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The Relationship between Drinking Water Consumption, Nutritional Status and Workload with The Incidence of Heat Strain in Tofu-Making Workers in West Kekalik Sub-District

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Abstract
Various cases of accidents and work-related illnesses, as well as other health problems, are often caused by factors in the work environment that do not meet the requirements. Workers in hot environments are one of the causes of workers experiencing work-related illnesses. Heat strain is an acute or chronic impact caused by exposure to heat stress experienced by a person from physical or mental aspects. The physical impacts of heat strain range from mild complaints such as skin rashes to fainting to life-threatening situations when sweating stops and heat stroke occurs. Tofu making is a hot work environment. This research uses a quantitative method with a sampling technique using a purposive sampling technique. The sample in this research was 44 tofu making workers. Data collection techniques used questionnaires and pulse measurements. Data analysis used the Spearman Rank test. The results of the research show that there is a relationship between drinking water consumption and the occurrence of heat strains with a value (p = 0.000), there is no relationship between BMI (p = 0.113) and there is a relationship between workload and the incidence of heat strains (p = 0.000) and complaints of heat strains in workers tofu factory. It is expected that workers consume >11 glasses of drinking water and wear clothing that can reflect heat such as wearing thin clothes, wearing loose shirts that absorb sweat easily.

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INTRODUCTION

Various cases of occupational accidents and diseases, as well as other health disorders, are often caused by an unsatisfactory work environment, in addition to several other factors (Firman, 2022; Sorensen et al., 2021). A hot work climate can affect workers' conditions (Badrianto & Ekhsan, 2020). A hot work environment imposes an additional workload on workers, requiring more energy than workers who work in a comfortable work environment with temperatures ranging from 24–26ºC (Adiningsih, R., 2013). According to government regulations related to workplace temperature, the Ministry of Manpower Regulation No. 13/MEN/X/2011 on Threshold Limit Values (TLVs) for Work Climate and Threshold Limit Values for Workplace Temperature, stipulates that the TLV for work climate is the work situation that can still be faced by workers in daily work without causing illness or health problems for continuous work not exceeding 8 hours per day and 40 hours per week. The lowest TLV for the work environment is 25°C and the highest TLV is 32.2°C depending on workload and work time arrangements (Ihsan, 2019). Workers in hot environments, such as around modern machinery, smelting, boilers, ovens, furnaces, or working outdoors under the

scorching sun, can experience heat stress. During activities in these hot environments, the body will automatically react to maintain a constant range of environmental heat by balancing the heat received from outside the body with the loss of heat from within the body (Tarwaka, 2015). Working in a hot work climate can lead to health and safety hazards (Patel et al., 2022). High temperatures in the workplace can result in heat cramps, heat exhaustion, heat stroke, and miliaria (Parashakti et al., 2020).

(Ansah et al., 2021) reported that extreme work environments, particularly those involving excessively high or low temperatures, can have serious effects on workers' health and safety. Such conditions are often found in various industrial sectors, including mining, construction, and manufacturing, where workers may be exposed to temperatures far beyond human comfort levels for extended periods (Fatima et al., 2021). Working in high-temperature environments can cause a range of health problems, from mild disturbances to potentially fatal conditions. When the body is exposed to excessive heat, natural mechanisms like sweating may not be sufficient to maintain normal body temperature (Filomena & Picchio, 2024). Heat stress occurs when the body cannot cool itself quickly enough. This can lead to dehydration, fatigue, and reduced concentration, significantly increasing the risk of workplace accidents (Wolkoff et al., 2021).

(Odonkor & Adams, 2022; Stoklosa et al., 2020) stated that heat exhaustion is a more advanced stage of heat stress, characterized by symptoms such as dizziness, nausea, headache, and excessive sweating. If not addressed promptly, this can escalate into more serious conditions. The most serious medical emergency due to extreme heat exposure (Bouchama et al., 2022) is heat stroke, which occurs when body temperature rises above 40°C, and the body's temperature regulation system starts to fail. Symptoms include confusion, loss of consciousness, and in severe cases, death (Bonafede et al., 2022; Palinkas & Wong, 2020).

