ORIGINAL ARTICLE

Impact of heat stress on health-related symptoms and physiological changes among workers at a palm oil mill in Mukah, Sarawak, Malaysia

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ABSTRACT

Introduction: The palm oil (PO) industry is one of the most important sectors in the Malaysian economy. Workers at PO mills are, however, at risk for a number of health and safety issues, including heat stress, as the PO is one of the industries with high heat exposure. Heat stress occurs when a person's body cannot get rid of excess heat. Heat stress can result in heat cramps, heat exhaustion, heat rash, and heat stroke. It also results in physiological and psychological changes that can have an impact on a worker's performance. Therefore, this study aimed to evaluate the impact of heat stress on health-related symptoms and physiological changes among workers in a PO mill.

Materials and Methods: This cross-sectional study was conducted in a PO mill located in Mukah, Sarawak, Malaysia. Thirty-one workers from the four workstations (sterilizer, boiler, oil, and engine rooms) were selected as the respondents in this study. Wet Bulb Globe Thermometer was used in this study to measure the environmental temperature (WBGTin). Body core temperature (BCT), blood pressure (BP), and heart rate (HR) were recorded both before and after working in order to assess the physiological effects of heat stress on workers. A set of questionnaires were used to determine sociodemographic characteristics of the respondents and their symptoms related to heat stress. Data were then analyzed using SPSS Ver28.

Results: The WBGTin was found to be above the ACGIH threshold limit value of heat stress exposure in the engine room, sterilizer, and boiler workstations (>28.0°C). Additionally, there was a significant difference in the worker's BCT in these three workstations before and after work ($p<0.05$). Only the systolic BP and HR of those working at the boiler workstation showed significant difference between before and after work ($p<0.05$). The most typical symptoms that workers experience as a result of being exposed to heat at work include headache and fatigue. However, statistical analysis using Spearman Rho's test showed that there is no correlation between heat stress level with physiological changes and health-related symptoms among study respondents ($p>0.05$).

Conclusion: Results of the present study confirmed that workers in PO mill were exposed to high temperatures while at work. Although the evidence indicates the physiological parameters in general are not significantly affected while working, it also demonstrated that worker's body adapts and acclimates to the level of heat. Even so, precautions should still be taken to reduce future heat exposure. It is recommended that a physiological study be carried out that focuses on cognitive function impairment to support the evidence regarding the effects of heat stress on PO mill workers.

KEYWORDS:
Heat stress, health-related symptoms, palm oil mill, physiological changes

INTRODUCTION

The palm oil industry is one of the most important sectors in the Malaysian economy.[1,2] However, workers in palm oil mills (PO) are exposed to numerous health and safety hazards, including heat stress as PO is one of the main workplaces with high heat exposure often throughout the course of an 8-hour shift.[3] PO process involves the physical extraction of crude palm oil and palm kernel from fresh fruit bunches (FFB), where almost all the processes involve high temperatures.[3] There are nine workstations in PO; loading ramp, sterilization, kernel, press, production room, boiler room, oil room, engine room and workshop.[4,5] Previous studies found that the highest ambient working temperatures in PO were in sterilisation, boiler room, oil room, and engine room.[2] Those working in sterilisation workstation are required to perform tasks such as cleaning both the inside and outside of the steriliser. This steriliser (a pressure vessel) operates with saturated steam at temperatures of approximately 140°C and medium pressure at 45 psi. Additionally, they are responsible for managing the sterilizer's operational switches and installing packing on the sterilizer door. In contrast, workers in the boiler room are responsible for tasks such as removing stones from the boiler furnace, mixing fibers within the furnace, dislodging stuck fibers, and maintaining cleanliness in the station area. Furthermore, employees stationed in the oil room are tasked with cleaning the separator and purifier machines, in

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addition to keeping the station area tidy. Meanwhile, those assigned to the engine room are primarily responsible for operating the engines.[6,7] Therefore, this study was focused on heat exposure to the workers in these four stations.

