Workload Measurement Using the Cardiovascular Load Method and Defense Research Agency Workload Scale

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Abstract

Workload is a collection of tasks set to be completed within a specific time. The workload can be broken down into "qualitative" (too much or too little) or "quantitative" (too much or too little), which occurs when people are unable to complete tasks or if they do not utilize the abilities they have in achieving a particular job. This study aimed to determine the workload of workers engaged in selling fresh or cut chicken meat. Cardiovascular Load is an estimate to determine the classification of workload based on the increase in work pulse compared to the maximum heart rate. The Defense Research Agency Workload Scale (DRAWS) method is a multidimensional technique that involves participants through subjective questions and assessments consisting of four workload dimensions: input demand, central demand, output demand, and time pressure. The results showed that the workload pulse using Cardiovascular Load, the level of fatigue based on workload obtained at the chicken slaughter station by worker 1 was 44.77%, and worker 2 was 41.11% with the category of improvement needed. At the chicken cleaning station, worker 1 was 44.13%, and worker 2 was 47.43%, with the category of needed improvement. At the chicken cutting station, worker 1 was 43.73%, and worker 2 was 45.85%, with the category of needed improvement. The study's DRAWS method results showed that at the chicken slaughtering station, worker 1 was 84.25%, and worker 2 was 87.05% with the overload category. At the chicken cleaning station, worker 1 was 86.75%, and worker 2 was 84.20% with the overload category. At the chicken cutting station, worker 1 was 85.75%, and worker 2 was 81.30%, with the overload category. This means that six respondents felt a high mental burden, so improvements are needed to reduce the impact of the cognitive workload of workers. The upgrades provided include the provision of chairs around the work area, especially at the chicken slaughtering station, so that workers can sit and rest for a moment to reduce the physical workload experienced by workers.

Keywords: Workload, Cardiovascular Load, Defense Research Agency Workload Scale, Qualitative, Quantitative.

1. Introduction

One of the goals that every business or company wants to achieve is for the production process to run smoothly at every workstation. This is closely related to employees who work to ensure the smooth running of the production process. The production system that occurs in the workplace can be disrupted by errors or carelessness on the part of employees [1][2]. Poor work arrangements or those that ignore the physical and mental capabilities of the workforce will hurt the business or company, such as low productivity, longer process completion times, and even the possibility of system or product failure with potentially disastrous results [3][4].

Workload is the ability issued by workers to meet the job's demands. Each worker also has a different capacity ability. This capacity can be measured from a person's physical and mental condition. Based on an ergonomic perspective, every workload a person receives must be appropriate and balanced with the physical and psychological abilities of the worker who gets the workload. A person's workload has been determined in standard form according to the type of work. Workload is a consequence of implementing activities given to a person or worker. This activity consists of physical and mental activities, where the workload encountered so far is a combination of both, with one activity being more dominant [5][6][7][8].

Cardiovascular Load (CVL) measures physical workload by comparing the working and maximum heart rates. Increased heart rate plays a vital role in increasing cardiac output from rest to maximum work [9][10][11][12][13]. The Defense Research Agency Workload Scale (DRAWS) is a multidimensional workload assessment technique that involves respondents conducting subjective research through questions from four different variables to obtain an overall workload score. The four variables are Input Demand (ID), Central Demand (CD), Output Demand (OD), and Time Pressure (TP). As for determining the workload score for certain variables based on the results of previous studies that have explained that the risk of mental workload experienced by many employees is very high and DRAWS consists of three workload categories starting from = 40%, which is included in the Underload workload, <40% Score = 60% which is included in the Optimal Load workload, and > 60% is included in the Overload workload [14][15][16][17].

This research was conducted at a company selling fresh or cut chicken meat (white, free-range, and duck) at UD. Rahmad. This company can sell 700 kg - 800 kg of white chicken, 200 kg - 300 kg to fulfill regular customer orders, and 500 kg - 600 kg for irregular customers. This company has six workers, working hours from 05.00 WIB to 12.00 WIB daily. The work elements or workstations in this company include selecting chickens, slaughtering chickens, boiling chickens, plucking chicken feathers, cleaning chickens, cutting chickens, and selling chickens.

