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ORIGINAL

Analysis Work Shifts, Workload and Smoking Habits on Blood Pressure Through Job Fatigue in Lift and Transport Operators of The New Makassar Container Terminal

Análisis de los turnos de trabajo, la carga de trabajo y los hábitos de tabaquismo en la presión arterial a través de la fatiga laboral en los operadores de elevación y transporte de la nueva terminal de contenedores de Makassar

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ABSTRACT

Introduction: occupational health disorders, including physical, mental, and cardiovascular diseases such as hypertension and hypotension, are increasing due to work factors such as workload, work shifts, and smoking habits, which impact workers' health and productivity.
Objective: the objective was to assess work shifts, workload, and smoking habits on blood pressure through job fatigue in New Makassar Container Terminal lift operators.
Method: this quantitative study used an analytic observational design with a cross sectional approach, conducted at PT Pelindo New Makassar Container Terminal from September to October 2024, with a sample of 170 operators and data analysis through chi-square test and logistic regression using SPSS.
Results: the results showed that work shifts and physical and mental workload had a direct effect on job fatigue, while smoking habits had a direct effect on blood pressure, but there was no direct effect of work shifts and physical workload on blood pressure. In addition, physical and mental workload influenced systolic and diastolic blood pressure through occupational fatigue.
Conclusions: for workers, it is important to organize sleep routines, apply ergonomic techniques in physical workload, maintain mental resilience with rest time, and reduce smoking to prevent health risks. For companies, it is important to design a fair work shift system, conduct physical workload analysis with ergonomists, provide psychological support, and establish a clear smoking policy in the workplace.

Keywords: Workload; Fatigue; Smoking; Shift.

RESUMEN

Introducción: los trastornos de salud ocupacional, incluyendo enfermedades físicas, mentales y cardiovasculares como la hipertensión y la hipotensión, están aumentando debido a factores laborales como la carga de trabajo, los turnos de trabajo y los hábitos de tabaquismo, que afectan la salud y la productividad de los trabajadores.
Objetivo: el objetivo era evaluar los turnos de trabajo, la carga de trabajo y los hábitos de tabaquismo en la presión arterial a través de la fatiga laboral en New Makassar.
Método: este estudio cuantitativo utilizó un diseño observacional analítico con un enfoque transversal, realizado en PT Pelindo New Makassar Container Terminal entre septiembre y octubre de 2024, con una muestra de 170 operadores y análisis de datos mediante la prueba de chi-cuadrado y regresión logística utilizando SPSS.

Resultados: los resultados mostraron que los turnos de trabajo y la carga de trabajo física y mental tenían un efecto directo sobre la fatiga laboral, mientras que los hábitos de tabaquismo tenían un efecto directo sobre la presión arterial, pero no se observó un efecto directo de los turnos de trabajo y la carga de trabajo física sobre la presión arterial. Además, la carga de trabajo física y mental influía en la presión arterial sistólica y diastólica a través de la fatiga laboral.
Conclusiones: para los trabajadores, es importante organizar rutinas de sueño, aplicar técnicas ergonómicas en la carga de trabajo físico, mantener la resiliencia mental con tiempo de descanso y reducir el tabaquismo para prevenir riesgos para la salud. Para las empresas, es importante diseñar un sistema de turnos de trabajo justo, realizar análisis de la carga de trabajo físico con ergonomistas, proporcionar apoyo psicológico y establecer una política clara sobre el tabaquismo en el lugar de trabajo.

Palabras clave: Carga de Trabajo; Fatiga; Tabaquismo; Turnos.

INTRODUCTION

Occupational health disorders are diseases that arise due to daily work activities.[1] Acording to Government Regulation No. 7 of 2019, Occupational Diseases are diseases caused by work activities and the work environment. These health problems can come from chemical, physical, and biological factors, and can affect various organ systems such as mental, musculoskeletal, respiratory, skin, and even skin cancer.[2] Data from the International Labour Organization states that as many as 2,78 million workers die each year due to occupational accidents and PAK, of which PAK accounts for 2,4 million or 86,3 % of the total deaths. In Malaysia, in 2022 there were 7,143 cases of PAK, with hearing and musculoskeletal disorders as the dominant cases. While in Indonesia, PAK cases have increased from 182,835 cases in 2019, to 221,740 in 2020, 234,370 in 2021, 297,725 in 2022, and reached 360,635 cases until November 2023.

