Energy Consumption of Workers in the Palm Fruit Calcium Inspection Process by Wearing Masks to Go Up and Down Stairs during the Pandemic

Agustina Hotma Uli Tumanggor*[a,1], Cynthia Eka Fayuning Tjomiadi [b,2], Madschen Sia Mei Ol Siska Selvija Tambun [c,3]

[a,c]Department of Industrial Engineering, Sari Mulia University, Banjarmasin, Indonesia
[b]Department of Nursing, Sari Mulia University, Banjarmasin, Indonesia
[1]agustina.hotma@gmail.com*, [2]tjomiadicynthia@gmail.com; [3]marunehubarat10041979@gmail.com

Abstract

The increase in the use of masks during this pandemic has greatly affected work. Wearing mask cuases difficulty in breathing when workers do their work by going up and down stairs. Workers are required to wear masks when checking calcium in reservoirs with the height of about 5 to 10 meters from the ground level at PT. Wijaya Borneo Tiganna. The purpose of this study was to identify the energy consumption of workers wearing masks in working up and down stairs during a pandemic. The method used was Cardiovascular Load (%CVL) and energy consumption of workers before and after wearing masks when going up and down stairs. The results of the study obtained that the %CVL value was 38.37% and was included in the level of need for improvement. The average energy consumption of 3.31 Kcal/minute is included in the light category.

Keywords: masks, pandemic, Cardiovascular Load, Energy Consumption.

I. INTRODUCTION

At the end of 2019, the COVID-19 disease caused by Coronaviruses (CoV) was transmitted through the respiratory tract. This disease causes flu to Middle East Respiratory Syndrome (MERS-CoV) and Severe Acute Respiratory Syndrome (SARS-CoV). The case of COVID-19 in Indonesia began on March 11, 2020 and was declared a pandemic period. Fever, cough, fatigue, shortness of breath and no appetite are symptoms experienced by COVID-19[1]. WHO data noted that on August 31, 2021, there were 216,867,420 total confirmed cases of COVID-19 in the world with 4,507,837 deaths, while in Indonesia there was 133,023 deaths out of 4,049,801 confirmed positive cases of COVID-19. The development of COVID-19 in South Kalimantan until January 16, 2022 totalled 69,962 people[2].

One of the health protocols that must be carried out during activities during a pandemic is to wear a mask. The benefits of using the correct mask can protect yourself and also others from the spread of the COVID-19 that can occur through the air[3].

Based on the Regulation of the Minister of Health Number HK.01.07-MENKES-328-2020 concerning Guidelines for the Prevention and Control of COVID-19 in the workplace and industry. Require the use of masks for all workers in the workplace[4]. Workers who do any work in the workplace are required to wear masks when working to protect themselves from exposure to splashes to the respiratory tract while working. The mask serves to protect breathing from dust / larger particles that enter the respiratory organs[5].

PT. Wijaya Borneo Tiganna is a palm oil company in Batang Kulur Village, Kelumpang Hilir District, Kotabaru Regency, South Kalimantan. The activities of the workers there include checking the condition of the calcium content. The place to check the condition of oil palm calcium is located above in the form of a reservoir that holds the calcium. The position of the reservoir is about 5 to 10 meters above ground level. Workers are obliged to go back and forth to check the condition of calcium within a certain period time by using a ladder. With this pandemic, workers are required to wear masks at work. The impact of work carried out by going up and down stairs using a mask will feel breathless (short breath). This is due to discomfort in breathing.

The main parameter in determining the level of physical workload is referred to as energy consumption[6]. Energy consumption at work can be determined indirectly (measurement of blood pressure, blood flow, chemical

composition in blood, body temperature, evaporation rate and the amount of air exhaled by the lungs).[7]and can be measured by measuring the pulse[8].

The measurement of workload based on muscle movement is called pulse[9]. A person's productivity will decrease if work fatigue is due to an excessive workload[10]. Calculation of workload level based on energy consumption is done by calculating VO2 and Heart Rate Range (HRR). The relationship between energy expenditure and heart rate can measure energy consumption (VO2)[6].

Research on energy consumption has been carried out in several fields. Physiological workload analysis in the process of making tofu based on energy consumption results in the energy consumption of workers based on each category of workload[11]. Rahmaniyah et al. examined the physiological and psychological workload of building material workers using the Cardiovascular Load Method and the NASA-TLX. The results showed that physiological workload based on cardiovascular load means short work and high energy consumption[12]. Analysis of work posture and measurement of energy consumption of stone lifters to reduce musculoskeletal disorders revealed that the highest percentage of complaints was on the workers' backs. The results of the workload calculation based on heart rate are in the range of 4 so workers need to improve their work posture[13]. K. Mohanavelu et.al examined the cognitive workload of fighter pilots in a flight simulator environment. Their results are beneficial for understanding pilot tasks and performance at each phase of flying and pilot cognitive demands during workload dynamics using HRV, which can help pilot training optimally.[14].