Based on the initial observations, workers experience physical and mental fatigue in the work elements of this company. Physical fatigue is caused by the standing position of workers for a long time, namely for 7 hours/day while working, while according to research by the British Journal of Sports Medicine, the ideal standing position for workers is 2 - 4 hours/day during working hours. There are often additional orders, so working hours are increased by 1-2 hours daily. Standing too long can cause muscle fatigue, joint pain, spinal disorders, and varicose veins in workers. Continuous hand movements in cutting chicken and moving quickly around the production area cause pain in workers' upper arms and back [18][19].

Mental fatigue is caused by time pressure to meet customer demand and noise from the plucking machine that reaches 90 dB caused by high usage of the machine during production, lack of lubrication to reduce friction on the machine, and high speed of the machine that causes noise. According to the Hearing Health Foundation [20], volume is at least 85 dB for noise exposure in the workplace for 8 hours a day. This triggers miscommunication between workers, workers, and buyers (such as mixed-up or late orders) but does not reach a dangerous stage. Based on the description above, the study's purpose is to determine workers' workload using the Cardiovascular Load method and the Defense Research Agency Workload Scale.

2. Research Methods

The research method for measuring the workload on workers begins with collecting primary data (observation, interviews, DRAWS questionnaires, documentation) and secondary data (Journals, books, and proceedings). After observation and data collection, data processing is carried out using the CVL and DRAWS methods.

Cardiovascular Load (CVL) Method. Data collection of workers' pulse rates (DN) is carried out directly by calculating the working pulse rate (DNK) and the workers' resting pulse rate (DNI) by calculating ten beats at three work stations, namely the chicken slaughtering station, the chicken cleaning station, and the chicken cutting station. The data processing process uses the CVL method by following the following steps:

a. Measuring the pulse rate during work is a method to assess CVL. This method can calculate the working pulse rate as follows:

$$\text{Pulse rate (Beats/minute)} = \frac{10 \text{ Pulse} \times 60}{\text{Observation Time}}$$

b. The increase in working heart rate compared to the maximum heart rate due to cardiovascular load (cardiovascular = %CVL) is calculated based on the formula below:

$$\%CVL = \frac{100 \times (\text{Working Heart Rate - Resting Heart Rate})}{\text{Maximum Heart Rate} - \text{Resting Heart Rate}}$$

After calculating the CVL, it is then compared with the classification that has been determined in Table 1:

Table 1. Cardiovascular Load Classification

% *Cardiovascular* Load (CVL)	Clasification of % *Cardiovascular* Load *(CVL)*
≤ 30 %	There is no fatigue in workers
30 % < %CVL ≤ 60 %	Repair needed but not urgent
60 % < %CVL ≤ 80 %	Allowed to work in a short time
80 % < %CVL ≤ 100 %	Immediate corrective action is required
%CVL > 100%	Work activities may not be carried out

Defense Research Agency Workload Scale (DRAWS) method. Data collection using the DRAWS method requires four variables, namely Input demand, which is a demand related to obtaining information from external sources that are observed. The central market is related to interpreting information and processes in deciding actions on tasks. Output demand is related to physical or verbal actions in a task. Time pressure is a demand related to the constraints associated with time pressure on workers in acting. The data processing method using the DRAWS method consists of the following steps:

a. Assigning workload values to the DRAWS operator variable

$$x = \frac{ID1 + ID2 + ID3}{n}$$

Description:
x = Average (DRAWS variable assessment score)
n = Number of data

b. DRAWS workload weighting

   At the DRAWS stage, the level of importance of mental and physical workload perceived by workers is used to weigh which types of work are the most difficult and easiest to do.

c. Determining the worker's workload score

   Based on the respondents' assessment and weighting data, the workload score is used to determine how much mental and physical work employees do. The workload score value is obtained by adding up the results of multiplying the assessment by the weighting according to the existing variables. The following is the scoring of the DRAWS variable:

$$\text{Total score} = \frac{ID + CD + OD + TP}{100}$$

3. Results and Discussion

The results of data collection and data analysis from workload measurements using the Cardiovascular Load method and the Defense Research Agency Workload Scale on workers by measuring physical and mental workload. Tables 2, 3, and 4 are data on pulse measurements of six workers.