Workers who work in hot environments or are exposed to extreme heat may be at risk of heat stress.[8] Heat stress occurs when a person's body cannot get rid of excess heat which will cause the body's core temperature and heart rate to increase. The person begins to lose attention and has problems focusing on a task while the body continues to retain heat. As a result, there is a reduction in work capacity, inefficiency, and risk of hazardous incidents.[9] They may also feel agitated or ill, and they frequently lose the desire to drink. If that person is not cooled down, the next stage is frequently fainting and, in extreme cases, death.[8] Heat stress not only causes heat rash, heat exhaustion, heat cramps and heat stroke, but also leads to psychological and physiological changes, which can affect workers' performance.[10] The physiological impacts of extreme temperatures, whether hot or cold, are intricately linked to the body's need to maintain its core temperature, ideally around 37°C (98.6°F). It's crucial to note that when the core temperature drops below 25°C (77°F) or rises to 45°C (113°F) or above, it can result in severe health consequences, including fatality.[11] Beyond the physical effects, there are also psychological considerations. Workers' perceptions of anxiety related to accidents and injuries, coupled with the potential for reduced concentration and increased frustration due to thermal stress, can significantly influence their cognitive well-being.[12,13]

According to International Labour Organization[14], while performing physical labor, exposure to a hot working environment or a combination of a hot working environment and high ambient humidity (80% or higher) can lead to a rapid increase in body temperature, potentially overwhelming the body's natural thermoregulation mechanisms. This situation poses serious risks, including the development of heat stress or even heat stroke, which can be fatal. Therefore, it is crucial to safeguard employee health and safety, as stated in the Occupational Health and Safety Act (1994), which states in section 15 that employers are obligated to take all necessary precautions for a worker's protection. This includes creating rules and procedures to guard against heat stress in workers who are exposed to high humidity, radiant heat sources, excessive air temperatures, direct physical contact with hot objects, or rigorous physical activity.[15] Hence, this study aimed to determine the level of heat stress, health-related symptoms, and physiological changes among workers in a selected palm oil mill in Mukah, Sarawak, as well as their association.

MATERIALS AND METHODS

Study Design and Setting

The data for this cross-sectional study was collected by measuring the environmental temperature at the workplace using Wet Bulb Globe Temperature (WBGT) (QUESTEMP °36 Thermal Environment Monitor, QUEST Technologies, USA).[3] Besides, the worker's heart rate (HR), blood pressure (BP), and body core temperature (BCT) had been measured for before and after 8 hours shifts using standard equipment. All instruments were calibrated before use for quality control.

The workers who participated in the study were given a set of questionnaires to obtain their demographic data, working information, and health-related symptoms due to heat exposure. Simple random sampling was used to recruit respondents for this study who met the following criteria: (i) were male, (ii) were at least 19 years old, (iii) had at least one year of work experience in PO mill, and (iv) worked in the boiler room, engine room, oil room, or sterilizer workstation. Those with history of high blood pressure and heat stroke were excluded from this study. There were 33 workers, of which 20 were in the boiler room, four in the engine room, five in the steriliser and four workers in the oil room. The sample size was calculated using the sample size formula. The sample size was calculated by keeping the margin of error at 5%, confidence interval at 95% and population size of 33. Based on the calculation, the sample size was 31.

To assess physiological changes due to heat exposure at workplace, worker's HR, BP and BCT were measured using Omron Healthcare Blood Pressure Monitor (Omron T3) and Instant Ear Thermometer (Omron MC510). Measurements were taken both before and after the eight hours of work. Personal information of workers, namely sociodemographic background, their risk factor history of heat exposure and other information relating to heat stress has also been collected in questionnaires. The questionnaire was adopted from previous study.[16]

Statistical Analysis

The Statistical Package for Social Sciences version 28 (SPSS ver28.0) was used to analyse all the data collected for this study. The frequency in percentage of sociodemographic data, occupational data, and health-related symptom data were calculated using descriptive analysis. Normalisation on data was performed before analysis. Paired sample t-test was conducted to analyse the physiological changes before and after 8 hours shifts.

Pearson correlation test was carried out to determine the association between heat stress level and physiological changes among workers while Spearman's Rho correlation test was carried out to determine the association between heat stress level and health-related symptoms among workers. A significance level (p-value) was set as 0.05 for all statistical analysis.

