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# The Effect of Noise, Blood Glucose, and Body Mass Index on Lactate Levels in Textile Industry Workers

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**Abstract:** Occupational fatigue remains a prevalent concern in occupational health. This study investigated the association between noise intensity, blood glucose levels, body mass index (BMI), and lactate levels as an indicator of occupational fatigue among textile industry workers in Surakarta, Indonesia. An analytical observational study with a cross-sectional design was conducted, with 82 participants recruited from a local textile industry. Multivariate analysis using multiple binary logistic regression revealed that noise intensity, blood glucose levels, and BMI were significant risk factors for occupational fatigue, as indicated by elevated lactate levels. These findings highlight the importance of noise reduction measures, a healthy lifestyle, and regular monitoring of blood glucose levels and BMI to mitigate occupational fatigue among textile industry workers.

**Keywords:** Blood glucose; Body mass index; Lactic acid; Noise

## Introduction

The role of noise as an environmental pollutant that can have a negative impact on health is increasingly recognized (Hahad et al., 2019), and one of the impacts is occupational fatigue in workers (Rahimimoghadam et al., 2023). Unwanted noise exposure in the workplace can affect the quality of work and the well-being of employees. Occupational fatigue caused by noise occurs through mechanisms of psychological and physical disturbances in workers (Radun et al., 2022). Noise can disrupt concentration, interfere with communication, and create stress (Fitria & Malik, 2022), all of which can contribute to occupational fatigue (Gyllensten et al., 2023). When workers work in a very noisy environment, the body will increase the body's metabolism process, thus requiring energy from lactate acid (Zhang et al., 2017). Increasingly increasing levels of lactate acid in the body can be an indication of intense physical work or increasing fatigue (Hidayah, 2018).

In addition to noise, individual factors that can affect occupational fatigue include blood glucose levels (Sulistyowati et al., 2019) and body mass index (Mansouri-yachou et al., 2019; Muriyati et al., 2023). Blood glucose levels are the body's main source of energy (Andayani et al., 2022; Safrida et al., 2023). Stable and sufficient blood glucose levels are essential to maintain adequate energy levels during intense physical or mental activities. When blood glucose levels drop, the body breaks down glucose into energy (Sudrajat et al., 2023), which can lead to increased levels of lactate acid in the blood. When working for long periods of time, workers may experience decreased energy and occupational fatigue (Koma & Terasawa, 2020).

Occupational fatigue can be exacerbated by body mass index (BMI) (Nurhidayah & Puspitosari, 2023) that exceeds the ideal range (Asnidar et al., 2023). Workers who are overweight or obese have a higher risk of health problems, such as heart disease, diabetes, and high blood pressure. Excess weight will require more energy when performing physical work (Widiastuti et al., 2023), which can lead to occupational fatigue. Obesity

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problems sometimes start in childhood, which can increase the risk of obesity in adulthood (Asnidar et al., 2023).

Textile spinning workers often engage in repetitive physical tasks, such as lifting spools of yarn, adjusting machines, and fixing technical problems. This can lead to chronic physical fatigue due to continuous and monotonous physical activity. On the other hand, environmental noise factors and individual factors, including blood glucose levels and body mass index, also pose a risk of occupational fatigue.

Understanding the impact of noise and other contributing factors on occupational fatigue in textile workers is crucial for developing effective preventive measures and promoting worker health and safety. By investigating the relationship between noise intensity, blood glucose levels, body mass index, and lactate levels as an indicator of occupational fatigue, this study aims to provide valuable insights into the multifaceted nature of fatigue in this industrial setting. The findings can inform targeted interventions to mitigate noise-induced fatigue and promote overall well-being among textile industry workers. Therefore, the purpose of this study is to analyze the effects of noise, blood glucose levels, and body mass index on occupational fatigue with the indicator of lactate acid.

