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Research

Association between Heat Stress, Work Fatigue, and Elevated Blood Pressure among Construction Workers in Yogyakarta

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ABSTRACT

Background: Excessive heat stress will cause fatigue and drowsiness, reduce stability and increase the number of work errors. The purpose of this study was to analyze the relationship between heat stress and work fatigue and increased blood pressure in construction workers at PT PP Urban Development Project at the University of Nahdlatul Ulama Yogyakarta.
Subjects and Method: Research with a cross sectional design was conducted at PT PP Urban Development Project, Nahdlatul Ulama University, Yogyakarta, from March to April 2022. A sample of 107 workers was selected by purposive sampling. The dependent variable is work fatigue and an increase in blood pressure. The independent variable is heat stress. Heat stress was measured by Heat Stress Monitor, work fatigue by reaction timer and increase in blood pressure was measured by digital sphygmomanometer. Test analysis using chi-square and the value of Odds Ratio (OR).
Results: Construction workers who experience high heat stress have a risk for an increase in blood pressure of 3.10 times compared to normal heat stress and are statistically significant (OR= 3.10; 95% CI= 1.01 to 9.24; p= 0.020), and have a risk of work fatigue 2.73 times compared to normal heat stress and statistically significant (OR= 2.73; 95% CI= 0.97 to 7.52; p= 0.020).
Conclusion: There is a relationship between high heat stress and work fatigue and an increase in blood pressure.

Keywords: heat stress, fatigue, blood pressure

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BACKGROUND

The hazard risks faced by workers are the dangers of accidents and occupational diseases, due to a combination of various factors, namely the workforce and the work environment. In addition, work environment factors that do not meet Occupational Safety and Health (K3) requirements, unsafe processes, and increasingly complex and modern work systems can be a separate threat to the safety and health of workers (Tarwaka, 2017). The number of work accidents in Indonesia in 2011 was 9,891, in 2012 there were 21,735 cases, in 2013 there were 35,917 and in 2014 there were 24,910 accident cases (Kemenkes RI, 2015). Meanwhile, in 2018 there were 173,313 cases (Putra, 2019) and in 2019 it decreased by 33%, namely there were 77,295 accident cases where work accidents occurred.

Based on data from the International Labor Organization (2013), it shows that every year there are more than 250 million accidents in the workplace and the death rate due to accidents and occupational diseases (PAK) is 2 million cases every year. In 2013, 1 worker in the world dies every 15 seconds due to a work accident and 160 workers experience work-related illness. Moreover, 1.2 million workers died due to accidents and illness at work (ILO, 2013). The latest data in 2018 shows that every year 2.78 million workers die due to work accidents and occupational diseases, around 2.4 million (86.3%) are due to work accidents (ILO, 2018).

Excessive heat stress will cause fatigue and drowsiness, reduce stability and increase the number of work errors. Work fatigue will reduce performance and increase the level of work errors. Work fatigue will increase the longer the work is carried out with high heat pressure and without adequate rest. This can trigger an additional burden on blood circulation so that it will affect systolic and diastolic blood pressure. High blood pressure or hypertension is one of the major health problems worldwide because of its high prevalence and associated with an increased risk of cardiovascular disease. The increasing prevalence of hypertension is associated with an increasing population, aging factors, and behavioral factors such as an unhealthy diet, excessive alcohol use, lack of physical activity, excessive body weight, and exposure to significant stressors (WHO, 2013).

Based on data from the World Health Organization (WHO) in 2015, it shows that around 1.13 billion people in the world have hypertension, meaning that 1 in 3 people in the world is diagnosed with hypertension. The number of people with hypertension continues to increase every year, it is estimated that by 2025 there will be 1.5 billion people affected by hypertension, and it is estimated that every year 9.4 million people die from hypertension and its complications. The 2014 Indonesian Sample Registration System (SRS) data shows that hypertension accompanied by complications is the fifth leading cause of death at all ages. The prevalence of hypertension will continue to increase sharply and it is estimated that by 2025 as many as 29% of adults worldwide are affected by hypertension (Ministry of Health, 2019).

