



FACTORS RELATED TO HEAT STRAIN IN TOUGH-MAKING INDUSTRIAL WORKERS

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ABSTRACT

Tofu manufacturing industry workers are a group that is vulnerable to heat strain due to exposure to high heat during work. Heat strains can cause serious health problems such as heat stroke, heat exhaustion, and heat cramps. Objective: This research aims to analyze factors related to heat strain in tofu making industry workers in South Kotabumi District, North Lampung Regency in 2024. Method: This study used a cross-sectional design. The population is all workers in the tofu making industry in South Kotabumi District, North Lampung Regency. Samples were taken using a total sampling technique, namely 30 workers. Data was collected through interviews, measurements and observations. Data analysis was carried out univariately, bivariately using the Chi-square test, and multivariately using the logistic regression test. Results: The results showed that the factors associated with heat strain in tofu making industry workers were heat stress ($P = 0.001$), age ($P = 0.003$), gender ($P = 0.007$), and obesity ($P = 0.012$). Conclusions : Work environment heat stress, age, gender, and obesity are factors associated with heat strain in tofu making industry workers. Efforts to control heat strain need to be made, especially through improving the work climate and weight loss programs for obese workers.

Keywords: age; heat strain; heat stress; tofu making industry workers

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INTRODUCTION

Work productivity can be achieved when workers feel comfortable with the work environment. Working climate or air temperature is one of the factors that can influence working environmental conditions. Keeping the working environment safe and comfortable from physical, chemical, biological, ergonomic and psychological risk factors is one strategy to protect workers in the workplace. Workplaces that have a risk of dangerous sources of heat stress need to measure and control the work climate, in accordance with Minister of Manpower Regulation Number 5 of 2018 concerning occupational health and safety in the workplace (Indonesian Minister of Manpower Regulation No5/2018) .According to OSHS (1997) Heat Strain is an acute or chronic impact resulting from exposure to heat stress experienced by a person from physical or mental aspects. What can happen to someone who is in a hot working climate is an increase in pulse rate, body temperature and respiratory rate, sweating, headaches, weakness, muscle cramps and decreased consciousness if it is severe. These physical responses can become more severe if they are supported by other factors such as age, physical condition, level of acclimatization, and dehydration of the worker. This can then cause several illnesses or complaints related to heat, such as heat cramps, heat exhaustion , or heat stroke (National Safety Council, 2002).

Workers who are exposed to heat in the work environment will experience heat strain . Heat strain is a response to both external and internal heat loads experienced by a person, where the body tries to dissipate heat into the environment to maintain stable body temperature (Li et al., 2022) .According to the Occupational Safety and Health Administration (OSHA), heat stress in a work area is influenced by the weather in the work environment, metabolic heat produced from workers' physical activity and is influenced by worker characteristics such as age, length of service, body mass index, and acclimatization (OSHA, 2017) Most people feel comfortable working at air temperatures around 20oC and 27oC. If the temperature is higher, people will feel uncomfortable, this situation does not cause harm as long as the body can adapt to the heat that occurs. A very hot environment can disrupt the body's adaptation mechanisms and lead to serious and even fatal conditions (Jacklitsch et al., 2016) .According to (International Labor Organization, nd) , almost all workers experience work-related health problems, work accidents, or work-related deaths. Approximately 2.4 million workers (86.3%) experienced health problems, and 380,000 workers (13.7%) experienced heat strain .

Apart from that, from a meta-analysis conducted by (Flouris et al., 2018) it is known that 35% of workers experience occupational heat strain , 30% of workers lose productivity, and 15% of workers experience kidney disease or acute kidney injury. Workers who work at temperatures above 22 ° C or 24.8 ° C are 4.01 times more likely to experience occupational heat strain compared to workers in thermoneutral conditions . According to (Nofianti & Koesyanto, 2019) , Workers who work in hot climates , such as in smelters, ovens, boilers, heating furnaces or outdoors in the hot sun are at risk of being exposed to heat stress which can cause heat strain . J ournal " Workers ' health and productivity under occupational heat strain: a systematic review and meta-analysis," states that heat strain is the physiological effect of environmental heat stress on the human body. Heat strain can occur when a person is exposed to high environmental temperatures or works in extreme hot conditions. Heat strain can cause an increase in core body temperature, changes in urine specific gravity, and can increase the risk of health problems such as kidney disease or acute kidney injury. Apart from that, heat strain can also have a negative impact on work productivity. Therefore, the journal emphasizes the need for serious international action to reduce the impact of heat strain , especially in the context of climate change and the anticipated increase in heat stress (Hartono, 2019) .