## Method

This study investigated the impact of noise exposure, blood glucose levels, and body mass index on lactate acid levels in textile industry workers using an observational analytical approach with a cross-sectional design. A sample of 82 participants was randomly selected from a population of 425 textile industry workers in Surakarta, Indonesia. The Rule of Thumb formula (n = 50 + 8m) was employed to determine the sample size, where m represents the number of independent variables. Data collection involved measuring noise levels using an Extech Sound Level Meter (dB(A)), blood glucose levels using an Autocheck 3 in-1 device, and body mass index (BMI) using an ACE S875 Digital Weight Scale and a GEA HT721 Digital Height Meter. The formula BMI = Weight/Height*Height was used to calculate BMI. Lactate acid levels were measured using a Blood Lactate Monitoring System S54108 from The Edge (mg/dL). Demographic characteristics were collected via a questionnaire. The scale of data variables was categorized based on established thresholds: Noise: Above threshold (> 85 dB(A)) or Below threshold (≤ 85 dB(A)); Blood Glucose Levels: Above normal (> 180 mg/dL) or Normal (≤ 180 mg/dL); Body Mass Index (BMI): Overweight (BMI > 25 kg/m2) or Ideal (BMI ≤ 25 kg/m2); Lactate Acid Levels: Above normal (> 45 mg/dL) or Normal (≤ 45 mg/dL). Frequency distribution tables were used for univariate analysis, simple binary logistic regression for bivariate analysis, and multiple binary logistic regression for multivariate analysis. Data analysis was performed using SPSS 27 software, and a significance level of α = 0.05 was applied. The study aimed to determine the associations between noise exposure, blood glucose levels, body mass index, and lactate acid levels in textile industry workers.

This research has obtained ethical approval from the Ethics Committee of Dr. Moewardi Hospital Surakarta through the issuance of letter No. 1.101/VI/HREC/2023 dated June 23, 2023.

## Result and Discussion

*Demographic Characteristics Questionnaire*

To describe the demographic characteristics of the respondents, an interview was conducted using a demographic characteristics questionnaire to ask or record data on gender, age, length of service, place of residence, family status, education, and smoking habits.

*Noise Intensity Measurement*

Noise intensity measurement was carried out in stages, namely ensuring that the Sound Level Meter was calibrated, ensuring that the batteries were fully charged, measuring the noise intensity at a point that represents the exposure of workers by using a tripod 1.2 meters high from the floor and ensuring that there are no obstacles. Measurements were taken at 9 a.m., 1 pm, and 3 pm, and then the Leq was calculated. Measurements were taken in noisy rooms with high intensity, namely the Spinning and Weaving sections, and low-intensity noise in non-weaving areas (Blowing, Carding, Warping, and Inspecting-Folding).

*Blood Glucose Level Measurement*

Blood glucose level measurement follows the following steps: Ensure that the device is ready to use and that test strips are available. The examiner washes their hands with clean water and dries them with a clean towel. Prepare the device by inserting a test strip. Turn on the device and wait until it is ready to take a blood sample. Prepare the lancet and sterilize the blood sampling area (usually the index or middle finger). Select the depth of the lancet according to the device instructions and prick the subject's finger until a small drop of blood is produced. Apply the end of the test strip to the produced drop of blood while ensuring that the test strip is completely absorbing the blood. The Autocheck 3 in 1 device will process the blood sample in a few seconds, displaying the results of the Blood Glucose Level Sewaktu on the screen in mg/dL units. Record the results.

*Body Mass Index Measurement*

Body mass index measurement follows the following steps: Measure the weight using a calibrated scale in kilograms (kg). Measure the height in meters (m) or centimeters (cm). Ensure that the height measurement is taken with the subject standing upright with their back straight, without shoes, and head up. Calculate BMI using the BMI formula.

*Lactic Acid Level Measurement*

The measurement of lactic acid levels follows the following steps: Prepare the device according to the operating instructions and ensure that the device is in good and clean condition. Prepare the lancet to take a blood sample by sterilizing the area on the finger where the blood sample will be taken. Take a blood sample by pinching the finger with the lancet according to the device's instructions. This will result in a drop of blood that will be used for the measurement. Place the drop of blood on the test strip. Insert the test strip into the device and wait for the device to complete the measurement. The measurement of lactic acid levels in the blood is based on a chemical reaction that occurs on the test strip. The results of the measurement of lactic acid levels will be displayed in mg/dL units on the device screen. Figure 1 shows the blood sampling of respondents in the measurement of blood glucose and lactate acid levels.

