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Ergonomic risk analysis with environmental interventions to reduce occupational diseases

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Abstract

Most small industries still rely on human labour as workers. The use of human labour requires special attention with regard to the risk of occupational diseases. Risks at work can arise from human, environmental and external factors. It has been observed that some manual jobs require energy beyond the worker's capabilities, a working environment that is not conducive and uncomfortable work equipment. Discomfort at work can cause workers to tire quickly. The risks associated with these working conditions can lead to long-term health problems. The aim of this research is to identify the human factors and work environment factors that can lead to occupational health risks. The approach used in this research is the ergonomic risk influenced by work environment factors to reduce the level of fatigue at work. The method used is REBA to identify postures that are not ergonomic due to the work environment and heart rate measurement to assess the level of worker fatigue. The research results show that the F-value < F-table is 1.23 < 3.478, which means that there is a significant relationship between temperature, noise, humidity and lighting on the level of fatigue experienced by workers. The Pearson correlation test confirmed a positive relationship between REBA scores and heart rate, showing that the worse the posture, the higher the level of physical fatigue experienced by workers.

Keywords

Environment, Ergonomic risk, Fatigue, Heart rate

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Introduction

The 2023 BPS data shows that 50.7% of Indonesia's population, or 139.8 million Indonesians, have jobs. Indonesian workers by gender are 54.5 million or 59% female workers and 85.3 million or 61% male workers. Of Indonesia's population of 275.8 million, 212.6 million or 75.9% are of working age. Based on the number of productive ages, there is a workforce of 147.7 million or 68.6%, of which 139.8 million or 94.1% are employed and the rest are unemployed. In terms of type of work, there are 57.1 million formal workers or 40.9%, while there are 82.7 million informal workers or 59.1% [1].

Informal workers mainly work in SMEs, where most work is still done manually by human labour. Some problems in SMEs are Un-ergonomic postures, foot pain, high workload and fatigue, and pain in some parts of the body. Employees hope that if they go to work in good health, they will be safe and comfortable while working in the company, so that they can go home in good health. A number of factors - physical, chemical, biological, ergonomic and psychological - can cause occupational diseases [2].

There are many types of work that cause fatigue in workers. This poses health risks ranging from mild to severe and can affect employee productivity, performance and quality of life. The working environment is one of the many causes of job burnout. Unpleasant working conditions such as dim lighting, high temperatures and loud noises can cause stress and fatigue in workers [3]. The effects of fatigue can reduce performance and productivity, increasing the risk of accidents and ill health. There are also other effects, such as mental and emotional health problems and a reduced quality of life. Factors that can influence work fatigue include workload, working hours and the physical conditions of the working environment.

Based on observations and measurements of work environment factors, it is known that very hot room temperatures cause excessive sweating during the production process and noise during the machining process. Fixed working positions and postures, continuous work and uncomfortable working conditions are the result of working 7 hours a day. Some jobs require the strength to lift a 35kg weight every half hour. The measurement of environmental factors showed values for noise of 90 dB, temperature of 370 C, humidity of 80% and lighting of 73 lux. The measurement results do not meet the thresholds specified in the Regulation of the Minister of Manpower of the Republic of Indonesia No. 5 of 2018 on Environmental Work Health and Safety. High temperatures can cause workers to become fatigued, resulting in reduced concentration on the job and product failure. Noise above threshold can cause hearing loss leading to temporary or permanent deafness. Lighting above or below the threshold can cause eye fatigue, which can affect safety at work.

Based on several problems encountered, it is necessary to carry out an assessment of ergonomic risks with work environment interventions that have an impact on occupational health. The hope of this research is that we can find out which factors have a strong influence on worker fatigue. Prolonged fatigue at work will have a long-term effect on health. Ergonomic risk assessment is based on the posture formed during work as a result of work environment factors. The posture assessment uses REBA by paying attention to the leaves that are formed from the results of photographing the posture that is formed. Meanwhile, work fatigue is measured based on the use of smart whach to see the heart rate value.