Data from the United States Central of Disease Control (CDC) In 2010, there were 4,190 cases of injury or illness due to exposure to environmental heat among private sector and state and local government workers that resulted in one or more days of work lost (CDC, 2020) . The complaints regarding heat strain that were most frequently indicated in research conducted on workers in Thailand who work in hot work climates were excessive sweating (70.71%), red rash (54.55%), and fatigue (52.02%) (Meesaard & Nathapindhu, 2022) , Based on data from the United States CDC (CDC, 2020) and research in Thailand, heat strain is a serious health problem for workers who are exposed to hot work environments. Therefore, further research needs to be carried out to determine the factors associated with heat strain in certain worker populations. The incidence of heat strain in Indonesia can be seen from several related studies that have been carried out. Research (Amir, Ikhrum Hardi S, & Sididi, 2021) shows that 67.5% of workers experience heat strain . There is a relationship between heat stress, age, nutritional status, and water consumption and the occurrence of heat strain . Research (Zulhanda et al., 2021) on tofu making workers in the Cambodian region of Palembang City shows that workers who experience heat strain are dominated by workers who are exposed to a hot working climate of >34.9 ° C (84.6%) .

The results of research (Saputra, 2022) conducted at a tofu factory in the Jelantung sub-district, Jambi City, also obtained results that 66.7% of respondents experienced complaints of severe heat strain, the average heat stress in the respondents' working environment was 29.6 ° C, as many as 56.7% of respondents do not consume enough drinking water, 10.0% of respondents have a BMI in the obesity category, this is because one of the tofu production processes is cooking using a heat source from firewood so that the working environment temperature is high/hot. In research conducted by (Ninike Apriyana, 2021) at a cracker factory located in South Lampung, the ISBB measurement results in the frying, oven and processing sections obtained an average value of 33.5 ° C (>NAB), while the ISBB measurement results in the packaging section, a value of 27.9 ° C (<NAB) was obtained. The results of measuring the working environment temperature with the hydration status of workers in the production section with a temperature >NAB, there were 30 workers (75.0%) who experienced dehydration and 10 workers (25.0%) did not experience dehydration. Meanwhile, among workers in the production section with temperatures < NAB, there were 6 workers (37.5%) who experienced dehydration and 10 workers (62.5%) who did not experience dehydration.

The cause of Heat Strain in a person is a response to heat stress received from environmental heat and heat produced by the body's metabolism. According to NIOSH (1986) heat stress in a work area is influenced by the weather in the work environment, metabolic heat produced from workers' physical activities and is influenced by worker characteristics such as age, length of service, body mass index, and acclimatization. The wet and spherical temperature index (ISBB) is a measure calculated using dry air temperature, natural wet temperature, and spherical temperature to determine the degree of hot working climate. According to (Regional Minister of Manpower Regulation No. 5/2018) regarding working environment temperature, a standard of average time received by workers during daily work within a certain period is set, namely no more than 8 hours per day or 40 hours per week, without becoming sick or injury (Indonesian Minister of Manpower Regulation No5/2018). One of the processing industries that is growing in Bandar Lampung City is the tofu and tempeh UKM, based on data obtained from the Indonesian Tofu Tempe Producer Cooperative Primer in Bandar Lampung City in 2016, there were 238 tofu and tempeh craftsmen in Bandar Lampung City. (Pentiana & Wijaya, 2018). Food processing that requires heat energy for a long time is the tofu processing industry. The tofu production process requires a heat source that comes from fire as a medium for cooking. The greater the production level, the greater the scale of fire use and this will cause the work environment to become hotter. The environmental temperature will get hotter if the work space does not have a good ventilation system and circulation management (Saputra et al., 2022).

Based on the description above, research will be carried out at a tofu factory in Kotabumi Selatan District, North Lampung Regency, Indonesia. This is different from several previous studies conducted in other places such as Thailand and other regions in Indonesia. The focus of this research is on workers in the tofu making industry, where there has not been much previous research examining this group of workers. Apart from work environmental factors (heat stress), this research also examines other factors such as age, length of service, body mass index, and acclimatization which can influence heat strain in workers. Not much research has focused on tofu-making industry workers in Indonesia, especially in South Kotabumi District, North Lampung Regency. It is hoped that this research will provide useful information for improving the working environment and preventing heat strain for tofu making industry workers at this location. survey was conducted on March 28 2024 in one of the tofu making industries in South Kotabumi District, North Lampung Regency through

interviews with workers during work time. Workers felt hot when they were at work which caused them to sweat excessively and itch. This is because the high temperature in the work environment comes from the production site, namely boiling and processing, workers can produce as much as 100 kg in a day. The work system carried out by the workforce starts at 08.00-17.00 with a 1 hour break, namely 12.00-13.00. Based on the results of observations in the field, the lack of air ventilation resulted in the temperature in the room being quite hot and the roof being made of zinc which resulted in heat being reflected by the sun.

