JOURNAL LA MEDIHEALTICO

VOL. 06, ISSUE 05 (1337-1351), 2025
DOI: 10.37899/journallamedihealtico.v6i5.2294

Analysis of Physical Workload and Work Fatigue Among Irrigation and Fertilization Workers using Physiological Methods and the Swedish Occupational Fatigue Index

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Article Info

Article history:
Received 21 August 2025
Received in revised form 24 September 2025
Accepted 30 November 2025

Keywords:
Work Fatigue
Physical Endurance
Fresh Fruit Bunches (FFB)
Swedish Occupational Fatigue
Workload Management

Abstract

Work fatigue is a decline in quality, efficiency, and physical endurance in completing tasks. High workloads can lead to increased fatigue among workers at PT. Simpang Kiri Plantation Indonesia, which operates in the palm oil plantation sector. This study aims to analyze the level of fatigue experienced by workers involved in loading Fresh Fruit Bunches (FFB) using physiological methods and the Swedish Occupational Fatigue Index (SOFI).Workers are required to perform under demanding physical conditions, with an average lifting load of 15-30 kg per load. The analysis results indicate that the workers' fatigue level falls within the moderate category, with a percentage of 100%. The highest dimension of fatigue is found in sleepiness, with a score of 10, followed by physical exertion with a score of 6.5. Additionally, lack of motivation and physical discomfort each have scores of 6.5 and 5.8, respectively, while lack of energy is recorded at the lowest value of 5.5.These findings provide important insights for improving work techniques and managing workloads within the company, as well as serving as a reference for further research aimed at reducing work fatigue.

Introduction

The plantation industry in the Indonesian archipelago began to develop in the form of large-scale plantation enterprises in the early 19th century. Oil palm cultivation in Indonesia was initiated in 1848, when four oil palm seeds were brought from Mauritius and the Hortus Botanicus, Amsterdam, the Netherlands, to the Bogor Botanical Gardens (Adam, 2020; Purba & Isa, 2024). These four seeds thrived in the Bogor Botanical Gardens and grew into the oldest oil palm trees in Southeast Asia. In 1875, oil palm seeds were distributed to Sumatra to be planted as ornamental plants along the roadsides (Luke et al., 2019; Suryaningsih et al., 2023). The expansion of plantation enterprises during that period stimulated the opening of new remote areas, the development of public facilities and infrastructure, as well as colonization. Over time, plantations underwent modernization through the implementation of improved management systems and the application of various technologies in both cultivation practices and processing activities (Hayami, 2010; Altieri, 2002; Vaintrub et al., 2021; Sharma et al., 2022; Ye, 2015).

The palm oil plantation sector not only makes a significant contribution to the national economy but also absorbs a substantial amount of labor (Syahza, 2019; Hirawan, 2011; Basiron, 2007; Obidzinski et al., 2014; Ayompe et al., 2021). The development of the palm oil

ISSN 2721-1215 (Print), ISSN 2721-1231 (Online)

industry in Indonesia has increased the demand for workers with good physical strength to operate optimally. Operational activities in palm oil plantations are characterized by high physical workloads, with one of the most demanding tasks being the loading of fruit (Ng et al., 2013; Escallón-Barrios et al., 2022; Asnan et al., 2024; Thaddeus et al., 2023; Asnan et al., 2024; Lesmana et al., 2025). This involves transferring Fresh Fruit Bunches (FFB) from the Collection Point (TPH) to transport trucks, where workers must lift and move fresh bunches weighing an average of 15-30 kg or more repeatedly in hot and humid working conditions, often on uneven terrain. These conditions can lead to excessive physical workloads and trigger work fatigue (MacDonald, 2003; Fan & Smith, 2017; Rose et al., 2017; Berek et al., 2022; Xiong et al., 2024; Souchet et al., 2023; Abbaszadeh et al., 2025). Excessive work fatigue can result in decreased productivity among workers (Ricci et al., 2007; Lestari et al., 2024; Yogisutanti et al., 2020; Lerman et al., 2012; Rahmasari et al., 2024; O'Neill & Panuwatwanich, 2013; Supriyadi et al., 2025).

