Heat Strains among Diesel Power Plant Operators and Related

by Iwan Muhamad Ramdan

Heat Strains among Diesel Power Plant Operators and Related Factors

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Abstract

Introduction: Research in occupational heat stress and heat strain in developing countries is limited because of several challenges and constraints.

Objectives: To describe the prevalence of heat strains of diesel power plant operators and analyze the related factors.

Method: Cross-sectional design has been carried out on the diesel power plant operators in the Indonesian state electricity company (N=35). The research variables consisted of heat strain, age, working period, nutritional status, hydration status and heat stress. Measuring instruments used consisted of a heat strain score index (HSSI), heat stress monitor, weight scale, microtoise, and questionnaire. Cramer's V test and odds ratio were applied to see an association between heat strain prevalence and related factors.

Results: 35.8% of diesel power plant operators experienced heat strain in the yellow zone/alarm category, 64.2% was included in the green zone/save category. The heat strain experienced by the operator was significantly related to age (p=0.000), years of service (p=0.000), hydration status (p=0.057) and heat stress (p=0.000).

Conclusion: The occurrence of heat strains began to show the alarm stage, this requires efforts to control heat pressure and others variables in order to prevent the heat strain does not get worse.

Keywords: *Heat stres, heat strain, age, working period, hydration status, nutrition status, diesel power plant operators.*

Introduction

Occupational heat strain (OHS) is an occupational health problem that requires the attention of researchers and practitioners of occupational health and safety because of its detrimental impact. Several studies have reported that OHS adversely affects workers' health, reduces workers performances, reduces worker productivity and even causes death.[1-4] OHS is defined as the body's physiological response to heat stress (e.g., sweating). Heat stress itself is the net heat load to which a worker may be exposed from the combined contributions of metabolic heat, environmental factors, and clothing requirements.[5]

Exposure to heat at work caused a variety of workers' health problems ranging from minor problems such as mild skin rash to the fatal condition of heatstroke. According to Srinivasan et al,[6] some of the acute health effects of excessive heat exposure include sweating,

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dehydration, salt loss, loss of perceptual and motor performance, heat exhaustion, loss of ability to work intensively due to heat exhaustion, increased accident risk, increased body temperature. Meanwhile, chronic health effects of excessive heat exposure include worse clinical status for people with common chronic diseases, kidney damage due to daily dehydration if lack of water access.

There are various risk factors associated with OHS, including personal risk factors such as heat acclimation as well as environmental factors and high metabolic rates,[7] acclimatization, water intake adequacy rate and body mass index,[8] heat exposure in the workplace,[9] air temperature & core body temperature,[10] lack of acclimitazation and volume depletion.[11] More complete, NIOSH details the factors that can affect OHS i.e environmental factors (high temperatures, direct sun exposure, lack of wind and proximity to engines ar other hot equipment), activities, no acclimatization, medications, dehydration, and others.[12] The prevalence of OHS is also related to the climatic conditions of a country, Kjellstorm et al[13] reported that workers in tropical and sub-tropical countries are very at high risk for experiencing heat strains

Research in OHS in developing countries is still lacking because of several challenges and constraints. Few challenges are a permission from industries to publish the data, resistance for change, and improper record of heat/any occupational disease, and paucity in a number of studies.[6] Indonesia is a developing country with a tropical climate.[14] In the context of early detection of heat strains experienced by workers, this study aims to analyze the prevalence of heat strains of diesel power plant operators in the Indonesian state electricity company, and analyze the factors that influence it.

Method

A cross-sectional study was conducted between September until October 2019 on all diesel power plant operators (total sampling) in the Indonesian state electricity company (N=35). Age and working periods were measured using a questionnaire. The OHS was measured by heat strain score index (HSSI),[15,16] and the score result of heat strain are categorized into 3 i.e <13.5=green zone/save; 13.5-18=yellow zone/alarm level; >18=red zone/danger level.