In the tofu making industry in South Kotabumi, North Lampung , research has never been conducted on factors related to heat strain . South Kotabumi District was chosen as the research location because it is an area with the presence of a tofu making industry. By conducting research in relevant locations, the research results will be more directly applicable in the industrial context. The availability of data and information related to the tofu making industry in South Kotabumi District can facilitate the research process, including collecting primary and secondary data. This can strengthen the validity and usefulness of research results. research aims to analyze factors related to heat strain in tofu making industry workers in South Kotabumi District, North Lampung Regency in 2024

METHOD

Quantitative research using a cross sectional approach was carried out on 24 May – 20 June 2024 at the Tofu Making Factory in South Kotabumi District, North Lampung Regency. The population and sample in this study are all tofu factory workers in Kotabumi Selatan subdistrict, North Lampung district, namely 30 workers consisting of kneading, frying, boiling and molding using total sampling using a questionnaire sheet which has been tested for validity and reliability. Based on the results of the validity test, the Heat Strain Variables, Heat Pressure, Age, Obesity, Drugs, and Chronic Diseases have a r-count value greater than the r-table (0.3882), so it can be concluded that all the statements in these variables are valid. Meanwhile, the Variables of Heat Pressure, Age, Obesity, Medications, and Chronic Diseases have Cronbach's Alpha coefficients of 0.753, 1,000, 1,000, 1,000, and 1,000 which means very high reliability. Showing that all variables in this study has a good level of reliability. Data analysis using univariate and bivariate analysis (chi-square).

RESULTS

Table 1.
Frequency Distribution Based on Heat Strain, Heat Stress, Age, Obesity, Medication, Chronic Disease

Variable	Category	f	%
Heat Strain	Yes	23	76.60
	No	7	23.40
Heat stress	Yes	20	66.70
	No	10	33.30
Age	≥30	11	36.70
	≤ 30	19	63.30
Obesity	Obesity(≥)	10	33.30
	Not obese (≤)	20	66.70
Drugs	Yes	10	33.30
	No	20	66.70
Chronic Disease	Yes	13	43.30
	No	17	56.70

Based on table 1, the results show that 23 workers experienced heat strain and the remaining 7 did not experience *heat strain*. There were 20 workers who experienced heat stress and the remaining 10 did not feel heat stress. There are 11 workers aged more than 30 years and the number of workers aged less than or equal to 30 years is 19 people. There are 10 workers who are obese with a BMI above 25. Meanwhile, the number of workers who are not obese with a BMI below or equal to 25 is 20 people. There were 10 workers who took antidepressant medication. Meanwhile, the number of workers who do not take antidepressant medication is 20 people. There were 13 workers who had a history of chronic disease. Meanwhile, the number of workers who do not have a history of chronic disease is 17 people.

Table 2 .
The Relationship between *Heat Strain* and Heat Stress

Variable	Category	<i>Heat Strain</i>		<i>P value</i>	<i>Odds Ratio</i>	<i>95%CI</i>
		Yes	No			
Heat stress	No	5	5	0.015	9,000	1,325-61,138
	Yes	2	18			

Based on table 2, it can be concluded that there are 5 workers who work without heat stress and experience *heat strain*, and there are 2 workers who work with heat stress and experience heat strain. Based on the results of the output table, the Asymp.Sig(2-sided) value for the *Pearson Chi-Square test* is 0.015, which is smaller than the significance value of 0.05. Therefore, it can be concluded that there is a significant relationship between heat stress and *heat strain* . *The odds ratio (OR)* value in the table above is 9,000 (95% CI 1,325-61,138) meaning that heat stress while working is 9,000 times more risky for experiencing heat strain.

Table 3.
Heat Strain Relationship with Age

Variable	Category	<i>Heat Strain</i>		<i>P value</i>	<i>Odds Ratio</i>	<i>95%CI</i>
		Yes	No			
Age	≤ 30	19	7	0,000	6,333	1,001-40,071
	≥ 30	4	0			
Total		23	7			

From the table above it can be concluded that there were 19 workers aged ≤ 30 who experienced *heat strain* and 4 workers aged > 30 who experienced heat strain. From the results of the output table, the Asymp.Sig(2-sided) value for the *Pearson Chi-Square test* is 0.000, which is smaller than the significance value of 0.05. Therefore, it can be concluded that there is a significant relationship between age and heat strain. *The odds ratio (OR)* value in the table above is 6.333, meaning that a person aged less than 30 years will tend to experience 6.3 times more *heat strain*.

