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THE EVALUATION OF PHYSIOLOGICAL CHANGES AND HEAT RELATED ILLNESS AMONG PALM OIL MILL WORKERS UNDER HEAT STRESS CONDITION

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BY

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ABSTRACT

THE EVALUATION OF PHYSIOLOGICAL CHANGES AND HEAT RELATED ILLNESS AMONG PALM OIL MILL WORKERS UNDER HEAT STRESS CONDITION

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Background: Palm oil mill production involved work processes with high temperature. However, less study has been conducted on the hazards of high temperature among the workers here. Therefore, the purpose of this study is to evaluate the physiological changes and heat related illness among palm oil mill workers under heat stress condition **Methods:** This cross-sectional study was conducted in three different palm oil mill. Palm oil mill workers (n=88) were interviewed using self-constructed questionnaire including heat related illness. Heat stress assessment (WBGTin) and the level of air velocity were measured using QUESTemp°34 Thermal Environment Monitor and TSI Velocicalc® Air Velocity Meters respectively. Meanwhile, Omron MC-510 Gentle Temperature Ear Thermometer (measure core body temperature), POLAR Heart Rate FT60 (measure heart rate) and OMRON T3 Automatic Blood Pressure Monitor (measure blood pressure) was used in the physiological measurement of the workers. All of these parameters were taken in three session; before shift, after 2 hours working and after 8 hours working. **Results**: The results highlighted that all the work sections in the palm oil mill were exceeded Threshold Limit Value (TLV) (>28.0°C). Heat exhaustion (86.4%) is the highest prevalence of heat related illness reported, followed by dehydration (78.4%), heat cramps (61.4%), heat rashes (38.6%), heat syncope (28.4%) and heat stroke (4.5%). The value of WBGTin has no correlation with the air velocity reading ($r(21)= .45$, $p= .86$). There was significant differences in physiological parameters (core body temperature, $F(1.86, 162.18) = 14.79$, $p < .001$; heart rate, $F(1.78, 154.79) = 22.38$, $p < .001$; and blood pressure $F(1.77, 153.85) = 34.114$, $p < .001$) between three session. **Conclusion:** The workers were exposed to high temperature due to their hot working environment. The air velocity in the mill indicates less air circulation which contribute to the no significance correlation with WBGTin. The highest prevalence of heat related illness among workers in palm oil mill is heat exhaustion. There is significant differences in physiological parameters between three different sessions which indicates the workers are subjected to high heat stress during the first two hours before the acclimatization process happened.

Keywords: Heat stress, heat related illness, palm oil mill, physiological

ABSTRAK

PENILAIAN PERUBAHAN FISIOLOGI DAN PENYAKIT BERKAITAN HABA DALAM KALANGAN PEKERJA KILANG MINYAK SAWIT DIBAWAH TEKANAN HABA

NUR ATHIRAH DIYANA BINTI MOHAMMAD YUSOF

Latar Belakang: Pengeluaran kilang minyak sawit terlibat dalam proses kerja dengan suhu yang tinggi. Walau bagaimanapun , kajian kurang dilakukan mengenai bahaya suhu yang tinggi dalam kalangan pekerja di sini. Oleh itu, tujuan kajian ini adalah untuk menilai perubahan fisiologi dan penyakit berkaitan haba dalam kalangan pekerja kilang sawit dibawah tekanan haba. **Metodologi:** Kajian keratan rentas telah dijalankan di tiga kilang minyak sawit yang berbeza. Pekerja-pekerja kilang minyak sawit (n = 88) telah ditemuramah menggunakan borang soal selidik yang dirangka sendiri termasuk penyakit berkaita haba. Penilaian tekanan haba (WBGTin) dan tahap halaju udara diukur dengan menggunakan pemantau suhu persekitaran (QUESTemp°34) dan pengukur halaju udara (TSI Velocicalc ®). Sementara itu, Termometer suhu telinga, Omron MC -510 Gentle (mengukur teras suhu badan), kadar denyutan nadi POLAR FT60 (mengukur kadar denyutan nadi) dan pemantau tekanan darah automatik OMRON T3 (mengukur tekanan darah) telah digunakan dalam pengukuran fisiologi responden. Semua parameter ini telah diambil dalam tiga sesi iaitu sebelum syif, selepas 2 jam bekerja dan selepas 8 jam bekerja. **Keputusan:** Keputusan membuktikan bahawa semua bahagian kerja dalam kilang minyak sawit telah melebihi Nilai Had Ambang (TLV) (> 28.0 °C). Keletihan haba (86.4 %) adalah prevalens paling tinggi penyakit berkaitan haba dilaporkan , diikuti oleh dehidrasi (78.4%) , kekejangan haba (61.4 %) , ruam panas (38.6%), pengsan haba (28.4%) dan strok haba (4.5%). Nilai WBGTin mempunyai tiada korelasi dengan bacaan halaju udara (r (21) = .45 , p = 0,86). Terdapat perbezaan yang signifikan dalam parameter fisiologi (suhu teras badan , F (1.86 , 162,18) = 14.79 , p < .001; kadar denyutan nadi, F(1,78 , 154,79) = 22.38 , p<.001; dan tekanan darah F(1.77, 153.85) = 34.114, p<.001) antara tiga sesi. **Kesimpulan:** Pekerja-pekerja di kilang sawit telah terdedah kepada suhu yang sangat tinggi kerana ia dipengaruhi oleh persekitaran kerja mereka yang panas. Halaju udara di kilang tersebut menunjukkan peredaran udara adalah sangat lemah dimana ia tidak mempunyai kolerasi dengan nilai WBGTin. Selain itu, prevalens yang tinggi dalam penyakit berkaitan haba dalam kalangan pekerja adalah keletihan haba. Terdapat perbezaan yang signifikan dalam parameter fisiologi antara tiga sesi berbeza dimana ia menunjukkan pada dua jam pertama, pekerja terdedah kepada tekanan haba yang tinggi sebelum proses penyesuaian haba di dalam badan berlaku.

Keywords: Tekanan haba, penyakit berkaitan haba, kilang sawit, fisiologi

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LIST OF ABBREVIATIONS

AAP	American Academy of Pediatrics
ACGIH	American Conference of Governmental Industrial Hygienists
BMI	Body Mass Index
bpm	beats per minute
DOSH	Department of Occupational Safety and Health
ILO	International Labor Organization
m/s	meter per second
mmHg	millimeter of mercury
MPOC	Malaysia Palm Oil Council
NIOSH	National Institute for Occupational Safety and Health
NWSWFO	National Weather Service Weather Forecast Office
OSHA	Occupational Safety and Health Administration
SOCSO	Social Security Organisation
TLV	Threshold Limit Value
WBGTin	Wet Bulb Globe Temperature indoor
WHO	World Health Organization

CHAPTER 1

INTRODUCTION

1.1 Background

Occupational heat stress is a one of the major problem, especially in tropical countries such as Malaysia which affecting health among workers (Tawatsupa et al., 2010). Workers who are working in high temperature need constant core body temperature for his body to function effectively. In order, to maintain a stable temperature, the body must release heat to the surrounding environment at the same rate as heat is produced (Andrew, 2011). Heat stress can happen when the body failed in controlling its internal temperature.

Exposure to extreme heat stress level can overwhelm the body's coping mechanisms leading to a serious condition such as heat stroke and possibly fatal (Azlis, 2007). Heat stress can result in heat stroke, heat exhaustion, heat cramps, heat rashes, or heat syncope. (National Institute for Occupational Safety and Health, 2013). When the human body is imposed to the heat stress, the body will tend to adapt by increase the body temperature, heart rate, and rate of sweating which causing physiological changes in the body. These changes are known as heat strain.

Heat stress has been identified as one of the major hazard in manufacturing industry (Azlis et al., 2007). In Malaysia industry, palm oil industry is the largest contributors in economy which it is currently contributes around 39 % of world palm oil production and 44% of world exports (Malaysian Palm Oil Council, 2013). However, it also contributes hazards to the workers in the palm oil mill. The palm oil involves variety of process in order to produce the end product that is crude oil. Among the hazardous area subjected to the heat stress in the palm oil mills are such as sterilization area which involves high air temperatures, radiant heat sources, and direct physical contact with hot objects. This area has a high potential for inducing heat stress among exposed employees. However, there is less study has been conducted on the intensity and consequences of this hazard among the palm oil mill workers.

1.2 Problem Statement

Most of the research that were done on heat stress among workers in different workplace show that, there is significant between high environmental temperature and negative impact on workers' performance, attitude and satisfaction level. Frequent exposure to the workplace induces physiological and psychological stresses which lead to sensitivity, irritation, and anxiety have a direct impact on performance, health and safety of the workers (Parson, 2003). Azlis (2007) stated that there are many industries in Malaysia that have high potential involving heat stress to their employees.

In palm oil mill, most of the work process has also involved with high temperature especially in sterilization area which the process involve 120°C-140°C at 40 psi to inactivate the lipolytic enzymes that cause oil hydrolysis and fruit deterioration (MPOC, 2013). Besides, the digestion process also involve a high temperature where it is commonly used a steam heated with 80°C-100°C to reduce the viscosity of the oil, destroys the fruits' mesocarp (outer covering) and loosening the mesocarp from the nuts (Nurulhuda, 2009).

Social Security Organization (SOCSO) statistics also showed that there is high number of accident cause by heat among workers. In the year 2009, there is 233 accident cases reported cause by exposure to heat and 398 cases accident reported due to contact with hot object. For the year 2010 and 2011, there are 197 cases and 441 cases respectively which involved exposure to heat. Meanwhile, accident cause by contact with hot object had recorded 169 cases and 355 cases respectively for the year 2010 and 2011.

1.3 Study Justification

The study on heat stress among the workers has been widely conducted and published in the worldwide. However, there is lack of study that has been conducted in Malaysia particularly among the palm oil mill workers. Therefore, this study was conducted to develop a baseline data about level of heat stress at Palm Oil Mills in Malaysia.