Table 2. Pulse Measurement Data of Workers at the Chicken Slaughter Station

Days	Worker	Time (Seconds)							
		DNI 05.00	DNK 06.00	DNK 07.00	DNI 08.00	DNK 09.00	DNK 10.00	DNK 11.00	DNK 12.00
Monday	1	9,32	5,70	4,50	9,45	5,78	6,30	5,24	4,35
	2	9,80	5,55	4,32	9,67	5,60	6,35	5,56	4,40
Tuesday	1	9,34	5,60	4,56	9,40	5,44	6,40	5,58	4,51
	2	9,58	5,63	4,44	9,54	5,43	6,44	5,49	4,55
Wednesday	1	9,77	5,53	4,67	9,56	5,40	6,53	5,33	4,63
	2	9,43	5,80	4,71	9,60	5,33	6,60	5,54	4,67
Thursday	1	9,81	5,76	4,46	9,59	5,39	6,54	5,21	4,31
	2	9,90	5,33	4,77	9,53	5,56	6,55	5,23	4,69
Friday	1	9,22	5,82	4,83	9,50	5,42	6,62	5,30	4,88
	2	9,32	5,92	4,85	9,49	5,74	6,61	5,42	4,84
Saturday	1	9,87	5,44	4,93	9,74	5,37	6,66	5,45	4,64
	2	9,79	5,54	4,89	9,77	5,60	6,82	5,33	4,52
Sunday	1	9,25	5,50	4,90	9,82	5,64	6,85	5,67	4,50
	2	9,20	5,53	4,94	9,83	5,80	6,90	5,69	4,64

Table 3. Pulse Rate Measurement Data of Workers at the Chicken Cleaning Station

Days	Worker	Time (Seconds)							
		DNI 05.00	DNK 06.00	DNK 07.00	DNI 08.00	DNK 09.00	DNK 10.00	DNK 11.00	DNK 12.00
Monday	1	9,45	5,80	4,44	9,66	4,9	6,20	5,11	4,10
	2	9,43	5,78	4,36	9,63	4,17	6,73	5,16	4,23
Tuesday	1	9,80	5,65	4,63	9,75	4,12	6,22	5,24	4,44
	2	9,41	5,89	4,71	9,77	4,32	6,16	5,28	4,71
Wednesday	1	9,33	5,46	4,44	9,65	4,54	6,41	5,51	4,20
	2	9,45	5,92	4,46	9,34	4,22	6,24	5,44	4,13
Thursday	1	9,60	5,45	4,62	9,37	4,19	6,73	5,24	4,15
	2	9,44	5,44	4,10	9,43	4,20	6,77	5,61	4,20
Friday	1	9,23	5,32	4,14	9,53	4,22	6,43	5,77	4,53
	2	9,89	5,75	4,78	9,75	4,27	6,44	5,43	4,52
Saturday	1	9,82	5,76	4,66	9,70	4,32	6,62	5,47	4,67
	2	9,77	5,88	4,82	9,68	4,21	6,41	5,52	4,75
Sunday	1	9,74	5,87	4,65	9,88	4,56	6,30	5,41	4,90
	2	9,69	5,84	4,64	9,90	4,44	6,31	5,20	4,93

Table 4. Pulse Rate Measurement Data of Workers at the Chicken Slaughtering Station