Ethics Approval and Informed Consent

Ethical approval was obtained from Ethics Committee of Universiti Teknologi MARA, Puncak Alam, Selangor (Ref. number: FERC/FSK/MR/2022/0237). Prior to the study, all respondents signed the consent form. Their identities were kept anonymous, and all the information are kept confidential by researchers.

RESULTS

Sociodemographic Characteristics of Study Respondents

The sociodemographic information of the study respondents

Table I: Sociodemographic characteristic of study respondents (n=31)

Characteristics	n	%
Age group (Years)		
19-28	11	35.5
29-38	14	45.1
39-48	6	19.4
Race		
Malay	4	12.9
Chinese	0	0
Indian	0	0
Others	27	87.1
Education Level		
Primary School	13	41.9
Secondary School	16	51.6
STPM/STAM/Diploma/Matriculation	2	6.5
Workstation		
Boiler	18	58.0
Oil room	2	6.5
Engine room	3	9.7
Steriliser	8	25.8
Duration of employment (Years)		
1-5	21	67.7
6-10	8	25.8
11-15	2	6.5

Table II: Exposure profile for heat stress at various workstation in PO mill

Workstation	WBGTin (°C)
Boiler	28.6
Oil room	27.7
Engine room	28.4
Sterilizer	28.6

Table III: Prevalence of health-related symptoms among PO mill workers

Workstation	Symptom	n	%
Boiler	Red rash on skin	2	11.1
	Muscle cramp	4	22.2
	Headache	9	50.0
	Weakness	2	11.1
	Fatigue	8	44.4
	Dizziness	5	27.8
	Irritability	2	11.1
	Hot and dry skin	3	16.7
	High body temperature	1	5.6
	Confusion	1	5.6
Engine room	Headache	1	33.3
	Fatigue	2	66.7
Oil room	Fatigue	1	50.0
	Hot and dry skin	1	50.0
	Confusion	1	50.0
Steriliser	Muscle cramp	1	12.5
	Headache	4	50.0
	Nausea	1	12.5
	Weakness	3	37.5
	Fatigue	4	50.0
	Dizziness	3	37.5
	Hot and dry skin	3	37.5
	High body temperature	1	12.5
	Confusion	2	25.0

Table IV: Comparison of BCT, BP and HR before and after work at different workstations

Work-station	Variables		p-value
	Before work	After work	
Boiler	BCT: 36.61±0.27°C	BCT: 36.96±0.13°C	<0.001*
	Systolic BP: 134.00±11.92 mm Hg	Systolic BP: 137.33±11.46 mm Hg	0.034*
	Diastolic BP: 78.61±7.00 mm Hg	Diastolic BP: 79.89±7.84 mm Hg	0.538
	HR: 74.94±11.61 bpm	HR: 82.11±16.0 bpm	0.016*
Oil room	BCT: 36.60±0.57°C	BCT: 36.70±0.71°C	0.500
	Systolic BP: 127.50±0.71 mm Hg	Systolic BP: 126.00±1.41 mm Hg	0.500
	Diastolic BP: 67.50±19.10 mm Hg	Diastolic BP: 68.00±15.56 mm Hg	0.874
	HR: 71.00±1.41 bpm	HR: 93.00±19.80 bpm	0.381
Engine room	BCT: 36.70±0.10°C	BCT: 37.00±0.00°C	0.035*
	Systolic BP: 130.67±6.51 mm Hg	Systolic BP: 131.33±6.35 mm Hg	0.742
	Diastolic BP: 76.00±3.61 mm Hg	Diastolic BP: 77.33±9.24 mm Hg	0.873
	HR: 74.00±6.56 bpm	HR: 79.33±6.35 bpm	0.067
Sterilizer	BCT: 35.95±0.53°C	BCT: 36.53±0.53°C	0.039*
	Systolic BP: 133.50±13.85 mm Hg	Systolic BP: 136.13±10.51 mm Hg	0.540
	Diastolic BP: 78.38±15.65 mm Hg	Diastolic BP: 74.50±12.32 mm Hg	0.263
	HR: 78.75±13.37 bpm	HR: 85.25±10.00 bpm	0.056

*p-value was significant at 0.05.