Energy consumption by using masks to go up and down stairs in checking calcium in palm oil companies has never been studied before. Based on this background, the research team is interested in researching to identify the energy consumption of workers using masks when working up and down stairs during a pandemic. This research can be the first step for further research related to ergonomics.

II. METHODS

A. Case Study

This research design uses a quantitative approach which aims to study the effect of workload on energy consumption before and after doing work by going up and down stairs and lifting heavy loads. The research location was conducted at PT. Wijaya Borneo Tiganna is a palm oil company in Batang Kulur Village, Kelumpang Hilir District, Kotabaru Regency, South Kalimantan. The research sample here is company workers who do work by going up and down stairs to check the calcium condition of palm fruit in the reservoir where the tendon position is about 5-10 meters from the ground.

Data retrieval using the Simple Random Sampling technique, namely the collection of sample data from the population is carried out randomly without regard to the strata that exist in the population.[15]. Processing of data taken in the form of heart rate working without using a mask when going up and down stairs and heart rate working using a mask when going up and down stairs. The research was continued by conducting a Wilcoxon ranking statistical test to determine whether or not there was a difference in heart rate before and after going up and down stairs without using a mask and using a mask and statistical tests on the effect of working using a mask by going up and down stairs on heart rate. This will be used to determine the level of workload (%CVL) and energy consumption on a light, medium (moderate), heavy or very heavy scale when doing work up and down stairs using a mask. If the level of risk is high, suggestions for improvement will be given. Figure1.