Method

Various situations at unergonomic workstations can result in the adoption of unnatural working postures. Some examples are squatting or sitting hunched over. Work posture is a crucial determining factor in analysing whether a job is effective or not. If the operator follows a good ergonomic work posture, the work outcome is likely to be positive. However, if the operator's work posture is less ergonomic, the operator tends to fatigue easily, potentially experiencing structural disorders, and the work output is not optimal. Operator fatigue can result in a decrease in performance that is not in line with expectations [4]. Ergonomic assessment has been widely assessed using a number of methods, but there are two main methods that are effective in ensuring worker health and safety - Rapid Entire Body Assessment (REBA) and Rapid Upper Limb Assessment (RULA). Ergonomic assessments evaluate the interaction between workers and their work environment to identify potential hazards and implement corrective measures [5].

REBA is a comprehensive ergonomic assessment tool that evaluates the posture and movements of workers across the whole body. It considers factors such as posture, force and repetition to assess the risk of MSDs. REBA assigns a score based on these parameters, indicating the level of ergonomic risk and recommending appropriate interventions. REBA can be used to assess your lifting posture and identify potential risks such as awkward postures or excessive force. Based on the assessment, ergonomic interventions can be implemented, such as providing lifting aids or adjusting work procedures to reduce the risk of injury. The REBA method is used to identify ergonomic risks by measuring body posture, which is divided into 3 filling tables to obtain the REBA value. Here is a table to calculate the REBA value as seen on Figure 1.

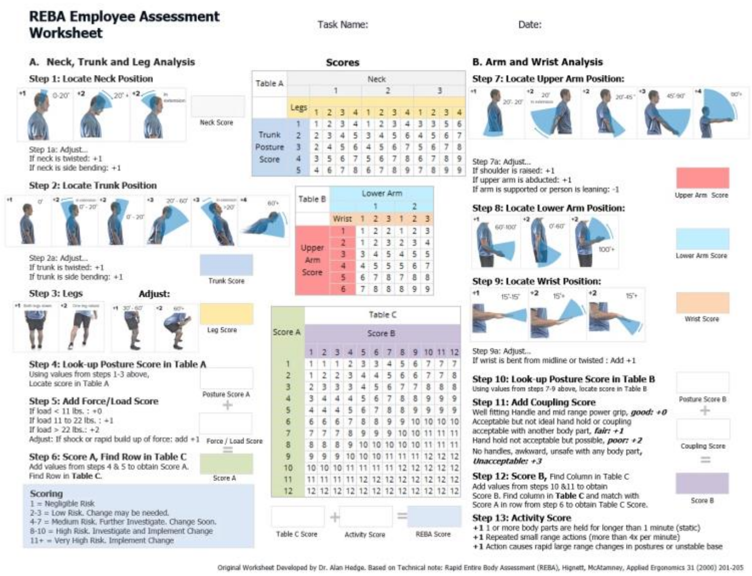

Figure 1. REBA assessment worksheet

Once the REBA score has been obtained, a decision is made on the level of risk and the measures to be taken with regard to posture at work. The following steps are used to find out the extent of worker complaints, starting with the recording of items to be observed, interviewing workers, carrying out risk identification, risk assessment and risk control [6]. The following is a model for continuous improvement of ergonomic risk analysis, where the sustainability of the process is achieved through continuous improvement as Figure 2.

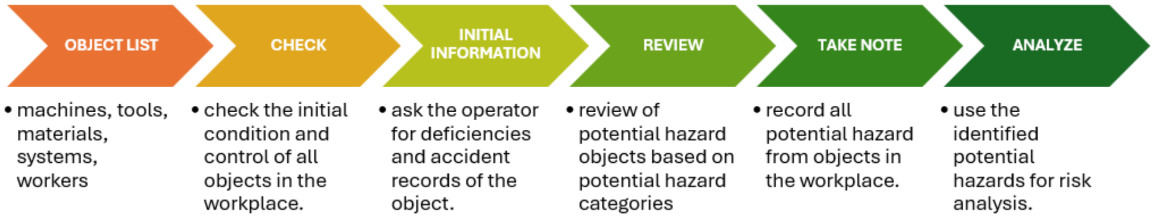

Figure 2. Identification of potential hazards

The following is a model for continuous improvement of ergonomic risk analysis, where the sustainability of the process is achieved through continuous improvement as seen on Figure 3.