In addition to these diseases, cardiovascular system disorders such as hypertension and hypotension are also significant occupational risks. Hypertension is known as the silent killer because it often develops without symptoms and is the leading cause of death globally.[3] Increased or decreased blood pressure affects the body's homeostasis and if prolonged can lead to hypertension (≥140/90 mmHg) or hypotension (<90/60 mmHg).[4] Hypertension can lead to heart disease, stroke and kidney failure,[5] while hypotension can cause dizziness, weakness and fainting. WHO states that 1,28 billion people aged 30-79 years suffer from hypertension and is predicted to increase to 1,5 billion by 2025. In Indonesia, the prevalence of hypertension in private workers is 24,37 %, and in DKI Jakarta it is 13,4 %.[6] In Makassar, hypertension cases reached 40,288 in 2020, with Rappocini District as the highest area.[7] Meanwhile, the global prevalence of hypotension is estimated at 35-45 %, especially in the elderly.[8]

Risk factors for changes in blood pressure consist of non-modifiable factors (age, gender, heredity) and modifiable factors such as obesity, physical inactivity, salt consumption, smoking and stress. According to the Health and Safety Executive, work shifts, tenure, and medication consumption also affect blood pressure. Tarwaka added that workload and fatigue also play a role. Work shifts, especially night shifts, trigger circadian rhythm disturbances, leading to an increased risk of hypertension and sleep disturbances.[9] Research shows that shift workers have a prevalence of hypertension of 22,4 % compared to 4,2 % in non-shift workers.[10] In addition, shift work also increases the risk of fatigue. A high workload can increase blood pressure as it triggers a physiological stress response that impacts the cardiovascular system. Strenuous activity accelerates heart rate and cardiac output, which ultimately increases blood pressure.[11] Workload can also lower psychological state and cause fatigue. Smoking exacerbates this as the chemicals in cigarettes, especially nicotine and carbon monoxide, damage blood vessels, speed up the heart and reduce lung capacity, leading to hypertension and fatigue.[12]

Occupational fatigue is a decline in physical and mental state that impacts productivity and health.[13] Physical and mental fatigue can lead to vasoconstriction, increased cardiac contractions, and higher cardiac output, thus contributing to increased blood pressure. Research by Nisya (2023) supports the relationship between occupational fatigue and hypertension. Field jobs such as haulage equipment operators have a high risk of exposure to occupational diseases due to the heavy work environment and great physical demands.[14] Based on the background previously described, the objective of this research is analyyze effect of work shifts, workload, and smoking habits on blood pressure through job fatigue in New Makassar Container Terminal transport lift operators.

METHOD

This study was a quantitative study with an analytic observational design using a cross-sectional approach. Prior to data collection, participants were contacted directly at the work site by the research team through

coordination with the company's human resources department. Informed consent was obtained from all participants after explaining the research objectives, procedures, benefits, and risks. Participation was voluntary, and all respondents signed a written consent form before being included in the study. The research was conducted at PT Pelindo New Makassar Container Terminal from January to March 2025. Data collection took place at the company's occupational health office and operational monitoring rooms, which were designated by the management to facilitate the health measurements and interviews. The population of this study included all operators of lifting and transporting equipment, totaling 246 workers, consisting of 10 Quay Container Crane (QCC) operators, 92 Rubber Tyred Gantry (RTG) operators, 127 Head Truck (HT) operators, and 17 Reach Stacker (RS) operators. Sampling was conducted using the Slovin formula, resulting in a total of 170 respondents: 7 QCC operators, 63 RTG operators, 88 HT operators, and 12 RS operators. Primary data were collected directly through on-site health measurements and structured interviews. Blood pressure was measured using a tensimeter (sphygmomanometer), and pulse rate was measured using a fingertip oximeter.