The purpose of this study was to measure the heat stress and the effect on physiological and heat related illness to workers who are exposed to the high temperature. Previous studied reported that the high temperature can reduce the quality of work, mental and physical ability (Victor, 2003). Thus, by conducting this study, the level of physiological changes can be identified either it increase or decrease by time exposure as well as level of heat related illness also can be determined.

Another important issue regarding heat stress among workers is related with the regulation. There is no such specific guideline related to the worker on heat stress in Malaysia. Therefore, this study can be one of the baseline data of heat stress in the palm oil mill. It also can provide an important data and information to the Department of Occupational Safety and Health (DOSH) in Malaysia in developing guideline for heat stress.

1.4 Objectives

1.4.1 General Objective

To evaluate the physiological changes and heat related illness among palm oil mill workers under heat stress.

1.4.2 Specific Objectives

1.4.2.1 To determine socio demographic data of respondents.

1.4.2.2 To determine the heat stress index (WBGTin) and metabolic workload at each work section in palm oil mill.

1.4.2.3 To determine the air velocity and relative humidity at each work section in palm oil mill.

1.4.2.4 To determine the correlation between WBGTin and air velocity in the palm oil mill.

1.4.2.5 To determine the prevalence of heat related illness among workers when exposed to heat.

1.4.2.6 To determine physiological parameters between before shift, after 2 hours working and after 8 hours working among respondents.

1.4.2.7 To compare the differences of blood pressure before shift, after 2 hours working, and after 8 hours working among workers exposed to heat.

1.4.2.8 To compare the differences of heart rate before shift, after 2 hours working, and after 8 hours working among workers exposed to heat.

1.4.2.9 To compare the differences of core body temperature before shift, after 2 hours working, and after 8 hours working among workers exposed to heat.

1.5 Study Hypotheses

1.5.1 There is a significant correlation between WBGTin and air velocity in palm oil mill.

1.5.2 There is a significant difference between blood pressure before working, after 2 hours working, and after 8 hours working among workers exposed to heat.

1.5.3 There is a significant difference between heart rate before working, after 2 hours working, and after 8 hours working among workers exposed to heat.

1.5.4 There is a significant difference between core body temperature before working, after 2 hours working, and after 8 hours working among workers exposed to heat.

1.6 Definition of Term

1.6.1 Heat Stress

1.6.1.1 Conceptual Definition

Heat stress is a combination of heat load in individual and environmental factors impose on workers' bodies which give effect to workers' performance, safety and health. (Rasoul Hemmatjo et al., 2013).

1.6.1.2 Operational Definition

Heat stress level was determined by using Questemp°34 Thermal Environmental Monitor to measure environmental temperature in degree Celsius.

1.6.2 Physiological Changes

1.6.2.1 Conceptual Definition

Physiological changes are physiological adaptations when the body tend to increase the temperature, heart rate, and blood pressure when exposed to the high level of temperature (Barbara & Patricia, 2002).

1.6.2.2 Operational Definition

Body core temperature will be measured by using Omron MC-510 Gentle Temperature Ear Thermometer and OMRON Blood Pressure Monitor Model T3 will be used to measure blood pressure. While heart rate, it will be measured by using POLAR Heart Rate Monitor Watch.

1.6.3 Heat Related Illnesses

1.6.3.1 Conceptual Definition

Heat-related illness is a person with symptoms including headache, nausea, and fatigue after exposure to the heat (MedicineNet.com, 2013). It is a set of preventable conditions ranging from mild forms such as heat exhaustion and heat cramps to potentially fatal heat stroke. (Jonathan et al.,2011).

1.6.3.2 Operational Definition

Heat related illness will be measured by using self-constructed questionnaire. In this questionnaire, it covers all symptoms related with heat effect after exposure to high level of temperature.

1.6.4 Natural Wet Bulb Temperature

1.6.4.1 Conceptual Definition

Natural wet bulb temperature is which the air is allowed to flow over the sensor naturally rather than being forced. When air flow is less than 3 m/s (meter per second), the temperature reduce for the same absolute humidity. Therefore, natural wet bulb temperature is sensitive to both humidity and air movement (Barbara & Patricia, 2002).

1.6.4.2 Operational Definition

Wet Bulb temperature is the temperature that will be measures by using a thermometer with the sensor covered by wetted cotton wick and exposed only to the natural air movement (NIOSH, 1986).

1.6.5 Globe Bulb Temperature

1.6.5.1 Conceptual Definition

Globe temperature responds to radiant heat from the solid surroundings and convective heat with the ambient air. It is used to estimate the average wall temperature of the surroundings (Barbara & Patricia, 2002).

1.6.5.2 Operational Definition

The globe temperature will be measured by using a six inch, thin-walled, copper sphere, painted matte black on the outside. The temperature sensor is placed at the centre of the globe (Barbara & Patricia, 2002).

1.6.6 Dry Bulb Temperature

1.6.6.1 Conceptual Definition

Dry bulb temperature is the direct measure of air temperature. The temperature sensor is surrounded by air, which is allowed to freely flow around the sensor. (Barbara & Patricia, 2002).

1.6.6.2 Operational definition

Dry Bulb Temperature will be measure by using a thermal sensor that is shielded from direct radiant energy sources (U.S. Department of Labor,1999).

1.7 Conceptual Framework

In occupational, workers are mainly exposed to five types of hazards. In this study of palm oil mills, one of the main hazards is heat stress. Heat Stress can cause when there are combination of environmental factor and individual activity. In this conceptual framework, among the concerned variables are environmental factors consists of humidity, air velocity, air temperature and radiant temperature. Meanwhile for the individual activity, it involves metabolic rate and workload.

Workers who are exposed to the high level of temperature during work will tend to get heat stress which can lead to physiological effect and the worst case, they will involve with heat-related illness (Douglas, 1999). The physiological effects would increase the body core temperature, heart rate and blood pressure of workers. Meanwhile, for the heat-related illness it involved heat cramps, heat stroke, heat syncope and heat exhaustion (Figure 1.1).

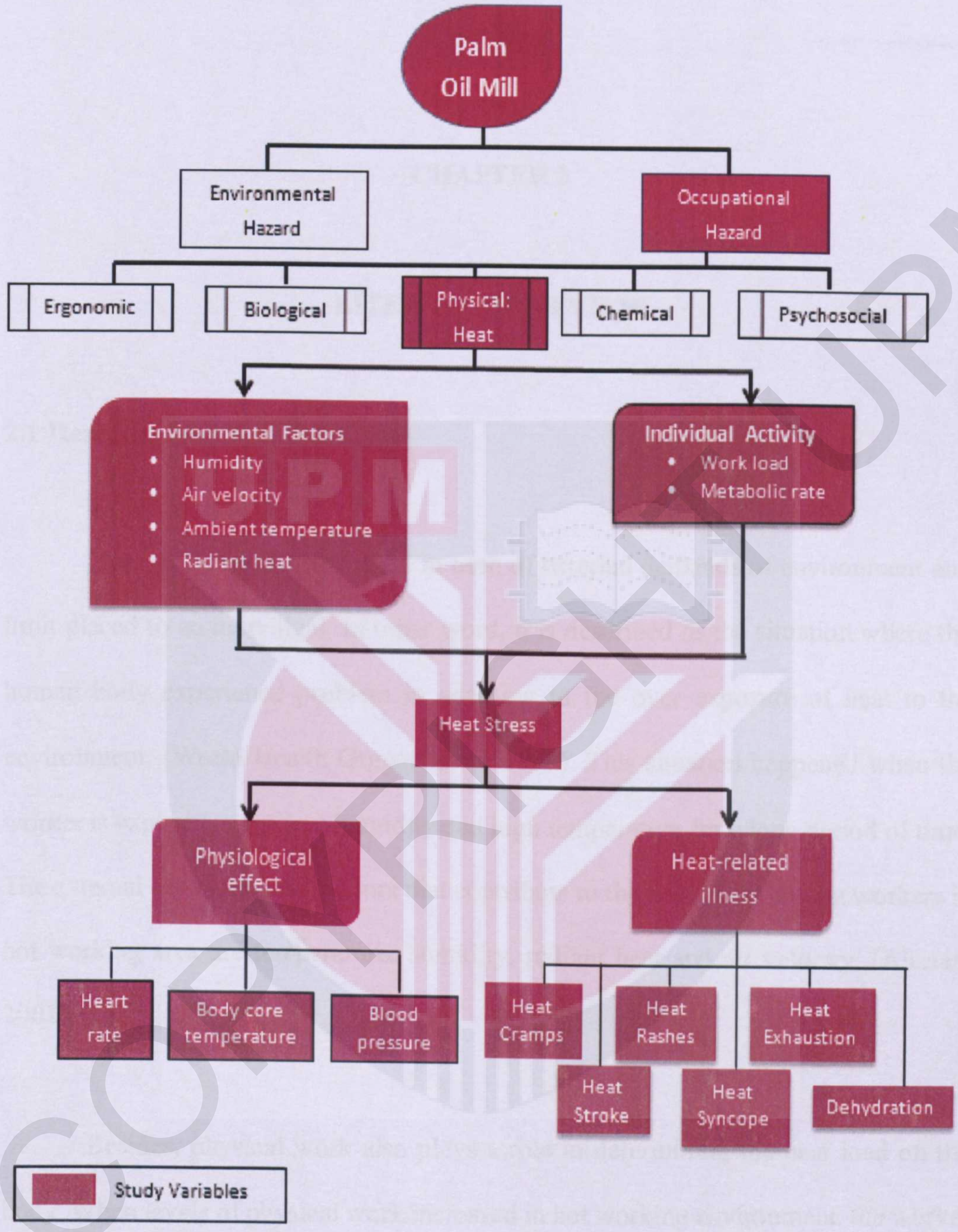

Figure 1.1: Conceptual framework

CHAPTER 2

LITERATURE REVIEW

2.1 Heat Stress

Heat stress can be described in term of external demands of environment and limit placed to an individual. In other word, it is described as the situation where the human body experience problem in adapting to the over exposure of heat to the environment. (World Health Organization, 1969). This situation happened when the worker is exposed to the low humidity and high temperature for a long period of time. The external environmental factors that contribute to the heat stress among workers in hot working area are temperature, humidity, radiant heat and air velocity. (Ahasan, 2001).