Among the subsidiaries of PT. Evans Indonesia is PT. Simpang Kiri Plantation Indonesia (PT. SKPI), located in the villages of Simpang Kiri and Tenggulun in the Tenggulun District, as well as in the Rongoh Village of the Tamiang Hulu District, Aceh Tamiang Regency, Aceh Province. The Simpang Kiri plantation cultivates oil palm, with the Fresh Fruit Bunches (TBS) being delivered to third parties. PT. Simpang Kiri Plantation Indonesia consists of five divisions, all of which produce TBS (Fresh Fruit Bunches). As one of the oil palm plantation companies, PT. Simpang Kiri Plantation Indonesia must maintain harvest productivity while also considering the health of its workforce. The fruit loading activity requires significant physical effort and carries a high risk of fatigue. Division II operates two trucks for loading TBS, with two workers assigned to each truck. The loading process is carried out manually, using tools such as hooks or metal prongs. In a single loading session, workers can lift hundreds of bunches per day, averaging 6-7 trips per truck each day. The TBS loading activity often requires overtime, extending late into the night until 11:00 PM or taking place outside of normal working hours. This overtime typically occurs due to truck breakdowns, getting stuck on the road, or experiencing other malfunctions, and may also happen during peak harvest seasons for TBS. Such circumstances lead to extended working hours, resulting in reduced break time and increased physical burden due to repetitive tasks over prolonged periods.Based on these conditions, an analysis can be conducted by determining the level of physical workload and work fatigue using physiological methods to measure the physical workload experienced by workers, and the SOFI method to assess the level of physical work fatigue among employees. The author is interested in conducting research titled "Analysis of Physical Workload and Work Fatigue Among Workers in Irrigation and Fertilization Utilizing Physiological Methods and the Swedish Occupational Fatigue Index (SOFI) at PT. Simpang Kiri Plantation Indonesia." This study is expected to provide a realistic depiction of the levels of workload and work fatigue among workers, aiming to enhance employee productivity.

Methods

Operational Definition of Variables

Physical Workload

Physical workload is the energy expended by workers in performing tasks that require physical activity, such as lifting, carrying, and moving objects.

Work Fatigue

Work fatigue is a physical or mental condition caused by excessive or unbalanced work, which results in workers feeling tired, sluggish, and lacking the energy to perform their tasks.

Loading Workers

Loading workers are employees responsible for loading Fresh Fruit Bunches (FFB) of oil palm onto transport vehicles, such as trucks. They are responsible for ensuring that the FFB is loaded properly and efficiently, as well as maintaining the quality of the FFB during the loading process.

Method of Analysis

Physiological Method

The physiological approach is a method within the field of ergonomics that focuses on measuring energy consumption, metabolic needs, bodily function performance, and its components in job design. Dr. Lucien Brouha delineated a classification table for workload based on physiological responses according to job levels, as shown in Table 1 below:

Table 1. Workload Classification and Physiological Responses

Work Category	***Energy Expenditure***		Heart Rate (Beats/Minute)
	(Kcal/Minute)	(Kcal/8hour)	
Very Heavy	>12,5	> 6000	> 175
Extremely Heavy	10,0 12,5	4800 6000	150 175
Heavy	7,5 10,0	3600 4800	125 150
Moderate	5,0 7,5	2400 3600	100 125
Light	2,5 5,0	1200 2400	60 100
Very Light	<2,5	< 1200	< 60

Source: (Annisa and Akhiri, 2019)

The steps of data processing using the physiological method are as follows:

Measuring pulse rate before and during work

The evaluation of physiological workload experienced by a worker can be conducted by measuring heart rate. This approach is applicable considering that the greater the intensity of physical activity, the greater the cardiac workload, as indicated by an increase in heart rate. Heart rate can be used to estimate an individual's physical condition or level of physical fitness. Heart rate measurement is an objective method and relatively easy to perform. The measurement can be carried out by assessing the pulse. One manual method commonly employed involves palpating the radial artery at the wrist and using a stopwatch with the 10-beat method (Euis Nina et al., 2021).