Table 4.
Relationship between *Heat Strain* and Obesity

Variable	Category	<i>Heat Strain</i>		<i>P - value</i>	<i>Odd Ratio</i>	<i>95%CI</i>
		Yes	No			
Obesity	Yes	4	6	0.001	28,500	2,649-306,638
	No	19	1			
Total		23	7			

From the table above, it can be concluded that there are 4 workers who are obese and experience *heat strain* and 19 workers who are not obese and experience *heat strain* . From the output table, it is known that the Asymp.Sig(2-sided) value for the *Pearson Chi-Square test* is 0.001, smaller than the significance value of 0.05. Therefore, it can be concluded that there is a significant relationship between obesity and heat strain. *The odds ratio (OR)* value

in the table above is 28.5 00 (95% CI 2,649-306,638) meaning that someone who is obese will tend to experience heat strain 28.5 00 times more than someone who is not obese.

Table 5.
Relationship between *Heat Strain* and Drugs

Variable	Category	<i>Heat Strain</i>		<i>P value</i>	<i>Odds Ratio</i>	<i>95%CI</i>
		Yes	No			
Drugs	Yes	4	6	0.001	28,500	2,649-306,638
	No	19	1			
Total		23	7			

From the table above it can be concluded that there were 4 workers who took medication during the study and experienced *heat strain* , and there were 19 workers who did not consume medication and experienced *heat strain* . From the results of the output table, it is known that the *Asymp.Sig(2-sided)* value for the *Pearson Chi-Square test* is 0.001, which is smaller than the significance value of 0.05. Therefore, it can be concluded that there is a significant relationship between chronic disease and *heat strain* . *The odds ratio (OR)* value in the table above is 28.5 00 (95% CI 2,649-306,638) meaning that someone who takes antidepressant medication tends to experience heat strain.

Table 6.
Relationship between *Heat Strain* and Chronic Disease

Variable	Category	<i>Heat Strain</i>		<i>P value</i>	<i>Odd Ratio</i>	<i>95%CI</i>
		Yes	No			
Chronic Disease	Yes	6	7	0.001	3,778	,648-22,017
	No	17	0			
Total		23	7			

From the table above it can be concluded that there are 6 workers who have chronic diseases and experience heat strain, and there are 17 workers who do not have chronic diseases and experience heat strain. From the results of the output table, it is known that the *Asymp.Sig(2-sided)* value for the *Pearson Chi-Square test* is 0.001, which is smaller than the significance value of 0.05. Therefore, it can be concluded that there is a significant relationship between chronic disease and *heat strain* . *The odds ratio (OR)* value in the table above is 3.778 (95% CI .648-22.017) meaning that someone who has a history of chronic disease will tend to experience heat strain 3.778 times more than someone who does not have a history of chronic disease.

DISCUSSION

Heat Strain

Heat strain is a condition that results from exposure to heat stress and can be chronic. Symptoms include muscle cramps, faster breathing rate, rapid pulse, fatigue, increased body temperature, excessive sweating, and decreased consciousness (OSH, 2016) . Factors that influence the emergence of heat strain are work environment factors (heat stress, workload, working hours) and individual characteristic factors (age, obesity, history of chronic disease, and use of medication). According to Jacklitsch et al., (2016) , increasing a person's age and obesity can enable a person to suffer from heat strain , because the activity of the sweat glands tends to decrease which can inhibit the sweat production process and if a person is obese, the layer of fat can inhibit the transfer of heat from inside the body to the body. outside the body. Then Kenny et al. (2010) , emphasized that diabetes mellitus and hypertension can increase the risk of heat strain . However, this study did not find a direct relationship between heat stress, increasing age, obesity, and drug use with the incidence of heat strain. Apart from age, obesity, history of chronic diseases, and use of drugs, work and environmental factors (heat

stress, workload, and working hours) can also cause heat strain . According to Gagnon & Kenny (2011) , the length of working hours affects the ability of a person's body's thermoregulation system. Apart from that, OSH (2016) also explains that a person can experience heat strain because they continue to experience heat stress. However, the results of this study show that there is no significant relationship between heat stress, working hours, and workload with the high incidence of heat strain in workers.

