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ANALYSIS OF THE PHYSICAL WORKLOAD OF SUGARCANE HARVEST WORKERS AS THE BASIS FOR DETERMINING THE LENGTH OF REST BREAK AT BONE ARASOE SUGAR FACTORY

Irma Nur Afiah[1], Dinda Dwi Adelya Musda[1], Dirgahayu Lantara[1], Arfandi Ahmad[1]
Jurusan Teknik Industri, Fakultas Teknologi Industri, Universitas Muslim Indonesia, Makassar, Indonesia
afiah.irma@umi.ac.id

ABSTRACT

Arasoe Bone Sugar Factory is one of the sugar factories in Bone Regency, South Sulawesi. The production process at this company entirely uses machines that run automatically. However, the sugarcane harvesting activity is still carried out manually. All sugarcane harvesting activities result in physical workload on workers, especially when lifting sugarcane since in one loading, the workers are able to lift more than 30 kg of sugarcane. This activity is carried out repeatedly which results in fatigue on the harvest workers. The other factors that affect fatigue on the harvest workers are the harvested sugarcane plantations that can reach approximately 7 hectares in area and the work that lasts for 7 hours each day. This study aims to determine how much physical workload is experienced by sugarcane harvest workers and to determine how long the rest break is based on the physical workload that is obtained while working for the sugarcane harvest workers. The assessment of physical workload was carried out using the Cardiovascular Load (%CVL) method and the calculation of the length of rest break was carried out using a physiological approach. Based on the results of calculating the percentage of Cardiovascular Load (%CVL), it was discovered that all respondents experienced fatigue consisting of 5 workers with a %CVL of ≤60%, 13 people with %CVL of ≤80%, and 2 people with %CVL of ≤100%. Therefore, all respondents were included into the category of heavy physical workload. The optimal rest break is 80.79 minutes, while the rest break given is only 60 minutes. Hence, an additional 20.79 minutes of rest break is needed. The rest break of 20.79 minutes is used for spontaneous breaks, i.e., short break after the workload.

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Universitas Muslim Indonesia
Address :
Jl. Urip Sumoharjo Km. 5 (Kampus II UMI)
Makassar Sulawesi Selatan.
Email :
Jiem@umi.ac.id
Phone :
+6281341717729
+6281247526640

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I. INTRODUCTION

Bone Arasoe Sugar Factory is one of the sugar factories in Bone Regency, South Sulawesi. The production process in this company entirely uses machines that run automatically. However, the sugarcane harvesting activities are still carried out manually. All of these harvesting activities result in physical workload on the workers, especially when lifting sugarcane. In one loading, the workers are able to lift more than 30 kg. Consequently, this also causes workers to experience fatigue because they work more than the recommended limit from the company. In addition, the area of the harvested sugar cane can reach approximately 7 hectares and the sugarcane harvest workers work for 7 hours each day.

Physical workload is the workload received by the physical of workers who carried out their work by relying solely on physical activity which will result in physical changes to the function of the organs of the body (Dewi et al., 2017). Physical workload of a person can be observed from the physiological approach where the severity of the load experienced will be evaluated when one is working on his physical work capacity (Lubis, 2020). Physical work is the work that requires physical energy in human muscles which will function as a source of energy. Physical work is also called "manual operation" where work performance will completely depend on human effort which acts as the source of energy and energy controller (Tarwaka, 2014).

The energy recovery factor is very important to note because fatigue occurs during the work process. One of the causes of this is physiological fatigue. What is meant by physiological fatigue is the fatigue that arises due to changes in the physiology of human body. Changes in the physiology of human body from a fresh condition to being tired will affect the optimal performance of workers. One of the factors that affect energy recovery is rest. Workers who carry out heavy workloads certainly need periods and frequencies that are different from workers who perform light workloads. Therefore, the length of rest break that is not equivalent with the workload given will cause workers to be in conditions that are not optimal (Zulfanuddin, 2012).

