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RESEARCH ARTICLE

The Effect of Noise Exposure On Work Fatigue with Blood Pressure and Pulse Rate in Construction Project Workers of the Makassar Vertical Hospital Development

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ABSTRACT

Noise can cause health problems for humans, such as increased blood pressure, where high blood pressure can cause the heart to work harder and can cause complaints for a person, such as getting tired quickly, getting angry quickly and getting stressed quickly. Knowing the effect of noise on work fatigue through blood pressure and pulse rate in construction workers of the Makassar Vertical Hospital. This study uses quantitative research with a cross-sectional approach and a sample size of 281 respondents. Noise has a direct effect on the variables of Systolic blood pressure (0.042), diastolic blood pressure (0.027), pulse rate (0.040), subjective fatigue (0.000) and objective fatigue (0.000) direct effect between systolic blood pressure on subjective fatigue (0.000), diastolic blood pressure on subjective fatigue (0.000) and objective fatigue (0.003) and direct effect between pulse rate on subjective fatigue (0.000) and objective fatigue (0.000). Indirect effect is noise on subjective fatigue through diastolic blood pressure (0.041) and through pulse rate (0.046). Management can prepare occupational safety and health plans and pay more attention to good work environment standards and workers can comply more with work regulations to minimize the risk of work fatigue.

INTRODUCTION

Humans have an important role in industry because production still depends on the interaction between machines, work tools and the environment which can cause additional burdens and fatigue for the workforce(1). The construction sector is at high risk of work accidents due to the many unsafe behaviors and conditions, so workers must master the knowledge and skills to meet competencies(2). WHO defines a work accident as an unexpected event that causes injury, while according to Bird (1989), work accidents also include damage to property. WHO calls severe fatigue the second killer disease after heart disease. ILO data 2015 recorded that every 15 seconds one worker dies and 153 workers experience work-related accidents, with a total of 2.3 million deaths per year, consisting of 321,000 due to work accidents and 2.02 million due to work-related diseases(3).

ILO data (2018) recorded that two million workers die each year due to work accidents triggered by fatigue. In 2019, 32% of world workers experienced fatigue, with severe complaints ranging from 18.3–27% and the prevalence of fatigue in industry reaching 45%. Deaths due to work accidents,

amounting to 60%, occurred in the agriculture, construction, transportation, fisheries, forestry, and warehousing sectors(4). The National Safety Council (NSC) reports that 13% of work injuries are fatigue-related, with 97% of workers having at least one risk factor, and more than 80% having multiple risk factors, which increases the potential for injury. In Indonesia, the construction sector recorded the highest number of work accidents (32%), followed by manufacturing (32%), transportation (9%), forestry (4%), mining (2%), and other sectors(5).

BPJS Ketenagakerjaan data recorded 147,000 cases of work accidents throughout 2021, with 4,678 deaths (3.18%) and a daily average of 40,273 cases, including 12 disabilities and 7 deaths. The Ministry of Manpower (2021) reported a daily average of 414 accident cases, 27.8% of which were caused by fatigue, with 9.5% or 39 cases resulting in disability. Every year, Indonesia records an average of 99,000 cases of work accidents, of which 70% are fatal, such as death or permanent disability(6). Ministerial Regulation No. 5 of 2018 mentions five hazard factors in the workplace: physical, chemical, biological, ergonomic, and psychological. One of the physical hazards is noise, which is defined as sound with unwanted intensity that can interfere with communication, health, and the environment. Noise can cause muscle tension, increased blood pressure, sleep disturbances, increased heart rate, and emotional changes. Types of noise include continuous, fluctuating, impulse, and intermittent noise (7).

Regulation of the Minister of Health of the Republic of Indonesia No. 70 of 2016 stipulates the Threshold Limit Value (NAB) for noise as the average noise pressure limit, while Regulation of the Minister of Manpower of the Republic of Indonesia No. 5 of 2018 stipulates the NAB for noise of 85 dB for exposure of 8 hours/day. The impact of noise is influenced by the intensity, frequency, type, duration of exposure, age, and individual susceptibility. Noise can cause physiological disorders (blood pressure, pulse, sensory disorders), psychological (stress, difficulty sleeping), communication, balance, and hearing disorders, to psychosomatic diseases such as gastritis and coronary heart disease (8)(9).Noise affects the inner ear and vestibular receptors, causing dizziness, nausea, insomnia, as well as disturbances in the nerves, endocrine glands, blood pressure, digestive system, and body balance, leading to fatigue (10).