Work climate was measured using a heat stress monitor (Questemp-34 heat stress meter, USA) with a wet bulb globe thermometer (WBGT) parameter.[17] The determination of the threshold limit value (TLV) of work climate based on Indonesia's Minister of Manpower Regulation number 05 of 2018, where the TLV of working climate with the Wet Bulb Globe Temperature (WBGT) parameter is 28°C. The nutritional status rs is measured based on body mass index,[18] with the following categories: BMI<17.0 (heavy underweight), BMI<17.0-18.5 (light underweight), BMI>18.5-25.0 (normal), BMI>25.0-27.0 (light fat) and BMI>27.0 (heavy fat). Hydration status is measured based on the volume of consumption of drinking water per day in units of glass (@ 240 ccs), if the volume of drinking water <8 glasses per day is categorized as less hydration if the volume of drinking water consumption> 8 glasses per day is considered sufficient.[19]

Cramers V test was applied to see the correlation between heat strain and independent variables (age of operators, working period, nutritional status, hydration status, and heat stress). Data analysis using the Statistical Package for the Social Sciences (SPSS ver. 21, Chicago, IL, USA).

Result

Distribution of age, working period, work climate, nutritional status (based on body mass index), hydration status, work climate and its correlation with occupational heat strain are shown in Table 1.

Table 1. Related factors associated with occupational heat strain (OHS) of diesel power plant operators (N=35) in Indonesian electricity state company

Variables	Work section										p	r	OR
	SWD		Sulzer		MFO		Maintenance		Office				
	n	%	n	%	n	%	n	%	n	%			
Age (years)											0.000	0.496	5.86
< 40	10	18.9	5	9.4	2	11.3	6	11.3	7	13.2			
> 40	16	11.3	7	13.2	2	3.8	2	3.8	6	11.3			
Working period (years)											0.000	0.506	3.49
< 10	10	18.9	5	9.4	1	1.9	6	11.3	1	3.8			
> 10	6	11.3	7	13.2	3	5.7	2	3.8	11	20.8			
Nutritional status											0.204	0.294	
Heavy Under weight	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0			
Light Under weight	0	0.0	1	1.9	0	0.0	0	0.0	0	0.0			
Normal	10	18.9	8	15.1	1	7.5	4	7.5	7	13.2			
Light fat	4	7.5	0	0.0	1	3.8	2	3.8	3	5.7			
Heavy fat	2	3.8	3	5.7	2	3.8	2	3.8	3	5.7			
Hydration status											0.057	0.428	1.21
Less	8	15.1	6	11.3	2	3.8	0	0.0	3	5.7			
Sufficient	8	15.1	6	11.3	2	3.8	8	15.1	10	18.9			
Work climate											0.000	0.554	2.39
< TLV	12	22.6	7	13.2	1	1.9	0	0.0	13	24.5			
> TLV	4	7.5	5	9.4	3	5.7	8	15.1	0	0.0			
Heat Strains													
Green zone/save	10	18.9	8	15.1	4	7.5	1	1.9	11	20.8			
Yellow zone/alarm	6	11.3	4	7.5	0	0.0	7	13.2	2	3.8			
Red zone/danger	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0			

Note: all % of total, SWD= Strork werkspor diesel, MFO= Marine fuel oil.

Overall, most operators were less than 40 years old (64%), with the largest percentage being operators in the SWD section (18.9%), most operators had working periods of less than 10 years (54.7%) with the largest percentage in the SWD section (18.9 %), nutritional status was mostly in the normal category (62.2%) with the largest percentage being in the SWD (18.5%), hydration status was mostly sufficient (more than 8 glasses per day) (64.2%) with the largest presentation in the office and SWD (18.9%), as well as maintenance (18.9%) and Sulzer (11.3%). Most operators are exposed to heat stress below TLV (62.2%), however, there are some operators who are exposed to heat pressure above TLV, i.e 15.1% operators in maintenance, 9.4% in the Sulzer section, 7.5% in the SWD portion and 5.7% in the MFO section.