Additionally, interviews were conducted using a structured questionnaire that included the Industrial Fatigue Research Committee (IFRC) Questionnaire and the NASA Task Load Index (NASA-TLX). Secondary data were obtained from company records and included information on the number of employees, shift schedules, and general work system conditions. All collected data were coded and securely stored in password-protected digital files. Physical documents such as consent forms and paper questionnaires were kept in a locked cabinet accessible only to the research team to maintain confidentiality. Data analysis was carried out in several stages. Univariate analysis was first conducted to describe the characteristics of each variable. This was followed by bivariate analysis using the chi-square test with a significance level of $\alpha = 0,05$ to examine relationships between variables. Multivariate analysis using logistic regression was then performed to assess the simultaneous influence of multiple variables, aided by the SPSS statistical software. This study obtained ethical approval from the Health Research Ethics Committee of Hasanuddin University, under the reference number 043/UN4.14.1/TP.01.02/2024. All research procedures adhered to the ethical principles of autonomy, beneficence, non-maleficence, and justice throughout the study implementation.

RESULTS

Pelindo Container Terminal Operator, known as Pelindo TPK, operates under the auspices of the largest port operator company in Indonesia. PT Pelindo Terminal Petikemas New Makassar provides various port services such as stevedoring, haulage, dock services, receiving/delivery, stacking services, as well as additional services such as quarantine and customs inspection.

Table 1. Respondent Characteristics

Variables	Category	Frequency (n)	Percentage (%)
Age	21-29 years old	45	26,5
	30-39 years old	74	43,5
	40-49 years old	47	27,6
	50-59 years old	4	2,4
TOTAL		170	100
Length of Service	1-9 years	105	61,8
	10-19 years old	59	34,7
	20-29 years old	6	3,5
Work Unit	RTG	63	37,1
	CC	7	4,1
	HT	88	51,8
	RS	12	7,1
TOTAL		170	100
Employment Status	Contract	166	97,6
	Stay	4	2,4
TOTAL		170	100
Blood Pressure History	High - Yes	15	8,8
	High - No	155	91,2
	Low - Yes	10	5,9
	Low - No	160	94,1
TOTAL		170	100

The majority of operators at New Makassar Container Terminal are in the productive age range of 30-39 years and have a tenure of 1-9 years.

Univariate Analysis

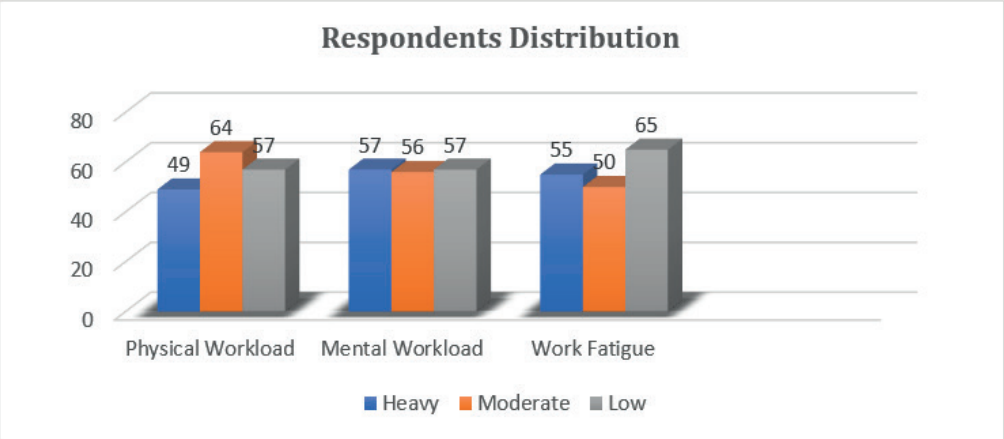

Figure 1. Distribution of Respondents

Based on data obtained from 170 operators at the New Makassar Container Terminal, the majority of workers in terms of physical workload, most operators fall into the moderate category (37,6 %), followed by the low (33,5 %) and heavy (28,8 %) categories. In terms of mental workload, the distribution is fairly balanced between the heavy (33,5 %), moderate (32,9 %) and low (33,5 %) categories. In terms of health conditions, 32,4 % of operators experienced high levels of job fatigue.