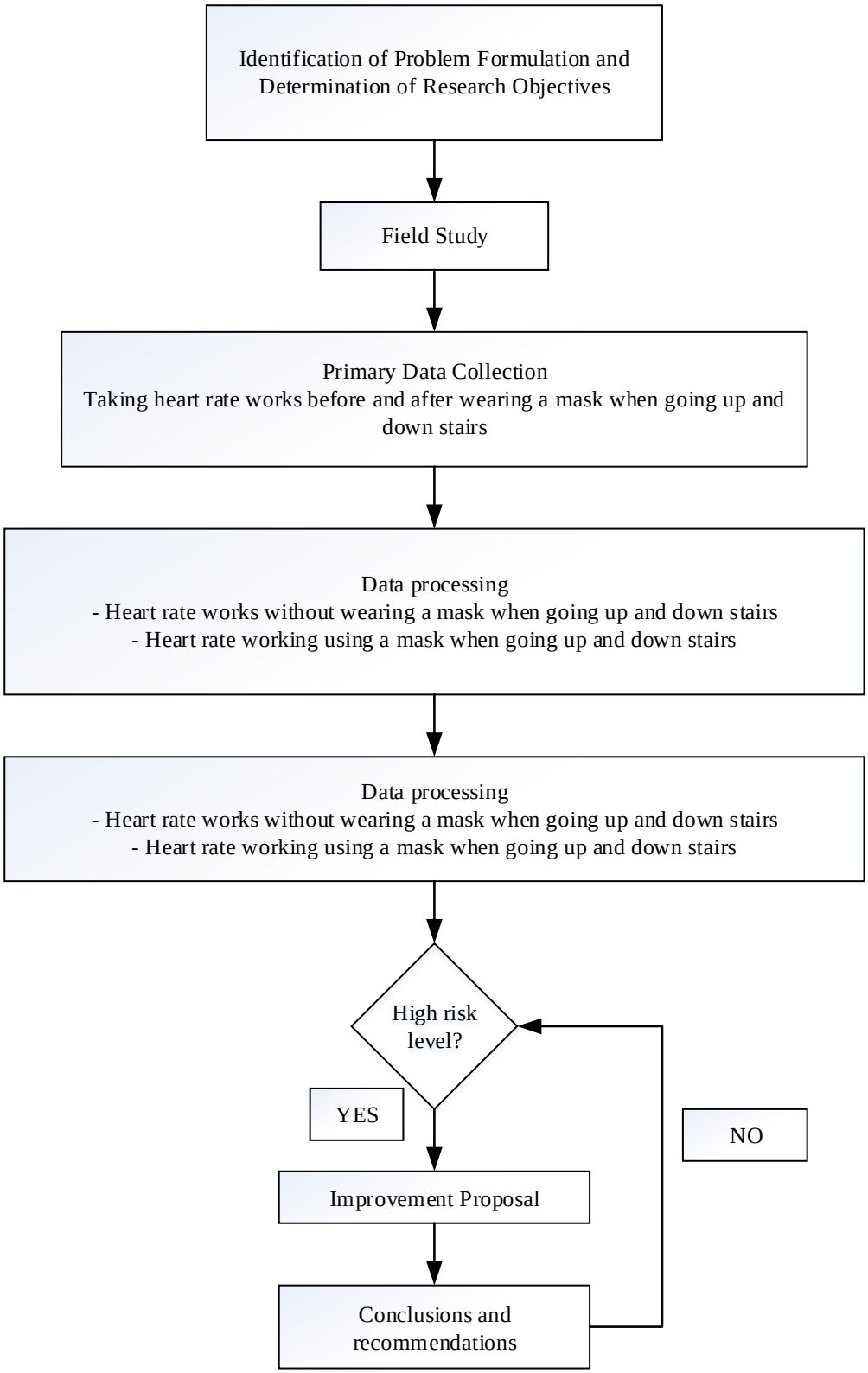

Figure1. Research Flowchart

B. Physical Work and Work Energy Consumption

Work that requires the physical energy of human muscles as a source of energy (power) is referred to as physical work. Physical work causes energy to leave the body which is related to energy consumption. Energy consumption at work can be determined by measuring heart rate or oxygen saturation[16]. Heart rate is a way of measuring workload based on body muscle movements. Heart rate is used to measure the physical condition of workers as the basis for fatigue parameters of workers. The greater the heart rate can indicate the greater the burden of a person's work[17]

C. Manifestation of Heavy Work

As muscle activity increases, several things to consider and analyze in the manifestations of strenuous work include : energy consumption, heart rate, blood temperature (body temperature), blood pressure (blood pressure), pulmonary output in litres per minute (cardiac output), blood chemical composition (lactic acid content), sweating rate (sweating rate), speed of opening or closing of pulmonary ventilation in litres per minute (pulmonary ventilation)[11].

D. Physical Workload Assessment

The physical workload consists of physical loads to carry out light or heavy activities. Ergonomics science views that every workload received by a person must be appropriate or balanced both in physical and cognitive abilities, as well as the limitations of humans who receive the burden. Each individual has a different work ability seen from the age, skill level, physical fitness and body size of the worker concerned. The relationship between workload and the condition of the human body is shown in Table 1[18].

Table1. The Relationship of Workload to The Condition of The Human Body

Category	**Oxygen Consumption (litre/minute)**	**Rectal Temperature (0C)**	**Energy (Kcal/min)**	**heart rate**	**Lung ventilation (liter/minute)**
Very light	0.25 – 0.3	37.5	<2.5	<60	6-7
Light	0.5 – 1	37.5	2.5 - 5	60 - 100	11 - 20
Moderate	1 – 1.5	37.5 - 38	5 – 7.5	100 - 125	20 - 31
Heavy	1.5 - 2	38 – 38.5	7.5 - 10	125 - 150	31 - 43
Very heavy	2 – 2.5	38.5 - 39	10 – 12.5	150 - 175	43 – 56
Extreme weight	>2.5	>39	>12.5	>175	60 - 100

E. Wilcoxon Ranking Test

The Wilcoxon test is used to analyze the results of paired observations of two data whether they are different or not. Wilcoxon signed-rank test is used only for interval or ratio type data, but the data follows a normal distribution[11].

F. Workload Assessment Based on Work Pulse

Heart rate measurement can be done in various ways, including:

a) Feel the heartbeat in the radial artery at the wrist.
b) Listen to the heart rate with a stethoscope.
c) Using ECG (ElectrocardioGraph), which measures electrical signals measured from the heart muscle on the skin surface of the chest

Heart rate is calculated by telemetry using ElectroardioGraph (ECG) stimulation. As an alternative, a stopwatch can be used using the 10 beats method[11]. The calculation of the working pulse is as follows:

$$\text{Pulse } (\textit{pulse.minute}) = \frac{10 \text{ pulse}}{\text{calculation time}} \text{ x } 60 \qquad (1)$$

In addition to the heart rate method, the pulse rate can also be calculated using the 15 or 30 second method. Classification of workload based on the increase in work pulse compared to the maximum pulse rate due to cardiovascular load (cardiovascular = %CLV) which is calculated based on the formula below[19]:

$$\%\text{CVL} = \frac{100 \text{ x (DNK-DNI)}}{\text{DNK}_{\text{Max}}\text{-DNI}} \qquad (2)$$

