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Measurement of the Physiological Workload of Sorting Station Operators in A Palm Oil Processing Factory

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A B S T R A C T

One of the palm oil processing industries in Riau that has isolated entrepreneurs as part of its work. Based on the results of continuous observations using the Nordic Body Map (NBM) Questionnaire, 75% of working waste handlers experience complaints in the hands, waist, and legs. So the workload of processing operators is measured using a physiological approach in one of the palm oil processing industries in Riau. Measurements using a physiological approach are carried out objectively using the method of heart rate, energy expenditure, %CVL, and energy consumption. Based on the principles of heart rate, energy expenditure budget and %CVL, the results were found to be non-standard which requires additional improvements based on the energy expenditure budget and %CVL method.

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1. INTRODUCTION

Palm oil is a plantation commodity that has a strategic role in Indonesia's economic development. Indonesia is the largest producer of palm oil in the world, so there is a palm oil processing industry in various regions in Indonesia. Meeting product demand from consumers and the market requires the industry to work effectively and efficiently according to standards. Production targets are planned to be met precisely by the industry. However, various factors, both internal and external, can prevent the achievement of production targets. Human resources are considered one of the most important factors in an enterprise due to its role as the driving subject of all activities and policies of the organization (Souisa et al., 2023). The success of a company is determined by the quality of its human resources (Pridynafiah & Waluyo, 2024).

In the palm oil processing industry, workers are needed in various parts of the process. One of the palm oil processing industries in Riau that has a separation operator as one of its employees is an internal factor. Operators are required to perform work with the same movement repeatedly. The balance of the operator's workload will affect the quantity and quality of the work output, where the body will have a limit on the accepted workload. In the current situation, the company has never measured the physiological workload of sorting operators. Based on the results of direct observation using the Nordic Body Map Questionnaire (NBM) or body map questionnaire containing data on body parts complained of by workers (Nadila & Suryadi, 2024; Atuna & Safirin, 2023), 75% of isolation operators who work experience complaints in

the hands, waist and legs. So the workload of separation operators was measured using a physiological approach in one of the palm oil processing industries in Riau.

2. LITERATURE REVIEW

Workload is the work tasks and responsibilities that need to be completed by a company or organization in a certain period of time(Vanny Rahmayeni et al., 2023). The workload received by an employee should be appropriate to his ability. Several negative impacts can occur if the workload exceeds the employee's physical and mental capacity, including work fatigue and employee health problems (Euis Nina Saparina Yuliani et al., 2021). The physical work factor greatly determines the amount of production, so that the production process remains optimal, a balance is needed between expenditure and recovery of energy. Fatigue can be divided into two, the first is physiological fatigue, which is fatigue that arises as a result of changes in the body. Second, psychological fatigue is fatigue that arises as a result of mental workload such as stress, psychological disorders, or stress resulting in psychological disorders (Hidayat et al., 2020) and affects employee performance (Cahyo Kuncoroyekti & Yuniawan, 2024)(Souisa et al., 2023).

Measuring the workload of a job is very important, especially to know how light the workload can be accepted by the working body. Measuring workload can be done using a physiological approach to measure physical workload and a psychological approach to measure mental workload (Yuliani et al., 2021). Workload measurement has been done with various motorcycle taxis, such as for entrepreneurs or workers in the tofu manufacturing process (Fathimahhayati et al., 2019), CPO and kernel production (Moh. Alyafi Dg. Matiro et al., 2021), PT. Semen Padang (Putri & Arfan Bakhtiar, 2023), the powdered rubber industry in West Sumatra (Sitorus et al., 2023), a basket dimpled restaurant (Hudaningsih *et al*., 2022), UKM Macaroni and DO' A Crackers IBU (Shakty Adhea Aditya et al., 2022), cassava chips processing business in Bogor (Oktaviani et al., 2021), Sports Station Plaza Surabaya (Baihaqi & Suryadi, 2024).

Measurements using a physiological approach can be carried out objectively or subjectively. Objectively, the method can be used: (a) Pulse or Heart Rate. Used to measure a person's dynamic workload as a manifestation of muscle movement. The greater the muscle activity, the greater the fluctuation in heart rate movement, and vice versa (Rahayu, 2020), (b) HR Reverse (HRR%), (c) %CVL, (d) Energy consumption. The oxygen used by a person is affected by the intensity of the work carried out. Specifically, oxygen consumption can be compared to physical work capacity (Rahayu, 2020). Subjective measurement can use the Borg CR 10 scale as a method. Measurement using a psychological approach can be done subjectively using SWAT and NASA-TLX analysis methods (Yuliani et al., 2021).