Table 2. Distribution of Respondents

Variables	Category	Frequency (n)	Percentage (%)
Work Shift	Shift 1	61	35,9 %
	Shift 2	50	29,4 %
	Shift 3	59	34,7 %
Smoking Habit	Heavy Smokers	64	37,6 %
	Low Smokers	43	25,3 %
	No Smoking	63	37,1 %
Systolic Blood Pressure	Hypertension	50	29,4 %
	Normal	72	42,4 %
	Hypotension	48	28,2 %
Diastolic Blood Pressure	Hypertension	50	29,4 %
	Normal	72	42,4 %
	Hypotension	48	28,2 %

Table 2 shows the distribution of respondents based on four variables: work shift, smoking habit, systolic blood pressure, and diastolic blood pressure. In the work shift variable, respondents were almost evenly distributed between Shift 1 (35,9 %), Shift 2 (29,4 %), and Shift 3 (34,7 %). For smoking habits, the majority of respondents were heavy smokers (37,6 %) and non-smokers (37,1 %), with a smaller number of low smokers (25,3 %). Furthermore, on systolic and diastolic blood pressure variables, the data showed that most respondents had normal blood pressure (42,4 %) on both parameters, with hypertension and hypotension totaling approximately 29,4 % and 28,2 % respectively.

Bivariate Analysis

The results of the analysis in the table 3 show that there is a significant relationship between work shifts and systolic blood pressure, diastolic blood pressure, and the level of fatigue, indicated by a p-value of 0,000 in all three variables. In shift 1, the majority of workers experienced hypertension and high fatigue, while in shift 3, the proportion of workers who experienced hypotension and low fatigue was more dominant. Meanwhile, shift 2 was dominated by blood pressure and fatigue conditions that tended to be normal or moderate.

Table 3. Relationship between Work Shift and Blood Pressure and Fatigue

Work Shift	Systolic Blood Pressure			Diastolic Blood Pressure			Work Fatigue		
	Hypertension	Normal	Hypotension	Hypertension	Normal	Hypotension	High	Medium	Low
Shift 1	27	19	15	27	19	15	47	11	3
Shift 2	8	41	1	8	41	1	5	36	9
Shift 3	15	12	32	15	12	32	3	3	53
P-Value		0,000			0,000			0,000	

Table 4. Relationship of Physical Load with Blood Pressure and Work Fatigue

Physical Load	Systolic Blood Pressure			Diastolic Blood Pressure			Work Fatigue		
	Hypertension	Normal	Hypotension	Hypertension	Normal	Hypotension	High	Medium	Low
Weight	14	18	17	14	18	17	21	12	16
Medium	26	28	10	26	28	10	23	23	18
Low Weight	10	26	21	10	26	21	11	15	31
P-Value		0,019			0,019			0,014	

The table 4 above shows the relationship between physical workload and systolic and diastolic blood pressure and fatigue. Based on the p-value obtained, the relationship between physical workload (mainly heavy and moderate) with systolic and diastolic blood pressure and fatigue was significant (p-value <0,05). For heavy physical loads, the proportion of workers with hypertension and high fatigue tended to be higher than that for low physical loads. In contrast, under low physical load, the proportion of workers with normal blood pressure and low fatigue was more dominant.

Table 5. Relationship of Mental Load with Blood Pressure and Work Fatigue

Physical Load	Systolic Blood Pressure			Diastolic Blood Pressure			Work Fatigue		
	Hypertension	Normal	Hypotension	Hypertension	Normal	Hypotension	High	Medium	Low
Weight	22	27	8	22	27	8	21	19	17
Medium	16	22	18	16	22	18	19	24	13
Low Weight	12	23	22	12	23	22	15	7	35
P-Value		0,039			0,039			0,000	

The table 5 presented shows the relationship between mental workload with systolic, diastolic blood pressure, and job fatigue in workers. Based on the p-value results, there was a significant association between heavy mental workload and systolic (p = 0,039) and diastolic (p = 0,039) blood pressure, as well as with high job fatigue (p = 0,000). In contrast, in moderate and low mental workloads, the relationship found was not significant or weaker.