Besides, physical work also plays a role in determining the heat load on the body. When levels of physical work increased in hot working environment, the worker is at risk of increased core body temperature which is above 38°C, and it will lead to reducing in physical work capacity (Kerslake, 1972; Bidger, 2003), mental task ability (Ramsey, 1995), increased accident risk (Ramsey 1983) and eventually heat stroke and death (Hales 1987). The individual reaction to the heat is depending on personal characteristics such as age, weight, lifestyle, medical condition and level of acclimatization. (Belding & Hatch, 1955). The most studied were conducted on the heat stress is in the firefighting industry (Barr et al., 2010; Budd, 2001b; Cheung, et al.,2010; Van Gelder et al., 2008). This is because it has distinctive job task, work physicality and also high exposure to heat source (fire) as well as high pressure situation (Cheung et al., 2010).

2.2 Palm Oil Mill

The oil palm origin is placed in the tropical rain forest of West Africa where the oil and vitamin is used as source (Orathai, 2006). Malaysia is the first country that commercial the oil palm plantation in 1917 (MPOC, 2013). World palm oil production by year 2000 is 21.8 million tones and Malaysia produced about half from the world palm oil production. Thus, it shows that, Malaysia is also the world's largest producer and exporter of palm oil in that time (Yusof, 2002).The palm oil involves variety of process in order to produce the end product which known as crude palm oil. However, almost work process in the palm oil mill has involved with high temperature which can give effect to workers' health.

In order to produce the end product which also known as crude oil, palm oil mill involves variety of process where almost of them involved with high temperature especially in Sterilization Area (Figure 2.1). Palm oil mill are normally generate their own electricity by burning their waste products such as fibres in the boiler with 104°C at 299.5 psi (Figure 2.2). Then, the steam are generates which drives a steam turbine to produce electricity. It also contributes as a source of heat hazards.

The first step in palm oil production is harvesting the fresh fruit bunch (FFB) to send to the processing plants for the extraction (Figure 2.3). The arriving FFB is then transferred to the fruit cages which also known as loading RAMP (Figure 2.4) and moved into a sterilizer (Figure 2.5). The sterilization process uses heat to partially cook the fruit. This process is used to stops enzymatic reactions that lead to oxidation and disrupts the cells in the mesocarp, allowing for easier oil extraction where the process involve 120°C-140°C at 40 psi (Nurulhuda, 2009). Next, the digestion process which take place in the Digester or Press Station which crushes the fruit before extraction and warms the pulp to maximize oil yield (Figure 2.6). This process also involve a high temperature where it is commonly used a steam heated with 80°C-90°C. The pulp is then pressed, which bursts the oil-containing cells, releasing the palm oil.

Next, the oil is heated and filtered to remove impurities. The clarifying tank in the oil room is used in this process to drives excess moisture out of the oil through heating to reduce the moisture content from 0.25% to 0.15% (Figure 2.7). Once the oil has been checked for appropriate moisture and fat content, it is ready to be stored and sold. In the nut processing, nuts from the nut silo are first cracked in a nut cracker (Figure 2.8). The cracked mixture which consists of kernels and shell is the processed to separate the shells and kernels. This is done in air columns and by a water bath in a hydro-cyclone. The shell is sent to the boiler house to be used as fuel. The kernels are dried in a silo and then packed in bags for sale (MPOC,2013).

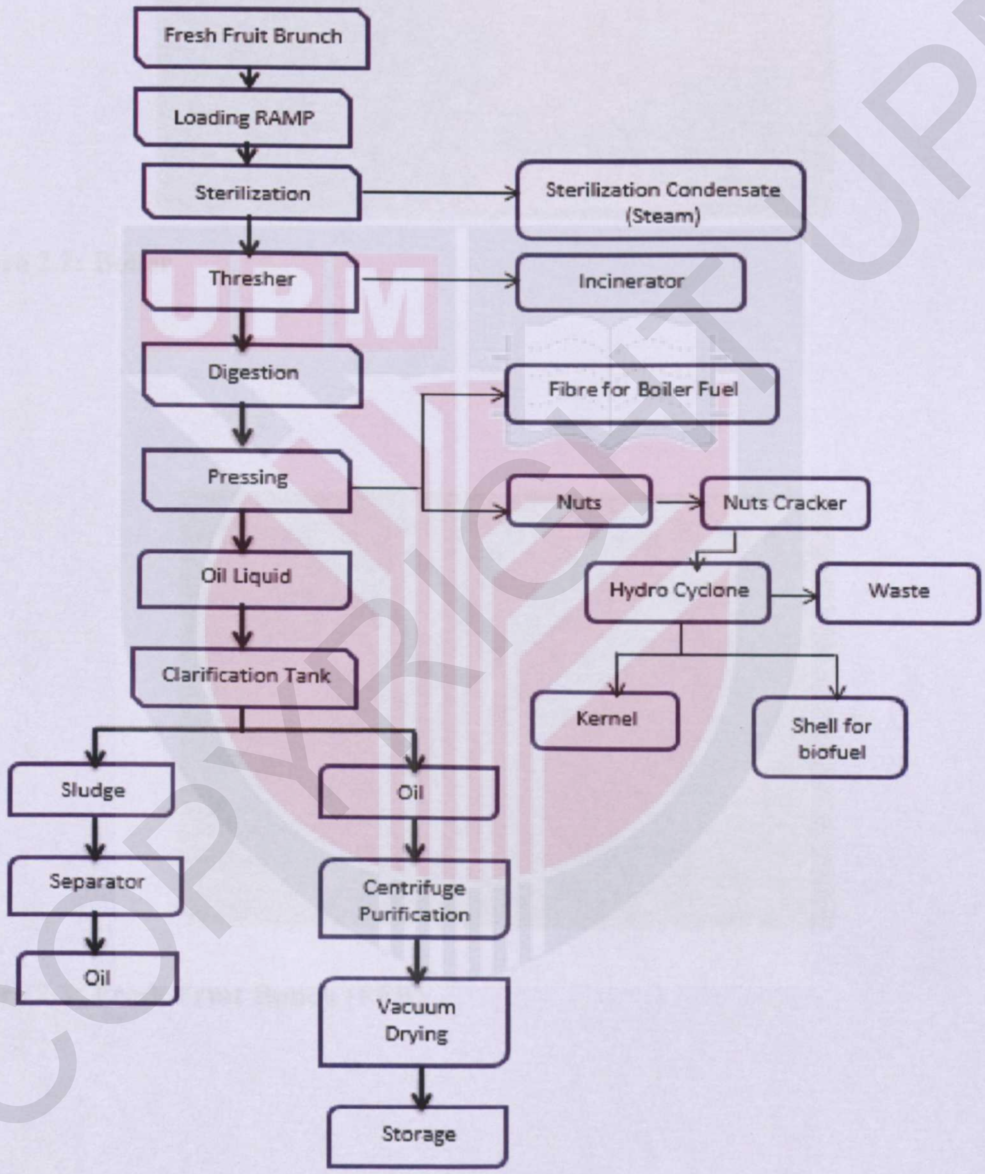

Figure 2.1: Process flow of the crude oil production

Figure 2.2: Boiler

Figure 2.3: Fresh Fruit Bunch (FFB)

Figure 2.4: Loading Ramp

Figure 2.5: Sterilizer

Figure 2.6: Digester/ Press Station

Figure 2.7: Oil Room

Figure 2.8: Nut/ Kernel Plant

2.3 Heat Exchange Rate by Conduction

Heat exchange by conduction involve direct heat transfer from one molecule to another through solid, liquid or gas. McArdle et al. (1994) stated that the rate of heat change depends on two factors which are the temperature gradient between skin and surrounding surface, and their thermal qualities. However, Barbara and Patricia (2002) suggested that the difference in temperature between the skin and solid surface, the thermal conductivity of the solid body that the person contacts and clothing that may separate the person from the solid surface are three depending factors of heat transfer rate.

2.4 Heat Exchange Rate by Convection

Convection is the cooling of the air around the body by the cooler air passing over the warmer skin that are exposed (Warren et al., 2013). When environmental temperature is lower than body temperature, thermal balance is maintained by convection of heat to the skin and radiation of heat to the environment (Brukner & Khan, 2012). Barbara and Patricia (2002) stated that the rate of convective heat exchange depends on three factors; i) the magnitude of the temperature difference, ii) the amount of air motion, and iii) clothing.

2.5 Heat Exchange Rate by Radiation

Barbara and Patricia (2002) defines radiant heat as a net heat flow of the solid bodies in different temperature from the hotter to the cooler surface in the infrared wavelength by radiation. It depends on the surrounding solid surface of average temperature, skin temperature and clothing. The exchange rate of heat gradient by certain environmental condition can inhibit appropriate thermoregulation (Howe & Boden, 2007).

2.6 Wet Globe Bulb Temperature Index

The Wet Globe Bulb Temperature (WBGT) is the most index commonly used to combines the relevant environmental heat condition reading include air temperature, relative humidity, and radiant heat which come out with one value (Eric, 2013). It is recommended measurement by governmental agencies in United State, American Conference of Governmental Industrial Hygienists, National Institute for Occupational Safety and Health and Occupational Safety and Health Administration. The WBGT was calculated under condition without direct sunlight (in the shade area), $WBGT_{in}$ or under conditions of direct sunlight (outdoors), $WBGT_{out}$ as the following equation:

$$WBGT_{out} = 0.7\,T_{nwb} + 0.2\,T_g + 0.1T_{db}$$

$$WBGT_{in} = 0.7\,T_{nwb} + 0.3T_g$$

Where:

T_{nwb} = Natural wet-bulb temperature

T_g = Globe temperature

T_{db} = Dry bulb temperature

Natural wet bulb temperature (T_{nwb}) is the temperature that allowed the air flow over the sensor naturally rather than being force. It is very sensitive to relative humidity and air movement. While radiant heat is detected by globe temperature (T_g) from the solid surroundings and convective heat with the ambient air. Dry bulb temperature (T_{db}) is function to measure air temperature directly from the environment.