On the other hand, working in environments with extremely low temperatures also poses serious risks. Excessive cold exposure can disrupt body metabolism and reduce blood flow to extremities, potentially leading to health problems. Hypothermia occurs when body temperature drops below 35°C. The body loses heat faster than it can produce it, causing disruptions in the nervous system and vital organs' functions (Rauch et al., 2021; van Veelen & Brodmann Maeder, 2021). Symptoms include shivering, slurred speech, confusion, and in severe cases, loss of consciousness and death. (Ebi et al., 2021; Jay et al., 2021) stated that exposure to extreme temperatures, whether high or low, can disrupt the body's metabolism, a series of chemical processes necessary for sustaining life. When metabolism is disturbed, bodily functions such as digestion, blood circulation, and respiration may be affected, leading to a decline in overall health. Furthermore, extreme temperatures can also affect workers' concentration, reflex responses, and physical endurance. When the body struggles to adapt to the environmental temperature, workers may tire more quickly, making them more susceptible to workplace accidents. Lack of concentration and delayed responses can lead to errors in operating machinery or heavy equipment, increasing the risk of injury or even death at the workplace (Wu et al., 2020).

In 2016, in the United States, the total number of heat strain incidents with at least one day of lost work was estimated at 1,432 cases. According to data on heat-related illnesses by occupation per 100,000 workers, cases were found in agriculture (8.13 cases), construction (6.36 cases), mining (5.01 cases), and other occupations (1.3 cases) (NIOSH, 2016). Heat strain is an acute or chronic impact caused by heat stress experienced by a person, both physically and mentally. The physical effects can vary from mild complaints such as skin rashes or fainting to life-threatening situations when sweating stops and heat stroke occurs (Nofianti & Koesyanto, 2019). In Indonesia, based on research conducted by Adiningsih

(2013), it was found that workers in environments with temperatures exceeding the TLV experienced heat strain complaints, such as extreme fatigue in 54.6% of cases, dizziness in 33.3% of cases, and muscle stiffness/cramps in 12.1% of cases. There are differences in body temperature, pulse rate, systolic and diastolic blood pressure between before and after work with heat exposure, which is closely related to heat strain (Adiningsih, 2013). Heat strain is a physiological consequence of heat stress that can cause an increase in core body temperature, heart rate, and weight loss. Based on the determination of the Thermal Comfort Threshold Value (TLV) according to the Minister of Manpower Regulation No. 5 of 2018, it is necessary to know the workers' physical workload, calculated by knowing the workers' body weight, work time, and basal metabolism (Fadhila & Santiasih, 2021). Prolonged exposure to heat stress can cause health problems, namely heat strain. (Ojha et al., 2024) stated that heat strain is a physiological response to heat load, both external and internal, experienced by a person, where the body attempts to release heat to the environment to maintain body temperature stability. Workers experiencing heat strain will have decreased performance, which will also impact the company's productivity.

One industry with a hot work climate is the tofu-making industry. Tofu production is a small and medium-sized enterprise that potentially has a hot work climate. The production process, which requires fire as a cooking medium, can create a hot work environment. The tofu-making process consists of five stages: grinding, cooking, filtering, hardening, and molding. In the tofu production process, it is evident that fire is used on a fairly large scale, necessary to support the process of cooking ground soybeans in a fairly large cooking vessel. The use of a significant amount of firewood is one of the factors contributing to the large flames. Although the use of fire only occurs during the soybean grinding cooking process, the hot work environment can be felt throughout the production area. Tofu workers, especially in the informal industry, are subjected to multiple physical workloads and work durations exceeding 8 hours, making the hot work environment even more burdensome. Many workers in the industry complain about the excessively hot temperatures, excessive sweating, and thirst. These complaints are physiological responses of the human body aimed at reducing body heat after exposure to heat effects, known as heat strain. (Juliana, M., Camelia, A., & Rahmiwati, A., 2018; Hoorfarasat et al., 2015).

