,32	12	4,46
14	Worker 29	14,24	14	4,81
15	Worker 30	19,04	18	3,83
Average		16,02	15,07	4,21

Source: Data processing

From the calculation results, the average value of the Bourdon Wiersma test on the speed variable is 16,02 (doubtful), the accuracy variable is 15,07 (uncertain), and the constant variable is 4,21 (sufficient).

This result is caused by job demands that are so great that they are even more significant than workers' abilities. The company has a large production target, so workers are required to be able to complete the production process quickly. Although assisted by machines, most of the work is still done manually, requiring high concentration. The high number of errors that occur is caused by reduced focus and

concentration of workers, which can be caused by work that is too monotonous for a long time, so it can cause workers to feel tired and bored. This workload problem can also result in a decrease in company performance if done continuously.

Suggestions that the author can give include:

a. Increase rest time
   With additional rest periods, fatigue can be minimized a little so that the increase in energy consumption until the afternoon break is not too high. And so on until working hours are over. Even though the level of energy consumption at each workstation is different, with the addition of rest hours, the amount of energy consumed by workers is slightly reduced compared to before the repair was carried out. Adding rest time also affects the fatigue felt by workers (Hidayat, Ristyowati and Putro, 2020). Adding rest time can also help workers who carry out heavy tasks and can increase the level of concentration of workers in completing their responsibilities. Short breaks done regularly are better than long breaks done only once.
b. Managing work shifts
   The division of work shifts by considering the age range of workers and implementing a rotating shift system with a short time to maintain the condition of the workers' bodies. Considering the age range of workers is done to increase the worker's accuracy.
c. Fixing the condition of the workshop
   The work environment is everything that surrounds the worker and can affect the performance and completion of the responsibilities assigned to him. One of the causes of an unsupportive work environment is the hot company environment because air temperature can affect workers' body temperature and employee performance (Herlambang, Wardani and Yuliawati, 2022). At this time, the condition of Workshop 1 has a high room temperature, so it can cause workers discomfort and disrupt the work process. Under these circumstances, workers may experience a decrease in their work output, resulting in the product being less good or optimal. So it is necessary to improve the temperature in the workshop by adding a fan.

4.CONCLUSION AND SUGGESTION

Based on the research and data processing that has been done, it can be concluded that workers in shift 2 have a heavier workload than shift 1 workers physically and mentally. In this case, working time dramatically affects the difference in the level of fatigue possessed by workers. The existence of such enormous job demands makes workers forced to be able to complete the production process quickly. Although assisted by machines, most of the work is still done manually and requires high concentration. A high number of errors occur due to reduced focus and attention of workers, which can also decrease company performance if done continuously. Corrective actions that can be taken for shift 2 workers include increasing rest time, arranging work shifts such as rolling shifts, and improving workplace workshops to make them more comfortable.

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