2.7 Metabolic Rate

Metabolic rate is define as a rate of internal heat generation from the body to maintain thermal equilibrium with surrounding (Barbara & Patricia, 2002). Metabolic rates can be measured by estimation of ACGIH created a Threshold Limit Value (TLV) which included an empirically-derived table of tasks to be converted into metabolic rate (kcal/min). The three components to consider are base metabolism value, body position or movement and type of work being performed (Table 2.1).

Table 2.1: Guideline for metabolic rate based on body position or movement and type of work being performed.

Body Position and Movement	Kcal/min	
Sitting	0.3	
Standing	0.6	
Walking	2.0-3.0	
Walking uphill	Add 0.8 for every meter rise	
Type of work	**Average kcal/min**	**Range kcal/min**
Hand work		
Light	0.4	0.2-1.2
Heavy	0.9	
Work: One Arm		
Light	1.0	0.7-2.5
Heavy	1.7	
Work: Both arms		
Light	1.5	1.0-3.5
Heavy	2.5	
Work: Whole body		
Light	3.5	2.5-15.0
Moderate	5.0	
Heavy	7.0	
Very Heavy	9.0	

For a "standard" worker of 70kg body weight (154 lbs) and 1.8m^2 body surface (19.4ft^2).

Source: ACGIH 1992

The following equation showed calculation average metabolic rate:

$$\text{Average} = \frac{(M_1)(t_1) + (M_2)(t_2) + \ldots + (M_n)(t_n)}{t_1 + t_2 + \ldots \ldots t_n}$$

Where: M = metabolic rate

t = time in minutes

Then, the averaging metabolic rates for the tasks that had been calculated were categorised in light work (up to 200kcal/hour), medium work (200-350 kcal/hour) or heavy work (350-500kcal/hour).

2.8 Physiological Changes

Physiologically, the body reacts to heat through a thermoregulatory response which its initiated central nervous system and body's heat loss mechanisms of vasodilation and perspiration (Boulant, 2000; Romanovsky, 2007). The major adaptive mechanisms of the body are peripheral blood circulation and sweating (ACGIH, 1992). When temperature of the body increase, the blood flow to the skin surface also is increases. The increase in blood flow to the surface of skin is at the expense of the circulatory system and other organ to eliminate heat to the environment by convection and radiation (Ramsey & Bernard, 2000).

Natural method for cooling the temperature of the body are convection, conduction and evaporation of sweat which it only happen when air temperature is higher than 35°C. This evaporation process will lead to the loss of water and electrolyte in the body such as sodium and chloride where they are responsible to kept fluid balance in the human body. (Tawatsupa et al., 2012). Sweating is also adaptive mechanism which initiated when evaporation is required. It will evaporate from the skin as long as the conditions are not excessively humid (Bird, 2002). Heart rate is another physiological indicator of the body mechanism closely associated with heat stress which it is considered a rapid physiological response to the heat (U.S. Department of Labor,1999; Givoni 1973 & International Labor Organization, 1983).

2.8.1 Core Body Temperature

Core body temperature is a one of the physiological changes in the heat stress which is used to describe internal body temperature. Internal body temperature is the best measurement for heat strain which it indicates the total heat content of the body (Bishop, 1997). Ishii et al. (1993) reported that the validity of mean ear canal temperature as a stable measure of mean core temperature. A correct reading of ear canal temperature may be more important than rectal temperature which actually reflect the brain temperature (Knochel,1996). The limit of the temperature is 38°C which is sustained over the course of the work day (Barbara & Patricia, 2002).

NIOSH (1986) also stated that deep body temperature exceed 38°C was unacceptable for an average industrial workforce. The range of core body temperatures between that which triggers shivering and initiates sweating is called inter-threshold zone which the autonomic nervous system is aims to maintain core body temperatures within these limits (Andrew, 2011). Kakitsuba et al. (2007) explored this concept in relation to core body temperature and skin temperature inter-threshold zone where the core inter-threshold range between 36.5 ± 0.17°C for initiate the shivering, and 37.5 ± 0.7°C to initiate sweating.

2.8.2 Heart Rate

Heart rate is one of the indicators in heat strain which it will determine by several factors at any given time. Four methods proposed for assessing heart rate are in use that consists of recovery heart rate, peak heart rate and average heart rates over 8 hours duration (NIOSH, 1986). Another method to evaluate is a set of averaged heart rates over a typical exposure period. Recovery heart rate is a tool for recognition. To demonstrate effective control of heat stress, the recovery heart rate at one minute (HRR1) should be less than 110 beat per minute (bpm). Alternatively, the heart rate at three minutes (HRR3) should be less than 90 bpm or the value of HRR1 – HRR3 should be at least 10 bpm (Barbara & Patricia, 2002).

If the daily average heart rate exceeds 110 bpm, then heat stress or very strenuous work may be is the root cause. This limiting average has been recommended by the WHO experts and confirmed in laboratory and field studies. The thermal rise in heart rate closely related to increase in core body temperature, with a 33 bpm increase in heart rate corresponding to a 1°C increase in body temperature (DiCorleto et al., 2003; International Organisation for Standardisation, 2004). Bishop (1997) and WHO (1969) also stated that heart rate is closely reflect the changes of body core temperature which making heart rate is the best index of physiological strain. The heart rate drift when exercising was closely related to the rise in body temperature which the greater heart rate probably increase the cardiac output is observed (Boivert et al., 1993). However, heart rate can be confounded by medication, physical fitness and disease state of the individual (Bernard & Kenny,1994).

2.8.3 Blood Pressure

Blood pressure is the fierce caused by blood pushing up against the walls of blood vessels (Green et al., 1996). In short term of heat exposure, there is an increase in blood circulation at exercising muscle areas, and this is met by a decrease of blood circulation at the renal, splanchnic and non-exercising muscles. When the body is over exposed to the heat, blood will increase and flow to the skin to lose the excess heat and to maintain the stability of the internal environment. Warm blood from the body core can then be cooled from the skin, which acts as a radiator (Gary & Kevin, 1997). Increased body temperature is a form of stress that triggers the sympathetic nervous system and induces physiological changes which the most obvious is cardiovascular response (Rowell, 1990). Researchers have shown that during heat stress, peripheral vascular resistance is reduced and blood volume shifts from the central body to the periphery to facilitate heat exchange (Luurila, 1992).

2.9 Heat Related Illness

Heat related illness is a condition where it results from the accumulative effects of heat in the body and inability of the body to maintain normal body temperature because of excess heat production and less heat transfer to environment (Hoa et al., 2013). From the relatively minor heat rash and cramp, to the critical heat exhaustion and heat stroke, heat related illness can present with headache, nausea, fatigue, loss of consciousness, and in extreme cases death (Andrew, 2011).

These symptoms are primarily caused by the effect of dehydration, an excessive rise in body temperature or both (Backer et al., 1999; Andrew, 2011). When the body temperature above 39°C, acute heat related illness may occur. While 40.6°C of core body temperature, it can lead to life-threatening severe hyperpyrexia or thermal injury (Leithead & Lind, 1964). The worst manifestation in heat related illness is a heat stroke. About 20% of those who have suffer heat stroke, they will also experience damage in vital organ such as heart, liver, kidneys or nervous system (Yeo, 2004). Figure 2.9 is a simple illustration of normal responses to the heat stress in the body and how it can lead to the heat related illness (Barbara & Patricia, 2002).

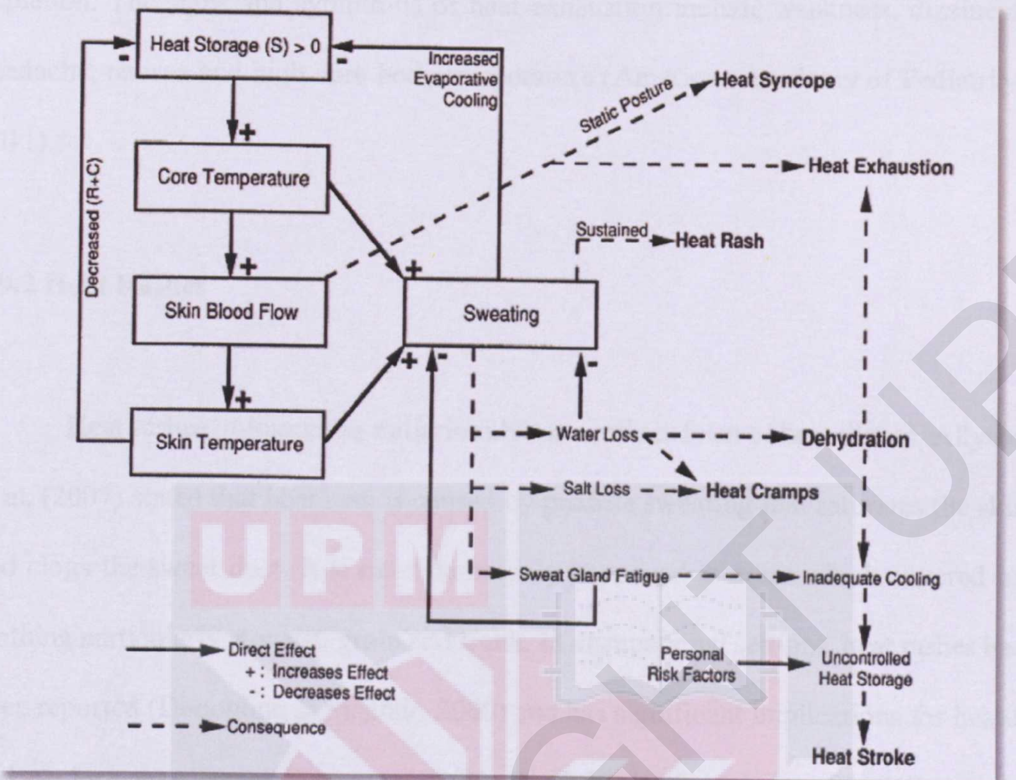

Figure 2.9: Normal responses to heat stress exposures and how they can lead to heat-related disorders.