The effects of noise are divided into two: high intensity which causes hearing loss, increased blood pressure and heart rate, as well as the risk of heart attacks and digestive disorders; and low intensity which causes stress, irritability, headaches, loss of concentration, impaired psychomotor reactions, and decreased work performance (11). Research by Lendo et al. (2021) shows a relationship between noise intensity and blood pressure and pulse rate in furniture industry workers(12). In addition, noise exposure has been shown to increase the risk of hypertension and cardiovascular disorders (13).

Noise exposure in the cement industry can increase heart rate, blood pressure, and blood vessel constriction, causing fatigue. Noise also affects cardiovascular health and releases the hormones cortisol and epinephrine, which cause stress and fatigue. Chronic exposure can disrupt blood pressure, blood lipids, and glucose..Workers exposed to noise have a 1.647 times higher risk of experiencing increased blood pressure than those who are not exposed. High blood pressure in workers can be dangerous, causing fainting, stroke, coronary heart disease, and organ damage such as the heart muscle. Research by Indriyanti et al. (2019) shows that noise intensity has a 19.8 times higher risk of increasing blood pressure(11).

Fatigue is a condition that reduces work capacity and endurance. Fatigue can be subjective and lead to a weakening of energy for activities, as well as decreased efficiency and work performance. There are two types of fatigue: mental and physical, which are caused by mental and physical work respectively. Fatigue can reduce self-control and increase the risk of work accidents. Factors causing fatigue include external (work environment) and internal (individual characteristics) aspects such

as age, gender, health history, and work posture(14). Noise in the work environment can increase fatigue, cause headaches, joint pain, reduced concentration, and hearing loss. (15). Research conducted by Imbara et al. (2023) on DT operators showed that the higher the noise level and the higher the blood pressure felt by the operator, the greater the work fatigue felt (6).

The Makassar vertical hospital construction project has complex work risks, including physical hazards such as noise. The measurement of noise intensity in the work area reached 91 dB, exceeding the Threshold Limit Value (NAB) according to Permenaker No. 5 of 2018. Noise comes from activities such as cutting ceramics, cutting and threading pipes, and cutting iron. Workers do not use ear protection such as earplugs. Noise control is needed to reduce its impact. SoBased on the background description, the purpose of this study is to analyze the effect of noise exposure on work fatigue with blood pressure and pulse rate as intervening variables in workers on the Makassar Vertical Hospital construction project in 2024.

Participants & Methods

The method used in this study is a quantitative method with a cross-sectional design, which will be implemented in the Vertical Hospital Development Project in the Center Point of Indonesia (CPI) Area of Makassar City, South Sulawesi Province, in June-July 2024. The population of this study was all construction workers totaling 1,050 people, with sampling using the purposive sampling method. The sample criteria include workers in the fabrication area who use tools such as grinders, cuttingwells, ceiling ramsets, and the like (inclusion criteria), as well as workers who are not willing to be respondents or have a history of hypertension (exclusion criteria). The total sample was determined using the Lemeshow formula, which was 281 people. Data collection instruments consisted of a reaction timer to measure fatigue, a sound level meter to measure noise intensity, and a digital tensiometer to measure blood pressure and pulse rate. Data analysis was carried out using SPSS version 25, with univariate, bivariate, and multivariate (path analysis) analysis.

Findings

Table1. Work Area Noise Intensity

Sampling Area	Average Measurement Results	Threshold Limit Value	Information
2nd Floor, Building A	86.5 dB	85 dB	Exceeding NAB
3rd Floor, Building A	87.5 dB	85 dB	Exceeding NAB
4th Floor, B Building	98.1 dB	85 dB	Exceeding NAB
4th Floor, Building C	92.4 dB	85 dB	Exceeding NAB
4th Floor, Building D	88.2 dB	85 dB	Exceeding NAB
Floor 11, Building B	90.1 dB	85 dB	Exceeding NAB
Floor 11, Building C	102.3 dB	85 dB	Exceeding NAB
Floor 11 Gd D	90.8 dB	85 dB	Exceeding NAB

The results of noise measurements show that the average highest noise intensity occurred on the 11th Floor of Building C (102.3 dB), exceeding the noise Threshold Limit Value (NAB) of 85 dB. Measurements in other areas also exceeded the NAB, such as on the 2nd Floor of Building A (86.5 dB), 3rd Floor of Building A (87.5 dB), 4th Floor of Building B (98.1 dB), 4th Floor of Building C (92.4 dB), 4th Floor of Building D (88.2 dB), 11th Floor of Building B (90.1 dB), and 11th Floor of Building D (90.8 dB). Measurements were carried out for 15 minutes at three points per area with readings every 5 seconds.