The prevalence of hypertension in Indonesia is quite high, where hypertension is the third leading cause of death after stroke and tuberculosis, which is 6.7% of the population at all ages. According to the results of the Basic Health Research (Riskesdas) of the Health Research and Development Agency (Balitbangkes) in 2019, based on the results of measurements over the age of 18 years, the prevalence of hypertension was 34.1% where the highest prevalence was in South Kalimantan at 44.1% while the lowest prevalence was in Papua Province at 22.2%. (Ministry of Health RI, 2019)

PT. PP Urban is a company engaged in urban development, construction, and precast. One of PT PP Urban's projects is the development project of the Yogyakarta Nahdlatul Ulama University which is still running in early 2022. The tight scheduling structure demands high performance from the workforce and is required to work overtime every day. Due to the high workload, complaints of fatigue among construction workers often occur during working hours and result in an increase in blood pressure. Based on observations made on February 17, 2022, there were subjective complaints of workers feeling hot and hot at work and feeling very tired both at work and after work. Of the 10 workers who were taken at random and then measured blood pressure after work and exposed to sunlight, 60% of

them experienced an increase in blood pressure.

Based on these subjective complaints, the author tries to dig deeper into the problem by measuring fatigue using the Reaction Timer with the reaction time method for 4 workers with the minimum average reaction time of 322.8 milliseconds including the category of mild fatigue and the maximum value of 424.3 milliseconds including the fatigue category. currently. Project environmental factors also trigger fatigue of construction workers considering that the work process is carried out outdoors or outdoors so that the obstacles that are often experienced are climate or hot weather and irregular blood pressure.

The results of a preliminary survey conducted by measuring heat stress in four areas using the Area Heat Stress Monitor tool for the Wet and Spherical Temperature Index (ISBB) obtained results of A 30oC with a medium workload, B 31oC with a light workload, C 31oC with a moderate workload. D 32oC with medium workload. According to the workload and duration of exposure to heat stress in this outdoor area, it exceeds the Threshold Value for a working time of 8 hours of work with 1 hour of rest.

The results of the workload measurement carried out on 4 workers by measuring the pulse rate obtained an average of 100 beats/minute so that it is included in the light workload category. Setting the working hours of employees per day is 75% - 100%. And the results of interviews with several workers found many complaints about workloads such as sleep disturbances, digestive disorders, increased blood pressure, and complaints of fatigue in workers.

The purpose of this study was to determine the relationship between heat stress and work fatigue and increased blood pressure in construction workers of PT PP Urban Development Project, University of Nahdlatul Ulama Yogyakarta.

SUBJECTS AND METHOD

1. Study Design

This was an analytic observational study with cross-sectional design.

2. Population and Sample

The target population in this study were construction workers in the Development Project of the University of Nahdlatul Ulama Yogyakarta. The total population in this study were 225 construction workers at the Yogyakarta Nahdlatul Ulama University Development Project. The technique for taking samples in this study used purposive sampling. The number of samples in this study were 107 construction workers at the Nahdlatul Ulama University Development Project, Yogyakarta.

3. Study Variables

The independent variable in this study is heat stress. The dependent variable in this study is work fatigue and an increase in blood pressure.

4. Operational Definition of Variables

Thermal stress is defined as the amount of heat from a combination of radiant temperature, dry temperature and wet bulb temperature that a person is exposed to at work and is sourced from the local work environment. The threshold value used is in accordance with Permenaker No. 13 of 2018.

Work fatigue is defined as a condition where construction workers feel physically and/or mentally tired due to doing work and is measured by a reaction timer.

Increased blood pressure is defined as the difference between systolic blood pressure and diastolic blood pressure in construction workers before work or before exposure to heat and after work or after exposure to heat.

5. Study Instruments

The instrument in this study used a Head Stress Monitor for measuring heat stress, a Reaction Timer for measuring work fatigue and a digital Sphygmomanometer for measuring blood pressure.

6. Data Analysis

Analysis of the data used is the Chi-Square test 95% confidence level and the value of the Odds Ratio (OR) to get the magnitude of the risk of the occurrence of effects.

RESULTS

Table 1 shows that the heat stress in the high category is 73.83%. This result is measured based on the point where 107 workers are on the project site. Blood pressure measurements were carried out 2 times, which were measureed before the worker worked and after work, the work fatigue examination was carried out after the worker worked and was exposed to heat with the result that workers experienced work fatigue as much as 72.90% and the measurement was 2 times known that most of the workers experienced an increase blood pressure after work (79.44%).