Measuring the pulse rate is useful for assessing the worker's workload based on muscle activity. Pulse rate measurement is carried out when the worker has not yet started the activity and while the worker is performing the task. The calculation of pulse rate is as follows:

$$\text{Pulse rate} = \frac{\text{10 beats}}{\text{measurement time (seconds)}} \times 60$$

Calculation of Caloric Needs

The requirement for calories in the combustion of substances to produce energy is one of the primary needs in muscle movement. Thus, the amount of calories utilized by the body during work serves as an indicator of workload throughout the activity. Consequently, every task requires energy derived from the combustion process. The greater the energy expended, the heavier the work performed will be (Celsa et al., 2021). Data processing of pulse rate through direct measurement methods is based on the calculation of energy consumption. The relationship between energy expenditure and pulse rate, according to the quadratic regression equation, is as follows:

$Y = 1{,}80411 \quad 0{,}0229038X + 4{,}71711 \times 10^{-4} X^2$

Where:

Y = Energy expenditure (Kcal/min)

X = Pulse rate (beats/min)

Caloric needs serve as an indicator required by the body during work activities. The greater the energy expended, the heavier or more demanding the work performed will be. The formula for calculating caloric needs is as follows:

CN = Caloric needs per hour × Body weight × Working hours

% CVL

The Cardiovascular Load (%CVL) method is a measurement approach for assessing physical workload based on the comparison between working heart rate and maximum heart rate. The increase in heart rate plays a crucial role in elevating cardiac output from rest to maximal work (Pusparanida Mellysa, 2021). This increase is defined as the Heart Rate Reserve (HRR).

The assessment of work load classification levels can be indirectly determined from the percentage of cardiovascular load (%CVL). The value of %CVL is calculated based on the classification level of workload derived from the increase in working heart rate compared to the maximum heart rate, using the following formula:

$$\% \text{ CVL} = \frac{(\text{Working heart rate} \quad \text{Resting heart rate})}{(\text{Maximum heart rate Maximum heart rate})} \times 100$$

The calculation of maximum heart rate is determined as follows:

Male = 220   age

Female = 200   age (Euis Nina et al., 2021)

The results of the Cardiovascular Load (%CVL) calculation are then compared with the classification presented in Table 2 as follows:

Table 2. Cardiovascular Load (%CVL) Classification

%CVL	Classification
≤ 30%	No fatigue occurs in workers
30% < %CVL ≤ 60%	Improvement is required but not urgent
60% < %CVL ≤ 80%	Work is allowed for a short duration
80% < %CVL ≤ 100%	Immediate corrective action is required
%CVL > 100%	Work activity should not be performed

Source: (Perdana, dkk, 2023)

Processing of the Swedish Occupational Fatigue Inventory (SOFI) Instrument

The SOFI method was designed by considering various indicators of fatigue, each consisting of five categories of questions (multidimensional). Ahsberg stated that multidimensional measurement of fatigue is related to the assessment of mental fatigue, physical fatigue, motivation, sleepiness, fatigue itself, and task aversion.The SOFI method measures five dimensions of fatigue, namely lack of energy, physical exertion, physical discomfort, lack of motivation, and sleepiness. Lack of Energy (LoE) represents the reduction of energy during work. The items included in the LoE dimension are: Worn out, Exhausted, Spent, Drained, and Overworked.The second dimension is Physical Exertion (PE), which is closely related to the need for physical work, particularly dynamic physical activity. The items in the PE dimension are: Sweaty, Breathing Heavily, Palpitations, Warm, and Out of Breath.The third dimension is Physical Discomfort (PD), which is strongly associated with static physical work. The items in

ISSN 2721-1215 (Print), ISSN 2721-1231 (Online)

the PD dimension are: Tense Muscles, Numbness, Stiff Joints, Hurting, and Aching.The fourth dimension is Lack of Motivation (LoM), where the items include: Indifferent, Passive, Listless, Lack of Concern, and Uninterested.The final dimension is Sleepiness (S), which is related to an individual's sleep duration. The items in the S dimension are: Drowsy, Falling Asleep, Sleepy (blurred vision due to drowsiness), Yawning, and Lazy. To identify the dimensions of the SOFI method in the questions provided to the respondents, they can be observed in Table 3 as follows:

Table 3. Questions of the SOFI Method Dimensions

No Questions	Dimension	Questionnaire Items
1	Questionnaire Items	Energy significantly reduced
		Energy drained for other activities
		Very tired;
		Energy depleted after work
		Overworked
2	Physical Exertion	Shortness of breath
		Body feels warm
		Heart palpitations
		Breathing heavily
		Sweating
3	Physical Discomfort	Feeling pain
		Body aching
		Experiencing cramps in certain parts of the body
		Feeling stiffness in joints
		Muscle tension
4	Lack of Motivation	Feeling unconcerned
		Indifferent
		Unenthusiastic
		fatigued
		Uninterested in surroundings
5	Sleepiness	Feeling lazy
		Frequently yawning
		Blurred vision due to drowsiness
		Urge to sleep immediately
		Drowsy