Days	Worker	Time (Seconds)							
		DNI 05.00	DNK 06.00	DNK 07.00	DNI 08.00	DNK 09.00	DNK 10.00	DNK 11.00	DNK 12.00
Monday	1	9,21	5,42	4,43	9,21	4,51	6,5	5,13	4,33
	2	9,24	5,47	4,42	9,19	4,40	6,12	5,20	4,20
Tuesday	1	9,45	5,52	4,51	9,43	4,52	6,15	5,23	4,53
	2	9,43	5,50	4,50	9,42	4,42	6,20	5,42	4,61
Wednesday	1	9,40	5,61	4,55	9,52	4,51	6,13	5,34	4,57
	2	9,25	5,64	4,62	9,59	4,12	6,34	5,21	4,76
Thursday	1	9,34	5,43	4,60	9,69	4,23	6,39	5,14	4,78

	2	9,45	5,60	4,31	9,70	4,41	6,65	5,76	4,40
Friday	1	9,69	5,78	4,9	9,62	4,52	6,85	5,75	4,43
	2	9,70	5,97	4,12	9,43	4,40	6,95	5,83	4,71
Saturday	1	9,56	5,92	4,32	9,80	4,25	6,32	5,66	4,56
	2	9,62	5,78	4,17	9,52	4,41	6,14	5,26	4,52
Sunday	1	9,65	5,34	4,12	9,62	4,60	6,11	5,71	4,77
	2	9,76	5,54	4,21	9,10	4,12	6,10	5,34	4,61

Meanwhile, the workload measurement data on workers using the DRAWS method can be seen in Table 5. The results of the weighting of the level of importance based on the DRAWS variables can be seen in Table 6.

Table 5. DRAWS Data Collection

Work Station	Worker	ID%	CD%	OD%	TP%
Chicken Slaughter		86	84	83	81
	1	87	88	84	84
		85	83	82	85
		79	86	93	84
	2	87	84	90	87
		83	90	91	88
Chicken Cleaning		89	85	91	86
	1	90	84	90	84
		91	86	83	87
		79	84	85	82
	2	80	81	90	86
		83	89	93	83
Chicken Cutting		88	86	89	83
	1	87	84	88	81
		89	85	82	88
		84	78	84	85
	2	81	79	83	84
		80	82	81	88

Table 6. The weighting of Importance Level Based on DRAWS Variables

Variables	Indicator	Weighting(%)
Input Demand (ID)	How much workload do you feel in preparing the equipment? How much of a workload is felt when positioning the tools and machines to be operated? How big is the workload felt when reading the accuracy of production targets?	25
Central Demand (CD)	How big is the workload felt when carrying out the production process? How big is the workload felt when dealing with production problems and solutions? How much of a workload is felt when identifying defects in chickens?	25
Output Demand (OD)	How much of a workload is felt when slaughtering chickens? How much workload do you feel when packing chicken meat? How much workload do you feel when delivering orders to customers? How much work does it take to complete the chicken cleaning process?	20
Time Pressure (TP)	How big is the workload felt in completing the time it takes to cut chicken meat? How big is the workload felt in completing the time required to pack chicken meat?	30
Amount		**100**

Mental Workload Score Measurement Based on DRAWS Variables, mental workload scores are calculated to assess employees' mental workload. This is done based on assessment data and weighting from respondents. The mental workload score is then sought by multiplying the assessment results by the weighting according to the variables as follows:

1. $\leq 40\%$: *Underload*
2. $40\% \leq 60\%$: *Optimal Load*
3. $> 60\%$: *Overload*

After calculating the workers' pulse rate using the cardiovascular load method, the workers' pulse rate recapitulation results were obtained, as shown in Table 7.