3. RESEARCH METHOD

At the Sorting Station, workers select the ripe fruit received before entering the Loading Ramp to determine the quality of the fresh fruit bunches to be processed and the production results. The separation process is carried out with a punching tool. A flow diagram of the research can be seen in Figure 1. The total number of employees is 4 people with working hours from 07:00 WIB to 18:00 WIB, where testing is done with the following criteria: (a) The operator is between 40 - 51 years old, (b) The operator is in good health and does not have any acute (congenital) disease, (c) Measurements are performed 3 times in 1 day for 2 days.

Measurements using a physiological approach are carried out objectively using the following methods:

a) Heart Rate

Measurement of physical workload using the 10-beat method by finding heart rate data before work and after work in the morning and evening using a stopwatch. With this method, heart rate can be calculated as follows (Basri & Suseno, 2023):

$$\frac{\Sigma\, Heart\ Rate}{10} \quad \text{.....(1)}$$

Then a comparison will be made between the standard level of physical workload based on heart rate and estimated energy expenditure.

EE = G (-55,0969 + 0,6309HR + 0,1988W + 0,2017A) + (1-G) x (20,4022+0,4472HR – 0,1263 x W + 0,074A)……....(2)

EE = Energy expenditure (kj/ minute)
G = Gender (Male = 1, Female = 2)
HR = Heart rate while working (beats/minute)
W = Weight (kg)
A = Age (years)

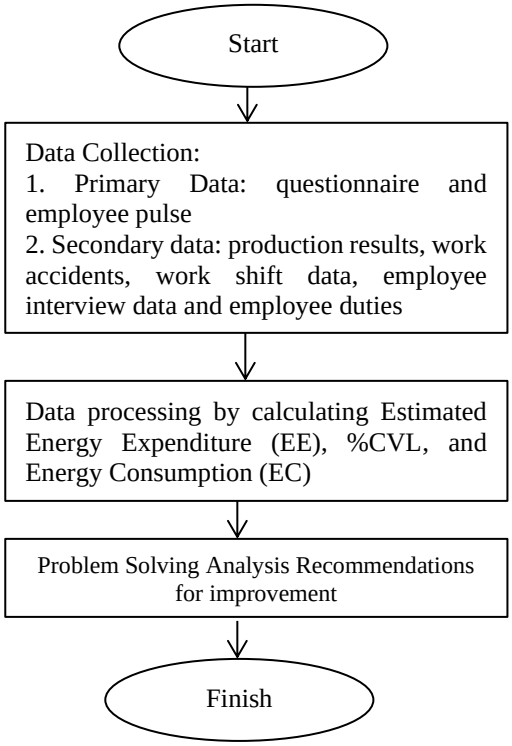

Figure 1. Research methodology flow diagram

b) %CVL
Cardiovascular Load (CVL) is determined by measuring the pulse. Calculation of Cardiovascular Load = %CVL value calculated using the following formula (Melliya et al., 2023)(Baihaqi & Suryadi, 2024):

$$\frac{100\ (\text{working pulse} - \text{resting pulse})}{(\text{Maximum Heart Rate} - \text{resting pulse})} \text{……..……..(3)}$$

Where the maximum heart rate calculation is (Muzakiki et al., 2023):
Male = 220 – Age
Female = 200 – Age

From the results of the CVL % calculation, it is then compared with the classification that has been determined as follows:

Table 1. Workload Classification Based on CVL %

% CVL	CVL % classification
<30%	No Fatigue Happens
30% - 60%	Repair Needed
60% - 80%	Work in Short Time
80% - 100%	Immediate Action Required
>100%	Activities are not allowed

Sumber : (Akbar et al., 2021)

c) Energy consumption
In determining energy consumption, a form of relationship between energy and pulse rate is usually used, which is a quadratic regression equation as follows (Sitorus et al., 2023):

$$Y = 1.80411 - 0.0229038\ X + 4.71733\ .10^{-4}\ .\ X^2 \text{……(4)}$$

Y = Energy (Kkal / menit)
X = Heart rate/pulse (beats/minute)

The form of the energy consumption equation is derived from the difference in energy spent during work and during rest with the following equation:

KE = Et – Ei……...…..(5)

KE = Energy consumption during certain work (Kkal/minute)
Et = Energy expenditure in a certain period of work (Kkal/minute)
Ei = Energy expenditure at rest (Kkal/minute)

The results of Et, Ei and KE are sought for energy consumption in the morning, afternoon and evening, to find the average over a 1-day work period. Where the results obtained show the level of work or physical load experienced by the operator.