Table 1. Results of the variable frequency distribution of heat stress and increased blood pressure

Variable	Frequency (n)	Percentage (%)
Heat Pressure		
Normal	28	26.17
High	79	73.83
Work Fatigue		
Not exhausted	29	27.10
Exhausted	78	72.90
Increased blood pressure		
No increase	22	20.56
There is an increase	85	79.44

Table 2. Relationship between heat stress and fatigue

Heat Pressure	Work Fatigue						OR	CI 95%	p
	Not exhausted		Exhausted		Total				
	n	%	n	%	n	%			
Normal	12	42.86	16	57.14	28	100			
High	17	21.52	62	78.48	79	100	2.73	0.97 – 7.52	0.02
Total	29	27.10	78	72.90	107	100			

Table 2 shows that research subjects who were exposed to normal heat stress and experienced work fatigue as much as 57.14%, while research subjects who were exposed to high heat stress showed 78.48% of work fatigue. There is a relationship between heat stress and the risk of workers experiencing work fatigue. Construction workers who experience high heat stress have a risk of work fatigue 2.73 times compared to normal heat stress and are statistically significant (OR=2.73; 95% CI= 0.97 to 7.52; p= 0.020).

Table 3. The relationship between heat stress and increased blood pressure

Heat Pressure	Increased Blood Pressure						OR	CI 95%	p
	No		Yes		Total				
	n	%	n	%	n	%			
Normal	10	35.71	18	64.29	28	100			
High	12	15.19	67	84.81	79	100	3.10	1.01– 9.24	0.020
Total	22	20.56	85	79.44	107	100			

Table 3 shows that subjects exposed to normal heat stress had an increase in blood pressure of 64.29%, while those exposed to high heat pressure had an increase in blood pressure of 84.81%. There is a relationship between heat stress and the risk of workers experiencing an increase in blood pressure. Construction workers who experienced high heat stress had a risk for an increase in blood pressure of 3.10 times compared to normal heat stress and was statistically significant (OR= 3.10; 95% CI= 1.01 to 9.24; p= 0.02).

DISCUSSION

The results of the measurement of heat pressure which are divided into 4 points where 107 workers are the sample of the study, it is known that most of the heat stress is in the high category (> 28^{o}C). This value is based on the Regulation of the Minister of Manpower Number 5 of 2018 concerning Occupational Safety and Health in the Work Environment, the figure exceeds the heat stress threshold in the light workload category.

The higher the environmental heat, the greater the effect on body temperature and vice versa, the lower the environmental temperature also affects body temperature. In other words, there is an exchange of heat between the human body obtained from metabolism and heat stress which is felt as a hot condition of the environment. As long as this exchange is balanced and harmonious, it will not cause any disturbance, either to work performance or occupational health. Excessive heat stress will be an additional burden that must be considered and taken into account (Suma'mur, 2009).

Additional loads in the form of environmental heat can cause physiological loads, such as fatigue, to increase. Minister of Manpower Regulation Number 5 of 2018 concerning Occupational Safety and Health in the Work Environment, for the type of light workload with the criteria of 50% work and 50% rest, the allowed temperature is 29.4 °C (light and moderate workload). The hot state of the work environment is also influenced by the environmental weather where during the research the ambient air temperature is uncertain due to the season and weather (Suma'mur, 2009).

The measurement of workers' blood pressure is carried out 2 times, which is measured before workers work and after work, these 2 measurements aim to find out whether there is an increase in workers' blood pressure. The difference was to determine whether there was an increase in blood pressure and resulted that 79.44% of construction workers had an increase in blood pressure. Construction workers at PT PP Urban Development Project at the University of Nahdlatul Ulama Yogyakarta, the sample is male. Blood pressure in men is higher than in women, women's risk of hypertension will increase after menopause which shows the influence of hormones (Purwanto, 2012).