The heat strain score index of most operators shows is still included in the green zone/save category (64,2%). However, there are several operators in various work sections that fall into the yellow-green/alarm category, including 13.2% in the maintenance section, 11.3% in the SWD section, 7.5% in the Sulzer section and 3.8% in the office section. Cramers V statistical test results showed that heat strain was significantly related to age (p=0.000, OR=5.86), working period (p=0.000, OR=3.49), hydration status (p=0.057, OR=1.21) and heat stress (p=0.000, OR=2.39). All variables significantly related to heat strain have an odds ratio of more than 1 which indicates risk factors.

Discussion

Prevalence of heat strain

We found 35.8% of diesel power plant operators (N=36) experiencing heat strain in yellow zone/alarm categories, while 64.2% of operators still included in the green zone/save category. This finding is quite interesting and proves that workers in Indonesia (one of the developing countries with tropical climate) experience heat strain. This requires the attention of stakeholders to control the work environment and prevent further adverse effects so that the heat strain does not change to red zone/danger. This result proves the previous hypothesis by Kjellstorm et al,[13] which states that workers in tropical and sub-tropical countries are very at high risk for experiencing heat strains.

Association between age and working period of operators with heat strain: The results prove that age and working periods are significantly related to heat strain. In accordance with previous theories, age-related changes in sweating and skin blood flow. Older individuals exhibit alterations in sweating during heat stress (decreasing functional of sweat gland), a delayed core temperature onset threshold for sweating, reduction in evaporative heat loss and decreasing ability to respond enable the distribution of internal heat content among various tissues in the body.[20] However, the results of this study are not in line with the research of Sutono et al,[8] which concluded no relationship between the age and heat strains in construction workers.

The results found an association between working period and heat strain. This result makes sense because the working period is closely related to the accumulation of work environment hazard exposure. The longer the operator's working period, the possibility of exposure to various hazards at workplace.[21]

Association between hydration status with heat strain: The results showed the operator's hydration status was significantly related to heat strain. The results of this study are in line with previous studies by Bolghanabadi[22] who concluded that hydration status is significantly related to heat strains in food industry workers in Mashad. This finding is consistent with Riebl and Davy's opinion[23] which states that during vigorous physical activity in a hot environment, the body experiences a lot of fluid loss with total water output is estimated to be around 1500–3100 mL/d.

Working in hot areas will affect kidney health by increasing the risk of urine crystal formation,[24] therefore adequate rehydration is needed so that it can offset the release of body fluids due to exposure to heat and can reduce the risk of crystallization of urine.

Association between work climate with heat strain: This study found that heat strain was significantly related to heat stress. This result can be explained from previous theories that explain working in a hot place will trigger the body's thermoregulation system to remove heat from the body, including through the expenditure of sweat. This condition will cause the body will experience a lot of loss of mineral salts, causing the body to dehydrate, and will affect other body systems causing various heat strain complaints.[11]

The results of this study further strengthen previous studies in various industries which conclude that heat exposure in the workplace is related to heat strains.[25-28] An important implication of this research is to reduce the heat strain, the management company should make decreasing heat exposure and improve the operator's hydration status by providing adequate drinking water in the workplace. As operators age and service life increases, companies are advised to reduce workloads and carry out shifting and limiting work time. According to NIOSH/CDC,[3] decreasingg heat stress can be done by engineering control, work and hygienic practices, heat acclimation plan, training and practicing heat alert program.

Conclusion and recomendations

35.8% of diesel power plant operators (N=36) experiencing heat strain in yellow zone/alarm categories, while 64.2% of operators still included in the green zone/save category. The heat strain was significantly related to age (p=0.000, OR=5.86), working period (p=0.000, OR=3.49), hydration status (p=0.057, OR=1.21) and heat stress (p=0.000, OR=2.39). All variables significantly related to heat strain have an odds ratio of more than 1 which indicates risk factors. To reduce heat strain, management companies are advised to carry out engineering control, administrative control, work and hygienic practices, and implement a heat alert program.

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Conflict of Interest: Nil

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