Source*: (Yuli Sarbena dan Sofiyanurriyanti, 2021)*

The data processing procedures using the Swedish Occupational Fatigue Inventory (SOFI) followed a series of systematic steps to ensure that the measurement of fatigue was both accurate and interpretable. The process began with the calculation of SOFI scores for each participant, where responses to all items within the instrument's multiple fatigue dimensions such as physical fatigue, mental fatigue, and lack of energy were summed to reflect the overall intensity reported in each domain. Once these raw scores were obtained, the next step involved computing the average score for each dimension. This averaging allowed the analysis to capture how strongly each type of fatigue was experienced, making it possible to compare variations across different aspects of occupational fatigue.

Following this dimensional analysis, an overall average score was generated by combining the mean values from all fatigue dimensions. This composite score served as a general indicator of respondents' total fatigue levels, offering a broader picture beyond individual symptom categories. Finally, the fatigue scores were interpreted using established SOFI cut-off values:

scores above 4.87 indicated high fatigue, scores between 1.13 and 4.87 reflected moderate fatigue, and scores below 1.13 suggested low fatigue. These thresholds enabled the classification of participants' fatigue levels in a meaningful way, allowing the results to be translated into practical insights regarding the severity and distribution of occupational fatigue.

Research Flowchart

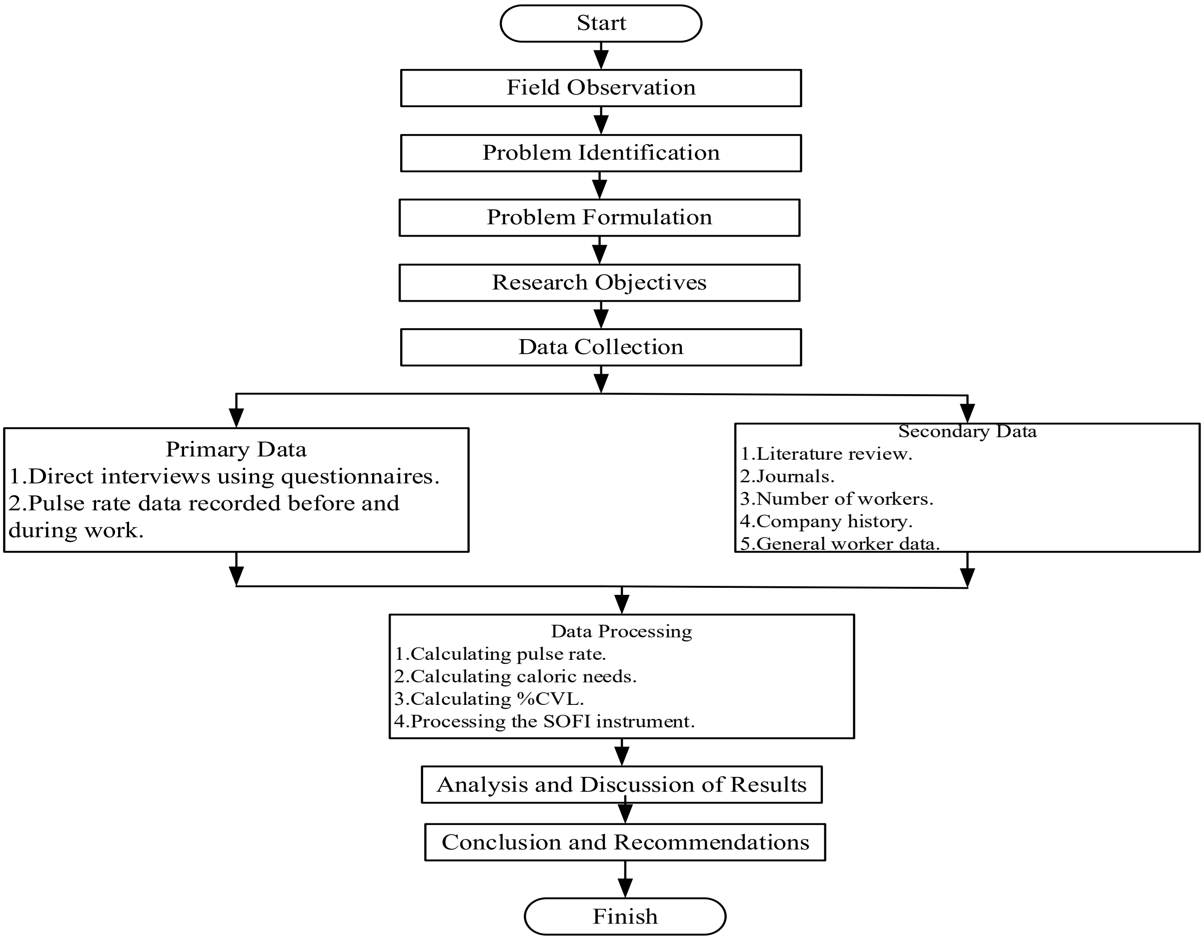

Figure 1 Research Flowchart

Result and Discussion

This study was conducted on Fresh Fruit Bunch (FFB) loading workers in Division II of PT. Simpang Kiri Plantation Indonesia to examine the level of physical workload and work fatigue experienced by the FFB loading workers. The data on the FFB loading workers are presented in Table 4 as follows:

Table 4. Data on Fresh Fruit Bunch (FFB) Loading Workers

Name	Age	Body Weight	Work Experience
Wawan Kurniawan	37	60 Kg	6 years
Yusriadi	37	64 Kg	7 years
Sahdan	36	70 Kg	5 years
Syafrizal	41	80 Kg	10 years

Source: Data Collection

ISSN 2721-1215 (Print), ISSN 2721-1231 (Online)

Physiological Method

Worker 1