2.9.1 Heat Exhaustion

Heat exhaustion is defines as depletion of water or salt when the body subjected exposed to the more heat that it can handle. Commonly, this situation happened in high environment temperatures followed by high humidity (Bauchama & Knochel, 2002). Heat exhaustion is a moderate heat illness which it occurs when blood pressure and sustain adequate cardiac output are unable to maintain. This results from strenuous physical activity, high temperature of environment, acute dehydration and energy depletion. The signs and symptoms of heat exhaustion include weakness, dizziness, headache, nausea and high core body temperature (American Academy of Pediatrics, 2011).

2.9.2 Heat Rashes

Heat rashes or known as miliaria rubra is a milder form of heat illness. Allyson et al. (2007) stated that heat rash is caused by profuse sweating that saturates the skin and clogs the sweat duct. It is most commonly happened in areas which covered by clothing particularly at waist, groin and trunk. In occupational settings, heat rashes had been reported (Donoghue & Sinclair, 2000) and has significant implications for health and performance (Pandolf et al., 1980a). Pandolf (1980b) also reported that body temperature and body heat storage were elevated in the affected subject and this condition can bring to the high risk of heat illness where the subjected can collapse if returning to the work before the renewal of the sweat ducts is complete.

2.9.3 Dehydration

Dehydration is a water loss in the body and insufficiently replaced which it can lead to reducing level of water in the body below the normal range (Andrew, 2011). Sweat range is estimated in between 0.5 to 2.0 litre per hour (ℓ/hr) in occupational settings (Brake & Bates, 2003; Kalkowsky & Kampmann, 2006) which the rate of sweat was became higher during wearing protective clothing that drastically limits the heat loss by evaporation (Kenefick & Sawka, 2007) and it is similar values been estimated in variety of sport settings (Sawka et al., 2007). Sawka et al. (1985) observed that the core body temperature increases with the extent of dehydration which the body temperature increase up to 0.15°C for each 1% decrease in body mass due to sweat loss.

Dehydration decrease the sweating rate and blood flow responses to heat stress. Level of mean sweat rate has been proven by many studies which is it decrease with body mass loss (Gonzalez-Alonso et al., 1995; Montain et al., 1995; Sawka et al., 1985). The threshold core body temperature at which sweating can raised when dehydrated (Montain et al., 1995). Gonzalez-Alonso et al. (1997) reported that dehydration also affect blood flow to the skin which reducing stroke volume during heat stress when dehydrated. As a results, heart rate is increased to maintain cardiac output, but it tends to decline with dehydration.

2.9.4 Heat Cramps

Micheal et al. (1998) defines heat cramps as a spasm of muscles of the arms, legs or abdomen which are a warning sign of developing heat stress. Muscle spasm or cramps are painful and involuntary contraction of skeletal muscle that happened commonly among athletes and in occupational settings which involve prolonged activity when exposed to the heat stress (Schwellnus et al., 2004; Cooper et al., 2006; Donoghue et al., 2000). Proponents of dehydration and electrolyte depletion theory by

Bergeron (1996) and Shearer (1990) give evidence that cramps occur during activity which involve profuse sweating and depletion of salt due to hypotonic fluid replacement.

2.9.5 Heat Syncope

Macknigt and Mistry (2005) stated that heat syncope occurs with orthostatic hypertension resulting from venous pooling and peripheral vasodilation. Prolonged standing after significant exertion and rapid change in position of the body after exertion may lead to heat syncope. It is usually preceded by light headedness and weakness (Barrow & Clark, 1998).

2.9.6 Heat Stroke

American Academy of Pediatrics (2011) defines heat stroke as a severe heat illness which characterised by abnormalities of central nervous system such as coma, convulsion, endotoxemia, circulatory failure, organ and tissue damage which results from high core body temperature (>40°C) and high environmental heat stress. Heat stroke is a life-threatening medical emergency which happened when the body generate or exposed to the more heat than it can handle (Bauchama & Knochel, 2002). It is usually happened more common among generally healthy person such as athletes and individual who usually do strenuous activity outdoors. Heat stroke can cause the individual may not be impaired when sweating and unable to cool down quickly enough after doing activity which it can happened even in moderate temperature during heavy activity (Williams, 1997).

2.10 Personal Factors

The main variables of interest in monitoring heat stress on respondents are core body temperature, heart rate and blood pressure. The results of these variables will be different between individuals depends on the heat exposure. However, individual's risk on heat stress also can be influence by personal factors. Bernard and Kenny (1994) and Windham (1974) discovered that acclimatization, prescription drugs, illness or disease, age, and diet can give negatively impact on an individual's thermoregulation and directly influence the degree of heat strain experienced.

2.10.1 Acclimatisation

The process of adaptation to any condition especially weather is known as acclimatisation (Armstrong, 2000; Moran et al., 1998). Sawka et al., 1996 and Wenger et al. (1988) stated that human have remarkable ability to adapt to heat stress by giving adequate water and sun protection which a healthy acclimated persons can tolerate to the extended exposure in any natural weather related with the heat stress. The physiological adaptations from acclimatisation will reduce the heat strain experienced by the individual, increase their tolerance to work in heat, and lower the risk of developing heat illness.

However, the adaptations are failure if exposure is not consistent or discontinued (Andrew, 2011). NIOSH (1986) and WHO (1969) also stated that when the exposure to heat stress ends after three and four weeks, adaptation to heat stress physically will be gradually disappeared. On the other hand, recent studied showed that the favourable acclimatisation effect on heart rate and temperature of body were still detectable 26 days after the most recent heat exposure (Weller et al., 2007). The acclimatisation raises the sweat rate of individuals working in heat, lowers the threshold for sweating initiation and increase the sensitivity of the response (Nielsen et al., 1993; Fumio & Kunshige, 2003). Heat acclimatisation occurs over a period of time where its approximately take 7 – 14 days. However, majority of adaptations takes around 4-6 days (Armstrong & Maresh, 1991; Moran et al., 1998).

2.10.2 Drugs

Drugs is the one of the factors that can contribute to the interfering processes of thermoregulatory in the individual's body. It is including antidepressants and bronchodilators which can alter the reading of heart rate and decrease the sweat rate. Drugs for heart blood pressure such as beta blockers can reduce the flow of blood to the skin and directly reducing convective cooling (Eric, 2013). Platt et al. (2010) stated that anti-histamines can both reduce the level of blood flow and increase body temperature as well as diuretic medications which will change the balance of fluid in the body.

2.10.3 Disease

If an individual is suffering from cardiovascular disease (CVD) and diabetic, their thermoregulatory response may affected which it will take them to high risk in heat related illness compared to healthy person. Same goes to hypothyroidism and hyperthyroidism which affect metabolism and directly affect the level of body temperature. Anemia is a disease which an individual having a lower count of red blood cell which also give effect to metabolism and cardiovascular as well as thermoregulatory response (Platt et al., 2010).

2.10.4 Age

Many studies were already conducted the effect of aging on heat tolerance by comparing the difference group of ages for their blood flow and sweating rate response when exposed to the heat. The results showed over 55 years old group had lower response in blood flow to the skin compared to the group less than 30 years old (Ho et al., 1997; Kenny & Ho, 1995; Kenny et al., 1997; Thomas et al., 1999). Similar findings also have been found between those age group when exposed to the passive heat (Inoue et al, 1998; Martin et al., 1995). Aging will give results in lower sweat rates, but increased that blood flow rates to the skin.

Besides, total amount of water in the body will decreases with age which may gave affect to the individual' body (Brothers et al., 2011). Previous study had proven that the sweating response differs between age group which older subjects, more than 52 years old, showed lower response in sweating rates compared to young subjects, less than 30 years old when exposed to heat during exercise (Inoue et al., 1999a; Tankersley et al., 1991). However, the number of heat activated of sweat gland still similar between age group and the difference only the sweat gland output decreases by age (Anderson & Kenny, 1987; Inoue et al., 1991; Kenny & Fowler 1988).

2.10.5 Diets

Many studies have investigated the effect of caffeine or coffee on heart rate and blood pressure acutely. Carrillo and Benitez (2000) found that the heart rate is increase slightly after caffeine intake among respondents. The results of the acute studies indicate that caffeine can induced increasing in systolic reading between range 5 to 55 mmHg and 5-10mmHg for diastolic blood pressure reading (James 1991c, Green et al., 1996).

CHAPTER 3

METHODOLOGY

3.1 Study Design

This is a cross sectional study where the exposure and the health effects was measured and observed at the specific point of time.

3.2 Study Location

This study was conducted in the Palm Oil Mill in Negeri Sembilan, Perak and Selangor.

3.3 Study Population

The study population involve the workers at palm oil mill who were exposed to the high level of temperature at the work area.

3.4 Sampling

3.4.1 Sampling Frame

The sampling frame was taken from the name list of all employees working at the Palm Oil Mill. The name lists will be obtained from the Human Resources Department of the mill.

3.4.2 Sampling Design

The respondent was selected using purposive sampling who have fulfilled the following inclusion criteria:

a) Male workers
b) Worker that employed not less than 3 months (ACGIH, 2001)
c) Age between 18-55 years old

d) Workers who are exposed to high temperature (≥28°C) at the workplace.

e) Has not been diagnosed with hypertension, diabetes and heart disease.

3.4.3 Sampling Unit

The workers in the workplace who are exposed to the high level of temperature during work shift were selected as a sampling unit.

3.4.4 Sampling Size

Study of sample size is determined by using Snedecor and Cochran (1982) formula. Calculation of sample size is done by using 95% confident interval (probability $\alpha \leq 0.05$).

$$N = \frac{4\,\delta^2}{L}$$

$$N = \frac{4\,(16.06)^2}{(5)^2}$$

$$= 41.27$$

$$\approx 41$$

Where;

N = Sample Size

δ = Standard deviation of systolic blood pressure (Siti Fawziah, 2002)

L = Level of significant is 5%.