Fatigue is the tiredness that occurs in the nerves of the human muscles so that they can no longer function as they should. The heavier the work load and the more irregular the movement, the faster the fatigue will occur. The emergence of this fatigue needs to be studied to determine the level of human muscle strength so that the work to be performed or charged can be in accordance with the capabilities of these muscles. Fatigue arises after carrying out work. The human body cannot work continuously. Therefore, rest break is necessitated to refresh workers' conditions (Susanti et al., 2015).

The function of the human body can be viewed as a rhythmic balance between energy needs (work) and replacement of the amount of energy that has been used (rest break). Both of these processes are an integral part of the work of the muscles, the work of the heart, and the whole biological function of the body. Thus, it is clear that to maintain work performance and efficiency, sufficient rest break must be provided, both during working hours and outside working hours (Grandjean, 1993).

There are four types of rest break taken by workers during working hours, i.e., spontaneous break, stolen break, work-related break, and officially stipulated break.

1. Spontaneous breaks are short breaks immediately after the workload.
2. Stolen breaks are breaks that occur when the workload cannot be matched by work ability. This type of break occurs when the workload, both physical and mental, is greater than the work capacity, causing the body reaction to overcome the overload.
3. Work-related break occurs because the work process depends on working machines, equipment, or work procedures.
4. Officially stipulated break is a break based on statutory provisions, such as a 1-hour break after 4 hours of work, interspersed with a 15-minute break after 2 hours of work.

In reality, the four types of rest break show interrelationships between one and the others (Tarwaka et al., 2004).

Cardiovascular Load (%CVL) is used to determine physical workload by measuring the heart rate. One of the tools utilized to measure the heart rate is an oximeter. A person's heart rate is influenced by various factors including normal or

abnormal conditions and physical activity which can be observed after checking the heart rate (Lubis and Siregar, 2017). The sensitivity of the heart rate to changes in the loading received by the body is quite high. The heart rate will immediately change in rhythm with the change in loading. The calculation is in accordance with an increase in working heart rate compared to the maximum heart rate (Tarwaka,2015).

The following is the classification of the severity of the workload based on %CVL

%CVL	%CVL Classification
≤ 30%	Fatigue does not occur in workers.
30% < %CVL ≤ 60%	Recovery is required but not urgent.
60% < %CVL ≤ 80%	Workers are allowed to work in a short time.
80% < %CVL ≤ 100%	Immediate recovery action is required.
%CVL > 100%	Work activities must not be carried out.

Source: Iridiastadi dan Yassierli, 2014

II. RESEARCH METHODS

2.1 Place and Time of Research

This research was conducted in the sugarcane plantation of the Bone Arasoe Sugar Factory located in Arasoe Village, Cina District, Bone Regency. This research started from 4 December 2021 to 4 January 2022.

2.2 Data collection

2.2.1 Data Primer

The primary data was data obtained directly from observations at research locations. The data is in the form of working heart rate data, resting heart rate data, and age of workers.

2.2.2 Secondary Data

The secondary data was data obtained through literature studies, reports related to research objects, and quantitative documentation related to research objects.

2.3 Data processing

The data processing carried out in this study is as follows:

1. Calculation of Physical Workload (Cardiovascular Load)

   Cardiovascular Load (%CVL) is an estimate to determine the classification of physical workload based on the increase in working heart rate compared to the maximum heart rate.

$$\%CVL = \frac{100 \text{ X } (\text{Working Heart Rate} - \text{Resting Heart Rate})}{\text{Maximum Heart Rate} - \text{Resting Heart Rate}} \quad \ldots\ldots(1)$$

Where:

Maximum heart rate for female is (200-umur)

Maximum heart rate for male is (220-umur)

2. Calculation of Energy Consumption

   In determining the energy consumption, a relationship between energy and heart rate is usually employed, i.e., a quadratic regression equation, as follows:

$$E = 1{,}804110 - 0229038X + 4{,}71733x10^{-4}(X)^2 \quad \ldots\ldots(2)$$

Where:

E = Energy (Kcal/minute)

X = heart rate/pulse rate (beats/minute)