The maximum pulse rate is (220 - age) for men and for women is (200 - age). After calculating the %CVL, it is classified according to the following provisions:[6]:

a) X 30% means no fatigue occurs
b) 30 < X < 60% means that improvement is needed (tiredness starts to occur)
c) 60 < X < 80% means working in a short time (tired)
d) 80 < X < 100% means urgent action is needed (very exhausted)
e) X 100% means not allowed to do activities

The quadratic equation for the regression form of the relationship between energy and heart rate in general is as follows:

$$E = 1.080441 - 0.0229038X + 0.000471733X2 \quad (3)$$

Where:
E = Energy expended (Kcal/minute)
X = Heart rate (pulse/minute)
While the energy consumption equation is the difference between energy expended during activities and energy at rest with the following equation:

$$KE = Et - Ei \quad (4)$$

Where:
KE = Energy consumption for certain work activities (Kcal/minute)
Et = Energy expenditure at the certain working time (Kcal/minute)
Ei = Energy expenditure at rest (Kcal/minute)

III. RESULTS AND DISCUSSION

A. Assessment of workload based on the pulse when going up and down stairs

The sample of this research is company workers who do work up and down stairs to check the condition of calcium palm fruit in the reservoir where the position of the reservoir is about 5-10 meters from the ground surface. Data was obtained by counting the number of pulses in the radial artery on the left thumb before and after work. Pulse rate data is collected from respondents a total of 6 people. Measurements were carried out on each worker 4 times, dividing into 2 groups of respondents, namely in the condition of going upstairs and going downstairs. Respondents carried out activities up and down stairs at their usual walking speed, then rested for about 5 - 10 minutes to restore their pulse while resting. The results of measuring the pulse of calcium-checking workers at PT. Wijaya Borneo Tiganna seen on Table 2.

Table 2. The Results of The Measurement of The Pulse on The Respondent

No	Name	Gender	Age (years)	Weight	DNI	DNK Average
1	Burhan	Male	21	47.6	5.56	4.98
2	Siti	female	20	65.2	6.52	5.24
3	Mishnah	female	22	57.8	5.94	5,12
4	Budi	Male	20	75.3	6.45	5.45
5	Rabbi	Male	20	51.3	8.57	5.29
6	Khairul	Male	20	85.3	5.26	4.34

Respondents carried out activities up and down stairs at the usual walking speed, then rested for about 5 - 10 minutes to restore their pulse when resting can be seen in Figure 2.

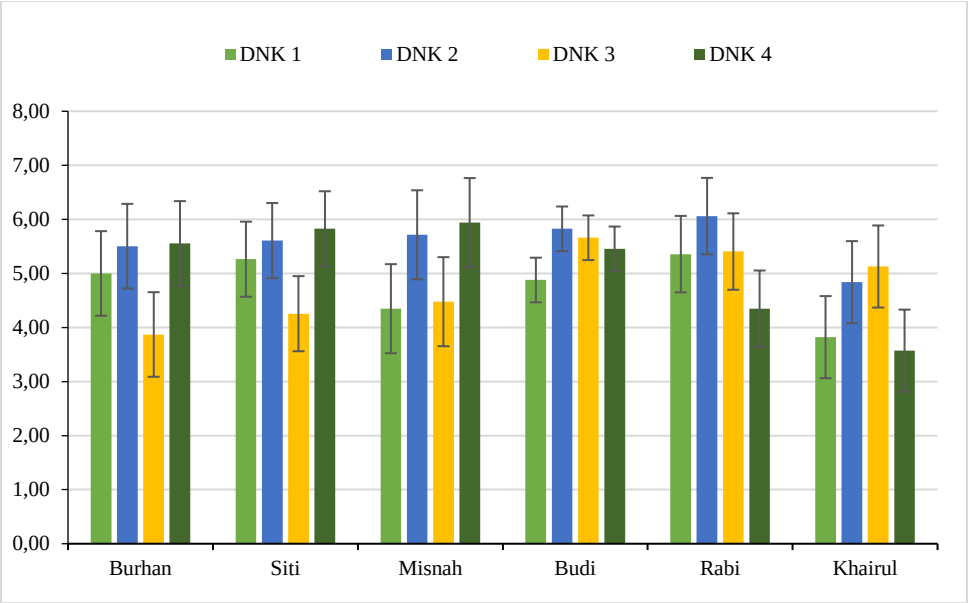

Figure 2. Work Pulse Measurement

B. Measurement Results Using the 10 Pulse Method

The results of measuring the respondent's pulse are then processed using the 10 beats method so that the respondent's pulse rate per minute (beats/minute).

$$\text{Pulse (beat.minute)} = \frac{10 \text{ beats}}{\text{calculation time}} \text{ x } 60$$

From the results of calculations with the above formula, the data obtained as shown in Table 3.