Based on above calculation, the value of Standard Deviation was taken from the Siti Fawziah (2002) studied where the value of variable (systolic blood pressure after eight hours working) gave the bigger sample size compare to other variables (Table 3.1). Calculation of sample size is done by using 5% level of significance. Since this study was conducted in three mills, there are several factors that had been taken into consideration in adjusted the sample size based on the number of sample size above.

N = Palm Oil Mil 1 + Palm Oil Mill 2 + Palm Oil Mill 3

= 41 + 41 + 41

= 123 respondents

From the formula above, the sample size of this study should be around 123 respondents for three palm oil mills.

Table 3.1: The value of sample size based on Standard Deviation for each type of variables from the Siti Fawziah (2002) studied.

Type of Variable	Standard Deviation	Sample Size
Core body temperature		
Before shift	0.60	0.06
After 2 hours working	0.40	0.03
After 8 hours working	0.50	0.04
Blood Pressure		
Before shift	14.80	35.05
After 2 hours working	13.97	31.23
After 8 hours working	**16.06**	**41.27**
Heart rate		
Before shift	3.96	2.51
After 2 hours working	4.89	3.83
After 8 hours working	3.44	1.89

3.5 Instrumentation

3.5.1 Questionnaire

A self-constructed questionnaire was used in this study which consists of four (4) parts:

a) Part A: Socio demographic

b) Part B : Occupational information

c) Part C : Health Information

d) Part D : Lifestyle information

e) Part E : Heat Related Illness complaints

These questionnaires were distributed to the respondents and required them to fill the informations as mentioned above.

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d) Part D : Lifestyle information

e) Part E : Heat Related Illness complaints

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3.5.2 Thermal Environmental Monitor

The environmental temperature was measured by using QUESTemp°34 Thermal Environment Monitor which calculate the value of Wet Bulb Globe Temperature (WBGTin) (Figure 3.1). This instruments was fixed at 1.1 meter by using tripod at every work station. This instrument is placed between the heat source and workers in that particular area for eight hours.

Figure 3.1: QuestTemp°34 Thermal Environment Monitor

3.5.3 Air Velocity Meter

TSI Velocicalc® Air Velocity Meters was used in this study to measure level of air velocity of the work area (Figure 3.2). The measurement was taken in three session which in the morning, at afternoon and in evening.

Figure 3.2: TSI Velocicalc® Air Velocity Meters

3.5.4 Personal Body Core Meter

Omron MC-510 Gentle Temperature Ear Thermometer was used to measure respondent body core temperature (Figure 3.3). Measurement of body core temperature was taken before, during and after work shift where the sensor was inserted into the respondent's ear when taking a temperature reading.

Figure 3.3: Omron MC-510 Gentle Temperature Ear Thermometer

3.5.5 Heart Rate Monitor Watch

POLAR Heart Rate FT60 was used in this study to measure heart rate of respondent in beat per minute (bpm) (Figure 3.4). The measurement was taken before work shift, 2 hours after work shift and 8 hours after work shift.

Figure 3.4: POLAR Heart Rate FT60

3.5.6 Blood Pressure Monitor

OMRON T3 Automatic Blood Pressure Monitor was used to measure blood pressure of the respondents (Figure 3.5). The cuff was fastened onto the left arm when taking the blood pressure measurement. The respondents were asked not to eat and drink for at least 15 minutes before the measurement.

Figure 3.5: OMRON T3 Automatic Blood Pressure Monitor

3.5.7 Weighing Scale and Height Meter

The SECA Body Meter was used to measure the height, while SECA Body Weighting was used to measure the weight of respondent (Figure 3.6 & Figure 3.7). Both of this data then will be used to calculate the Body Mass Index (BMI) of the respondents.

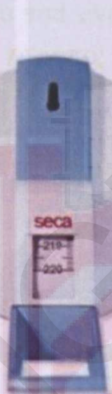

Figure 3.6: SECA Body Meter

Figure 3.7: SECA Body Weighting

3.6 Quality Control

3.6.1 Pilot Study

Prior to the actual data collection from the research, a pilot study was conducted on 10% of the workers at palm oil mill. The respondents was tested on the self-constructed questionnaire to observe and evaluate their level of knowledge and understanding towards the questionnaire. The questionnaire of heat related illness was found to be highly reliable (21 items; $\alpha = .823$).

3.6.2 Calibration

All the instrument that use in this study was calibrated first before the actual data collection is made. This is because, calibration is very important to ensure that the instrument in good condition when collecting the data, eliminate any possible error of data and give an accurate results during sampling. Each instrument that use in this study was calibrated based on the standard procedure that already given.

3.6.3 Standard Operating Procedure (SOP)

The Standard Operating Procedure, SOP was followed during the measurement. SOP for QuestTemp°34 Thermal Environment Monitor had been provided by Quest Technologies. This SOP was circulated from NIOSH standard.

3.7 Data Analysis

All the data gathered from questionnaire and measurement was analysed by using IBM SPSS (Statistical Package for the Social Sciences) Version 22 software. The assumption of normality for significance level was (p>0.05). Since all the data were normally distributed, parametric test was used. The types of data analysis that was used in this study are shown in the following Table 3.2.

Table 3.2: Types of data analysis

Variable	Type of analysis
To determine socio demographic data of respondents.	Descriptive Analysis
To determine the heat stress index (WBGTin) and metabolic workload at each work section in palm oil mill.	Descriptive Analysis
To determine the air velocity and relative humidity at each work section in palm oil mill.	Descriptive Analysis
To determine the correlation between WBGTin and air velocity.	Pearson Correlation
To determine the prevalence of heat related illness among workers when exposed to heat.	Descriptive Analysis
To determine physiological parameters between before shift, after 2 hours working and after 8 hours working among respondents.	Descriptive Analysis
To compare the differences of blood pressure before shift, after 2 hours working, and after 8 hours working among workers exposed to heat.	Repeated Measure ANOVA
To compare the differences of heart rate before shift, after 2 hours working, and after 8 hours working among workers exposed to heat.	Repeated Measure ANOVA
To compare the differences of core body temperature before shift, after 2 hours working, and after 8 hours working among workers exposed to heat.	Repeated Measure ANOVA

3.8 Study Limitation

3.8.1 Information bias

The information bias can happened when the respondent may not remember some important information related to this study or their answer given do not reflect the situation that they are facing. This scenario can give effect to the outcome of this study. Besides, they also may reluctance to tell undesirable social behavior such as consumption of alcohol and drug.

3.8.2 Smoking

Smoking will temporarily increase the blood pressure and heart rate of the smoker (WebMD, 2014). Moo-Yong et al. (2006) stated that smoking caused a significant acute increase of heart rate and systolic blood pressure at 15 minutes after smoking. However, the blood pressure will return to the normal level when they stop smoking. Thus, respondent was asked not to smoking for an hour before the measurement taken.

3.8.3. Diet

Diet can influence the reading of physiological which involve high caffeine of drink or food. Emmanouil et al. (2005) indicated that systolic blood pressure was significantly high in caffeinated consumption compared to the decaffeinated respondents. This is because caffeine is a stimulant drug that influences the nervous system to increase heart rate and blood pressure (Livestrong.com, 2014). Besides, consumed large quantities of food, may also increase the heart rate reading. Heart rate can rise above 100 beats per minute, reaching a tachycardic rate due to the effects of eating. Therefore, the respondents were asked not to take any food and drink for 30 minutes before measurements were taken.

3.8.4 Anxiety

Anxiety is a feeling that respondents may feel when their physiological measurements were taken by the researcher which also known as white coat syndrome. This phenomenon can elevated the blood pressure to high reading even the respondents were not in high blood pressure condition. It cannot be eliminated but it can be reduced by asking the respondents to relax and calm down within 5 to 10 minutes and the physiological measurements should take at three times to get the accurate reading.

3.9 Research Ethics

This study was approved by Ethic Committee for Research involving Human Subjects of Universiti Putra Malaysia (JKEUPM) on January 10^{th}, 2014. A written consent forms of participant for this study was given to the respondents. The respondents were given and explanation about the entire of process measurement and evaluation along this research. All the information and identity used in this study were remain confidential.

CHAPTER 4

RESULTS

4.1 Socio-Demographic Data of Respondents

All the respondents are Malaysian, Malay and male in the age group between 21 to 55 years old. Among the eighty-eight respondents, majority of them were below 29 (34.1%) years old. Most of them (83.0%) had completed education until secondary school. Half of the respondents had a normal BMI in the range of 18.5 to 24.9 kg/m^2. Majority of the respondents have been working for 1-12 years (67.0%). The detail background information of the respondents are presented in Table 4.1.

Table 4.1: Socio-demographic of the workers who participated in the study (N=88)

Variables	Frequency (n)	Percentage (%)
Age group (years)		
≤ 29	30	34.1
30-38	11	12.5
39-47	21	23.9
≥ 48	26	29.5
Education		
No formal education	2	2.3
Primary school	8	9.1
Secondary school	73	83.0
Higher education	5	5.7
Body Mass Index		
Underweight (<18.5)	5	5.7
Normal (18.5-24.9)	47	53.4
Overweight (25.0-29.9)	28	31.8
Obese (>30)	8	9.1
Duration of employment (years)		
1-12	59	67.0
13-24	17	19.3
≥ 25	12	13.6

4.2 WBGTin and Metabolic Workload in Each Work Section

The Table 4.2 present Heat Stress Index value (WBGTin) for every work section in palm oil mills. The WBGTin results indicated that the temperature lies between 30.0°C to 35.7°C and the mean value was 32.0°C. The results show that all work sections had been exceeded the Threshold Limit Value (TLV) by ACGIH which 28.0°C for moderate metabolic workload level. The moderate metabolic workload category in this present study was range between 200.10 to 208.5 kcal/hour. Overall, the work regimen involve for all work section was 75% work, 25% rest regimen.

Table 4.2: Exposure profile for WBGTin and metabolic workload at various work sections.