Heat strain measurements are carried out by monitoring the air temperature and heat radiation sources of workers while they work. An increase in these two parameters indicates the presence of heat strain. Evaluation of heat strain in workers is very important because it can cause serious health problems. According to (OSH, 2016) , the effects of heat strain can vary from mild symptoms to cause death, mild symptoms such as rashes on the skin and fainting, to life-threatening conditions such as cessation of sweat production and heat stroke. This research was conducted on workers in the tofu making industry in Kotabumi Selatan District, North Lampung Regency. The results of measuring heat strain using a questionnaire showed that 23 out of 30 workers experienced heat strain. This shows that the incidence of heat strain in the tofu making industry is quite high. The research findings regarding heat strains need to be studied further by related parties in order to improve worker safety and prevent heat strains , especially in the informal sector such as workers in the tofu making industry. According to the Bureau of Labor Statistics (BLS), in the period 1999-2003 there were more than 15,000 cases of heat strain in workers and 200 deaths caused by heat strain. The federal and California Occupational Safety and Health Administrations (OSHA) have also designated heat strain as a top priority in the past three years. Jacklitsch et al., (2016) noted that in the United States in 1979, it was estimated that there were around 1,432 cases of heat strain incidents which caused the loss of at least one day of work.

Heat strain can have an impact on reducing work productivity. According to Poulton (1970) , an increase in environmental temperature can cause a decrease in worker productivity. If worker productivity decreases, apart from being detrimental to workers, it will also reduce company productivity due to a decrease in worker performance. Then furthermore, the occurrence of heat strain in the long term will cause sweat production to stop and can lead to death. According to the Bureau of Labor Statistics (2009), the estimated cost of heat strain is \$7,500 per incident, as well as \$150 in average lost wages per day. This figure is only for acute heat strain cases and does not include cases that result in death (Brown, 2013) .This is in line with research (Amir, 2021) Heat strain is an acute or chronic impact caused by exposure to heat stress experienced by a person from both physical and mental aspects. This study aims to determine the factors related to the incidence of heat strain in production division workers at PT. Indonesia Ship Industry (Persero) Makassar City. The type of research used is quantitative observational analytical method with a cross sectional study design. The research population was 104 workers, the research sample was 77 workers who were taken by simple random sampling from workers in the production department of PT. Indonesia Ship Industry (Persero) Makassar City.

The method of data collection is to conduct observations, interviews and documentation using heat stress monitors, questionnaires, stationery and cameras. The data analysis technique used the Chi-square correlation test in the SPSS program with a confidence level of 95% ($\alpha= 0.05$). There was a relationship between heat stress and heat strain ($p= 0.015$), there was a relationship between age and heat strain ($p= 0.044$), there was no relationship between disease history and heat strain ($p= 0.426$), there was a relationship between nutritional status and heat

strain ($p= 0.001$) and there was a relationship between drinking water consumption and heat strain ($p= 0.008$) in PT. Indonesia Ship Industry (Persero) Makassar City. The conclusion of this study is that there is a relationship between heat pressure with Heat Strain ($p= 0.015$), Age with Heat Strain ($p= 0.044$), nutritional status with Heat Strain value ($p= 0.001$) and drinking water consumption with Heat Strain ($p= 0.008$).

The Relationship between Heat Stress and Heat Strain

Environmental factors such as heat stress are one of the main factors that cause heat strain . Heat stress refers to workers who are continuously exposed to heat from the work environment plus heat generated from the worker's body metabolism. Heat stress can also increase due to heavy workloads, thereby affecting the body's metabolism (Ramsey, 1994) . OSH (2016) says that heat stress that occurs due to exposure to heat from the environment can result in heat strain. Then according to Jacklitsch et al., (2016) heat stress occurs due to a combination of the heat of the workplace and the heat produced by the body's metabolism. Jacklitsch et al. (2016) , explains that an increase in metabolic heat will increase the amount of heat in the body, which in turn requires the release of more heat into the surrounding environment. If the body is unable to get rid of this heat, body temperature will rise, increasing the risk of exposure to heat stress. From the research results, it shows that 5 workers who worked at temperatures ≤ 28 experienced heat strain , and there were 2 workers who worked at temperatures > 28 experienced heat strain . The number of workers affected by heat stress is influenced by the level of workload, length of working time, and hot conditions in the workplace. According to Hunt (2011) , heat stress generally increases core body temperature, heart rate, and sweat production. The results of the bivariate analysis in this study show that the Asymp.Sig(2-sided) value for the Pearson Chi-Square test is 0.015, which is smaller than the significance value of 0.05. Therefore, it can be concluded that there is a significant relationship between heat stress and heat strain. These results are in line with the findings of Brown (2013) who confirmed that workers who are exposed to high heat stress have a higher risk of experiencing heat strain.