When the body is exposed to heat, it reacts to maintain a balance between the heat received from the external environment and the heat lost from within. This physical response can become more severe when influenced by other factors such as age, physical condition, activity level, and dehydration (Nofianti & Koesyanto, 2019). One of the factors that can influence the occurrence of heat strain in workers is nutritional status. Nutritional status can also affect a worker's susceptibility to heat strain in hot working environments. Being either overweight or underweight is a risk factor for heat-related health issues because it can reduce the body's ability to dissipate heat. Overweight individuals also generate more heat during physical activity (Marif, A., 2013). Individuals with excess weight are 3.5 times more likely to experience heat-related illnesses. Increased body weight demands more energy for activity, thereby requiring more oxygen. The increase in metabolic energy, produced as muscle work, leads to a rise in body temperature that must be dissipated compared to non-obese individuals performing the same tasks in the same environment. Heat transfer from the muscles to the skin is also hindered by layers of fat (Centers For Disease Control, 2018). Additionally, the ratio of body surface area to weight in obese individuals is less favorable for heat dissipation. This results in the body generating more heat, disrupting temperature regulation, and increasing the risk of heat strain (Saputra, et al., 2022).

Apart from nutritional status, workers in hot climates need to pay extra attention to their water and salt intake to replace fluids lost from the body (Suma'mur, 2014). Water consumption is a key factor in causing heat strain among workers. Workers in hot

environments experience a rise in body temperature, which leads to sweating. If workers do not consume adequate water, heat strain can occur (Tarwaka, 2014). To replace lost fluids, it is essential to focus on water and salt needs. In hot work environments, more than 2.8 liters of water per day is required, while in non-hot environments, at least 1.9 liters per day is recommended. Water should be consumed in small amounts but more frequently, such as drinking twice every hour with 20-30 minute intervals, and the optimal water temperature is between 10˚C and 21˚C (Sari, M. P., 2017). The sweat produced as a bodily response to heat exposure indicates a continuous loss of fluids, which must be replaced by sufficient water intake. If fluids and salts lost through sweat are not replenished, dehydration can occur. Workers in hot climates need to be encouraged to drink water regularly, not just when they feel thirsty (Berry et al., 2011). Dehydration in workers can reduce physical and cognitive performance and lead to illnesses that decrease work productivity. Furthermore, dehydration can disrupt the body's thermoregulation, causing thirst, dry mouth, drowsiness, reduced concentration, headaches, tingling sensations, and even fainting (Suprabaningrum & Dieny, 2017). The effects of dehydration can lead to acute conditions such as heatstroke and increase the risk of kidney stones, chronic kidney failure, urinary tract infections, cardiovascular diseases, and metabolic disorders. Even mild dehydration can affect cognitive function and mood (Nakamura, et al., 2020).

In addition to nutritional status and water consumption, Ministerial Regulation No. 12/2008 states that workload refers to the amount of work that must be handled by a position or organizational unit, which is the product of work volume and time norms. If a worker's ability is higher than the job demands, boredom may arise. Conversely, if the worker's ability is lower than job demands, excessive fatigue may occur. Workload can be categorized into three conditions: standard workload, overcapacity, and undercapacity. From an ergonomic perspective, physical workload must match the worker's physical and cognitive capacity, considering the worker's endurance limits (Tarwaka, 2016). Physical workload can be influenced by external factors (stressors) and internal factors (strain). Therefore, the severity of a worker's physical workload should also be assessed based on the work environment. The energy and calories needed will increase if the physical workload becomes heavier. Measuring the heart rate during work for one minute can be used to determine physical workload, as this method is a good and easy estimation of the metabolic rate (Anggraini, 2022).