Table 3. Data Calculation using The 10 Beats Method

No	Name	Gender	Age (years)	Weight	DNI	DNK Average
1	Burhan	Male	21	47.6	108	123
2	Siti	female	20	65.2	92	116.25
3	Mishnah	female	22	57.8	101	119.5
4	Budi	Male	20	75.3	93	110.5
5	Rabbi	Male	20	51.3	70	115
6	Khairul	Male	20	85.3	114	141.5

The results of measuring the respondent's pulse are then processed using the 10 beats method so that the respondent's pulse rate per minute (beats/minute) is obtained on Figure 3.

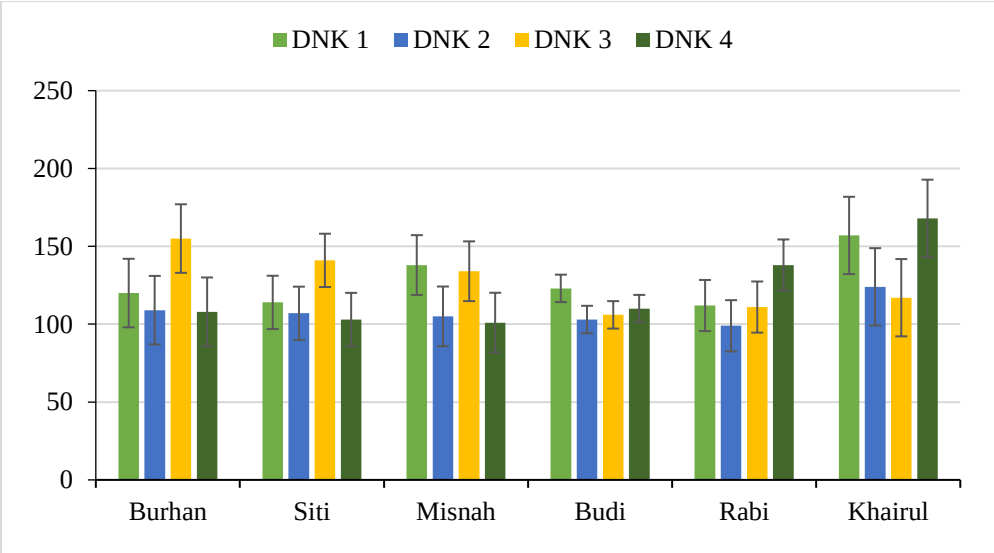

Figure 3. DNK Measurement with 10 Pulse Method

The results of the calculation analysis using the 10 beats method, the average resting pulse rate for workers is 96 beats/minute, while the working pulse rate is 121 beats/minute, the average maximum working pulse is 193. through the calculation of (220 – age) in men and (200 – age) in women. The normal pulse rate for adults is 60-100 beats per minute at rest[20].

C. Calculation Result Recapitulation

After being processed using the 10 beats method, the recapitulation of the results of these calculations can be seen in Table 4.

Table 4. Pulse Rate Recapitulation

No	Name	Gender	Age (years)	DNI	DNK	DNK Max	Work Pulse
1	Burhan	Male	21	108	123	199	15
2	Siti	female	20	92	116	180	24
3	Mishnah	female	22	101	120	178	19
4	Budi	Male	20	93	111	200	18
5	Rabbi	Male	20	70	115	200	45
6	Khairul	Male	20	114	142	200	28
Average				96	121	193	25

Information :
Maximum pulse
1. Male = 220 – Age
2. Female = 200 – Age

D. Calculation of Cardiovascular Strain (%CVL)

The workload (%CVL) was calculated from the data obtained at the time of the study. The formula used is as shown below and the results of the calculation of %CVL for 6 calcium-checking workers are shown in Table 5.

$$\%CVL = \frac{100 \text{ x } (DNK\text{-}DNI)}{DNK_{Max}\text{-}DNI}$$

$$\%CVL= \frac{100 \text{ x } (123-70)}{199-70} = 41{,}09\%$$

Table 5. %CVL Calcium Checker Worker at PT. Wijaya Borneo Tiganna

No	Name	Gender	age	DNK	DNI	DNK Max	%CVL	Classification
1	Burhan	Male	21	123	70	199	41.09	repair needed
2	Siti	female	20	116	83	180	34.02	repair needed
3	Mishnah	female	22	120	70	178	46.30	repair needed
4	Budi	Male	20	111	71	200	31.01	repair needed
5	Rabbi	Male	20	115	75	200	32.00	repair needed
6	Khairul	Male	20	142	93	200	45.79	repair needed
Average							38.37	