In this study, workers who received heat stress served in the frying and boiling section. They have to stand continuously while operating the stirrer and filter equipment to process the tofu. In this case, workers in the frying and boiling section are workers with heavy workloads. According to (Mcneely & Davis, 2011) when the workload increases, the heart has difficulty meeting the body's overall needs. As a result, the worker's heart rate increases and the worker's body temperature increases, while muscle capacity decreases. To reduce the risk of heat exhaustion in workers in the tofu manufacturing industry, workload control needs to be carried out. This can be done through adjusting working positions or using automation devices to reduce heat released by the body. Furthermore, it is known that workers in the tofu making industry in South Kotabumi District, North Lampung Regency work 8 hours per day. According to (Sawka, 2003) continuous exposure to heat can cause dehydration in the body because the body needs a lot of fluids and if this is not met, workers can become dehydrated. Apart from heavy workload levels, long working hours can also increase heat exposure. (Gagnon & Kenny, 2011) stated that the time workers spend at work can affect the body's ability to regulate temperature. An imbalance between working hours and rest time can disrupt the body's thermoregulation process, resulting in difficulty in maintaining body temperature when exposed to hot environments, and this increases heat stress.

Researchers argue that a work environment that continuously produces heat can cause workers to experience heat stress. In the tofu factory environment, heat is often caused by machines and fires used in the process of boiling tofu and frying tofu. When the boiling and

frying process takes place, workers feel the heat from the frying machine and the stove fire. They must be close to the heat source and also have a heavy workload. At this stage, the worker stands with both hands holding a stirrer and filter, around a large frying pan which is heated using fire. Exposure to heat can cause heat strain in workers, which can have serious consequences even death if not treated. Therefore, controlling heat exposure is very important to reduce the risk of heat strain in workers. Some technical steps that can be taken include installing adequate ventilation so that the temperature in the production area remains normal and not hot, or using barriers between heat sources and workers' work areas.

Relationship between Age and Heat Strain

According to research by Jacklitsch et al. (2016), heat strain can also occur due to aging. Aging causes sweat glands to become less responsive, thereby reducing the efficiency of body temperature regulation. WHO (1969) also noted that as age increases, the response of the sweat glands to changes in temperature becomes slower, resulting in less effective sweat production. Therefore, the older a person is, the higher the risk of experiencing heat strain. Research by (Kenney, 2001) found that as a person ages, the body's ability to tolerate heat tends to decrease, because there is a decrease in blood flow to the skin which plays a role in the process of releasing heat from the body into the environment, thus causing body temperature to rise more quickly and can heat strain occurs. The study by Näyhä et al. (2014) showed that heat strain often occurs in workers aged 75 years. Another study by Brown (2013) also confirmed the existence of a significant relationship between age and heat strain. In theory, increasing age can increase health complaints. Research by Soemarko shows a relationship between age and heat-related health effects, such as urine output. Important factors related to age that influence health complaints are a decrease in heart function and the efficiency of sweat production. Older people have a reduced and slower ability to pump blood by the heart than young people, so the body is slower to transfer heat from the core of the body to the skin. However, this research shows that the chance of experiencing complaints due to heat stress is the same for each age range. This means that the complaints that occur in respondents in each age range are not caused by age, but by other factors such as high room temperatures, long periods of work, or adjustments to newly formed bodies that make them susceptible to complaints due to heat stress.

In this study it was inversely proportional, there were 19 workers aged ≤ 30 who experienced heat strain and 4 workers aged > 30 who experienced heat strain. Then the results of the bivariate analysis in this study show that the Asymp.Sig(2-sided) value for the Pearson Chi-Square test is 0.000, which is smaller than the significance value of 0.05. Therefore, it can be concluded that there is a significant relationship between age and heat strain. This is because the young age group of workers aged ≤ 30 are more often exposed to heat than workers aged > 30 , many young workers work in frying and boiling departments, so they experience exposure to heat stress, which influences the incidence of heat strain. Although some theories suggest that the risk of heat stress increases with age, this research is in accordance with the view of Young & Lee (1997) which states that the level of body tolerance to heat in older age groups can be equivalent to younger age groups. The study conducted by Stapleton et al. (2014) also found similar things in two different age groups, namely an average age of 21 years and 65 years, there was no significant difference in body temperature between two different age groups in the same workplace situation. Another study conducted by Marszałek et al. (2004) also supported these findings, showing that there were no significant differences in heat stress among three different age groups (20–29 years, 41–55 years, and 58–65 years) exposed to similar levels.

