Implementation of The Cardiovascular Load and Rating Scale Mental Effort To Reduce The Bakery Worker’s Workload

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**Abstract.** This paper proposes measuring the physical and mental workload in a bakery where the human factor significantly influences the entire bread-making process. The significant use of human labor in the production process brings some drawbacks, including the increasing physical and mental workload and a high-temperature workspace. This study evaluates the physical and mental workload of bread makers in Yogyakarta, Indonesia, to formulate proper recommendations to improve the working environment depending on the typical working activities. The physical workload is calculated using the cardiovascular load method (CVL), while the Rating Scale Mental Effort (RSME) measures mental workload. The materials include the dataset containing the type of activities, the worker’s heart rate, and the RSME questionnaire reflecting the worker’s mental conditions. The result indicates three types of activities that are required to be improved, namely baking, cutting, and flavoring. Then, some treatments can be proposed for the baking activities, such as keeping the distance of workers when the oven is not operating, providing drinking water, increasing the time-off frequency, changing the working procedures, and worker’s postures. Lastly, increasing time-off, providing supportive tools, and improving working postures can also be applied to cutting and flavoring activities.

# INTRODUCTION

The worker’s workload is an essential factor in working activity. The evaluation is necessarily important to investigate the workload of workers in their environment. The term the workload has been defined in several ways. It includes the gap between worker’s ability or capacity of workers compared to the demands of the jobs that have to be completed. Besides, it is classified into two groups, namely physical workload and mental workload [1].

This paper demonstrates the workload evaluation of bread makers where the activities are manually operated depending on their workforce. The production capacity can increase by utilizing machines, such as a mixer to knead the dough, an oven to bake, and a packaging machine to package the products. In addition, six types of activities have been identified to produce bread, namely mixing, molding, baking, cutting, flavoring, and packaging. Then, two problems have been identified concerning the bread-making process, which is: (1) the increasing both physical and mental workload of workers, and (2) the high-temperature observed in the workspace area. The high physical and mental workload is caused by manual activities such as molding, cutting, and flavoring. Besides, the workers spending eight hours with a monotonous movement also affects boredom at work. Another high-temperature problem is caused by the oven operating throughout the production process, exacerbated by the narrow space between workers and the tool.

The objective of this study was to evaluate the physical and mental workload of bread makers so that they can formulate appropriate recommendations to improve the work environment by considering job activity. Case study research is a bakery located in Yogyakarta, Indonesia. Firstly, to measure the physical workload, the CVL is employed as it can measure physical activity manually [2]. The physical workload is achieved by measuring the worker’s pulse after the data has been classified based on the increasing working pulse compared to the maximum pulse rate. The technique to measure the physical workload using the worker’s pulse can categorize which activities require some treatments.

Secondly, the mental workload evaluation was physical to distinguish the workload based on the type of works and the level of difficulties [3]. The evaluation is calculated using the RSME method since it focuses on mental workload assessment [4]. The RSME method uses the questionnaire to determine the subjective workload with a single scale [5]. Subsequently, the method will describe the result in the form of RSME scales indicating whether improvements are required to reduce the mental workload in a great effort, very great effort, or extreme effort [6].

# MATERIAL AND METHODS

**Material**

This study is carried out at the bread factory Berkat in Yogyakarta, Indonesia, where the company currently employs ten workers. Three variables are needed to measure the workload in this research that the type of work, heart rate, and scale RSME. The dataset is collected using observation, heart-rate measurement, and questionnaires, respectively. Table 1 presents the type of tasks and description for each activity.

**TABLE 1.** *The type of task and its description.*

|  |  |  |  |
| --- | --- | --- | --- |
| **Task**  | **Workers Number** | **Description of The Task Being done** | **Actor** |
| Mixing | 1 | Standing; to operate a mixer | Worker, Machine |
| Molding | 2 | Sitting; to mold the dough | Worker |
| Baking | 2 | Standing; to operate oven – risk of heat expose | Worker, Machine |
| Cutting | 2 | Sitting; to slice bread | Worker |
| Flavoring | 2 | Standing; to prepare a variety of flavors | Worker |
| Packaging | 1 | Sitting; to operate the packaging machine | Worker, Machine |

Physical workload measurements were performed using the CVL. Two variables should be calculated: the resting pulse rate (PR) and pulse rate of employment (WP). The RP is collected during a 60-minute break starting at 12.00 am for ten days, while the WP is collected once the workers complete tasks between 07.00 – 11.00 am and 02.00 – 03.00 pm for ten days. Then, the RSME scores for the ten workers are obtained from the questionnaire. The value of physical and mental workload for the ten workers is reported in Table 2.