**Figure 1**. Blood sampling for the measurement of blood glucose and lactate acid levels

The results of the measurement of demographic characteristics, noise intensity, blood glucose level, body mass index, and lactic acid levels are shown in Table 1.

**Table 1.** Results of the Measurement of Research Variables

| Variables | | Level lactic acid (mg/dL) | | p | OR | 95% C.I. for OR | |
|---|---|---|---|---|---|---|---|
| | | ≤ 45 | > 45 | | | Lower | Upper |
| Gender | Male | 24 | 13 | 0.102 | 0.47 | 0.19 | 1.15 |
| | Female | 21 | 24 | | | | |
| Age (year) | > 40 | 43 | 32 | 0.163 | 0.29 | 0.05 | 1.63 |
| | ≤ 40 | 2 | 5 | | | | |
| Years of experience | > 30 | 33 | 26 | 0.349 | 1.25 | 0.78 | 2.01 |
| | > 20 - 30 | 9 | 5 | | | | |
| | > 10 - 20 | 0 | 1 | | | | |
| | ≤ 10 | 3 | 5 | | | | |
| Place of residence | Urban | 17 | 16 | 0.616 | 1.25 | 0.51 | 3.04 |
| | Rural | 28 | 21 | | | | |
| Marital status | Unmarried | 2 | 1 | 0.679 | 0.59 | 0.05 | 6.85 |
| | Married | 43 | 36 | | | | |
| Education | Bachelor's degree | 3 | 0 | 0.856 | 1.05 | 0.60 | 1.82 |
| | Diploma 3 | 4 | 5 | | | | |
| | Senior high school | 31 | 25 | | | | |
| | Junior high school | 5 | 7 | | | | |
| | Elementary school | 2 | 0 | | | | |
| Smoking habit | Smoker | 8 | 3 | 0.212 | 0.40 | 0.10 | 1.66 |
| | Non-smoker | 37 | 34 | | | | |
| Noise intensity (dB(A)) | > 85 | 3 | 14 | 0.002* | 8.52 | 2.21 | 32.76 |
| | ≤ 85 | 42 | 23 | | | | |
| Blood glucose levels (mg/dL) | > 180 | 6 | 21 | 0.000* | 8.53 | 2.90 | 25.06 |
| | ≤ 180 | 39 | 16 | | | | |
| BMI (kg/m2) | > 25 | 17 | 26 | 0.004* | 3.89 | 1.54 | 9.84 |
| | ≤ 25 | 28 | 11 | | | | |

*Significant at p = 0.05

There were 10 risk factors for lactic acid as an indicator of work fatigue, with 7 variables being insignificant ($p > 0.05$) and 3 variables being significant ($p < 0.05$). The significantly correlated variables were

Noise, Blood Glucose Level, and Body Mass Index. Next, these three significant variables proceeded to multiple binary logistic regression analysis to determine the influence of these three variables simultaneously or in a partial relationship.

The results of the multiple binary logistic regression analysis produced several pieces of information, namely that the three independent variables simultaneously affect work fatigue, as can be seen in the Omnibus Tests of Model Coefficients analysis ($X^2 = 27.235$; $p = 0.000 < 0.05$). In the Model Summary output, the Nagelkerke R Square value is 0.378. Thus, the three independent variables (noise, blood glucose level, and body mass index) simultaneously affect work fatigue by 37.8%, while 62.2% are affected by other variables that are not discussed in this study. The Hosmer and Lemeshow Test analysis shows that the three independent variables can predict the value of work fatigue ($X^2 = 3.25$; $p = 0.524 > 0.05$).

The results of the analysis of the influence of noise level, blood glucose level, and body mass index on lactic acid using multiple binary logistic regression can be seen in Table 2.