The calculation of caloric needs for Worker 1 who is 37 years old and weighs 60 kg, with the type of activity being the loading of Fresh Fruit Bunches (FFB). The average heart rate before, during, and after working for Worker 1 can be seen in Table 5 as follows:

Table 5. Average Heart Rate Before, During, and After Work for Worker 1

	Average Heart Rate											
Time (Minute)	1	2	3	4	5	6	7	8	9	10	11	12
Heart Rate (bpm)	78	75	75	75	122	136	144	142	77	78	78	78
Average	76				136				78			

Source: Data Processing

The calculation of the energy expended during loading work by Worker 1 is as follows:

$Y = 1{,}80411 \quad 0{,}0229038X + 4{,}71711 \times 10^{-4} X^2$

$= 1{,}80411 \quad 0{,}0229038(76) + 4{,}71711 \times 10^{-4} (76)^2$

$= 2{,}66$

Table 6. Energy Expenditure of Worker 1

Heart Rate	76	136	78
Minute	4	8	12
Energy	2,66	7,41	2,85

Source: Data Processing

The calculation of caloric requirements during loading work for Worker 1 is as follows:

CR = Energy expenditure × body weight × working hours

= 7,41 x 60 x 8

= 3.557 KKal

The calculation of Cardiovascular Load (CVL) during loading work for Worker 1 is as follows:

Maximum Heart Rate = 220   Age
= 220   37
= 183

% CVL = x 100

= x 100

= 56%

Based on the calculation of the pulse rate data of the loading worker, Worker 1 was found to have a pulse rate of 136 beats per minute, indicating that the loading activity falls into the category of heavy work. The calculation of caloric requirements for Worker 1 yielded a result of 3,557 Kcal, which also falls into the category of heavy work.The calculation of Cardiovascular Load (CVL) for Worker 1 resulted in 56%, indicating that the loading activity belongs to the category of heavy work and requires improvement.

Worker 2

The calculation of caloric requirements for Worker 2 aged 37 years with a body weight of 64 kg, engaged in the activity of loading Fresh Fruit Bunches (FFB). The average pulse rate before, during, and after work for Worker 2 can be seen in Table 7 as follows:

Table 7. Average Heart Rate Before, During, and After Work for Worker 2

	Average Heart Rate											
Time (Minute)	1	2	3	4	5	6	7	8	9	10	11	12
Heart Rate (bpm)	88	82	80	78	137	141	142	143	94	84	78	77
Average	**82**				**141**				**83**			

Source: Data Processing

The calculation of the energy expended during loading work by Worker 2 is as follows:

$Y \quad = 1,80411 \quad 0,0229038X + 4,71711 \text{ x } 10^{-4} X^2$

$= 1,80411 \quad 0,0229038(82) + 4,71711 \text{ x } 10^{-4} (82)^2$

$= 3,25$

Table 8. Energy Expenditure of Worker 2

Heart Rate	82	141	83
Minute	4	8	12
Energy	3,25	7,95	3,15

Source: Data Processing

The calculation of caloric requirements during loading work for Worker 2 is as follows:

CR = Energy expenditure × body weight × working hours

= 7,95 x 64 x 8

= 4070 KKal

The calculation of Cardiovascular Load (CVL) during loading work for Worker 2 is as follows:

Maximum Heart Rate = 220   Age
= 220   37
= 183

% CVL = x 100

= x 100

= 58%

Based on the calculation of the pulse rate data of the loading worker, Worker 2 was found to have a pulse rate of 141 beats per minute, indicating that the loading activity falls into the category of heavy work. The calculation of caloric requirements for Worker 2 yielded a result of 4,070 Kcal, which also falls into the category of heavy work.The calculation of Cardiovascular Load (CVL) for Worker 2 resulted in 58%, indicating that the loading activity belongs to the category of heavy work and requires improvement.

Worker 3

The calculation of caloric requirements for Worker 3 aged 36 years with a body weight of 70 kg, engaged in the activity of loading Fresh Fruit Bunches (FFB). The average pulse rate before, during, and after work for Worker 3 can be seen in Table 9 as follows:

Table 9. Average Heart Rate Before, During, and After Work for Worker 3

	Average Heart Rate											
Time (Minute)	1	2	3	4	5	6	7	8	9	10	11	12
Heart Rate (bpm)	72	70	69	67	127	130	139	139	77	77	78	77
Average	69				134				77			

Source: Data Processing

The calculation of the energy expended during loading work by Worker 3 is as follows:

Y = 1,80411   0,0229038X + 4,71711 x 10^{-4} X^2

= 1,80411   0,0229038(69) + 4,71711 x 10^{-4} $(69)^2$

=2,49

Table 10. Energy Expenditure of Worker 3

Heart Rate	69	134	77
Minute	4	8	12
Energy	2,49	7,2	2,8

Source: Data Processing

The calculation of caloric requirements during loading work for Worker 3 is as follows:

CR = Energy expenditure × body weight × working hours

= 7,2 x 70 x 8

= 4032 KKal

The calculation of Cardiovascular Load (CVL) during loading work for Worker 3 is as follows:

Maximum Heart Rate = 220   Age
= 220   36
= 184

% CVL = x 100

= x 100

= 56%

Based on the calculation of the pulse rate data of the loading worker, Worker 3 was found to have a pulse rate of 134 beats per minute, indicating that the loading activity falls into the category of heavy work.The calculation of caloric requirements for Worker 3 yielded a result of 4,032 Kcal, which also falls into the category of heavy work.The calculation of Cardiovascular Load (CVL) for Worker 3 resulted in 56%, indicating that the loading activity belongs to the category of heavy work and requires improvement.

Worker 4

The calculation of caloric requirements for Worker 4 aged 41 years with a body weight of 80 kg, engaged in the activity of loading Fresh Fruit Bunches (FFB). The average pulse rate before, during, and after work for Worker 4 can be seen in Table 11 as follows:

Table 11. Average Heart Rate Before, During, and After Work for Worker 4

	Average Heart Rate											
Time (Minute)	1	2	3	4	5	6	7	8	9	10	11	12
Heart Rate (bpm)	79	78	75	75	126	131	137	139	78	78	78	79
Average	77				133				78			

ISSN 2721-1215 (Print), ISSN 2721-1231 (Online)

Source: Data Processing

The calculation of the energy expended during loading work by Worker 4 is as follows:

Y = 1,80411   0,0229038X + 4,71711 x 10^{-4} X^2

= 1,80411   0,0229038(77) + 4,71711 x 10^{-4} $(77)^2$

= 2,81

Table 12. Energy Expenditure of Worker 4

Heart Rate	77	133	78
Minute	4	8	12
Energy	2,81	7,15	2,91

Source: Data Processing

The calculation of caloric requirements during loading work for Worker 4 is as follows:

CR = Energy expenditure × body weight × working hours

= 220   41

= 179

The calculation of Cardiovascular Load (CVL) during loading work for Worker 4 is as follows:

Maximum Heart Rate = 220   Age
= 220   41
= 179

% CVL = x 100

= x 100

= 55%

Based on the calculation of the pulse rate data of the loading worker, Worker 4 was found to have a pulse rate of 136 beats per minute, indicating that the loading activity falls into the category of heavy work. The calculation of caloric requirements for Worker 4 yielded a result of 4,608 Kcal, which also falls into the category of heavy work.The calculation of Cardiovascular Load (CVL) for Worker 4 resulted in 55%, indicating that the loading activity belongs to the category of heavy work and requires improvement.