Work section	Metabolic workload (kcal/hour)	Metabolic Workload Category	WBGTin (°C)
Loading RAMP	200.10		30.67 ± 0.55*
Sterilizer	200.23		30.73 ± 2.25*
Press Station	203.50		33.93 ± 4.47*
Oil Room	203.30	Moderate	32.17 ± 3.73*
Kernel Plant	201.17		30.00 ± 0.66*
Boiler	208.45		35.67 ± 4.36*
Workshop	204.71		30.77 ± 2.44*

* WBGTin is above the standard ACGIH, Threshold Limit Value (TLV) = 28.0°

4.3 Air Velocity and Relative Humidity in Each Work Section

The distribution of air velocity data and relative humidity at each work section is illustrated in Table 4.3. The range of air velocity was 0.2733 to 0.559 meter per second (m/s). The highest value was identified in Boiler Section and the lowest value in Workshop. Overall, the mean reading for the air velocity was 0.3689 m/s. Meanwhile, in the relative humidity results it showed that the mean value was 82.76%. The Oil Room (89.67%) was identified as a high value of relative humidity among all work sections, followed by Workshop (87.00%) and Loading Ramp (84.67%).

Table 4.3: Exposure profile for air velocity and relative humidity at various work sections.

Work section	Air Velocity (m/s)	Relative Humidity (%)
Loading Ramp	0.31 ± 0.13	84.67 ± 2.889
Sterilizer	0.36 ± 0.07	81.67 ± 13.503
Press Station	0.30 ± 0.10	74.33 ± 23.116
Oil Room	0.37 ± 0.12	89.67 ± 2.082
Kernel Plant	0.42 ± 0.25	79.00 ± 21.932
Boiler	0.56 ± 0.29	83.00 ± 13.229
Workshop	0.27 ± 0.05	87.00 ± 4.359

4.4 Correlation between WBGTin and Air Velocity

The correlation between WBGTin and air velocity results was showed in Table 4.4. The results indicated that there is a no significant correlation between WBGTin and air velocity ($r(21) = 0.45$, $p = 0.86$).

Table 4.4: Correlation between WBGTin and air velocity

Variable	Mean ± S.D	*r*	*p*
WBGTin	31.99 ± 3.22	0.45	0.86
Air Velocity	.369 ± .166		

p-value is not significant at p>0.05

4.5 Prevalence of Heat Related Illness

The Table 4.5 represent the prevalence of heat related illness among workers when exposed to heat. The highest prevalence of heat related illness complaints among workers when exposed to the heat was heat exhaustion (86.4%), followed by dehydration (78.4%), heat cramps (61.4%) and heat rashes (38.6%). Meanwhile, heat stroke (4.5%) was the least heat related illness reported by the workers.

Table 4.5: Prevalence of heat related illness complaints among workers (N=88)

Heat Related Illness	Frequency (n)	Percentage (%)
Heat Exhaustion	76	86.4
Heat Stroke	4	4.5
Dehydration	69	78.4
Heat Rashes	34	38.6
Heat Syncope	25	28.4
Heat Cramps	54	61.4

4.6 Differences of Core Body Temperature, Heart Rate and Blood Pressure Between Before Shift, After 2 Hours and After 8 Hours Working.

The results of mean in three parameters of physiological between three different sessions is presented in Table 4.6. Meanwhile, the results for differences of physiological measurement is illustrated in Table 4.7 by using a repeated measure ANOVA with a Greenhouse-Geisser correction. There was significant differences ($p<0.001$) of core body temperature, heart rate and blood pressure between before shift, after 2 hours working, and after 8 hours working. Thus, the post hoc tests using the Bonferroni (Table 4.8) was used to determine the significant differed between three sessions.

4.6.1 Differences of Core Body Temperature between Before, After 2 Hours and After 8 Hours Working among Workers.

The results revealed that mean was differed statistically significantly ($F(1.86, 162.18) = 14.79$, $p<0.001$) between sessions in core body temperature. A post hoc Bonferroni correction test showed that the core body temperature before shift (35.97 ± .57°C) was significantly ($p<0.001$) differences to after 2 hours working (36.23 ± .56 °C) and after 8 hours working (36.26 ± .52°C). However, only a slight increased occurred in core body temperature from 2 hours working to after 8 hours working which was not statistically significant ($p = 1.00$).

4.6.2 Differences of Heart Rate between Before, After 2 Hours and After 8 Hours Working among Workers.

The results showed that the heart rate significantly differed across time $F(1.78, 154.79) = 22.38$, $p < .001$. A post hoc Bonferroni correction test indicated that heart rate had been slightly increased from after 2 hours working (86.89 ± 11.27 bpm) to after 8 hours working (88.64 ± 1.50°bpm) which was not differed in significant ($p > 0.05$). However, the mean value before shift (80.99 ± 11.08 bpm) had been drastically increased which was significantly different between after 2 hours working ($p < 0.001$)

and after 8 hours working (p <0.001). Hence, it emphasized that there is a significant different of heart rate between before shift, after 2 hours and after 8 hours working.

4.6.3 Differences of Blood Pressure between Before, After 2 Hours and After 8 Hours Working among Workers.

A repeated measures ANOVA with a Greenhouse-Geisser correction determined that mean blood pressure statistically significantly difference over time ($F(1.77, 153.852) = 34.114$, $p < 0.001$). Post hoc tests using the Bonferroni correction showed that the significant differences (p<.001) between before shift (117.26 ± 8.65 mm Hg) with after 2 hours working and after 8 hours working. However, there is no significantly (p=1.00) difference between after 2 hours (130.58 ± 14.92 mm Hg) and after 8 hours working (130.40 ± 15.60 mm Hg).

Table 4.6: Descriptive profile of core body temperature, heart rate and blood pressure between before shift, after 2 hours and after 8 hours working

Variable	Mean ± S.D.
Core body temperature	
Before shift	35.9670 ± 0.57230 °C
After 2 hours working	36.2284 ± 0.56262 °C
After 8 hours working	36.2636 ± 0.51866 °C
Blood Pressure	
Before shift	117.26 ± 8.650 mmHg
After 2 hours working	130.58 ± 14.916 mmHg
After 8 hours working	130.40 ± 15.602 mmHg
Heart rate	
Before shift	80.99 ± 11.077 bpm
After 2 hours working	86.89 ± 11.268 bpm
After 8 hours working	88.64 ± 14.105 bpm

Table 4.7: The differences of core body temperature, heart rate and blood pressure between before, after 2 hours and after 8 hours working

Variables	MD ± SE	*p*	*F*
Core body temperature			
Before shift – after 2 hours	-.261 ± .051		
Before shift – after 8 hours	-.297 ± .065	<0.001***	14.786
After 2 hours – after 8 hours	-.035 ± .062		
Heart rate			
Before shift – after 2 hours	-.5898 ± 1.010		
Before shift – after 8 hours	-7.648 ± 1.375	<0.001***	22.384
After 2 hours – after 8 hours	-1.750 ± 1.180		
Blood Pressure			
Before shift – after 2 hours	-13.318 ± 1.912		
Before shift – after 8 hours	-13.136 ± 2.087	<0.001***	34.110
After 2 hours – after 8 hours	.182 ± 1.500		

***P value is significant at p<0.001

Table 4.8: Post hoc test (Bonferroni correction) of physiological parameters at three different sessions

Variable (Pair)	*p*
Core body temperature	
Before – after 2 hours	<0.001***
Before – after 8 hours	<0.001***
After 2 hours – after 8 hours	0.571
Heart rate	
Before – after 2 hours	<0.001***
Before – after 8 hours	<0.001***
After 2 hours – after 8 hours	0.904
Blood Pressure	
Before – after 2 hours	<0.001***
Before – after 8 hours	<0.001***
After 2 hours – after 8 hours	0.142

***P value is significant at p<0.001

CHAPTER 5

DISCUSSION, CONCLUSION AND RECOMMENDATION

5.1 Discussion

5.1.1 Socio-demographic data of respondents

The eighty-eight out of ninety-five respondents were selected to participate in this study. The inclusion criteria was respondents should not been diagnosed with hypertension, diabetes and heart disease, exposed to high temperature at the workplace, and employed not less than 3 months. The seven workers were excluded due to not fulfil this criteria. The response rate for this study was 71.54%. This showed that the response rate was a bit lower than expected (>80%).

This study had been conducted on respondents aged between 21 and 55 years old. The mean age of respondents was 38.58 years which considered as average for the working population. In 2011, Analysis of Labour Force in Malaysia stated that more than 57% of the employed person comprised of aged 25 years and older, which showed that the average age is well with this respondents' population (Department of Statistics Malaysia, 2014). However, the respondents aged above 55 years old was excluded in this study because previous studied prove that this age group had lower response in blood flow to the skin compared to the group less than this aged (Kenny et al., 1997 & Thomas et al., 1999).

About half of the respondents in this study are within the normal BMI. The BMI had influenced in body response to heat stress. Chung and Pin (1996) and Bar-Or et al. (1968) stated that obese individuals had high risk in heat stress due to the fat layer composition and lower density of sweat glands which can decrease heat loss. The duration of the employment for all workers in the palm oil mills was one year and above. Majority of them had completed education until secondary school (83.0%). This results are similar with Labour Force Participation Rate (LFPR) Malaysia 2011 where the secondary education recorded the highest increase compare to other level of education (Department of Statistics Malaysia, 2014).

5.1.2 WBGTin and metabolic workload in each work section

In this present study, the mean value of WBGTin for whole work sections was 31.99 ºC. Based on the ACGIH (American Conference of Govermental Industrial Hygienists) (as cited in U.S. Department of Labor,1999), all of the temperature in work sections were exceeded the Threshold Limit Value (TLV) (>28.0°C) for moderate metabolic workload level with 75% work, 25% rest regimen.