Table 6. Relationship of Smoking Habits with Blood Pressure and Fatigue

Smoking Habit	Systolic Blood Pressure			Diastolic Blood Pressure			Work Fatigue		
	Hypertension	Normal	Hypotension	Hypertension	Normal	Hypotension	High	Medium	Low
Heavy Smokers	18	18	28	18	18	28	28	14	22
Low Smokers	12	21	10	12	21	10	13	10	20
No Smoking	20	33	10	20	33	10	14	26	23
P-Value		0,006			0,006			0,033	

The table 6 presented shows the relationship between smoking habits with systolic, diastolic blood pressure, and job fatigue in workers. The p-value results show a significant association between heavy smoking and systolic (p = 0,006) and diastolic (p = 0,006) blood pressure, as well as high work fatigue (p = 0,033), indicating that heavy smokers are more at risk of hypertension and high work fatigue compared to low smokers and non-smokers. Low smokers and non-smokers tended to show more normal blood pressure and lower levels of fatigue. Meanwhile, the relationship between job fatigue and systolic and diastolic blood pressure in workers, with a significant p-value (p = 0,000) in both types of blood pressure. Workers with high levels of occupational

fatigue showed a greater tendency to experience hypertension in both systolic and diastolic blood pressure, compared to those with moderate or low levels of fatigue. On the other hand, workers with moderate or low fatigue tend to have more normal blood pressure.

Multivariate Analysis

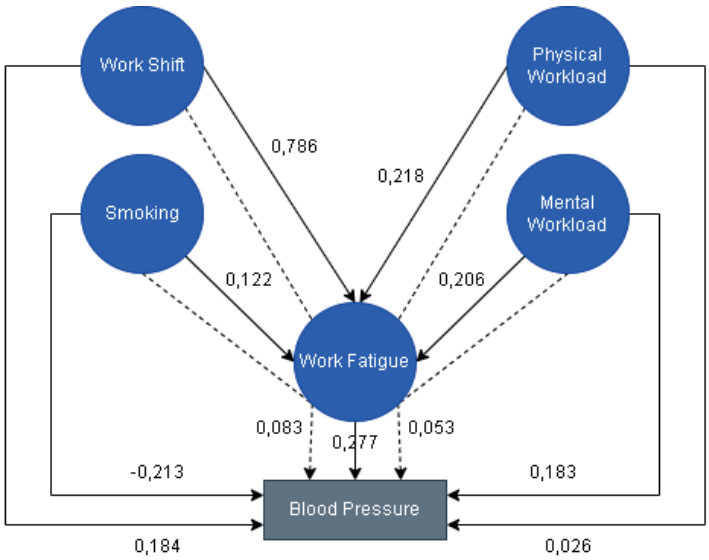

Figure 2. Path Analysis

Table 7. Results of Direct Effect Path Analysis

Hypothesis	Variables	Estimation	*P value*	Conclusion
H1	Work shift -> Systolic Blood Pressure	0,184	0,129	Not Significant
H2	Shift Work -> Fatigue	0,786	0,000	Significant
H3	Physical Load -> Systolic Blood Pressure	0,026	0,735	Not Significant
H4	Physical Load -> Fatigue	0,218	0,004	Significant
H5	Mental Load -> Systolic Blood Pressure	0,183	0,016	Significant
H6	Mental Load -> Fatigue	0,206	0,007	Significant
H7	Smoking habit -> Systolic blood pressure	-0,213	0,004	Significant
H8	Smoking habit -> Fatigue	0,122	0,112	Not Significant
H9	Fatigue -> Systolic Blood Pressure	0,277	0,000	Significant
H10	Work shift -> Diastolic Blood Pressure	0,184	0,129	Not Significant
H11	Physical Load -> Diastolic Blood Pressure	0,026	0,735	Not Significant
H12	Mental Load -> Diastolic Blood Pressure	0,183	0,016	Significant
H13	Smoking habit -> Diastolic blood pressure	-0,213	0,004	Significant
H14	Fatigue -> Diastolic Blood Pressure	0,277	0,000	Significant

The results of path analysis showed that job fatigue had a significant influence on systolic and diastolic blood pressure (p = 0,000; coefficient = 0,277), confirming that the higher the level of fatigue, the higher the blood pressure. Mental load also had a significant effect on both systolic (p = 0,016) and diastolic blood pressure (p = 0,016), as well as on work fatigue (p = 0,007). In addition, smoking had a significant effect on systolic and diastolic blood pressure (p = 0,004), although the negative direction of the coefficient (-0,213). Meanwhile, work shifts and physical load did not show a significant direct effect on blood pressure. Shift work only had a

significant effect on fatigue (p = 0,000). Similarly, physical load only affected fatigue (p = 0,004), but not blood pressure directly (p = 0,735).