Characteristics of construction workers show that the majority are aged 26-35 years (33.5%), followed by ages ≤25 years (32%), 36-45 years (22.8%), and >45 years (11.7%). Most have a high

school education or equivalent (51.3%), followed by junior high school (32%), elementary school (12.8%), and college (3.9%). As many as 68% of workers are married, while 32% are not married. The majority of workers work ≥8 hours a day (97.9%), and only 2.1% work <8 hours a day. Based on length of service, 52.3% of workers have a length of service <5 years, and 47.7% have worked >5 years.

Table 2. Frequency Distribution of Blood Pressure and Pulse Rate

Variables	Before Noise Exposure		After Noise Exposure	
	Normal	Abnormal	Normal	Abnormal
Systolic Blood Pressure	258	23	47	234
Diastolic Blood Pressure	161	120	47	234
Pulse	256	25	109	172

Before exposure to noise, the majority of respondents had normal systolic blood pressure and pulse rate (91.8% and 91.1%). However, after exposure to noise, the proportion of the normal category decreased drastically to 16.7% for systolic blood pressure and 38.8% for pulse rate. The same thing happened to diastolic blood pressure, which decreased from 57.3% to 16.7%, indicating that noise significantly affects the cardiovascular health of workers.

Table 3. Frequency Distribution of Work Fatigue

Subjective Work Fatigue		Objective Work Fatigue	
Criteria	N	Criteria	N
Not Tired	60	Severe Fatigue	153
Tired	91	Moderate Fatigue	56
Very tired	130	Mild Fatigue	46
		Normal	26

The distribution of work fatigue shows that based on subjective measurements, the majority of workers are in the very tired category (46.3%), while objective measurements show that most workers experience severe fatigue (54.4%). Only a few workers are considered not subjectively tired (21.4%) or in normal conditions objectively (9.3%), indicating a high level of work fatigue among respondents.

Table 4. Relationship of Noise with Blood Pressure and Pulse Rate

Noise	Systolic Blood Pressure		Diastolic Blood Pressure		Pulse	
	Normal	No	Normal	No	Normal	No
86.5 dB	16	19	10	25	22	13
87.5 dB	15	47	17	45	25	37
88.2 dB	0	33	4	29	13	20
90.1 dB	0	14	1	13	6	8
90.8 dB	4	26	2	28	7	23
92.4 dB	1	42	3	40	14	29
98.1 dB	10	33	10	33	17	26
102.3 dB	1	20	0	21	5	16
P-Value	0,000		0.004		0.044	

In the table above, the p-value for the relationship between noise and systolic, diastolic, and pulse pressures shows a significant value. The p-value for systolic blood pressure is 0.000, indicating that

noise has a significant effect on systolic blood pressure. The p-value for diastolic blood pressure is 0.004, also indicating a significant relationship between noise and diastolic blood pressure. The p-value for pulse rate is 0.044, indicating that noise has a significant effect on changes in pulse rate. All p-values smaller than 0.05 indicate a significant relationship between noise and the three variables.

Table 5. The Relationship Between Noise and Work Fatigue

Noise	**Subjective Work Fatigue**			**Objective Work Fatigue**			
	No	Tired	Very	Normal	Light	Currently	Heavy
86.5 dB	16	9	10	12	7	11	5
87.5 dB	17	20	25	12	7	14	29
88.2 dB	5	10	18	0	9	3	21
90.1 dB	2	3	9	1	1	2	10
90.8 dB	0	12	18	0	1	6	23
92.4 dB	7	12	24	0	5	7	31
98.1 dB	11	17	15	1	12	9	21
102.3 dB	2	8	11	0	4	4	13
P-Value	0.006			0.004			

The p-value in the table shows that noise has a significant relationship with subjective (0.006) and objective (0.004) work fatigue, because both p-values are less than 0.05.