Table 7. Results of Recapitulation of Worker Pulse Rate Assessment and %CVL Calculation

Name	Average DNI (beats/min)	Average DNK (beats/min)	DN Maks	CVL (%)	Informations
Worker 1	62,88	118,93	188	44,77	Improvement Required
Worker 2	62,50	112,20	184	41,11	Improvement Required
Worker 3	62,46	119,63	192	44,13	Improvement Required
Worker 4	62,43	119,12	182	47,43	Improvement Required
Worker 5	63,28	119,42	192	43,73	Improvement Required
Worker 6	63,58	120,07	185	45,85	Improvement Required

The results of the calculation of the recapitulation of mental workload scores using the DRAWS method at the chicken slaughtering station can be seen in Table 8.

Table 8. Workload Score Using the DRAWS Method at the Chicken Slaughtering Station

No	Name	Scoring				Total Score (%)	Workload Category
		ID	CD	OD	TP		
1	Worker 1	86 x 25 2150	85 x 25 2125	83 x 20 1660	83 x 30 2490	84,25	*Overload*
2	Worker 2	83 x 15 1245	86 x 20 1720	91 x 30 2730	86 x 35 3010	87,05	*Overload*

The results of the calculation of the recapitulation of mental workload scores using the DRAWS method at the chicken cleaning station can be seen in Table 9.

Table 9. Workload Score Using the DRAWS Method at the Chicken Cleaning Station

No	Name	Scoring				Total Score (%)	Workload Category
		ID	CD	OD	TP		
1	Worker 3	90 x 20 1800	85 x 25 2125	88 x 25 2200	85 x 30 2550	86,75	*Overload*
2	Worker 4	80 x 25 2000	84 x 15 1260	89 x 30 2670	83 x 30 2490	84,20	*Overload*

The results of the recapitulation calculation of mental workload scores using the DRAWS method at the chicken slaughtering station can be seen in Table 10.

Table 10. Workload Score Using the DRAWS Method at the Chicken Slaughtering Station

No	Name	Scoring				Total Score (%)	Workload Category
		ID	CD	OD	TP		
1	Worker 5	88 x 25 2200	85 x 25 2125	86 x 25 2150	84 x 25 2100	85,75	*Overload*
2	Worker 6	81 x 25 2025	79 x 30 2370	82 x 30 2460	85 x 15 1275	81,30	*Overload*

From the research results, the proposed improvements for the three workstations are as follows:
1. The work area's cleanliness needs improvement, such as maintaining floor cleanliness. Slippery floors can cause someone to slip and result in work accidents.
2. Tools or work equipment are placed in their place to make it easier to take or return the work tools. It is recommended that a label or sign be provided for the placement of work tools.
3. Equal division of tasks must be improved so that no workers experience excess workload. It is hoped that no workers will be unemployed during working hours.
4. Communication between workers needs to be improved because there are still frequent errors in conveying information that results in orders being exchanged, orders being forgotten to be delivered, and orders being cut incorrectly.
5. Do not be late to work; if a worker is late, other workers will get extra work when dealing with buyers.
6. Providing chairs around the work area, especially at the chicken slaughtering station, so that workers can sit and rest for a moment to reduce the physical workload experienced by workers.

5. Conclusion

The results of physical workload measurements using the Cardiovascular Load (CVL) method for workers at the chicken slaughtering station by worker 1 were 44.77%, and worker 2 was 41.11%, with the category of improvement needed. At the chicken cleaning station, worker 1 was 44.13% and worker 2 was 47.43%, respectively, with the category of necessary improvement. At the chicken cutting station, worker 1 was 43.73%, and worker 2 was 45.85%, with the category of improvement needed. The results of mental workload measurements using the Defense Research Agency Workload Scale (DRAWS) method for workers at the chicken slaughtering station by worker 1 were 84.25%, and worker 2 was 87.05% with the category of overload. At the chicken cleaning station, worker 1 was 86.75%, and worker 2 was 84.20% with the overload category. At the chicken cutting station, worker 1 is 85.75%, and worker 2 is 81.30% with the overload category. This means that six respondents feel a high mental burden. For this reason, measuring the workload using the

Cardiovascular Load score and the Defense Research Agency Workload Scale can be said that workers are included in jobs that require further improvement.

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