From the calculation above, it is obtained that the results of the calculation of cardiovascular strain. Khairul has the highest score with a value of 45.79% and enters the level of need for improvement. Budi has the lowest CVL with a value of 31.01% and is in the level of need for improvement. The average CVL value in the measurement results is 38.37%. The situation requires improvement in doing his job. This is because in the classification of the determination of the level of fatigue, the percentage of cardiovascular strain, at a value of 30% - 60% means that improvements are needed (starting from fatigue)[6]. The suggestion for improvement for workers in the calcium-checking section of palm fruit should be rearranged regarding shifts or changing workers who check calcium and given more rest time than previously are given[21].

E. Calculation of Cardiovascular Strain (%CVL)

The quadratic equation for the regression form of the relationship between energy and heart rate after calculating 10 beats, the next step is to calculate energy consumption as in the example below:

et1 = (1.080441 – 0.0229038(123) + 0.000471733(123)2)
= (1.080441 – 2.82 + 0.000471733 × 15.129)
= 5.40 Kcal
Ei1 = (1.080441 – 0.0229038(70) + 0.000471733(70)2)
= (1.080441 – 2.47 + 0.000471733 × 11.664)
= 1.79 Kcal
K1 = Et1 – Ei1
= 5.40 – 1.79 = 3.61 Kcal/Minute

The results of all calculations for each respondent for energy consumption can be seen in Table 6

Table 6. Assessment of Energy Consumption on Respondents

No	Name	Et (Kcal/minute)	Ei (Kcal/minute)	K (Kcal/minute)	Classification
1	Burhan	5.40	1.79	3.61	Light
2	Siti	4.77	2.43	2.34	very light
3	Mishnah	5.12	1.79	3.34	Light
4	Budi	4.35	1.83	2.52	Light
5	Rabbi	4.69	2.02	2.67	Light
6	Khairul	7.34	3.03	4.31	Light
Average				3.13	

Energy consumption spent on activities up and down stairs in checking calcium for palm fruit is included in the light category[18]. influenced by the distance and time spent climbing and descending stairs. This amount is a very light category for energy consumption per minute, this is influenced because energy consumption is the main parameter for determining the level of physical workload of workers when checking calcium.[6]. The average energy consumption expended by 6 workers is 3.13 Kcal/minute, Siti have the smallest energy consumption is 2.34 Kcal/minute. In measuring energy consumption in this study by measuring the pulse. The physical workload experienced by workers is only going up and down stairs using masks without any additional workload that uses other body muscles.

All types of work will result in work burnout. Work fatigue will reduce performance and increase the level of work errors. Increased work errors will provide opportunities for work accidents. The pulse rate measurement to determine fatigue was carried out 2 times to determine the average resting pulse rate. Before doing work, first of all, the resting pulse rate is calculated. Immediately after the respondent has done work and has not had time to rest and take measurements.

Examination of calcium in oil palm companies must go through the stairs. The analysis in this study when considering environmental ergonomics will also affect the breathing of workers using masks by going up and down stairs. The work climate load received by the human body and non-climatic factors will affect the pulse of workers in doing their work[22]

IV. CONCLUSION

The conclusions that can be drawn from the research above include the following:

a. The mean value of Cardiovascular Strain (%CVL) was 38.37%. This value is included in the category of need for improvement. The highest value is 45.79% and the lowest value is 31.01%. This is influenced by the activity of going up and down stairs that affects the work pulse of workers so it is necessary to improve work shifts.
b. The average energy consumption expended by 6 workers is 3.13 Kcal/minute. The largest amount of energy consumption by workers is 3.61 Kcal/minute and the smallest value is 2.34 Kcal/minute. This is influenced by the distance and time the worker reaches the tendon.

Suggestions for further research are the need for environmental ergonomics analysis at the research site. Measurement of air humidity, temperature and noise will affect the work pulse of workers when checking calcium.

V. ACKNOWLEDGMENT

The researcher would like to thank you for this research opportunity at PT. Wijaya Borneo Tiganna. Researchers also thank DIKTI for supporting this research. In addition, the researcher would like to thank Sari Mulia University for supporting this research activity.