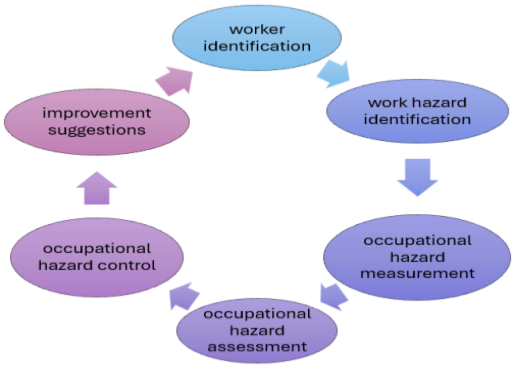

Figure 3. An Ergonomic risk analysis model for continuous improvement

Three statistical tests were used in this study, namely the normality test, the linearity test and the Pearson correlation test [7]. There are several ways to test for normality, one of which is the Kolmogorov-Smirnov test. The linearity test aims to determine whether two or more variables under test have a linear or non-significant relationship. This test is used as a prerequisite for correlation or linear regression analysis. Pearson's correlation is a number that indicates the direction and strength of the relationship between two or more independent variables and a dependent variable.

The Pearson correlation model involves more than one independent variable or predictor. It is based on a 95% confidence level and a significance level of 0.05. The Pearson correlation test is used to measure the strength and direction of the linear relationship between two variables [8], [9]. The hypotheses of this study are as follows:

H0: There is no relationship between the REBA score and the worker's heart rate.

H1: There is a relationship between the REBA score and the worker's heart rate.

Result and Discussion

Demographic data of employees

In the production of moulded products, there are 10 activities, from pouring aluminium liquid to picking up the moulded products. At each workplace, one person is taken as a respondent and they are male. The average age of the workers is 41.20 ± 9.11 years. The average height of the workers is 162 cm ± 5.55 cm. The body weight of the workers is 55.20 kg ± 9.27 kg. During the production process, workers work in a static posture and stand for 7 working hours.

Work hazard identification

Figure 4 shows 10 postures of 10 workers in metal moulding activities. It can be seen that all postures formed are not ergonomic so that they can have an impact on pain in several parts of the body, especially the back, legs and hands. Sustained body pain can lead to health problems in workers. Each posture number describes the initials of the worker. e.g. posture 1 is the posture of worker 1.

Figure 4. Moulding postures

REBA measurement

The following is the average result of the reba assessment for 50 respondents in 5 SMEs. it can be seen that the highest average reba value is 10.3. Table 1 shows the REBA measurement results.

Tabel 1. The REBA measuring result

Respondents	Table A Scores	Table B Scores	Table C Scores	REBA Scores
Worker 1	6,5	3,95	7,1	8,1
Worker 2	5,85	5,6	7,65	8,65
Worker 3	7,7	4,2	8,7	9,7
Worker 4	7	4,8	8,4	9,4
Worker 5	7,4	5,45	8,55	9,55
Worker 6	7,1	4,25	8,1	9,1
Worker 7	7,4	4,8	8,85	9,85
Worker 8	7,7	3,75	8,45	9,45
Worker 9	7,6	5,75	9,3	10,3
Worker 10	7,25	5,19	9	10

Risk level measurement

Below are the results of the REBA assessment for the highest score on each table, it can be seen that the highest REBA score is 11, so immediate improvements need to be made. The risk level of the measurement is shown in Table 2.