**Table 2**. Results of Multivariate Analysis

| Variables | Level lactic acid (mg/dL) | | β | p | aOR | 95% C.I.for OR | |
|---|---|---|---|---|---|---|---|
| | ≤ 45 | > 45 | | | | Lower | Upper |
| Noise (dB(A)) | | | | | | | |
| > 85 | 3 | 14 | 1.51 | 0.043* | 4.54 | 1.04 | 19.77 |
| ≤ 85 | 42 | 23 | | | | | |
| Blood glucose levels (mg/dL) | | | | | | | |
| > 180 | 6 | 21 | 1.56 | 0.009* | 4.80 | 1.48 | 15.53 |
| ≤ 180 | 39 | 16 | | | | | |
| BMI (kg/m²) | | | | | | | |
| > 25 | 17 | 26 | 1.12 | 0.000* | 3.06 | 1.06 | 8.86 |
| ≤ 25 | 28 | 11 | | | | | |
| | | Constant | -1.61 | 0.000* | | | |

*Significant at p < 0.05

The results of the multiple binary logistic regression test produced standardized values with a constant of -1.61. This means that if noise, blood glucose level, and BMI are all 0, then the lactic acid level will decrease by -1.61, which is statistically significant ($p = 0.000 < 0.05$). The regression coefficients of all independent variables show positive results, which means that if blood glucose level and BMI are held constant, then exposure to noise above 85 dB(A) can increase the lactic acid level by 1.51 points. If noise exposure and BMI are held constant, then a blood glucose level > 180 mg/dL can increase the lactic acid level by 1.56 points. If noise exposure and blood glucose level are held constant, then BMI > 25 kg/m² can increase the lactic acid level by 1.12 points. From the results of the multiple binary logistic regression analysis, the following regression equation model can be presented:

$y = -1.61 + X_1*1.51 + X_2*1.56 + X_3*1.12$

$p = 1/(1 + 2{,}7^{-y})$

p = Logistic probability of lactic acid level > 45 mg/dL (value: 0 to 1).

y = The value of the calculation results of the regression model formula.

$X_1$ = Noise (> 85 dB(A) = 1, ≤ 85 dB(A) = 0).

$X_2$ = Blood glucose level (> 180 mg/dL = 1, ≤ 180 mg/dL = 0).

$X_3$ = BMI (> 25 kg/m² = 1, ≤ 25 kg/m² = 0).

An increased risk of high lactic acid levels was found based on the aOR values of each independent variable, namely noise (aOR = 4.544), blood glucose level (aOR = 4.801), and BMI (aOR = 3.407). Therefore, blood glucose is the greatest risk factor. Lactic acid ($C_3H_6O_3$) is an organic compound that is formed in the human body as a result of glucose metabolism. During heavy physical activity such as working, lactic acid production can increase significantly. Lactic acid is used as an indicator of work fatigue in the context of work, exercise, and other physical activities (Hall et al., 2016). Lactic acid production occurs when the body requires additional energy for intense physical activity (Brooks, 2020). Muscle cells begin to break down glucose into energy through anaerobic pathways, which produce lactic acid as a byproduct (Ma, 2023). As the intensity of physical activity increases, as well as the influence of environmental factors such as noise in the workplace, and the influence of individual factors such as blood glucose levels and BMI, the body produces more lactic acid to meet energy needs when physical load also increases (Dias et al., 2023). The increase in lactic acid production will further trigger the sensation of muscle fatigue and discomfort, so lactic acid is often considered an important indicator of work fatigue (Tornero-Aguilera et al., 2022).