The results of the analysis of the relationship between heat stress and work fatigue. Statistical calculations using the chi-

square test resulted in significant values (OR= 2.73 95% CI=0.97 – 7.52; p=0.02). Heat stress can cause fatigue due to high environmental temperatures, so that body temperature will rise. This will cause the hypothalamus to stimulate the sweat glands so that the body will sweat. Sweat contains various sodium chloride salts, the release of sodium chloride salt with sweat will reduce its levels in the body, thereby inhibiting the transport of glucose as an energy source. This will cause a decrease in muscle contraction so that the body experiences fatigue (Guyton, 2008).

Based on another study conducted by Agus (2011), the value of the chi-square test results = 8.19 and p value = 0.004, that p < 0.01, the p value is very significant, it can be concluded that there is an effect of heat stress on work fatigue. This study is also in line with research conducted by Ulfa et al. (2017), the results of the study show that there is a relationship between heat stress p= 0.014 and age p= 0.026 with work fatigue in factory workers I PT. Maruki International Indonesia. However, the results of the study do not show this so that this is not in line with the results of research conducted by Shinly (2013), which showed as many as 60% of respondents experienced an increase in blood pressure, and research conducted by Septya (2011), which showed as many as 35 % of respondents experienced severe fatigue due to heat stress.

Thermal stress is a limitation of the ability to receive heat received from the combined contribution of the body's metabolism due to doing work and environmental factors (such as air temperature, humidity, air movement and heat transfer radiation) and clothing used. Mild or severe heat can cause discomfort and adversely affect performance and safety (American Conference of Governmental Industrial Hygienists, 2017). The effect of heat metabolism with the body in a crepe cycle with a lot of formation of lactic acid will be produced more quickly will get muscles to work slowly and cause fatigue. The work environment has factors that can affect health both naturally and modified by humans. Improving the work environment is one of the efforts to create jobs and carry out work more efficiently and productively.

Construction workers are particularly affected by heat stress, as body heat production is caused by physically demanding tasks, and hot and humid working conditions (Wen, 20-17). The workforce in the work that is their duty, the work environment, the exercises experienced and the adaptation by the workforce to their work. Workers will experience short-term effects in the form of fatigue, bad feelings, pain and long-term effects in the form of many absenteeism, low work capacity for rest. As a result of high environmental temperatures, body temperature will increase (the body gets more warm) some sweat is secreted to the skin surface by sweat glands, sweat contains various electrolytes, especially sodium and chloride ions. The release of sodium and chloride ions will cause a decrease in strength. This will decrease muscle concentration so that the body experiences fatigue. Because for muscle concentration, glucose is needed as an energy source (Tarwaka, 2014).

The relationship between heat stress and increased blood pressure of construction workers was significant (OR= 3.10; 95% CI= 1.01 – 9.24; p=0.02). The results of this study are not in line with several previous studies which showed a relationship between heat stress and blood pressure. According to Kurniawati (2015) there is an influence between pressure and changes in blood pressure in workers in the tea plantation production room Ciater Subang 2015. Workers who are exposed to heat in the

work environment will experience strain heat. Thermal strain or thermal strain effect is introduced into the body at the expense of the working climate. Heat stress involves the body's core temperature, heart rate and sweat. Other important responses are allocation of body fluid volume, electrolyte concentration in the intra and extracellular spaces, hormone levels, and blood pressure. Strain heat indicators are increased pulse rate, blood pressure, body temperature, sweating, and weight loss. Exposure to heat stress in healthy individuals causes various physiological reactions that are important for thermoregulation. One of them is increased blood flow through the skin.

Research by Shintyar (2015) that 24 out of 30 workers experienced an increase in blood pressure with a temperature above 28°C, the average blood pressure before work was 121/81 mmHg, while the blood pressure after work was 133/89 mmHg. This shows that there is a relationship between heat stress and an increase in blood pressure in motorized vehicle parking workers at the Basement Plaza Center Point Medan. Then research conducted in South Sulawesi by Nurmagfira (2016) at the Tofu Factory, BaraBaraya Village, Makassar City which proved that there was a very significant relationship between heat stress and blood pressure in workers.

AUTHOR CONTRIBUTION

Nisa Nur Kusuma is the main researcher in research, seeking and collecting research data and processing this research data, Bhisma Murti and Sumardiyono as supervisors in research.

CONFLICT OF INTEREST

There is no conflict of interest in this study.

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