**TABLE 2.** *The Physical and Mental Workload for The 10 Workers.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Tasks** | **Worker ID** | ***RP* Average****(pulse per minute)** | ***WP* Average****(pulse per minute)** | **Mental Workload****Score** |
| Mixing | Worker 1 | 71.50 | 87.50 | 80 |
| Molding | Worker 2 | 66.00 | 102.50 | 80 |
|  | Worker 3 | 73.50 | 90.50 | 70 |
| Baking | Worker 4 | 71.50 | 108.00 | 100 |
|  | Worker 5 | 71.50 | 112.00 | 100 |
| Cutting | Worker 6 | 65.00 | 87.50 | 90 |
|  | Worker 7 | 63.50 | 98.00 | 70 |
| Flavoring | Worker 8 | 75.00 | 97.50 | 70 |
|  | Worker 9 | 63.50 | 109.50 | 90 |
| Packaging | Worker 10 | 74.00 | 82.50 | 60 |

**Methods**

In general, this research is conducted in three stages, which are: (1) physical workload measurement, (2) mental workload measurement, and (3) the recommendation. The first and second stages of measuring physical workload using CVL and mental workload using RSME refer to Elbert et al. [7] and Harris et al. [8].

*The CVL method to measure physical workload*

The CVL method is computed using the following steps:

1. Computing the value of *RP* and *WP* using equation (1)

 $Pulse rate (P)=\frac{10 Beats}{Time calculated}×60$ (1)

1. Computing the physical workload (*% CVL*) using equation (2)

 $\% CVL= \frac{100×(WP-RP)}{P\_{max}-RP}$ (2)

RP is the average pulse rate before starting the tasks, and WPis the average pulse rate during the tasks. Subsequently, the *Pmax* for male and female workers is obtained using equations (3) and (4), respectively.

 $P\_{max}^{m}=220-age$ (3)

 $P\_{max}^{f}=200-age$ (4)

The value of % CVL is then grouped according to the physical workload classification [7] into five groups. These are < 30% (no fatigue), 30%-60% (treatment is required), 60%-80% (short-time working), 80%-100% (immediate action is needed), and > 100% (not allowed to work).

*The RSME method to measure mental workload*

The RSME method has a single dimension of a closed questionnaire with a scale of 0 – 150 and is utilized to measure the mental workload [9]. There are three major steps to measure the mental workload using RSME as follows:

1. Questionnaire preparation. The RSME questionnaire is distributed to the ten workers, including nine male workers and one female worker at the production department. The ten questionnaires were completed when the workers have finished their tasks by circling the numerical value on given scales based on the nine anchor points as shown in Table 3.
2. Compute the average RSME scale. The average RSME score will indicate the tasks that must be treated to reduce the mental workload.
3. Formulate the recommendation depending on the tasks that have high RSME scale. As shown in Table 3, the recommendation is strongly encouraged to improve the tasks with the 81-100 and the >100 scales.

**TABLE 3.** *The RSME Scale.*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Anchor Point** | **9** | **8** | **7** | **6** | **5** | **4** | **3** | **2** | **1** |
| Scale | 0-10 | 11-20 | 21-30 | 31-40 | 41-60 | 61-70 | 71-80 | 81-100 | >100 |
| Linguistic Scale | Absolutely no effort | Almost no effort | A little effort | Some effort | Rather much effort | Considerable effort | Great effort | Very great effort | Extreme effort |

# RESULTS AND DISCUSSION

Table 4 reports the result of physical workload measurement using the CVL method. As reported, two bread makers experience excessive physical workload, namely Worker 5 and Worker 9. The value of %CVL of these two workers is 31.64% for Worker 5 and 40.52% for Worker 9. Based on the tasks information, the workers are assigned to bake and flavor, which requires standing activities during the task completion. Accordingly, these two tasks need improvements.

**TABLE 4**. *The value of RP, WP, Pmax, and %CVL.*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Tasks** | **Worker ID** | ***RP* average** | ***WP* average** | ***P*max** | ***%CVL*** | **Remarks** |
| Mixing | Worker 1 | 71.50 | 87.50 | 195 | 12.95 | No treatment is required |
| Molding | Worker 2 | 66.00 | 102.50 | 201 | 27.03 | No treatment is required |
|  | Worker 3 | 73.50 | 90.50 | 198 | 13.65 | No treatment is required |
| Baking | Worker 4 | 71.50 | 108.00 | 200 | 28.40 | No treatment is required |
|  | Worker 5 | 71.50 | 112.00 | 200 | 31.64 | Treatment is required |
| Cutting | Worker 6 | 65.00 | 87.50 | 199 | 16.79 | No treatment is required |
|  | Worker 7 | 63.50 | 98.00 | 201 | 25.09 | No treatment is required |
| Flavoring | Worker 8 | 75.00 | 97.50 | 182 | 21.02 | No treatment is required |
|  | Worker 9 | 63.50 | 109.50 | 177 | 40.52 | Treatment is required |
| Packaging | Worker 10 | 74.00 | 82.50 | 200 | 6.74 | No treatment is required |