The results of previous studies are consistent with the results of this study, but this study uses lactic acid as an indicator, while previous studies used the Fatigue Measurement Questionnaire and Subjective Self Rating Test. In a study of 348 workers at a crumb rubber factory in Padang, Indonesia, a correlation was found between noise exposure and work fatigue (t = 2.024; p = 0.046 < 0.05). The results showed that 26.19% of the workers experienced mild fatigue, 71.43% experienced moderate fatigue, and 2.38% experienced severe fatigue (Ihsan et al., 2021). A study in Iran that compared administrative department workers exposed to noise of 51.42 dB(A) (n = 26) and production department workers exposed to noise of 79.78 dB(A) (n = 26) showed significant differences in work fatigue using the Mann Whitney U Test (p = 0.000) (Heidari et al., 2021). In two different noise intensities, both above 85 dB(A), no significant differences in work fatigue were found between the 93.1 dB(A) exposure group and the 103.2 dB(A) exposure group using the Coefficient Contingency Test. The study found that 64.1% of the workers experienced mild work fatigue (Rahmawati & Tualeka, 2019). In the Oil and Gas Industry, it was also found that noise has a 39% effect on work fatigue at noise intensities between 85.967 dB(A) and 87.155 dB(A) (Hebrani et al., 2018).

The relationship between blood glucose levels and work fatigue has also been studied previously. A study in a Midwestern city in the United States found that there was a relationship between blood glucose levels and fatigue after controlling for BMI, gender (Zuhara et al., 2019), and depression (b = 0.123; p = 0.05). However, when analyzed separately, the relationship between blood glucose levels and fatigue was significant in women (b = 0.163, p = 0.011), but not in men (b = 0.116, p = 0.313) (Fritschi et al., 2020). A study in Australia found a significant relationship between blood glucose levels and fatigue. The study compared a sample of people with diabetes mellitus (DM) (n = 16) to a control group (n = 41). The DM group had significantly higher blood glucose levels than the control group (p < 0.01) (Beehan-quirk et al., 2020). The results of the studies in the United States and Australia are consistent with the results of this study, which show a significant relationship between blood glucose levels and fatigue. However, the indicators used are different. This study used casual blood glucose, while the previous studies used HbA1c.

Several studies confirm the relationship between diabetes and fatigue, although further research is needed to delve deeper into how and why this occurs. One study found that individuals with diabetes are 10 times more likely to experience fatigue compared to those with normal blood glucose function. Among the study participants, as many as 68% claimed to have experienced fatigue (Long, 2023). A study in Iran that used a sample of 85 people with an average age of 39.07 ± 8.84 years found that fatigue scores were directly correlated with BMI (r = 0.23; p = 0.030). This study is consistent with the results of this study, which also found a relationship between BMI and fatigue (Rezaeimanesh et al., 2023), and a study in the United States found that adults with normal body weight showed a 21.7% longer endurance time against fatigue than obese adults. This was based on the results of an ANOVA test, which showed a value of F(2, 130) = 2.54 and p = 0.080 (Mehta et al., 2017). A study conducted by Sumardiyono et al. found an association between noise exposure, blood glucose levels, and body mass index (BMI) with lactate levels in textile industry workers. High noise exposure can increase blood glucose levels and BMI, which can ultimately lead to increased lactate levels. This is because noise exposure can cause stress, which can increase cortisol production. Cortisol can increase blood glucose levels and BMI, which can ultimately lead to increased lactate levels (Sumardiyono et al., 2017). The results of a literature review found that obesity is emerging in the workforce, as published in leading human factors and occupational safety and health journals in the past decade. Overall, 44 studies were found, of which 27% focused on the general effects of obesity on work performance, including work fatigue (Mahboobeh Ghesmaty Sangachin, 2016).

## Conclusion

This study identifies noise exposure, blood glucose levels, and BMI as risk factors for work fatigue, characterized by elevated blood lactate levels. It recommends using ear protection in noisy environments, adopting healthy lifestyle habits, and regularly monitoring blood glucose and BMI to mitigate work fatigue.

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Conceptualization: SMD and B.C; methodology: SMD and F.S.N.S.; validation: SMD, R.P.F.; formal analysis: R.W; investigation: M.P.W; resources: SMD and Y.R.A.; data curation: SMD, B.C., F.S.N.S., R.P.F., and M.P.W.; writing—original draft preparation: SMD and M.P.W.; writing—review and editing: SMD; visualization: F.S.N.S., R.W., and Y.R.A. All authors have read and agreed to the published version of the manuscript.

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**Conflicts of Interest**

In the activity of conducting this research, there were no conflicts of interest or hidden interests among the researchers.

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