4. RESULT AND DISCUSSION

Based on the heart rate calculation time data using a stopwatch that was carried out for two days, the operator's heart rate data (beats/minute) can be known after being processed using the 10-beat method, as can be seen in the following Table 2.

Table 2. Operator physical parameter data

Operator	Data	Heart Rate	Day (beats/minute)		Average
			1	2	
1	Morning	Before	61	66	63,5
		After	115	111	113
	Afternoon	Before	64	65	64,5
		After	122	133	127,5
	Evening	Before	64	67	65,5
		After	118	109	113,5
2	Morning	Before	63	61	62
		After	122	128	125
	Afternoon	Before	65	68	66,5
		After	113	136	124,5
	Evening	Before	69	71	70
		After	111	122	116,5
3	Morning	Before	68	63	65,5
		After	120	122	121
	Afternoon	Before	63	77	70
		After	107	118	112,5
	Evening	Before	77	67	72
		After	107	115	111
4	Morning	Before	63	67	65
		After	139	128	133,5
	Afternoon	Before	61	66	63,5
		After	122	109	115,5
	Evening	Before	65	70	67,5
		After	113	102	107,5

(Source: Processed data, 2023)

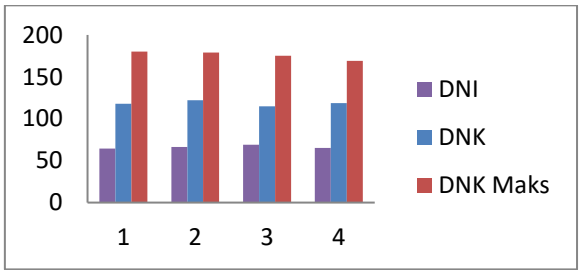

Figure 2. Recapitulation of sorting operators' heart rate while working (Source: Processed data, 2023)

DNI = Resting Heart Rate
DNK = Working Heart Rate
DNK $_{Maks}$ = Maximum Working Heart Rate

Based on Figure 2, it is known that the working pulse rate is at a medium workload level which is 100-125 beats/minute (Ariq Adhari Basri & Agustian Suseno, 2023).

Table 3. Recapitulation of energy expenditure estimates-EE

Operator	Energy Expenditure Estimates (EE) (Kcal/minute)		
	Morning	Afternoon	Evening
1	8,41	10,59	8,48
2	11,26	11,19	9,98
3	10,09	8,81	8,58
4	12,98	10,26	9,06
Average	**10.68**	**10.21**	**9,02**

(Source: Processed data, 2023)

Based on Table 3, the highest average value is in the morning, because more trucks containing fresh fruit bunches arrive at the same time so that more fresh fruit bunches are arranged and more energy is spent. When referring to the level of workload, the range of 10.00 – 12.5 falls into the category of very heavy workload. So improvements need to be made at that time by adding operators, especially in the sorting section.

Table 4. Recapitulation of %CVL

Operator	Average DNI	Average DNK	% CVL	Average of % CVL
1	64,5	118	46,32	**47,63**
2	66,16	122	49,48	
3	69,16	114,83	43,15	
4	65,33	118,83	51,60	

(Source: Processed data, 2023)

Based on table 4, the average %CVL value of 4 operators is 47.63% with %CVL classification needing improvement.

Table 5. Recapitulation of energy consumption calculations

Operator	Energy Consumption (Kkal/menit)			Average of EC
	Morning	Afternoon	Evening	
1	2,98	4,27	2,96	3,40
2	4,12	3,9	3,02	3,68
3	3,61	2,68	2,47	2,92
4	4,85	3,2	2,39	3,48
Average	**3,89**	**3,51**	**2,71**	**3,37**

(Source: Processed data, 2023)

Based on table 5, the average energy consumption is 3.37 Kcal/minute for male workers which is in standard conditions which is 5 kcal/minute. This is due to work carried out in groups and using rest time optimally.

5. CONCLUSION

Based on the method of heart rate, estimated energy expenditure and %CVL, it was found that the results did not meet the standards that required improvement based on the estimated method of energy expenditure and %CVL. Repairs can be done in various ways such as: (1) The addition of operators for morning hours or improvements in workload distribution, (2) Reduction of the distance to lift with a better layout of the station, (3) Use material handling as needed, (4) Training related to work instructions applicable at the isolation station.

This is done to reduce the risk of complaints to the operator. After implementing the improvement proposal, the evaluation of the improvement proposal can be implemented as a form of improving the quality of the operator's work.

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