VI. REFERENCES

[1] N. Mona, "Konsep Isolasi dalam Jaringan Sosial untuk Meminimalisasi Efek Contagious (Kasus Penyebaran Virus Corona di Indonesia)," *J. Sos. Hum. Terap.*, vol. 2, no. 2, pp. 117–125, 2020.

[2] Kalsel Tanggap Covid-19, "Angka Sebaran COVID-19 di Kalimantan Selatan," *Banjarmasin*, 2022. http://corona.kalselprov.go.id (accessed Sep. 26, 2022).

[3] R. Fadli, "Manfaat Penggunaan Masker yang Benar di Masa Pandemi," *Halodoc*, 2022. https://www.halodoc.com/ (accessed Sep. 26, 2022).

[4] Kanwil DJKN DKI Jakarta, "Meningkatkan Efektivitas Penggunaan Masker dalam Mencegah Covid-19 Pemakaian Masker Ganda," *Kementrian Keuangan Republik Indonesia*, 2021. https://www.djkn.kemenkeu.go.id/kanwil-jakarta/baca-artikel/14118/Meningkatkan-Efektivitas-Penggunaan-Masker-dalam-Mencegah-Covid-19-dengan-Pemakaian-Masker-Ganda.html. (accessed Sep. 27, 2022).

[5] A. D. Pratiwi, "Gambaran Penggunaan Masker di Masa Pandemi COVID-19 pada Masyarakat di Kabupaten Muna," *Pros. Semin. Nas. Probl. Sos. Pandemi COVID-19 "Membangun Optimisme di Teng. Pandemi COVID-19*, pp. 52–57, 2020.

[6] H. dan Y. Iridiastadi, *Ergonomi Suatu Pengantar*. Bandung: PT. Remaja Rosdakarya, 2014.

[7] E. Grandjean and K. Kroemer, *Fitting The Task to The Human: A Textbook of Occupational Ergonomics*. Philadelphia: CRC Press, 1997.

[8] L. D. Fathimahayati, T. Amelia, and A. N. Syefa, "Analisis Beban Kerja Operator Mesin Pemotong Batu Besar (Sirkel 160 cm) dengan menggunakan Metode 10 Denyut," *J. Ilm. Tek. Ind.*, vol. 11, no. 2, pp. 136–143, 2012.

[9] E. Purba and A. J. M. Rambe, "Analisis beban Kerja Fisiologis Operator di Stasiun Penggorengan pada Industri Kerupuk," *J. Tek. Ind. USU*, vol. 5, no. 2, pp. 11–16, 2014.

[10] Y. Helianty, M. Ario, and C. Wahyuning, "Perbaikan Lingkungan Kerja pada Bagian Permesinan dengan Kriteria Beban Fisiologis Kerja," *J. Tek. Ind. Itenas*, vol. 1, no. 2, pp. 280–289, 2013.

[11] E. Susanti, W. Sugianto, and Z. Azharman, "Analisis Konsumsi Energi Kerja Karyawan Ketika Melakukan Olahraga Tenis: Studi Kasus Karyawan PT. Aker Solution Batam," *J. Rekayasa Sist. Ind.*, vol. 3, no. 2, pp. 117–122, 2018.

[12] R. D. Astuti, A. Rosyidasari, and U. Tyastuti, "Analisis Beban Kerja Fisiologis dan Psikologis Pada Pekerja Bahan Bangunan UD Selo Tirto Menggunakan Metode Cardiovascular Load dan NASA-TLX," pp. 1–9, 2021.

[13] K. T. Sanjaya, A. Kalista, and M. A. Rizal, "Analisis Postur Kerja Dan Pengukuran Konsumsi Energi Pekerja," vol. 5, no. 2, pp. 88–99, 2022.

[14] K. Mohanavelu *et al.*, "Cognitive workload analysis of fighter aircraft pilots in flight simulator environment," *Def. Sci. J.*, vol. 70, no. 2, pp. 131–139, 2020, doi: 10.14429/dsj.70.14539.

[15] Sugiono, *Metode Penelitian Pendidikan Pendekatan Kuantitatif, Kualitatif dan R&D*. Alfabeta, 2018.

[16] M. Rahayu, "Analisis Beban Kerja Fisiologis Mahasiswa Saat Praktikum Analisa Perancangan Kerja Dengan Menggunakan Metode 10 Denyut," *Unistek*, vol. 7, no. 1, pp. 16–20, 2020, doi: 10.33592/unistek.v7i1.463.