Exposure to high heat stress in workers is also felt by both age groups so that heat strain incidents can occur in both age groups. Heat strain incident experienced by tofu manufacturing industry workers in South Kotabumi District, North Lampung Regency This is because many elderly workers who work in areas exposed to heat stress do not meet the requirements. Because many young workers work in frying and boiling departments, they experience exposure to heat stress, which affects the incidence of heat strain. Sources of heat exposure can come from fire heat and engine heat. In the tofu-making industry, machines such as wood-burning stoves, boiling machines, and fryers are the heat source. One solution to reduce heat exposure in the work environment is to increase ventilation. Apart from that, an elderly worker >30 years old can still work safely in a hot environment as long as he is allowed to work according to his ability. This means they must be able to rest when they start to experience health complaints. Rest time plays an important role in reducing subjective complaints due to heat stress. Researchers believe that worker age has a significant relationship with the incidence of heat strain. Older workers tend to be more susceptible to heat strain compared to younger workers. This is caused by a decrease in the body's physiological adaptability to heat exposure as we age. The body's thermoregulatory mechanisms, such as the ability to sweat and maintain body temperature, decrease in older workers. Prevention strategies that take age factors into account, such as scheduling job rotations or better managing rest periods, need to be considered to protect older workers.

The Relationship between Obesity and Heat Strain

Heat Strain can also be caused by someone who is obese. According to research results (Journal & Issn, 2021) obesity can cause various kinds of diseases and has a 6.6 times chance of experiencing disease when compared to respondents who are not obese. According to Donoghue et al. (2000) obese sufferers can be at risk of heat strain when working in places that are continuously exposed to heat. According to Anderson (1999) , the body's ability to dissipate heat is closely related to body weight. Then in research by Bar-Or et al. (1969) ; Another study by Selkirk & McLellan, (2001) showed that two groups with different body fat, namely 10.9% and 18.8%, carried out walking activities on a treadmill. The result was that the group with lower body fat was able to last longer on the treadmill. treadmill and had better body temperature stability, compared to the group with high body fat. Body structure plays an important role in rising body temperature. Individuals with greater body weight tend to experience a faster rise in body temperature, thereby increasing the risk of heat stress.

However, in this study the opposite was true, there were 4 workers who were obese and experienced heat strain and 19 workers who were not obese and experienced heat strain. From the output table, it is known that the Asymp.Sig(2-sided) value for the Pearson Chi-Square test is 0.001, smaller than the significance value of 0.05. Therefore, it can be concluded that there is a significant relationship between obesity and heat strain. This is because all workers who are obese also experience heat strain, while workers who are not obese are exposed to continuous heat stress which results in them experiencing heat strain too. Therefore, even though they are not obese, workers still experience heat strain due to exposure to the heat stress they receive during the boiling and frying process. Then, all members of the obese group were in work positions which involved boiling and frying processes which resulted in them being continuously exposed to heat and thus experiencing heat strain. This finding is in line with research by Mcnelly et al. (2011) who compared two groups, namely those with obese body weight and those with thin body weight. Even though both groups carried out the same activities, there were no differences in body temperature that would indicate heat strain. This is also in line with the results of Puspita's 2017 research showing that there is no relationship between body mass index and subjective complaints. This is because the majority

of respondents have a normal body mass index, so the distribution of body mass index in the research sample is not proportional. As a result, subjective complaints in workers with a body mass index are fewer than those with a normal body mass index.

Researchers believe that obesity nutritional status was also found to be a risk factor that increases the incidence of heat strain in tofu manufacturing industry workers. Excessive body fat tissue in obese workers can inhibit the process of releasing heat from the body, thereby increasing the risk of heat strain. Apart from that, obesity can also cause cardiovascular and respiratory problems which can worsen heat strain conditions. Promotive and preventive efforts related to weight control, such as nutritional education and weight loss programs, need to be carried out to protect workers with obesity nutritional status. .

Relationship between drug consumption and heat strain

Heat strain can occur because workers take drugs that interfere with the thermoregulation process, including antidepressant drugs which can affect heart rate and reduce sweat production. Antidepressant drugs can also reduce blood flow to the skin, inhibit the body's cooling process, and affect the availability of fluids in the body (Brown, 2013) . According to Jacklitsch et al. (2016) almost all drugs that affect the central nervous system can have an impact on a person's body's ability to receive heat. Therefore, individuals who use medications and work in hot environments have a higher risk of developing heat strain. In this study, there were 4 workers who took medication during the study and experienced heat strain, and there were 19 workers who did not consume medication and experienced heat strain. From the results of the output table, it is known that the Asymp.Sig(2-sided) value for the Pearson Chi-Square test is 0.001, which is smaller than the significance value of 0.05. Therefore, it can be concluded that there is a significant relationship between chronic disease and heat strain. However, data collection on drug use by workers in this study was only through interviews with workers, so there is the possibility of information bias. Therefore, it is recommended that future researchers conduct in-depth interviews with workers and their families or friends to confirm the use of drugs consumed by workers

Antidepressants and bronchodilators can interfere with thermoregulation by changing heart rate and inhibiting sweating. Medications for hypertension reduce blood flow to the skin and convective cooling. Antihistamines also reduce blood flow to the skin and increase basal body temperature (Brown, 2013). According to NIOSH (2016), drugs that affect the central nervous system can reduce tolerance to heat, so people who take drugs are at high risk of experiencing heat strain. Researchers argue that the use of certain drugs has also been found to be a factor that can increase the risk of heat strain. Some types of medications, such as diuretics, beta-blockers, and antidepressants, can interfere with the body's thermoregulatory mechanisms, thereby worsening the response to heat exposure. Identification and control of the use of medications that may interfere with thermoregulation through health screening and treatment management may be a useful effort to protect vulnerable workers.