Table 6. Relationship between Work Fatigue and Blood Pressure and Pulse Rate

Variables	**Systolic Blood Pressure**		**Diastolic Blood Pressure**		**Pulse**	
	Normal	**No**	**Normal**	**No**	**Normal**	**No**
Subjective Work Fatigue						
No	23	37	24	36	44	16
Tired	16	75	20	71	53	38
Very	8	122	3	127	12	118
P-Value	0,000		0,000		0,000	
Objective Work Fatigue						
Normal	11	15	9	17	22	4
Light	8	38	15	31	25	21
Currently	9	47	11	45	17	39
Heavy	19	134	12	141	45	108
P-Value	0.003		0,000		0,000	

The p-value in Table 6 shows that there is a significant relationship between subjective and objective work fatigue with systolic blood pressure (0.000), diastolic blood pressure (0.000), and pulse rate (0.000) because all p-values are less than 0.05. In addition, the relationship between objective work fatigue and systolic blood pressure is also significant with a p-value of 0.003.

1. Path Analysis

Multivariate analysis was conducted using path analysis using the Smart PLS application. The model construction in this study is given in the following figure.

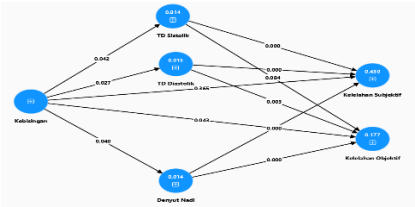

Figure 1. Path Analysis Model Construction

Then, to see the significance of the direct influence, you can see it from the statistical value or p-value in the table below.

Table 7. Results of Direct Influence Analysis

Hypothesis	Original Sample	Sample Mean	Standard Deviation	T Statistics	P Values
Noise -> Systolic BP	0.120	0.120	0.059	2,031	0.042
Noise -> Diastolic BP	0.121	0.120	0.055	2,209	0.027
Noise -> Pulse	0.118	0.117	0.057	2,056	0.040
Noise -> Subjective Fatigue	-0.041	0.041	0.045	0.907	0.365
Noise -> Objective Fatigue	0.109	0.108	0.054	2,027	0.043
Systolic BP -> Subjective Fatigue	0.225	0.225	0.053	4,204	0,000
Systolic BP -> Objective Fatigue	0.112	0.111	0.065	1,728	0.084
Diastolic BP -> Subjective Fatigue	0.267	0.265	0.053	5,076	0,000
Diastolic BP -> Objective Fatigue	0.197	0.196	0.066	3,005	0.003
Pulse Rate -> Subjective Fatigue	0.460	0.462	0.050	9,266	0,000
Pulse Rate -> Objective Fatigue	0.249	0.251	0.059	4,254	0,000

*p-value < 0.05: there is a significant relationship

Table 7 shows several significant relationships with p-value < 0.05, namely noise with systolic blood pressure (0.042), diastolic (0.027), pulse rate (0.040), and objective fatigue (0.043).However, the relationship between noise and subjective fatigue was not significant (p-value 0.365). For the variables of blood pressure and pulse rate on fatigue, the relationship between systolic and diastolic blood pressure with subjective fatigue (0.000), and pulse rate with subjective and objective fatigue (0.000), were all significant. Indirect testing is displayed in the structural model with statistical values (p-value). The following are the results of indirect testing.

Table 8. Results of Indirect Influence Analysis

Hypothesis	Original Sample	Sample Mean	Standard Deviation	T Statistics	P Values
Noise -> Systolic BP -> Subjective Fatigue	0.027	0.027	0.015	1,811	0.070
Noise -> Systolic BP -> Objective Fatigue	0.013	0.015	0.012	1,090	0.276

Noise -> Diastolic BP -> Subjective Fatigue	0.032	0.032	0.016	2,042	0.041
Noise -> Diastolic BP -> Objective Fatigue	0.024	0.024	0.014	1,686	0.092
Noise -> Pulse -> Subjective Fatigue	0.054	0.054	0.027	1,999	0.046
Noise -> Pulse -> Objective Fatigue	0.029	0.029	0.016	1,788	0.074

*p-value < 0.05: there is a significant relationship

In Table 8, the relationship between noise and subjective fatigue through diastolic blood pressure (0.041) and pulse rate (0.046) shows significant results, because the p-value is smaller than 0.05. However, the indirect effect of noise through systolic blood pressure on subjective fatigue (0.070) and objective fatigue (0.276), as well as noise through pulse rate on objective fatigue (0.074), is not significant because the p-value is greater than 0.05.