Table 8. Results of Indirect Effect Path Analysis

Hypothesis	Variables	P value	Indirect Effect	Total Effect
H15	Shift work -> Fatigue -> Systolic blood pressure	0,379	0,083	0,563
H16	Physical Load -> Fatigue -> Systolic blood pressure	0,032	0,053	0,058
H17	Mental Load -> Fatigue -> Systolic blood pressure	0,048	0,044	0,231
H18	Smoking habit -> Fatigue -> Systolic blood pressure	0,139	0,034	0,074
H19	Shift work -> Fatigue -> Diastolic blood pressure	0,379	0,083	0,563
H20	Physical Load -> Fatigue -> Diastolic blood pressure	0,032	0,053	0,058
H21	Mental Load -> Fatigue -> Diastolic blood pressure	0,048	0,044	0,231
H22	Smoking habit -> Fatigue -> Diastolic blood pressure	0,139	0,034	0,074

The results of the indirect effect path analysis showed that physical load and mental load significantly influenced systolic and diastolic blood pressure through fatigue (p < 0,05), with a total effect of 0,058 and 0,231, respectively. The same was seen for mental load, which consistently contributed to increased blood pressure through the fatigue pathway. Meanwhile, work shifts and smoking habits did not show significant indirect effects on either systolic or diastolic blood pressure (p > 0,05), although the total effect value of work shifts was quite high (0,563), which is most likely due to its direct effect on fatigue.

DISCUSSION

Direct Influence

Work shifts, especially night shifts, can affect blood pressure due to sleep disturbances and stress. However, research at New Makassar Container Terminal showed no significant relationship between work shifts and systolic or diastolic blood pressure (p-value = 0,129). Several other studies have also found no significant relationship, while other studies have shown the effect of work shifts on blood pressure.[15] Work shifts, especially night shifts, are significantly associated with fatigue. Research at the New Container Terminal Makassar found a strong relationship between work shifts and fatigue (p-value = 0,000). Similar results were found in nurses at Balung Jember Regional Hospital and other workers.[16] However, some other studies, such as in gas station operators, suggest environmental factors are more influential on fatigue. Individual factors and adaptability also influence the impact of shift work on fatigue.[17]

Physical workload can affect blood pressure, mainly because the body adapts by increasing heart rate to meet oxygen demand during physical activity. However, research on operators at New Makassar Container Terminal showed no significant effect between physical workload and systolic or diastolic blood pressure (p-value = 0,735). This finding is in line with several other studies showing that although physical workload can affect blood pressure, other factors such as age, lifestyle and diet have more influence on blood pressure changes. Occupational fatigue occurs due to various factors, including excessive physical workload. In this study, there was a significant relationship between physical workload and work fatigue (p-value = 0,004). The heavier the physical workload, the higher the level of fatigue felt by workers. This result is in line with research at PT X Surakarta and others which show that physical workload can increase fatigue. However, there are other factors such as individual physical condition, work duration, and rest time that also affect fatigue.

Mental workload can be divided into two types: physical (which focuses on body muscles) and psychological (which focuses on brain performance). Mental workload is measured based on an evaluation of the brain's capacity to handle tasks. This workload can affect systolic and diastolic blood pressure, with the results showing a positive association between heavy mental workload and high blood pressure. Multivariate test results with a p-value = 0,016 indicated that mental workload was closely associated with increased systolic and diastolic blood pressure.[18] Other studies have also shown that high mental workload contributes to hypertension as sustained stress affects the body's response, including increased blood pressure.[4]