After carrying out the calculations above, the energy consumption can be calculates using the following equation:

$$K = Et - Ei \quad \ldots\ldots(3)$$

Where:

K : Energy consumption (kilocalories/minute)

Et : Energy expenditure at a certain time of work (kilocalories/minute)

Ei : Energy expenditure at the time before work

3. Determination of the Length of Rest Break (Physiology)

   Next, energy consumption is converted into rest break requirements using the Murrel equation as follows:

$$Rt = 0 \quad \text{Untuk } K<S \quad \ldots\ldots(4)$$

$$Rt = \frac{\frac{K}{S} - 1\, x\, 100 + \frac{T\,(K-S)}{K-BM}}{2} \quad \text{UntukS<K<2S} \quad \ldots\ldots(5)$$

$$Rt = \frac{T\,(K.S)}{K.BM} \text{ x } 1.11 \quad \text{Untuk } K>2S \ldots\ldots$$

……..…...…(6)

Where:

Rt : Break Time

K : Energy expenditure during work

S : Standard energy expenditure (men = 5 kcal/minute, women = 4 kcal/minute)

BM: Basal metabolism (male = 1.2 kcal/minute, female = 1.4 kcal/minute)

T : Length of Work (minutes)

III. RESULTS AND DISCUSSION

3.1 Heart Rate/Pulse

The data taken in this study were data measuring the resting heart rate, the working heart rate, and the age of sugarcane harvest workers. The taking or measurement of the resting heart rate was carried out twice, i.e., before starting the work at 07.00 WITA and during the lunch break at 12.30 WITA. The data on the resting heart rate of sugarcane harvest workers can be observed in Table 1. Meanwhile, the taking or measurement of the working heart rate was carried out on when workers did their work at 08.00, 09.00, 10.00, 11.00, 13.15, 14.00 and 14.50 WITA. The data on the work heart rate of sugarcane harvest workers can be observed in Table 2.

Table 1. Resting Heart Rate of Sugarcane Harvest Workers

No	Name	Age	Gender	Resting Heart Rate (Beats/Minute)		Average Resting Heart Rate
				07.00 WITA	12.30 WITA	
1	Ansar	50	M	61	65	63.00
2	Mansur	47	M	69	73	71.00
3	Sanudin	35	M	61	70	65.50
4	Harun	56	M	62	65	63.50
5	Ambo	68	M	65	77	71.00
6	Anto	35	M	62	66	64.00
7	Lansi	45	F	73	65	69.00
8	Jumaru	46	F	74	69	71.50
9	Indah	45	F	62	69	65.50
10	Sariani	30	F	64	72	68.00
11	Marni	44	F	77	69	73.00
12	Ida	57	F	73	79	76.00
13	Ghina	45	F	71	65	68.00
14	Salmiah Fitri	41	F	65	72	68.50
15	Juliana	44	F	78	70	74.00
16	Samsida	40	F	75	70	72.50
17	Salma	32	F	65	71	68.00
18	Sidar	50	F	71	74	72.50
19	Sumarni	46	F	79	68	73.50
20	Hasniati	31	F	73	67	70.00

Table 2. Working Heart Rate of Sugarcane Harvest Workers

No	Working Heart Rate (Beats/Minute)							Average Working Heart Rate
	08.00 WITA	09.00 WITA	10.00 WITA	11.00 WITA	13.15 WITA	14.00 WITA	14.50 WITA	
1	118	131	138	149	125	139	150	135.71
2	129	130	142	148	134	144	138	137.86
3	117	128	139	149	130	145	148	136.57
4	116	125	136	148	139	145	149	136.86
5	120	140	138	155	133	142	150	139.71
6	114	130	144	145	130	136	148	135.29
7	111	126	129	135	120	132	138	127.29
8	101	122	134	142	131	130	145	129.29
9	105	122	139	130	127	129	135	126.71
10	108	124	130	137	119	127	140	126.43
11	115	122	135	138	125	132	140	129.57
12	118	136	145	150	123	127	138	133.86
13	110	125	128	136	126	135	130	127.14
14	112	121	127	135	129	138	134	128.00
15	105	129	138	143	118	126	145	129.14
16	100	122	136	145	121	132	149	129.29
17	103	117	140	128	125	133	144	127.14
18	110	126	135	139	129	138	141	131.14
19	106	124	141	147	119	132	139	129.71
20	112	129	132	140	120	128	136	128.14