DISCUSSION

a. Effect of Noise on Systolic Blood Pressure

Noise, which comes from work tools such as grinders and cutting wells, can have a negative impact on the body, especially systolic blood pressure. Of the 281 respondents, 83.3% had abnormal systolic blood pressure after being exposed to noise. Bivariate analysis showed a significant relationship between noise and systolic blood pressure (p-value 0.000 < 0.05), with noise intensity of 87.5 dB and 92.4 dB associated with increased blood pressure. The results of the path analysis showed that noise had a direct effect on systolic blood pressure (p-value 0.042 < 0.05), with a positive effect of 0.120. Noise that exceeds the hearing threshold and is unstable triggers an increase in blood pressure, which is at risk of causing hypertension, especially in productive age (16).

b. Effect of Noise on Diastolic Blood Pressure

AnalysisUnivariate analysis showed that the majority of respondents (83.3%) had abnormal diastolic blood pressure, while 16.7% had normal blood pressure. Noise, distance of use of the device, and duration of exposure were factors causing abnormal diastolic blood pressure, mainly due to inappropriate use of the device and continuous noise exposure. Bivariate analysis showed a significant relationship between noise and diastolic blood pressure (p-value 0.000 <0.05), with a noise intensity of 87.5 dB which often caused diastolic blood pressure to increase. The results of the path analysis showed that noise had a direct effect on diastolic blood pressure (p-value 0.027 <0.05) with a positive effect of 0.121. This finding is in line with the research of Amin et al. (2019) which showed an increase in diastolic blood pressure in workers exposed to noise.

c. Effect of Noise on Pulse Rate

The noise thattallcan increase the pulse rate, because it triggers the heart to work harder. In univariate analysis, out of 281 respondents, 172 (61.2%) had an abnormal pulse rate (>100/minute). Bivariate analysis showed that noise was significantly related to pulse rate (p-value 0.044> 0.05), especially at noise intensities of 87.4 dB and 92.4 dB. The influence test with path analysis showed that noise had a direct effect on pulse rate (p-value 0.040 <0.05) with a positive effect of 0.118. This finding is in line with previous studies that found that noise causes an increase in pulse rate, because noise is considered a stressor for the body (17).

d. The Effect of Noise on Subjective Work Fatigue (KAUPK2 Questionnaire)

Fatigue is a body signal that indicates the need for rest. Excessive noise can cause discomfort, difficulty concentrating, and even headaches. In univariate analysis, the majority of respondents (46.3%) experienced severe fatigue, while in bivariate analysis, higher intensity noise (86.5 dB to 102.3 dB) was associated with more severe fatigue complaints, especially due to not using ear protection. Multivariate analysis showed that noise had no direct effect on subjective work fatigue (p-value 0.365 > 0.05), which may be influenced by other mental factors such as conflict. This finding is in line with research by Pradipta et al. (2021), which showed that high noise intensity increased workers' fatigue levels, reduced their concentration, and their quality of rest(18). However, this study also explains that in addition to noise, it is also necessary to pay attention to other factors that cause work fatigue such as workload, weather, lighting, mental state and medical history.

e. The Effect of Noise on Objective Work Fatigue (Reaction Timer)

The results of the univariate analysis showed that the majority of respondents experienced severe fatigue (46.3%) due to noise. Bivariate tests with chi-square showed a significant relationship between noise and objective work fatigue (p-value 0.000 <0.05). In the direct effect analysis, noise was shown to have an effect on work fatigue (p-value 0.043 <0.05, effect 0.109). These findings indicate that high noise intensity and duration, as well as working positions close to noise sources, increase physical and psychological fatigue. Respondents often feel pain in the body and have difficulty focusing. In addition, the lack of ear protection (EAP) worsens the impact of noise. This study is in line with the findings of Rotua et al. (2023), which stated that noise has a significant effect on work fatigue (19).

f. The Effect of Systolic Blood Pressure on Subjective Work Fatigue (KAUPK2 Questionnaire)

Bivariate analysis showed a significant relationship between systolic blood pressure and work fatigue, with a p-value of 0.000 < 0.05. Path analysis test also showed a direct effect between systolic blood pressure and subjective work fatigue (p-value 0.000 < 0.05, effect 0.225), which means that increased systolic blood pressure can trigger work fatigue. Observations showed that respondents with abnormal systolic blood pressure often felt tired, lethargic, and lazy even after resting. High noise exposure can worsen cardiovascular function, causing blood vessels to narrow and increasing the workload of the heart, leading to fatigue.

g. The Effect of Systolic Blood Pressure on Objective Work Fatigue (Reaction Timer)

Bivariate analysis showed a significant relationship between systolic blood pressure and objective work fatigue, with a p-value of 0.003 < 0.05. However, the multivariate effect test showed no direct effect between systolic blood pressure and objective fatigue, with a p-value of 0.084 > 0.05. Although the majority of respondents with abnormal systolic blood pressure experienced severe fatigue, their objective fatigue was not directly influenced by systolic blood pressure. Other factors, such as the type of work involving physical movement or the use of heavy equipment, may contribute to perceived fatigue.