Relationship of Chronic Illness to Heat Strain

Heat strain experienced by workers can also be triggered by heart disease, hypertension and diabetes (OSH, 2016). According to Brown (2013), individuals with diabetes are at high risk of experiencing heat strain because there is a disruption in their body's thermoregulation system. The study by Gardner et al. (1996) found that someone who has diabetes is more susceptible to heat strain. Other findings by Gangnon et al (2011) showed significant differences in the incidence of heat strain between a group of workers who had healthy bodies and a group of workers who had heart disease. The theory proposed by Kenny et al. (2010)

which states that diabetes has a negative impact on the body's metabolism and affects the body's thermoregulatory mechanisms when exposed to heat, the thermoregulatory system cannot effectively deal with increased body temperature, thus causing heat strain. Other research indicates that in people with diabetes mellitus, vasodilation occurs which results in a higher body temperature than in non-diabetes mellitus individuals (Jacklitsch et al., 2016). Apart from that, disturbances in sweat production also occur in diabetes mellitus sufferers due to disturbances in the body's glucose regulation. As a result, the heat that should be released through sweat evaporation is blocked, causing an increase in body temperature.

In this study, the opposite is true, namely that it shows that there are 6 workers who have chronic diseases and experience heat strain, and there are 17 workers who do not have chronic diseases and experience heat strain. The chronic disease experienced by workers is diabetes mellitus. Then it was discovered that the Asymp.Sig(2-sided) value for the Pearson Chi-Square test was 0.001, which was smaller than the significance value of 0.05. Therefore, it can be concluded that there is a significant relationship between chronic disease and heat strain. This is because data collection regarding chronic disease variables is only carried out through interviews, so there is the potential for information bias. It would be a good idea to carry out a simple check on data collection regarding chronic diseases such as diabetes and hypertension, to ensure that workers who actually suffer from chronic diseases but do not consult a doctor, can be identified.

As Flouris's research in 2018 showed that health conditions did not have a significant relationship with heat strain in cracker making workers in Giri Village, Banyuwangi Regency ($p=0.851$). However, health conditions such as hypertension, respiratory diseases, and skin diseases can cause heat strain. Hypertension, with elevation of peripheral resistance and changes in peripheral circulation, can impair blood flow to the skin and impair body temperature regulation. Hypertension sufferers experience greater heat strain during activities compared to those with normal blood pressure (Robinson et al, 2023). Chronic skin disease reduces the body's ability to sweat, while heart disease and a low-salt diet weaken heat loss. Other conditions that pose a risk for heat strain include diabetes mellitus, cystic fibrosis, and hyperthyroidism, which reduces the body's ability to adapt to changes in temperature. Diabetes mellitus interferes with the dilation of blood vessels to release heat, reducing the body's tolerance to hot temperatures (Dia et al, 2023). Researchers believe that the presence of chronic diseases suffered by workers has also been found to be a factor that can increase the risk of heat strain. Chronic disease conditions, such as diabetes, heart disease, and kidney disorders, can affect the body's ability to adapt to heat stress. Identification and control of these factors through health screening can be a useful measure to protect vulnerable workers.

CONCLUSION

The number of workers experiencing heat strain in the tofu making industry in South Kotabumi District, North Lampung Regency is 23 workers. There were 5 workers who worked at temperatures ≤ 28 experienced heat strains, and there were 2 workers who worked at temperatures > 28 experienced heat strains. There were 19 workers aged ≤ 30 years who experienced heat strain and 4 workers aged > 30 years who experienced heat strain. There were 4 workers who were obese and experienced heat strain and 19 workers who were not obese and experienced heat strain. There were 6 workers who had chronic illnesses and experienced heat strain, and there were 17 workers who did not have chronic illnesses and experienced heat strain. There were 4 workers who took medication during the study and experienced heat strain, and there were 19 workers who did not consume medication and experienced heat strain. There is a significant relationship between heat stress, age, obesity,

and chronic diseases, and drug consumption with heat strain in tofu making industry workers in South Kotabumi District, North Lampung Regency. It is hoped that controlling heat strain needs to be done, especially through improving the working climate and weight loss programs for obese workers

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