The taking of heart rate data was obtained by using an oximeter. There are two heart rate data collection times, i.e., resting heart rate and working heart rate. The taking the resting heart rate was carried out twice, i.e., before the work and during the lunch break. The taking of working heart rate was performed when workers did their work. Based on Table 1, the average resting heart rate of sugarcane harvest workers is still in the normal category, i.e., 60-100 per minute. This is because during the rest break, the workers have recovered their energy by resting, eating and not doing strenuous activities such as working. Based on Table 2, the average working heart rate has increased outside the normal category, which ranges from 120-150 per minute. This occurs due to various factors, including the age factor and workload while working factor.

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According to a research by Mei (2010), it was mentioned that age greatly influences the increase in heart rate because the older the age, the lower the ability of the organs, causing the workers to get tired easier and increased heart rate. Apart from getting older, the increase in heart rate is also influenced by a workload that is too high. Hence, the workers will tend to experience an increase in heart rate more quickly. The heart rate will immediately change in harmony with changes in the workload, including from mechanical, physical and chemical workload (Lubis and Siregar, 2017).

3.2 Calculation of Physical Workload Based on Cardiovascular Load (%CVL)

After calculating the average resting heart rate and working heart rate of sugarcane harvest workers, the %CVL percentage was calculated as displayed in Table 3

Table 3. %CVL Percentage Calculation Results

No	Name	Age	Gender	%CVL	Description
1	Ansar	50	M	67.95%	Workers are allowed to work in a short time.
2	Mansur	47	M	65.55%	Workers are allowed to work in a short time.
3	Sanudin	35	M	59.47%	Recovery is required but not urgent.
4	Harun	56	M	73.00%	Workers are allowed to work in a short time.
5	Ambo	68	M	84.83%	Immediate recovery action is required.
6	Anto	35	M	58.92%	Recovery is required but not urgent.
7	Lansi	45	F	67.78%	Workers are allowed to work in a short time.
8	Jumaru	46	F	70.05%	Workers are allowed to work in a short time.
9	Indah	45	F	68.39%	Workers are allowed to work in a short time.
10	Sariani	30	F	57.28%	Recovery is required but not urgent.
11	Marni	44	F	68.16%	Workers are allowed to work in a short time.
12	Ida	57	F	86.36%	Immediate recovery action is required.
13	Ghina	45	F	67.98%	Workers are allowed to work in a short time.
14	Salmiah Fitri	41	F	65.75%	Workers are allowed to work in a short time.
15	Juliana	44	F	67.24%	Workers are allowed to work in a short time.
16	Samsida	40	F	64.90%	Workers are allowed to work in a short time.
17	Salma	32	F	59.14%	Recovery is required but not urgent.
18	Sidar	50	F	75.66%	Workers are allowed to work in a short time.
19	Sumarni	46	F	69.83%	Workers are allowed to work in a short time.
20	Hasniati	31	F	58.73%	Recovery is required but not urgent.
Average				67.84%	Workers are allowed to work in a short time.

Based on the results of calculating the percentage of Cardiovascular Load (%CVL) that has been carried out on 20 respondents which can be observed in Table 3, there were 5 people with %CVL of ≤60% with the %CVL classification of requiring recovery but not urgent, 13 people with %CVL of ≤80% with the %CVL classification of allowed to work in a short time, and 2 people with %CVL of ≤100 % with %CVL classification of requiring immediate recovery action. The average physical workload of sugarcane harvest workers

results in %CVL of ≤80% with %CVL classification of allowed to work in a short time.