One of the industries with a hot working environment is the tofu-making industry. Tofu production is one of the small and medium-sized enterprises that may have a hot working environment. The production process, which requires fire as a cooking medium, can create a hot working climate. The tofu-making process involves five stages: grinding, cooking, filtering, solidifying, and molding. In the tofu production process, the use of fire is quite extensive, primarily to support the cooking of ground soybeans, which requires a large cooking vessel. The large-scale use of firewood is one factor contributing to the large flames. Although the use of fire is only necessary during the cooking of ground soybeans, the heat from the working environment can be felt throughout the production area. Tofu workers, especially in the informal industry, often face multiple physical workloads and work durations exceeding eight hours. The hot working environment adds to the physical strain, leading many workers in the industry to complain about excessive heat, sweating, and thirst. Measurements of heat stress in tofu production facilities were conducted in two places, both of which exceeded the threshold limit value (TLV) of 31.3°C and 30.8°C. According to the Ministerial Regulation on Occupational Safety and Health No. PER.13/MEN/X/2011, the TLV for physical and chemical factors in the workplace is no more than 28°C. If workers are exposed to a hot working environment exceeding the permitted TLV, it can lead to work-related illnesses such as heat strain. If heat strain is not managed promptly, it can result in

heat-related illnesses like heat cramps, heat exhaustion, heat stroke, and miliaria (Suma'mur & Soedirman, 2014). Based on the above background, the purpose of this study is to identify the factors associated with heat strain complaints among tofu factory workers in Kekalik Barat.

METHOD

This research is a quantitative study using a cross-sectional approach aimed at examining the relationship between workload, nutritional status, and water consumption with the incidence of heat strain among tofu factory workers in Kekalik Barat Village in 2023. The design of this study is cross-sectional, meaning that there is no division between the two groups to be studied. Cross-sectional research is a type of study that focuses on measuring or observing the independent and dependent variables only once during the research. In this type of study, the dependent and independent variables are assessed simultaneously at one point in time, with no follow-up. The research sample consists of tofu factory workers in Kekalik Barat Village. The sample size is determined by the total population of 80 workers, with a sample size of 44 people, using the simple random sampling technique. The information sources in this study are obtained from primary data, including observations, examinations, or observations with questionnaires through interviews and direct examination. The research instruments include the HSSI questionnaire sheet to measure the level of heat strain, water consumption, scales and stadiometers to measure the nutritional status of workers, and a stopwatch used to measure pulse rates, which reflects workload. Data analysis is conducted using SPSS, with bivariate analysis performed using the Spearman Rank test.

RESULTS AND DISCUSSION

Univariate Variable

Based on the research conducted on 44 tofu factory workers in Kekalik Barat Village, the distribution of water consumption results is presented in Table 1.

TABLE 1. Distribution of Drinking Water Consumption

No	Drinking water consumption	Frequency	Percentage (%)
1	Not enough	19	43.2
2	Currently	16	36.4
3	Enough	9	20.5
	Total	44	100

In table 1. It is known that the majority of respondents (43%) consumed less drinking water, 19 respondents. Drinking water is an important body cooling element in hot environments, especially for workers who are exposed to high heat so they sweat a lot. To replace lost fluids, the need for water and salt needs attention. In hot work environments, ≥2.8 liters/day is required, while for work with non-hot environmental temperatures, it is recommended that at least 1.9 liters/day of water be required (Sari, 2017). This water should be given in small quantities but more frequently, namely 2 drinks every hour, with an interval of 20-30 minutes, with the optimum temperature of the water being 10℃-21℃ (Sari, 2017).

Table 2. Distribution of Nutritional Status

No	Nutritional status	Frequency	Percentage (%)

1	Not enough	15	34.1
2	Currently	20	45.5
3	Enough	9	20.5
	Total	44	100

In table 2, it can be seen that the majority of respondents had adequate nutritional status, namely 20 respondents (45.5%). The existence of occupational nutrition is important because nutritional status will represent the physical quality and immunity of workers, as a component of building blocks and energy input when the body feels tired from work, and can increase motivation or enthusiasm for work which will determine work productivity. The nutritional problems of workers, especially in Indonesia, are quite complex, including poor eating patterns (such as skipping breakfast), the lack of a special dining room for workers, the provision of food incentives in the form of money and the unclear division between rest time and work time (Ramadhanti , 2020).