h. The Effect of Diastolic Blood Pressure on Subjective Work Fatigue (KAUPK2 Questionnaire)

Bivariate analysis showed that out of 281 respondents, 45.2% with abnormal diastolic blood pressure experienced severe fatigue, while 25.3% felt tired and 12.8% were less tired. In multivariate analysis, diastolic blood pressure was shown to have a direct effect on subjective work fatigue with a p-value of 0.000, indicating a relationship between increased diastolic blood pressure and feelings of fatigue. Field observations revealed that respondents

in the mechanical, electrical, and plumbing (MEP) and finishing work departments more often complained of fatigue and did not receive enough attention from their superiors, such as not being provided with personal protective equipment (PPE). The noise intensity factor that exceeded the threshold and long working hours worsened this condition, triggering increased blood pressure and fatigue in respondents.

i. The Effect of Diastolic Blood Pressure on Objective Work Fatigue (Reaction Timer)

Bivariate analysis using the chi-square test showed that diastolic blood pressure was associated with objective work fatigue, with 45.2% of respondents who were very tired having abnormal diastolic blood pressure. Multivariate analysis revealed a direct effect between diastolic blood pressure and objective work fatigue, with a p-value of 0.003 and an effect size of 0.197. This means that increased diastolic blood pressure is associated with increased work fatigue. Noise exposure has also been shown to cause long-term impacts, both physiologically and psychologically, including hearing loss,heart disease and blood circulation (20)(21).

j. Pulse Against Subjective Work Fatigue (KAUPK2 Questionnaire)

The analysis shows that pulse rate has a significant relationship with subjective work fatigue based on the chi-square test, with a p-value of 0.000 <0.05. This shows that pulse rate is an important indicator in determining the level of work fatigue. An increase in pulse rate directly increases the potential for work fatigue. This happens because the heart works harder to pump blood, increasing the pulse rate, thus triggering feelings of fatigue, such as dizziness, thirst, or weakness. In addition, an unsupportive work environment and heavy physical activity can accelerate the increase in pulse rate, so that the body becomes tired more quickly. If this condition continues, work productivity can be disrupted, and respondents may have difficulty completing work targets. Therefore, pulse rate is an important indicator in monitoring subjective work fatigue and overall worker health (22).

k. The Effect of Heart Rate on Objective Work Fatigue (Reaction Timer)

Analysisshowsignificant relationship between heart rate and objective work fatigue (p-value 0.000 < 0.05), with a direct effect of 0.249. Respondents with abnormal heart rates tend to experience severe fatigue (38.4%). Observations also noted complaints of weakness and muscle aches, possibly due to low oxygen supply which reduces muscle work efficiency.

l. The Effect of Noise on Subjective Work Fatigue (KAUPK2 Questionnaire) Through Blood Pressure

The results of the analysis showed that noise did not have an indirect effect on subjective work fatigue through systolic blood pressure (p-value 0.070 > 0.05) but had an indirect effect through diastolic blood pressure (p-value 0.041 < 0.05). Noise directly affected diastolic blood pressure (p-value 0.043 < 0.05) but did not affect subjective work fatigue (p-value 0.365 > 0.05). Increased blood pressure due to long-term noise is supported by previous studies, which showed that noise triggers the release of adrenaline hormones, thereby increasing blood pressure, especially in respondents with a working duration of > 8 hours per day.(23).This study supports the findings of Lamawuran & Siprianus (2021), which showed that noise of 91.42 dB increased systolic blood pressure in 61.9% of factory workers. Noise triggers the brain to respond as a threat or stress, which affects the release of stress hormones such as epinephrine, norepinephrine, and cortisol, which play a role in the body's metabolism and physiological response to stress (24).

m. The Effect of Noise on Objective Work Fatigue (Reaction Timer) Through Blood Pressure

The results of the multivariate analysis showed that noise had a direct effect on systolic blood pressure (p-value 0.042), diastolic (p-value 0.027), and objective work fatigue (p-value 0.043), but systolic blood pressure did not affect objective work fatigue (p-value 0.084), while diastolic blood pressure had a significant effect (p-value 0.003). Noise did not have an indirect effect on objective work fatigue through systolic blood pressure (p-value 0.276) and diastolic (p-value 0.092). It is possible that fatigue is more influenced by heavy physical activity such as lifting materials repeatedly and not just blood pressure, in contrast to previous studies that showed a relationship between noise and hypertension due to long-term exposure (25).