Swedish Occupational Fatigue Index (SOFI) Method

Data collection was carried out by distributing the Swedish Occupational Fatigue Index (SOFI) questionnaire to workers engaged in loading Fresh Fruit Bunches (FFB). The data processing using the Swedish Occupational Fatigue Index (SOFI) method is as follows:

Calculating the average of each dimension and the overall average

The recapitulation of data for each dimension obtained from the distribution of questionnaires to the loading workers can be seen in Table 13 as follows:

Based on Table 13, it can be seen that the results obtained for the average score of the lack of energy dimension are 4.5 for A1, 4.5 for A2, 4.5 for A3, 4.5 for A4, and 4.0 for A5, with an overall average score of 4.4. In the physical exertion dimension, the scores are 3.8 for B1, 3.8 for B2, 4.3 for B3, 3.3 for B4, and 4.5 for B5, with an overall average score of 3.9. In the physical discomfort dimension, the scores are 4.3 for C1, 3.3 for C2, 3.5 for C3, 3.8 for C4, and 3.8 for C5, with an overall average score of 3.7. In the lack of motivation dimension, the scores are 2.0 for D1, 3.0 for D2, 3.8 for D3, 3.5 for D4, and 2.5 for D5, with an overall average score of 2.95. In the sleepiness dimension, the scores are 2.8 for E1, 1.5 for E2, 1.8 for E3, 1.8 for E4, and 3.5 for E5, with an overall average score of 2.25.

Table 13. Recapitulation of SOFI Questionnaire Data by Each Dimension

Respondents	**Dimension 1**					**Dimension 2**					**Dimension 3**					**Dimension 4**					**Dimension 5**				
	A1	**A2**	**A3**	**A4**	**A5**	**B1**	**B2**	**B3**	**B4**	**B5**	**C1**	**C2**	**C3**	**C4**	**C5**	**D1**	**D2**	**D3**	**D4**	**D5**	**E1**	**E2**	**E3**	**E4**	**E5**
1	4	4	4	4	2	3	4	4	3	4	4	3	3	4	2	3	2	2	2	2	2	1	1	1	4
2	5	5	5	5	5	4	3	4	3	5	4	5	3	5	4	2	4	5	5	2	2	2	2	3	4
3	4	4	4	4	4	4	4	4	4	4	5	4	4	2	4	1	2	3	2	4	2	2	2	2	4
4	5	5	5	5	5	4	4	5	3	5	4	1	4	4	5	2	4	5	5	2	5	1	2	1	2
TOTAL	**18**	**18**	**18**	**18**	**16**	**15**	**15**	**17**	**13**	**18**	**17**	**13**	**14**	**15**	**15**	**8**	**12**	**15**	**14**	**10**	**11**	**6**	**7**	**7**	**14**
Avareage	**5**	**5**	**5**	**5**	**4**	**4**	**4**	**4**	**3**	**4.5**	**4**	**3**	**3.5**	**4**	**3.8**	**2**	**3**	**3.8**	**4**	**2.5**	**3**	**2**	**2**	**2**	**4**
Overall Average	**4.4**					**3.9**					**3.7**					**2.95**					**2.25**				

Source: Data Processing

Interpretation of the Recapitulated Score Values

Based on the results of the questionnaires distributed to the loading workers, the average score for each dimension according to the SOFI method can be seen in Table 14 as follows:

Table 14. Interpretation of SOFI

No	**Dimension**	**Average**
1	Lack of Energy	4,4
2	Physical Exertion	3,9
3	Physical Discomfort	3,7
4	Lack of Motivation	2,95
5	Sleepiness	2,25
Total		3,44

Source: Data Processing

Based on the results in Table 14 it can be seen that the fatigue experienced by loading workers falls into the moderate category, which includes lack of energy with a score of 4.4, physical exertion with a score of 3.9, physical discomfort with a score of 3.7, lack of motivation with a score of 2.95, and sleepiness with a score of 2.25. The graph below illustrates the level of work fatigue experienced by the loading workers, as shown in the following figure:

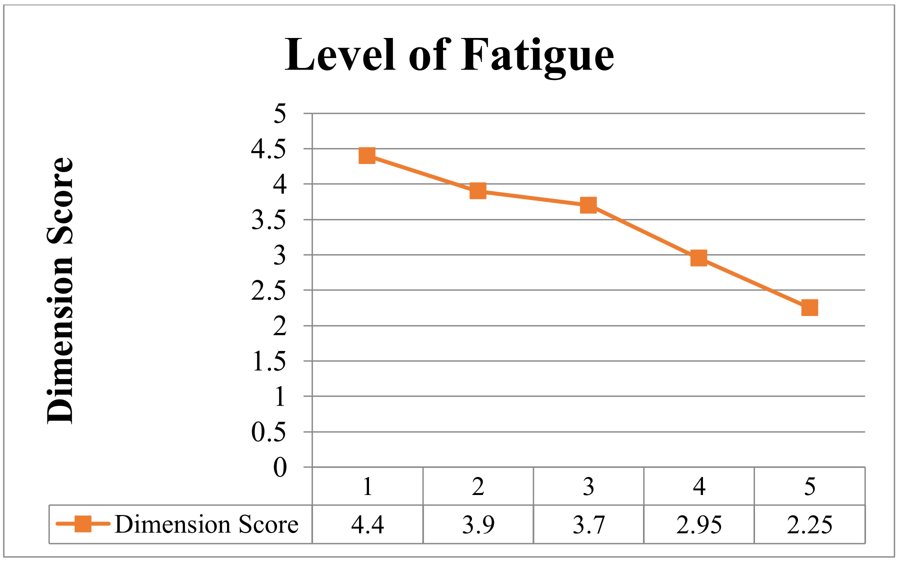

Figure 2. SOFI Dimensions of Fatigue Level

Explanation: 1) Dimension of Lack of Energy; 2) Dimension of Physical Exertion; 3) Dimension of Physical Discomfort; 4) Dimension of Lack of Motivation; 6) Dimension of Sleepiness

Based on Figure 2, it can be observed that the highest level of fatigue is found in the dimension of lack of energy, followed by the dimension of physical exertion, then the dimension of physical discomfort, then the dimension of lack of motivation, and the lowest level of fatigue is in the dimension of sleepiness.

Analysis of the Physiological Method

Based on the calculation of the pulse rate data of loading workers, the results obtained are as follows: Worker 1 had a working heart rate (WHR) of 136 beats per minute, indicating that the loading work falls into the heavy workload category; Worker 2 had a WHR of 141 beats per minute, also indicating heavy workload; Worker 3 had a WHR of 134 beats per minute, categorized as heavy workload; and Worker 4 had a WHR of 136 beats per minute, also categorized as heavy workload.Furthermore, the calculation of caloric needs showed that Worker 1 required 3,798 KCal, Worker 2 required 4,055 KCal, Worker 3 required 4,030 KCal, and Worker 4 required 4,608 KCal, all indicating heavy workload.Additionally, the calculation of Cardiovascular Load (CVL) revealed that Worker 1 had a CVL of 56%, Worker 2 had 58%, Worker 3 had 56%, and Worker 4 had 55%. These values indicate that the loading work falls into the heavy workload category and requires improvement.

Analysis of the SOFI Method

Based on the calculations, the results obtained are as follows: the lack of energy dimension scored 4.4, physical exertion scored 3.9, physical discomfort scored 3.7, lack of motivation scored 2.95, and sleepiness scored 2.25. Therefore, the fatigue experienced by the loading workers falls within the moderate level.

Conclusion

SOFI results, it can be concluded that the loading work performed by the workers is categorized as heavy in terms of physiological workload, as indicated by high pulse rates, caloric needs, and cardiovascular load (%CVL), all requiring improvement. Meanwhile, according to the SOFI assessment, the perceived fatigue by the workers falls within the moderate level, with the highest fatigue observed in the lack of energy dimension, followed by physical exertion, physical discomfort, lack of motivation, and the lowest in sleepiness. These results suggest that although the physiological load is heavy, workers' subjective perception of fatigue is moderate, highlighting the need for ergonomic interventions and workload management.

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