Table 3. Distribusi Beban Kerja

No	Workload	Frequency	Percentage (%)
1	Light	8	18.2
2	Currently	18	40.9
3	Heavy	12	27.3
4	Very heavy	6	13.6
5	Total	44	100

In table 3, it can be seen that the majority of respondents had a sufficient workload, namely 18 respondents (40.9%). The greater the workload will affect the energy possessed by workers. The more energy expended to meet the predetermined workload, the more it affects the heat produced and received by the worker's body, this will increase the factor of heat strain in workers.

Table 4. Heat strain distribution

No.	Heat Starin	Frequency	Percent
1	Light	7	15.9
2	Currently	19	43.2
3	Heavy	18	40.9
	Total	44	100.0

In table 3, it can be seen that the majority of respondents who were exposed to moderate heatstrain were 19 people, namely (43.3%). The incidence of heat strain in the workplace is due to the room temperature in tofu making being around 31.3°C exceeding the NAB. Heat strain is the overall physiological response resulting from heat stress which is dedicated or aimed at removing heat from the body (OHSA, 1997).

Variabel Bivariat

Based on the research results (Table 5), it can be seen in the table that the majority of workers who do not consume enough drinking water are 16 people and experience heat strain, with a value of (p-value=0.000). The results show that there is a relationship between drinking water consumption and the incidence of heat strain in tofu making in Kekalik Barat sub-district. According to (Suma'mur, 2009) working in hot places must pay special attention to the need for water and salt as a substitute for liquids for evaporation. For workers in hot environments,

these workers are at risk of losing excess body fluids. If fluids lost in the body are not replaced, dehydration will occur, resulting in an increase in core body temperature, this can cause heat strain. This is in line with the results of this research, there is a relationship between drinking water consumption and the incidence of heat strain in tofu making workers in Kekalik Barat sub-district because when working the workers consume less drinking water even though the drinking water is not far from where they work. Workers usually only drink during breaks, namely after 5-8 hours of work and the majority of workers drink only 1-2 glasses of water.

Table 5. Distribution of drinking water consumption by the incidence of heat strain

No	Variable	*Heat strain*						Amount		*P*
	Drinking Water Consumption	Light		Currently		Heavy				
		N	%	N	%	N	%	N	%	
1	Not enough	1	2,3	2	4,5	16	36,4	19	4,3	
2	Currently	0	0	14	31,8	2	4,5	16	36,4	0,000
3	Enough	6	13,6	3	6,8	0	0	9	20,5	
	Total	7	15,9	19	42,3	18	40,9	44	100	

This research is also in line with research (Saputra & Subakir, 2022) where there is a relationship between drinking water consumption (p=0.000) and complaints of heat strain from tofu factory workers in Jelutung sub-district in 2022. He said that during the process of boiling the tofu raw materials, the environmental temperature experienced Increased, hot environmental temperatures caused respondents to sweat but this was not followed by consuming enough drinking water, so that tofu making workers became dehydrated and experienced heat strain. Drinking water is an important body cooling element in hot environments, especially for workers who are exposed to high heat so they sweat a lot. As a replacement for lost fluids, the need for water and salt needs to be given attention. In hot work environments, ≥ 2.8 liters/day is required, while for work with non-hot environmental temperatures, the recommended water requirement is at least 1.9 liters/day (Sari , 2017).

Table 6. Distribution of nutritional status with the incidence of heat strain

No	Variabel	*Heat strain*						Amount		*P*
	Nutritional status	Light		Currently		Heavy				
		N	%	N	%	N	%	N	%	
1	Not enough	2	4.5	4	9.1	9	20.5	15	34,1	
2	Currently	3	6.8	10	22,7	7	15.9	20	45.5	
3	Enough	2	4.5	5	11,4	2	4.5	9	20.5	0,113
	Total	**Total**	15,9	19	43,2	18	40,9	44	100	