Tabel 2. The level of risk measured

Respondents	Table A Scores	Table B Scores	Table C Scores	REBA Scores	Risk Level
Worker 1	7	6	9	10	High
Worker 2	7	6	9	10	High
Worker 3	9	6	10	11	Very High
Worker 4	7	6	9	10	High
Worker 5	9	6	10	11	Very High
Worker 6	8	6	10	11	Very High
Worker 7	8	6	10	11	Very High
Worker 8	9	4	10	11	Very High
Worker 9	9	6	10	11	Very High
Worker 10	8	6	10	11	Very High

Ergonomic risk analysis with the rapid entire body assessment (REBA) method

The calculation of REBA scores from 200 work activities is based on the recording of the work postures of 10 workers in 5 SMEs in the Metal Casting Industrial Centre. The lowest score generated was 5 out of 5 work activities, or 3%, which was classified as a medium risk category requiring action. Scores of 8, 9 and 10, which fall into the high-risk category and require immediate action, were identified in 158 work activities or 79%. The highest score generated is 11, which is in the very high-risk category and requires immediate action, and was found in 37 work activities or 19%.

Recap of employee heart rate values

Next is a recapitulation of the heart rate measurements in each type of posture. seen at all ages, the heart rate obtained is almost the same and includes high. The risk level of the measurement is shown in Table 3.

Tabel 3. The level of risk measured

Respondents	Age	Heart Rate
Worker 1	23	123,4
Worker 2	29	124,4
Worker 3	41	126
Worker 4	35	125
Worker 5	52	129,2
Worker 6	47	127,2
Worker 7	43	126,4
Worker 8	42	126,4
Worker 9	51	128,8
Worker 10	49	128,4

Based on the results of heart rate measurements, a standard mean heart rate of 110-130 bpm is classified as heavy work [10]. This may be due to the high room temperature of over 37°C and supported by heavy work activities such as lifting weights, continuous activity and continuous work. This is in line with research conducted by Artayasa [11], where the average heart rate of coconut transport workers was 126.24 ± 14.10 bpm, which was also classified as heavy work. Physical factors may also influence age. Worker 1, Worker 2 and Worker 4 are workers aged 23-35 years who have better resistance to physical stress than Worker 2, Worker 3, Worker 4, Worker 5, Worker 6, Worker 9 and Worker 10 who are workers aged 41-52 years.

Statistical Test Results

Normality test, the results of the normality test obtained a significance value of 0.200, it can be concluded that the REBA score data and the worker's heart rate are normally distributed, so the requirements for the Pearson correlation test are met.

Linearity test, the results of the linearity test obtained a significance value of 0.706, which means that there is a linear relationship between the REBA score data and the worker's heart rate. The result of F-count is 0.467 and F-table is 2.65, so it can be interpreted that there is a linear relationship.

Pearson correlation test, the results of the Pearson correlation value of 0.22 and the Pearson correlation table value of 0.138 indicate that H0 is rejected, which means that there is a significant relationship between REBA scores and workers' heart rate. The Pearson correlation value of 0.22 indicates that the relationship is weakly positive.

Relationship between REBA score and heart rate (HR)

The results of the REBA score calculation show that worker 1, worker 2 and worker 4 are at a high level while the other workers are at a very high level. This is in line with the results of measuring the pulse rate of the three workers which is lower than the other workers. This shows that there is a close relationship between the REBA score and the level of fatigue. The relationship can be interpreted that work with high REBA scores may be caused by unergonomic postures or heavy physical loads. Bending or repetitive lifting of 35 kg can result in a high REBA score [12]. This is associated with an increase in heart rate as the body expends excess energy to lift the weight. The use of HR and REBA data can provide a comprehensive picture of fatigue and injury risk. Ergonomic risk assessment can be used as a basis for ergonomic interventions to reduce fatigue experienced by workers [13].

According to the National Institute for Occupational Safety and Health (NIOSH), the recommended weight load that is considered safe for ideal lifting is 23 kg, while in the case of prolonged standing, the body can only tolerate standing for 20 minutes. If it exceeds this limit, tissue elasticity will decrease, muscle stress will increase, and discomfort will occur in the back region.

Conclusion

Unergonomic postures can cause fatigue and put workers at risk of physical injury. In addition, ergonomic risk analysis using the REBA method can identify worker postures that can cause occupational diseases. The high average heart rate of 126.52 bpm indicates a high physical workload. The Pearson correlation test confirmed a positive relationship between REBA scores and heart rate, suggesting that the worse the posture, the greater the physical fatigue of the workers.

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