Then, Figure 1 illustrates the comparison between physical and mental workload for the ten bread makers. Worker 5 has an excessive physical workload caused by weight activity, unsafe working posture, and heat thermal. The weighted activity includes lifting bread into the oven, pushing bread into the oven, and lifting bread from the oven. The unsafe working posture occurs for the worker who performs a standing position and squatting physical activity. The heat thermal is due to the hot working environment caused by the roasting process, and thus, the hot temperature at the roasting area increases the physical workload experienced by Worker 5. In addition, the distance between the worker and the oven is relatively close, while the space is narrow, bringing hot temperatures during the baking process. The mouth and drumhead temperatures of bread makers are also higher than other task types [10]. The excessive physical workload will cause fatigue and decreasing performance [11]. There is a significant relationship between heat strain and distance from workers to the oven [12]. The higher heat strain will cause higher heat stress, while the close distance between the worker and the oven will cause high heat stress. It is proposed to overcome the physical workload for the worker during the baking process. First, increasing the time-off frequency and improve the working methods in terms of weight activity. Second, for the unsafe working posture, it is encouraged to improve the working posture. Third, setting the distance between workers and the idle oven and installing an exhaust fan to address the heat thermal. The recommendation for weight activity is under the study conducted by Nourollahi-Darabad et al. [12], while the improvement to setting the worker-oven distance is in line with Bolghanabadi et al. [10].



**FIGURE 1.** *The Normalized Physical and Mental Workload Scores for The Ten Bread Makers.*

The further observation turns to Worker 9, who also experiences the excessive physical workload caused by the most manual work, unfeasible working methods, and unsafe working posture. Most manual work is indicated by the activity of moving bread from the table to the shelf. The unfeasible working method includes preparing flavor, grating cheese, preparing chocolate and shredded, and applying flavor. The unsafe working posture occurs as all activities from moving bread to spreading flavors are taken by workers in a standing position. The proposed improvement for the most manual work is to provide tools, for the unfeasible work method is to change the working method, and for the unsafe working posture is to redesign the facility. The changing working method can be applied by analyzing the sequence of tasks on the flavoring task type. The improvement of working posture can be solved by completing the tasks in a sitting position. Then, redesigning the facility applies to the placement of tools and working areas to complete the tasks quicker. Lastly, the treatment of the unfeasible working method is solved using the change of working method conducted by Widiastuti et al. [13].

Table 3 also describes the mental workload score using the RSME method indicating four workers are classified into the very great effort. They are Worker 4, Worker 5, Worker 6, and Worker 9. Worker 4 and Worker 5 have the RSME scale of 100, while Worker 6 and Worker 9 have the RSME scale of 90. These four workers are assigned to the baking task, cutting task, and flavoring task. The baking task is categorized into a high-temperature activity ranging from 320-360 C for further analysis. This temperature exceeds the threshold value, 280 C, set by the Ministry of Manpower and Transmigration of The Republic of Indonesia [14]. Heat stress can also be causing psychological fatigue in workers [15].

Subsequently, the cutting task is categorized as a very great effort, and it needs improvement. The monotonous bread-making task majorly causes the mental workload in this category. These activities can lead to boredom and lack of focus. Flavoring and cutting task has the same category. It is observed that the mental workload in the task is also due to the monotonous bread-making task. Several improvements proposed to reduce mental workload at the baking process is similar to the recommendations suggested on heat thermal effect, namely keeping the distance between the workers and the idle oven, providing drinking water, and installing the exhaust fan. For the cutting task, it is suggested to increase the time-off frequency. While the flavoring task, it is encouraged to provide tools and improving working posture. The score of CVL and RSME indicates that the baking process and flavoring process have the highest physical and mental workload score. Therefore, this may lead to the relationship between physical and mental workload [16].

# CONCLUSION

The successful implementation of CVL and RSME for bakery workers reveals the type of work that requires improvement. There are baking, cutting, and flavoring processes. Workers in baking and flavoring jobs experience high physical and mental workloads. In baking, the high workload is caused by unsafe working posture and heat thermal, while in flavoring work type, it is caused by the most manual work, unfeasible working methods, and unsafe working posture. In cutting, workers face a high mental workload caused by the work being monotonous. Based on the analysis of work posture and work environment, five corrective treatments can be recommended, such as keeping the distance of workers when the oven is not operating, providing drinking water, increasing the time-off frequency, changing the working procedures, and worker's postures. For the type of cutting and flavoring work type, from the analysis of work postures and work methods, three treatments can be recommended, namely increasing time-off, providing supportive tools, and improving working postures. A future study should be carried out to measure the effectiveness of the proposed improvements in reducing workload.

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