[17] L. D. Fathimahhayati, T. Amelia, and A. N. Syeha, "Analisis Beban Kerja Fisiologi Pada Proses Pembuatan Tahu Berdasarkan Konsumsi Energi (Studi Kasus: UD. LANCAR ABADI SAMARINDA)," *J. INTECH Tek. Ind. Univ. Serang Raya*, vol. 5, no. 2, pp. 100–106, 2019.

[18] D. Susandi and R. Wikananda, "nalisis Beban Pada Olahraga Panahan Dengan Menggunakan Metode Fisiologi," *Pros. Ind. Res. Work. Natl. Semin.*, vol. 9, pp. 432–437, 2018.

[19] Tarwaka, *Ergonomi Industri, Dasar-Dasar Pengetahuan Ergonomi dan Aplikasi Tempat Kerja*. Surakarta: Harapan Press, 2010.

[20] Cleveland Clinic Medical Professional, "Pulse & Heart Rate," *Cleveland Clinic*, 2022. https://my.clevelandclinic.org/health/diagnostics/17402-pulse--heart-rate (accessed Sep. 29, 2022).

[21] N. Aliffian Vollytanio Putra and Sunardi, "Analisis Sistem Kerja Untuk Mengurangi Kelelahan Pekerja Bagian Produksi Dengan Metode Cardiovascular Load (CVL) Dan Bourdon Wiersma Di PT. XYZ," *Juminten J. Manaj. Ind. dan Teknol.*, vol. 02, no. 03, pp. 155–166, 2021.

[22] Y. Nurchoiruniesa, M. R. Setiawan, and M. T. Anggraini, "Hubungan Beban Kerja Fisik dan Durasi Kerja dengan Kejadian Heat Strain Pada Pekerja Industri Kerupuk," *J. Ilm. Kesehat. Vol. 21 No. 2 Tahun 2022*, vol. 21, no. Heat strain, beban kerja fisik, durasi kerja., p. 7, 2022.

[23] Z. B. Sibiya, P. Ackerman, and S. A. Ackerman, "Productivity and workload analysis between manual and motor-manual pruning of Pinus patula at two different lifts," *Int. J. For. Eng.*, vol. 32, no. 3, pp. 191–201, 2021, doi: 10.1080/14942119.2021.1906568.

[24] D. Wahyuni, I. Budiman, M. Tryana Sembiring, E. Sitorus, and H. Nasution, "The workload analysis in welding workshop," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 126, no. 1, 2018, doi: 10.1088/1755-1315/126/1/012095.

[25] K.R.A.T, Suharyono, and S. Hadinegoro, "Manusia Masker dan Ekonomi Eksponensial," *Perpustakaan Republik Indonesia*, 2021. https://www.perpusnas.go.id/news-detail.php?lang=id&id=2007071256146negq4YLK2. (accessed Sep. 27, 2022).

[26] A.M.K.Wahyudi, "Pentingnya Menggunakan Masker di Masa Pandemi," *RSU Harapan Kita*, 2020.

[27] Y. A. Suwanto, Lusiana, and Y. Purnama, "Perbedaan Denyut Nadi dan Saturasi Oksigen Sebelum dan Sesudah Senam Bhineka Tunggal Ika (SBTI) di Era Pandemic Covid-19," *J. Sport Coach. Phys. Educ.*, vol. 6, no. 1, pp. 59–62, 2021.

[28] L. Yang *et al.*, "Evaluation of physiological workload assessment methods using heart rate and accelerometry for a smart wearable system," *Ergonomics*, vol. 62, no. 5, pp. 694–705, 2019, doi: https://doi.org/10.1080/00140139.2019.1566579.

[29] Z. Arman, M. Nikooy, P. A. Tsioras, M. Heidari, and B. Majnounian, "Physiological workload evaluation by means of heart rate monitoring during motor-manual clearcutting operations," *Int. J. For. Eng.*, vol. 32, no. 2, pp. 91–102, 2021, doi: https://doi.org/10.1080/14942119.2021.1868238.

[30] A. Nasution and A. L. Simangunsong, "Analisa Beban Kerja Pada Operator Mesin Pon Dengan Menghitung Denyut Nadi Pekerja Di CV. XYZ," *Pros. Ind. Eng. Conf.*, pp. 257–263, 2020.

[31] W. Hidayat, T. Ristyowati, and G. M. Putro, "Analisis Beban Kerja Fisiologis sebagai Dasar Penentuan Waktu Istirahat untuk Mengurangi Kelelahan Kerja," *J. Optimasi Sist. Ind.*, vol. 13, no. 1, pp. 62–69, 2020, doi: https://doi.org/10.31315/opsi.v13i1.3469.