n. The Effect of Noise on Subjective Work Fatigue (KAUPK2 Questionnaire) Through Heart Rate

Multivariate analysis showed that noise had a direct effect on heart rate (p-value 0.040), which then had a direct effect on subjective work fatigue (p-value 0.000). An indirect effect was also detected, with noise affecting subjective work fatigue through heart rate (p-value 0.046). Field observations revealed that many respondents experienced increased heart rate and showed signs of discomfort due to noise, such as frequently holding the back of the neck and yawning. Several respondents also complained of ringing in the ears and headaches. Long-term implications of noise exposure are the risk of hypertension, which can lead to serious complications such as heart disease, kidney failure, or stroke (26). This finding is in line with research by Tiara & Perdana (2019) which shows that high heart rates in workers indicate easy fatigue due to work activities and the work environment (27).

o. The Effect of Noise on Objective Work Fatigue (Reaction Timer) Through Pulse Rate

The results of the analysis showed that noise did not have a significant effect on objective work fatigue through the mediation of heart rate (p-value 0.074 > 0.05), indicating that heart rate is not the main factor in influencing work fatigue, with the possibility of other factors such as physical workload playing a role (28). This study shows that although noise exposure increases heart rate, it is still within the normal category and does not mediate the effect of noise on work fatigue. This may be due to the adaptation of the respondents' bodies to noise, as well as other factors such as sleep quality, physical fitness, and health conditions that also affect fatigue.

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REFERENCES

1. Yanti R, Ihsan T, Lestari RA. Pengaruh Faktor Lingkungan Kerja Terhadap Kelelahan Kerja Industri Semen Di Indonesia : Sebuah Review. Heal Care J Kesehat. 2022;1–12.
2. Hansen S. Identifikasi Jenis Bahaya dan Parameter Penilaian Bahaya Pada Pekerjaan