Fatigue is a decline in physical and mental ability that can reduce performance. Excessive mental workload

can lead to stress and fatigue. The analysis showed that 12,4 % of operators with heavy mental workload experienced high fatigue. Multivariate test with p-value = 0,007 showed that mental workload has a strong positive influence on fatigue. Other studies have also found a strong relationship between mental workload and fatigue, such as in welding workers at PT PAL Indonesia and career women in Maros Regency.[19]

Smoking increases blood pressure through the effects of nicotine which triggers vasoconstriction and adrenaline release. Multivariate test results showed a significant association between smoking and blood pressure (p = 0,004), with a negative effect coefficient (-0,213). This means that smoking is correlated with changes in blood pressure, although the direction of the relationship in this study is not always consistent with general theory. Smoking is thought to trigger fatigue due to decreased oxygen in the blood. However, the test results showed no significant effect (p = 0,112) between smoking and fatigue levels. Although most of the moderate and mild fatigue was found in non-smokers. This suggests the possibility of physiological adaptation to nicotine or the influence of other more dominant factors. Occupational fatigue was shown to have a significant influence on blood pressure elevation (p = 0,000), with a positive influence coefficient (0,277). The higher the level of fatigue, the higher the systolic and diastolic blood pressure. These results support the theory that physical and mental fatigue can increase blood pressure through the activation of stress hormones and autonomic nervous system disorders.

Indirect Effect

Shift work, while providing certain benefits, can cause serious disruptions for workers, especially on night shifts which often result in sleep deprivation. Sleep deprivation impacts metabolic hormones, decreases growth hormone production, and disrupts the circadian melatonin rhythm, which can lead to health problems such as obesity, diabetes, and hypertension (Consultanlive). Hypertension can lead to serious complications such as heart disease, stroke, kidney disorders, and visual impairment.[20] In addition, a nervous system that is constantly stimulated due to stress and lack of sleep can increase blood pressure.[21] Similar research conducted on nurses at Benyamin Guluh Hospital also showed no significant relationship between work shifts and job fatigue, with a p-value of 0,531, which is greater than 0,05.[22] In contrast to other studies which show that fatigue due to night shifts can increase the risk of hypertension.[10]

Heavy physical workloads can trigger muscle fatigue and increased blood pressure. Physical fatigue can affect the autonomic nervous system, which regulates body functions automatically such as blood pressure. Based on the test results, it was found that physical load has a significant effect on blood pressure through fatigue as an intervening variable. Heavy physical workload affects the body's energy, increasing stress hormones such as cortisol and adrenaline, which contribute to increased blood pressure. Research on truck drivers also shows that occupational fatigue can increase blood pressure due to narrowed blood vessels,[14] while research on health workers at the Malang City Health Center showed no relationship between physical workload and fatigue.

High mental workload can increase blood pressure through fatigue. When mental workload exceeds a person's capacity, it can cause fatigue and trigger a hypertensive response.[23] Other studies have also shown a close relationship between mental workload and fatigue, which increases the risk of hypertension due to prolonged stress.[24] Nonetheless, research on haul dumptruck drivers suggests that despite high mental workload, fatigue management can reduce its impact.

Smoking contributes to increased blood pressure, both acutely and chronically, by constricting blood vessels and increasing heart rate. In addition, smoking increases the risk of fatigue as it reduces lung capacity and sleep quality, which worsens the body's condition.[25] Smoking is associated with increased fatigue, which in turn increases sympathetic nervous system activity, leading to increased blood pressure. Long-term fatigue can exacerbate this condition, leading to further health problems, including hypertension.

CONCLUSIONS

The conclusions of this study indicate that mental workload, smoking habits, and fatigue levels have a significant impact on workers' blood pressure, both directly and indirectly, while physical workload and shift work systems have a greater impact on fatigue than on blood pressure directly. Therefore, it is recommended that companies prioritize fatigue management through healthy shift scheduling, work rotations aligned with biological rhythms, and adequate rest periods. Additionally, it is important to conduct regular assessments of mental workload, provide psychosocial interventions such as stress management training, and implement smoking control policies in the workplace. These efforts should be supported by the integration of long-term occupational health programs that include routine blood pressure checks, screening for non-communicable disease risk factors, and promoting a healthy lifestyle to maintain overall worker productivity and well-being.

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