This result occurs entirely due to the hot work environment because working in an open space, i.e., the sugarcane plantation which is directly exposed to sunlight. The age factor also affects the physical workload because among the 20 respondents, there were 5 people with a %CVL of ≤60% the age range of whom was between 30-35 years old, 13 people with %CVL ≤80% the age range of whom was between 40-56 years old, and 2 people with %CVL ≤100% the age range of whom was between 57-68 years old. Every day, the workers do their work while standing so that the physical activity they do feels heavy. Moreover, a lot of the work is carried out manually, starting from cutting the sugarcane, cleaning the sugarcane, and lifting the sugarcane that weighs more than 30 kg at a time to be collected, and this work is performed repeatedly.

3.3 Calculation of Energy Consumption

Before calculating the energy consumption, calculation of the working heart rate and resting heart rate is carried out, which are equated in the form of energy. The calculation results can be observed in Table 4.

Table 4. Calculation Results of the Resting Heart Rate and Working Heart Rate Equated in the Form of Energy

No	Name	Age (Year)	Gender	EDNK/Et (kcal/min)	EDNI/Ei (kcal/min)
1	Ansar	50	M	7,384	2,233
2	Mansur	47	M	7,612	2,556
3	Sanudin	35	M	7,475	2,328
4	Harun	56	M	7,505	2,252
5	Ambo	68	M	7,812	2,556
6	Anto	35	M	7,340	2,270
7	Lansi	45	F	6,532	2,470
8	Jumaru	46	F	6,728	2,578
9	Indah	45	F	6,476	2,328
10	Sariani	30	F	6,449	2,428
11	Marni	44	F	6,756	2,646
12	Ida	57	F	7,191	2,788
13	Ghina	45	F	6,517	2,428
14	Salmiah Fitri	41	F	6,601	2,449
15	Juliana	44	F	6,713	2,692
16	Samsida	40	F	6,728	2,623
17	Salma	32	F	6,517	2,428
18	Sidar	50	F	6,913	2,623
19	Sumarni	46	F	6,770	2,669
20	Hasniati	31	F	6615	2,512

After calculating the working heart rate and resting heart rate which are equalized in the form of energy, the sugarcane harvest workers' energy consumption is calculated. The calculation results can be observed in Table 5.

Table 5. Energy Consumption Calculation Results

No	Name	Age (Years)	Gender	Energy Consumption (kcal/min)
1	Ansar	50	M	5,151
2	Mansur	47	M	5,056
3	Sanudin	35	M	5,147
4	Harun	56	M	5,253

5	Ambo	68	M	5,256
6	Anto	35	M	5,070
7	Lansi	45	F	4,062
8	Jumaru	46	F	4,150
9	Indah	45	F	4,148
10	Sariani	30	F	4,021
11	Marni	44	F	4,110
12	Ida	57	F	4,403
13	Ghina	45	F	4,089
14	Salmiah Fitri	41	F	4,152
15	Juliana	44	F	4,021
16	Samsida	40	F	4,105
17	Salma	32	F	4,089
18	Sidar	50	F	4,290
19	Sumarni	46	F	4,101
20	Hasniati	31	F	4,103

Based on the results of energy consumption calculations that can be observed in Table 5, the energy consumption of all respondents exceeds the standard energy expenditure for men (5 kcal/minute) and for women (4 kcal/minute). The reason is that the amount of energy expenditure is still greater than the amount of energy input from food. The calories contained in the food consumed by workers cannot meet the energy needs expended by workers while working.

Kartasapoetra and Marsetyo (2010) stated that energy is needed by the body for the continuity of blood circulation, breathing, heart rate, and other physiological processes. Energy in the body arises from the burning of carbohydrates, proteins, and fats. Energy balance is achieved when the energy that enters the body through food is the same as the energy released (Almatsier, 2016).