Konstruksi. J Tek Sipil Univ Warmadewa. 2022;94–102.
3. Innah M, Alwi MK, Gobel FA, Habo H. Faktor Yang Berhubungan Dengan Kelelahan Kerja Pada Penjahit Pasar Sentral Bulukumba. Wind Public Heal J. 2021;1(5):471–81.
4. Boekoesoe L, Prasetya E, Samani GG, Ahmad ZF, Nurdin SSI. Faktor Risiko Yang Berhubungan Dengan Kelelahan Kerja Dengan Metode Fatigue Assessment Scale (FAS) Pada Pekerja Konstruksi. Jambura J Epidemiol. 2023;27–36.
5. Alfiansah Y, Kurniawan B, Ekawati. Analisis Upaya Manajemen K3 Dalam Pencegahan dan Pengendalian Kecelakaan Kerja Pada Proyek Konstruksi di PT X Semarang. J Kesehat Masy. 2020;595–600.
6. Imbara, Fitriawan S, Badriah DL, Iswarawanti DN, Mamlukah. Faktor-Faktor Yang Berhubungan Dengan Kelelahan Kerja Pada Operator Dump Truck Mining Dept Saat Shift Malam di PT X Cirebon 2023. J Heal Res Sci. 2023;175–87.
7. Endrianto E. Upaya Pencegahan Kebisingan di Industri Petrokimia. J Educ. 2023;16479–93.
8. Syafila AA, Putri AR, Putri DRS, Amin MI, Altika N, Agustin S. Literature Review: Faktor Risiko Paparan Kebisingan Terhadap Gangguan Kesehatan Tenaga Kerja. Madani J Ilmia Multidisipline. 2023;676–86.
9. Suhardi, Bambang, Citrawati A, Astuti RD. Ergonomi Partisipatori Implementasi Bidang Kesehatan dan Keselamatan Kerja. Sleman: Deepublish; 2021.
10. Fuadi N, Arif M, Zelviani S. Pengaruh Kebisingan Terhadap Frekuensi Denyut Nadi dan Kelelahan Kerja Menggunakan Uji Statistik SPSS Pada Uji Paired Sampel T-Test. J Insitek. 2022;325–33.
11. Indriyanti LH, Wangi PK, Simanjuntak K. Hubungan Paparan Kebisingan terhadap Peningkatan Tekanan Darah Pada Pekerja. J Kedokt dan Kesehat. 2019;36–45.
12. Lendo C, Maddusa SS, Sekeon S. Hubungan Antara Intensitas Kebisingan Dengan Tekanan Darah dan Denyut Nadi Pada Pekerja Industri Mebel Di Desa Touliang Oki. J Kesmas. 2021;54–63.
13. Wojciechowska W, Januszewicz A, Drożdż T, Rojek M, Bączalska J, Terlecki M, et al. Blood Pressure and Arterial Stiffness in Association With Aircraft Noise Exposure: Long-Term Observation and Potential Effect of COVID-19 Lockdown. HYPERTENSIONAHA. 2022;325–34.
14. Hijah NF, Setyaningsih Y, Jayanti S. Iklim Kerja, Postur Kerja, dan Masa Kerja Terhadap Kelelahan Kerja Pada Pekerja bengkel las. JPPKMI. 2021;11–6.
15. Sari, Patimah, Zakaria M, Erliana CI. Analisis Pengaruh Kebisingan Terhadap Kelelahan Kerja Pada Operator Mesin di PT PSU Kebun Tanjung Kasau. J Manaj dan Tek Ind. 2023;83–94.
16. Ratri NPATA, Noviana AC, Kadir A. Studi Literatur Hubungan Paparan Kebisingan Dengan Kejadian Peningkatan Tekanan Darah Pada Pekerja Industri. Calvaria Med J. 2023;1–10.
17. Masdi, Amir R, Patintingan A. Pengaruh Intensitas Kebisingan Terhadap Frekuensi Denyut Nadi Pada Pekerja Penggilingan Gabah Di Desa Sanglepongan Kecamatan Curio Kabupaten Enrekang. J Ilm Mns dan Kesehat. 2019;220–9.
18. Pradipta I, Hardiyono, Yuliana L. Pengaruh Kebisingan Terhadap Tingkat Kelelahan Kerja PT Pertamina Hulu Mahakam Area Peciko Offshore. J Keselamatan, Kesehat Kerja dan Lindungan Lingkung. 2021;9–16.
19. Rotua A, Selasdini V, Siregar E. Pengaruh Intensitas Kebisingan Terhadap Kelelahan Kerja Pada Awak Kapal PT Surfmarine Indonesia. Pros Forum Stud Transp antar Perguru Tinggi. 2023;708–17.
20. Thepaksorn P, Koizumi A, Harada K, Siriwong W, Neiel RL. Occupational noise exposure and hearing defects among sawmill workers in the south of Thailand. 2019;458–66.
21. Kerns E, Masterson EA, Themann CL, Calvert GM. Cardiovascular conditions, hearing difficulty, and occupational noise exposure within US industries and occupations. Am J Ind Med. 2018;477–91.

22. Izzadini AF, Ekawati MR, Hapsari A. Pengaruh Intensitas Kebisingan dan Postur Kerja terhadap Peningkatan Denyut Nadi pada Siswa Jurusan Teknik Pengelasan SMK Negeri 1 Singosari. Sport Sci Heal. 2022;1111–20.
23. Sumardiyono, Wijayanti R, Hartono, Budiastuti, Sri MT. Pengaruh Kebisingan terhadap Tekanan Darah, dengan Stres Kerja sebagai Variabel Mediator. J Kesehat Vokasional. 2020;124–31.
24. Lamawuran WW, Singga S. Pengaruh Kebisingan Terhadap Peningkatan Tekanan Darah Dan Denyut Nadi Pekerja Pabrik Es Di Pasar Ikan Oeba Kupang Tahun 2020. Oehonis J Environ Heal Res. 2021;52–8.
25. Yandoyo C, Merijanti L. Hubungan antara Intensitas Kebisingan dan Tekanan Darah pada Pekerja PT X. J Biomedika dan Kesehatan. 2019;4–10.
26. Nisya K. Hubungan Hipertensi Dengan Faktor Risiko Kelelahan Kerja Pada Sopir Truk (Studi Literatur). J Heal Med Res. 2023;388–94.
27. Tiara, Perdana S. Analisis Beban Kerja Fisiologi Pada Proses Produksi Pembuatan Rumah Boneka Dengan Pekerja Penyandang Disabilitas. Fakt Exacta12. 2019;193–200.
28. Putri, Putri NKD, Pangkahila A, Indra Lesmana S, Sandi N, Dwi Primayanti DAI, et al. Renang Lambat Gaya Bebas Lebih Efektif Menurunkan Denyut Nadi Pemulihan Daripada Senam ai Chi Pada Anggota Tni-Ad Rindam Ix/Udayana. Sport Fit J. 2018;