Based on the table above, we can see the distribution of nutritional status of tofu making workers, most of the respondents had adequate nutritional status, namely 10 respondents (22.7%) who experienced moderate heat strain, with a value of (p-value=0.113). Which means there is no relationship between nutritional status and the occurrence of heat strain in tofu making workers in the West Kekalik village. (Nawawinetu, 2010) said that workers who are obese with thick fat, the ratio between body surface area and body weight is relatively low and this results in obstacles in regulating body temperature so that the risk of heat stress will occur in workers who work in a dangerous environment. hot. Based on existing theory, it can be concluded that someone who is overweight will find it easier to produce heat so they are more at risk of experiencing heat strain. However, the results of this research are not in line with existing theory. This could be due to the uneven distribution of the nutritional status of respondents in the research sample. If we look at the distribution of respondents who have

obese nutritional status, there are 9 people, there are 20 people who have adequate nutritional status and 15 people who have poor nutritional status.

This research is in line with research (Puspita 2017), showing that there is no relationship between body mass index and subjective complaints because the majority of respondents have a normal body mass index so that the body mass index is disproportionate in the research sample which causes fewer subjective complaints to be found in BMI workers. compared to normal BMI. The heat strain experienced by the respondent was caused by the respondent receiving exposure to excessive heat stress so that with the heat stress received, the respondent would still experience heat strain even though the respondent had normal or excessive nutritional status.

Table 6. Distribution of workload with heat strain incidence

No	Variable	*Heat strain*						Amount		*P*
	Workload	Light		Currently		Heavy				
		N	%	N	%	N	%	N	%	
1	Ringan	5	11,4	3	6,8	0	0	8	18,2	0,000
2	Sedang	0	0	14	31,8	4	9,1	18	40,9	
3	Berat	2	4,5	2	4,5	8	18,2	12	27,3	
4	Sangat Berat	0	0	0	0	6	13,6	6	13,6	
	Total	7	15,9	19	43,2	18	40,9	44	100	

From the research results, it can be seen that the workload and the incidence of heat strain in tofu making workers, the majority of respondents have a moderate workload, namely 14 (31.8%) with a value (p-value = 0.000), which means there is a relationship between workload and the incidence of heat strain in tofu making workers in West Kekalik sub-district. According to the Indonesian Ministry of Health (2003), workload is the burden received by workers to complete their work, such as lifting, running and so on. Every job is a burden for the doer. These burdens can be physical, mental or social. However, in the work of making tofu, the workload that is widely accepted is physical workload, this is because most of the work of making tofu, namely milling, cooking, filtering, hardening and molding, still requires the help of workers or does not fully use tools.

This research is in line with research conducted by Kalpika (2010) on the workshop unit, the results of this research showed that the value of $p = 0.013$ ($p<0.05$) for pulse rate during work can calculate the workload of workers in the workshop unit which is related to the incidence of heat strains. The results of measuring the workload using heat pressure have an influence on workers in the workshop unit.

From the results of this research, if you look at the table, there are 6 people with very heavy workloads who experienced heat strain. From the results of interviews on the Heat Star questionnaire, the complaints felt by tofu making workers were feeling tired quickly, dizzy, dry mouth and muscle cramps. So they often take breaks during working hours. Or just work once making tofu. (Nofianti and Koesyanto, 2019). Symptoms that can occur in someone who is in a hot working climate are an increase in pulse rate, body temperature and respiratory frequency, sweating, headaches, weakness, muscle cramps, and decreased consciousness if it is severe. Flouris, et al (2018) found that the prevalence of workers experiencing heat strain due to work was 35% and as many as 30% of workers lost productivity. Apart from that, it is also said that workers who work in hot work climates are four times more likely to experience heat strain due to work during or at the end of a work shift compared to workers who work in thermoneutral conditions.

CONCLUSION

There is a relationship between drinking water consumption and workload on the incidence of heat strain in tofu making workers in West Keakalik Village.

RECOMMENDATIONS

From the results of this research, it can be suggested that tofu production owners in Kelalik Barat Subdistrict are expected to have workers consume >11 glasses of drinking water and wear clothes that can reflect heat, such as wearing thin clothes, wearing loose shirts that absorb sweat easily, alternating work shifts to reduce the workload of workers. not too heavy so workers do not experience heat strain

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