3.4 Determination of the Length of Rest Break

After calculating the energy consumption, energy consumption is then converted into rest break requirements by using the Murrel equation. The length of rest break is 7 hours which is then converted into 420 minutes and with existing rest break of 60 minutes. The results of calculating the length of rest break can be observed in Table 6

Table 6. Calculation Results for Additional Rest Break and Total Rest Break Requirement

No	Name	Age (Years)	Gender	Additional Time (Minutes)	Total Rest Requirement (Minutes)
1	Ansar	50	M	17.81	77.81
2	Mansur	47	M	6.77	66.77
3	Sanudin	35	M	17.36	77.36
4	Harun	56	M	29.10	89.10
5	Ambo	68	M	29.42	89.42
6	Anto	35	M	8.43	68.43
7	Lansi	45	F	10.85	70.85
8	Jumaru	46	F	25.42	85.42
9	Indah	45	F	25.10	85.10
10	Sariani	30	F	3.73	63.73
11	Marni	44	F	18.92	78.92
12	Ida	57	F	62.56	122.56
13	Ghina	45	F	15.43	75.43

14	Salmiah Fitri	41	F	25.74	85.74
15	Juliana	44	F	3.73	63.73
16	Samsida	40	F	18.09	78.09
17	Salma	32	F	15.43	75.43
18	Sidar	50	F	46.78	106.78
19	Sumarni	46	F	17.43	77.43
20	Hasniati	31	F	17.76	77.76
		Average		20.79	80.79

According to the research by Syamsul et al (2012, it was mentioned that the amount of rest break needed by workers to recover their physical condition is different for each worker. This can be seen from the working heart rate because the faster the heart rate of the worker, the greater the rest time needed.

The result can be observed in Table 6 that the rest break for each worker is different. The rest break provided by the company is between 12.00-13.00 for lunch, so the rest time provided by the company is 1 hour. Determination of the length of rest break by calculating the energy consumption required during work which is converted into the need for rest break discovers that it is necessary to increase the rest break because the energy consumption value of all respondents is greater than the S value, i.e., the energy expended during work is greater than the standard value of energy released by men (5 kcal/minute) and women (4 kcal/minute). This means that the current rest break which is 1 hour or 60 minutes is not sufficient. Therefore, it needs additional rest break. Each respondent has a different additional rest time, but on average, the workers need an additional 20.79 minutes. Hence, the total rest break that should be applied is 80.79 minutes. The additional rest break for 20.79 minutes is used for spontaneous breaks, i.e., short breaks after the workload. After cleaning the sugarcane, the workers manually lift the sugarcane weighing more than 30 kg. Then, after laying the sugarcane, the workers will take a short break to recharge the loss of oxygen that has been used when cleaning and lifting the sugarcane.

IV. Conclusions And Recommendations

4.1 Conclusion

According to the results of data processing and data analysis that has been carried out, it can be concluded that:

1. Based on the results of calculating the percentage of Cardiovascular Load (%CVL) from 20 respondents, there were 5 people with %CVL of ≤ 60% with the %CVL classification of requiring recovery but not urgent, 13 people with %CVL of ≤ 80% with the %CVL classification of allowed to work in a short time, and 2 people with %CVL of ≤ 100% with %CVL classification of requiring immediate corrective action. With an average physical workload of 67.84% and %CVL of ≤ 80% with the %CVL classification of allowed to work in a short time, the work is included in the category of heavy physical workload because it is less than %CVL of ≤ 30%.
2. Based on the physiological approach to determination of the length of rest break by calculating the energy consumption required during work which is converted into rest break requirements, the optimal rest break is 80.79 minutes while the rest break provided is 60 minutes. Hence, an additional 20.79 minutes of rest break is needed from the 60 minutes of rest before calculation based on the workload and energy consumption of workers. The rest time for 20.79 minutes is used for spontaneous breaks, i.e., short breaks after the workload. After cleaning the sugarcane, the workers manually lift the sugarcane weighing more than 30 kg. Then, after laying the sugarcane, the workers will take a short break to recharge the loss of oxygen that has been used when cleaning and lifting the sugarcane.

4.2 Recommendation

In accordance with the results of the conclusions above, the writer proposes an advice that it is necessary to take a rest break even for a short time outside the usual rest hours. This is necessary to carry out so that the workers can recover their energy and have more concentration to improve their work results.

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