Table V: Correlation between heat stress level with physiological changes and health-related symptoms at different workstations

Work-station	Physio-logical variable	p-value[a]	Health-related symptoms	p-value[b]
Boiler	BCT	0.574	Red rash on skin	0.076
	Systolic BP	0.335	Muscle cramp	0.139
	Diastolic BP	0.498	Headache	0.441
	HR	0.893	Weakness	0.787
			Fatigue	0.765
			Dizziness	0.669
			Irritability	0.076
			Hot and dry skin	0.909
			High body temperature	0.100
			Confusion	1.000
Engine room	Systolic BP	0.031*	Headache	1.000
	Diastolic BP	0.698	Fatigue	0.333
	HR	0.031*		
Sterilizer	BCT	0.571	Muscle cramp	0.846
	Systolic BP	0.598	Headache	0.604
	Diastolic BP	0.501	Nausea	0.555
	HR	0.390	Weakness	0.334
			Fatigue	0.429
			Dizziness	0.200
			Hot and dry skin	0.689
			High body temperature	0.555
			Confusion	0.766

* Correlation is significant at the 0.05 level (2-tailed).
[a] Pearson correlation test
[b] Spearman correlation test

was summarized in Table I. Most of the respondents were between the ages of 29 and 38 (45.1%). Only 12.9% of respondents identify as Malay, with the remaining 87.1% belonging to other ethnic groups. In terms of education level, most of the respondents (51.6%) had finished their secondary school. Out of the 31 respondents, 58.0% work in the boiler room, followed by the sterilizer (25.8%), engine room (9.7%), and oil room (6.5%). Besides, most respondents (67.7%) had worked in the PO mill for between one and five years in terms of working experience.

Level of Heat Stress (WBGTin) and Health-Related Symptoms among Workers

The level of heat stress in each workstation was presented in Table II. Three out of four workstations (boiler, engine room and sterilizer) were found to be above the ACGIH threshold limit value of heat stress exposure (>28.0°C) for moderate metabolic workload level and 75% work, 25% rest regimen.

Table III summarised the prevalence of health-related symptoms due to heat exposure at different workstations. The three health-related symptoms that were most reported by those who were working in a boiler workstation were headache (50.0%), fatigue (44.4%), and dizziness (27.8%). Workers in the engine room, meanwhile, reported feeling fatigued (66.7%) and having headaches (33.3%) while working in the heat. Those who worked in the oil room reported feeling fatigued (50.0%), confused (50.0%), and having hot, dry skin (50.0%). On the other hand, most workers at the sterilizer workstation reported having

headaches (50.0%), fatigue (50.0%), weakness (37.5%), dizziness (37.5%), and hot and dry skin (37.5%).

Comparison of Body Core Temperature (BCT), Blood Pressure (BP) and Heart Rate (HR) Before and After Work at Different Workstations

Comparison of worker's BCT, BP, and HR before and after work are shown in Table IV. Statistical analysis using Paired t-test showed the workers' BCT, systolic blood pressure, and heart rate were significantly different before and after working at the boiler workstation ($p<0.05$). Besides, a statistically significant difference between BCT before and after work was seen among workers at the steriliser and engine room ($p<0.05$). Meanwhile there was no significant difference for physiological variables were found among workers in oil room.

Correlation between Heat Stress Level with Physiological Changes and Health-Related Symptoms at Different Workstations

Correlation between heat stress level with physiological changes and health-related symptoms at three different workstations (boiler, engine room, and sterilizer) are shown in Table V. Statistical analysis using correlation tests revealed that there was a correlation between heat stress level experienced by engine room workers with their systolic BP and HR ($p<0.05$). However, no association was found between heat stress level experienced by the workers with their health-related symptoms ($p>0.05$). Additionally, there was no correlation between the level of heat stress and physiological changes or health-related symptoms in individuals who worked at boiler and sterilizer workstations ($p>0.05$).

DISCUSSION

The present study investigated the possible impact of heat stress on health-related symptoms and physiological changes among workers at a PO mill in Mukah, Sarawak, Malaysia. Three out of four workstations were found to have WBGTin level that were higher than the permitted ACGIH Threshold Limit Value (TLV) limit of 28.0°C for a moderate metabolic workload level and 75% work with 25% rest time regime during the study period.[17] These results are similar with previous studies, which found that the level of WBGTin in the boiler, engine room, and sterilizer workstations in the PO mill exceeded the ACGIH permitted limit.[1,3,18] These indicate that individuals who work in these workstations are having heat stress. In addition, there was a significant different found of workers' BCT in these three workstations before and after work ($p<0.05$) which is consistent with the finding of the preceding study.[3,18]

Human body normally keeps its internal temperature around 37.0°C at a constant level, even when subjected to changing environmental temperatures, emotional state or level of physical activity.[3,19] However, being exposed to or working in a hot environment can stress the body.[17] The body tends to warm-up along with the surrounding environment. By pumping more blood to the skin and increasing sweat production, the body's internal "thermostat" maintains a consistent internal body temperature.[19] However, the body temperature starts to rise when the rate of "heat gain" is more than the rate of "heat loss" in an extremely hot environment, which can lead to heat illness.[17,19] Therefore, an increase in core body temperature is one of the best indicators of upcoming heat stress.[20]

In this study, workers' systolic BP and HR were also found to be significantly increase before and after work at boiler workstation ($p<0.05$). These results were consistent with the earlier studies, which revealed that all physiological variables increased following a work shift in the PO mill.[1,3,18] Since the blood has to carry oxygen to the working muscles, exposure to high heat stress may also put additional load on the blood circulation. In addition, blood also acts as a medium to carry heat from the body to the skin's surface. Therefore, the heart may have to work harder to pump more blood, which raises blood pressure.[21] These might explain the elevated HR and BP measurements that study respondents experienced after working.

Further statistical analysis proved that, except for workers' systolic BP and HR with heat stress level in engine room, there was no correlation between heat stress levels at different workstations with physiological changes or health-related symptoms ($p<0.05$). This indicates that workers had adapted to the high working temperature and the body had acclimatised to the level of heat, regardless of their heat exposure and metabolic load.[18] As demonstrated in this study, heart rate is another physiological variable that best demonstrates the impact of heat exposure. Although heart rate measurement after work at all workstations showed an increase, this increase is regarded as normal and previous suggested that the Malaysian workers have successfully adapted to the tropical climate and high temperature.[18]

In terms of health-related symptoms due to heat exposure, most of the workers experienced fatigue and headaches. These results are supported by an earlier study that identified fatigue and headaches as the most typical symptoms of heat stress.[22] This is probably happens due to workers who spend most of their time in non-air-conditioned indoor workplaces that have a greater risk of health-related symptoms even though they are not directly exposed to sunlight. All the workers experienced minor symptoms of heat illness. However, none of them ever experienced heat stroke while working in PO mill. Even so, PO mill management should encourage workers to take appropriate rest breaks and regularly drink plain water in the workplace to stay hydrated and keep normal core body temperature, heart rate and stroke volume throughout the working hours.[23]

CONCLUSION

Results of the present study indicate that the heat level in boiler, engine room and steriliser workstation exceed the ACGIH TLV limit suggested for moderate work category (75% work with 25% rest regime). Although the results of this study indicated that the PO mill's workers did not experience significant physiological changes or health-related symptoms due to heat exposure at work, continuous improvements to the workplace condition should be made to reduce the risk of heat stress among workers. Hence, it is advisable to enhance ventilation and airflow in both the boiler and engine rooms to mitigate heat accumulation. Effective ventilation not only

dissipates heat but also eliminates potentially harmful pollutants, such as gases and fumes generated during combustion processes in these areas. This contributes to improved indoor air quality, reducing the likelihood of workers inhaling hazardous substances. Regarding sterilization processes, optimization is recommended to minimize heat emissions. Elevated temperatures in the workplace can result in heat stress and related health concerns for employees, including symptoms like fatigue, dizziness, nausea, and, in severe cases, heat exhaustion or heatstroke. By reducing heat emissions, the risk of heat-related illnesses among workers can be significantly lowered. It is also recommended that future physiological study be carried out that focuses on cognitive function impairment to support the evidence regarding the effects of heat stress on PO mill workers.

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CONFLICT OF INTEREST

No conflict of interest.

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