The highest value for WBGTin was recorded in Boiler Section (35.67°C) where the process involve 102.6°C at 299.5 psi and followed by Press Station (33.93°C) where the workers were exposed the steam heated generate by the machine with 80°C-100°C. Kishor et al. (2012) and Srivatsa et al. (2000) concluded that the factory which involve with furnace in their process such as industrial boiler can be major contributor to heat stress which is also known as radiant heat source. The radiant heat is a main element of the high temperature which can cause overheating although the air temperature is low (WorkSafeBC, 2007). Plus, workers contact with the source of radiant heat in Boiler Section and Press Station was very close compare to other work sections (Figure 5.1, Figure 5.2, and Figure 5.3). Previous study stated that, an individual who exposed to the high temperature can lead to the decreasing in job performance (Geoffrey & Jisung, 2014) and task productivity (Wendt et al., 2007).

The standard value (ACGIH) for moderate metabolic workload category was between 200-350kcal/hour which the temperature should 28°C and below and the metabolic workload range for this study was between 200.10 to 208.5 kcal/hour which the mean temperature was 31.99ºC. Thus, the heat exposure level with moderate workload category in this study was not suitable for 8 hours duration of the workers in palm oil mill.

Figure 5.1: The worker is cleaning up the stone from the furnace.

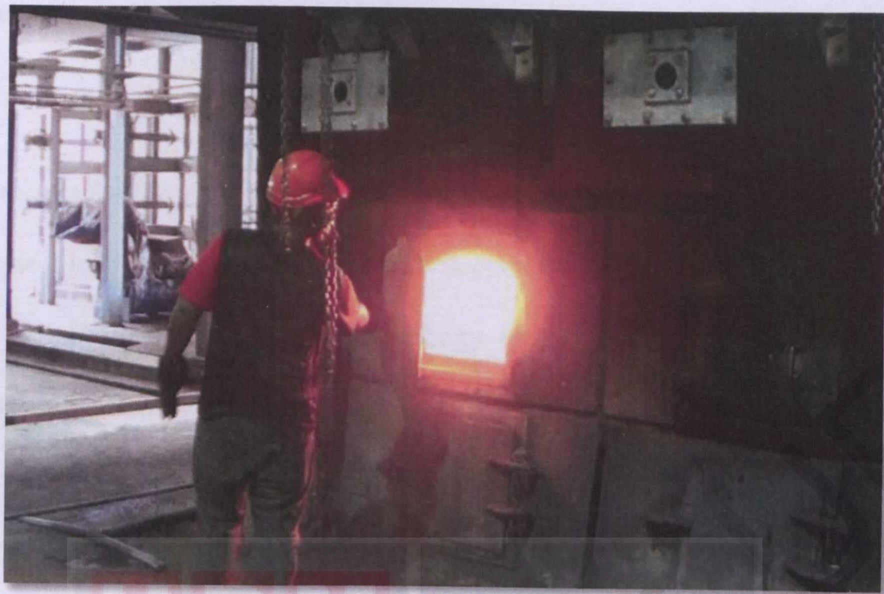

Figure 5.2: The worker is opening the furnace's door which involve close distance from the source of heat.

Figure 5.3: The worker in Press Station which exposed to high temperature of steam from the machine in close distance

5.1.3. Air velocity and relative humidity in every work section

The results for the air velocity was in the range between 0.2733 m/s to 0.5589 m/s. The highest value was recorded in Boiler Section (0.5589m/s). However, based on Barbara and Patricia (2002), the air velocity in every work stations are still considered low because the air temperature for 30°C to 35°C is suitable if the air movement is increase from less than 1 m/s to 2 m/s to enhance evaporative cooling and convective cooling. This is the significant reduction for heat stress that can be done because if the air movement is too high, it can frequently increases the level of air borne particles.

Meanwhile, the results for the relative humidity in every work section were quite high which in the range of 74.33% to 89.67%. Based on USA Today (2008), the high level of humidity makes heat more dangerous to the exposed people. This is because it slows the evaporation of perspiration in human body. In other words, the human body feels warmer in high humidity conditions. However, when the relative humidity is low, the apparent temperature can actually be lower than the air temperature. This condition is known as heat index.

The heat index is an apparent temperature which it represent the actual feels of the temperature to the human body when the relative humidity is combined with the air temperature (NWSWFO, 2014). In this study, the high relative humidity

(89.67%) was revealed at oil room with 32.17°C in temperature. Based on the calculation, the actual heat that workers may feel in that area was 50°C (NWS, 2013). This showed that the workers were exposed to the very high temperature which it can lead to the high prevalence in heat related illness. Since all the work sections were in high relative humidity (>70%), it means that all the workers were exposed to the heat stress. In order to overcome this problem, the number of fan in every work section should be increased and every work sections should provide the rest room with air-condition for the workers.

5.1.4 Correlation between air velocity and WBGTin

The results revealed that there is a no statistically significant correlation between air velocity and WBGTin ($r(21) = .45$, $p = .86$). This showed that the increases or decreases in air velocity do not significantly relate to increases or decreases in the WBGTin. In this situation, the highest air velocity (0.5589 m/s) was recorded in the Boiler Section as well as temperature (35.67°C). However, for the second highest of the WBGTin value which was Press Station (33.93°C), it showed that, the value of air velocity (0.2967 m/s) was the second lowest after in the Workshop Section area. This may influence by the air that release from the machine during process which also release heat to the working environment in the particular area. Thus, this situation will lead to the poor air circulation and give the inconsistently in the reading of WBGTin value with level of air velocity for every work section.

5.1.5 Prevalence of heat related illness among workers when exposed to heat.

The highest prevalence of heat related illness complaints among workers was heat exhaustion (86.4%), followed by dehydration (78.4%) and heat cramps (61.4%) due to high exposure of heat during eight working hours. This outcome was similar to the previous findings where heat exhaustion most commonly occurred in hot environment of occupational setting (Patel et al., 2006; Kishor et al., 2012 & Donoghue, 2004) and high humidity (Bauchama & Knochel, 2002). The heat exhaustion is a less extreme manifestation of heat related illness which it involve mild symptoms such as thirst, weakness, dizziness and malaise (James L. & Glazer M. D., 2005). However, the untreated heat exhaustion may lead to the heat stroke due to the central nervous system (CNS) dysfunction such as coma and even death. Thus, the high prevalence of heat exhaustion should be taken seriously in this case to prevent any worst case happened.

Furthermore, the dehydration (78.4%) also need to be taken into the consideration since it is the second highest cases reported was also high after heat exhaustion. This can be related to the facts that the workers drink less amount of water after their exposed to the heat during their working hours. Moreover, the employees also showed they were lack in awareness on the dangerous heat related illness based on the interview with them. It indicate that the employees should be provided with heat stress training in order they can perform a more efficient in work performance. This is similar to previous study by Bates and Matthew (1996) which found that 2% of dehydration could reduce in mental performance and affect the physical and cognitive of the workers.

In this current study, heat stroke is still reported (4.5%) although all the workers were acclimatised for employed more than one year. This is supported by previous study which indicated that there is no relationship between heat acclimatisation and the incidence of the heat stroke (Armstrong & Maresh, 1991).

5.1.6 Difference of core body temperature, heart rate and blood pressure between before, after 2 hours and after 8 hours working.

The results of repeated measure ANOVA found that there is a significant difference of physiological parameters between before shift, after 2 hours and after 8 hours working ($p<0.001$). However, by doing post hoc comparison between sessions (Table 7), the significant differences was found between core body temperature, heart rate and blood pressure in before shift with after 2 hours working and before shift with after 8 hours working. However, there is no a significant differences in other session.

This can be related to the rest period between 2 hours and 8 hours working period where the workers were away from the heat source. Therefore, the rate of heat production in the body was drastically reduced in that period of time which give effect to the reading value at after 8 hours of working (Hoa et al., 2013).

5.1.6.1 Difference of core body temperature between before, after 2 hours and after 8 hours working.

The results showed there is a significance difference ($p<.001$) of core body temperature before shift (35.97 ± .57°C) with after 2 hours and after 8 hours working. However, between after 2 hours (36.23 ± .56 °C) and after 8 hours working (36.23 ± .56 °C), there is no significance difference shown in the ANOVA analysis. However, Nurul Ainun (2003) showed that there is a significance difference ($p<.05$) after 2 hours and after 8 hours working in the automotive industry. This can be related to the facts that the difference in types of work activities between this two industry. Therefore, this contributes to the physiological changes pattern in these two industries. Furthermore, Frye and Kamon, (1993) stated that the physical activities that involved continuous work will produce more heat in the body and directly will increase the reading of core body temperature. Plus, the workers of palm oil mill may take less period to acclimatize in the heat which there is only slightly changes in core body temperature after 8 hours working.

ACGIH (as cited in Derrick & Graham, 2002) stated that deep body temperature which exceed 38°C was unacceptable for an average industrial workforce in an eight hours working period. In this present study, core body temperature was in the range of 34.7°C to 37.9°C. This indicated that the workers were still in safe core body temperature. Although, it can be concluded that the pattern of core body temperature was increased quite steadily but it is still under acceptable limit.

5.1.6.2 Difference of heart rate between before, after 2 hours and after 8 hours working.

Physiological measurements in heart rate showed that, it had been drastically increased and have significance difference ($p<.001$) from before shift (80.99 ± 11.08 bpm) to after 2 hours working (86.89 ± 11.27 bpm). However, there is only slightly increased after 8 hours working (88.64 ± 14.50bpm) which showed there is no significance difference in after 2 hours and after 8 hours working ($p>.05$). This study supported by Goh (2002) which it indicate that there is only significant difference in before shift with after 2 hours and after 8 hours working.

Based on Barbara and Patricia (2002), the mean value for the heart rate in this present study was still considered under the limit which the mean value was 85.70 bpm as it does not exceed 110 bpm. Previous study also have indicated that when the heart rate level was above the limit, the work period for the next shift should be shorten by one third. However, the rest period should be maintained as usual (U.S. Department of Labor, 1999).

5.1.6.3 Difference of blood pressure between before, after 2 hours and after 8 hours working.

In this study, the systolic blood pressure was one of the elements in physiological measurement. This is supported by Adrian et al. (2007) which proved that the systolic blood pressure have statistically significant effect on temperature changes. Besides, the high indoor temperature level represent the strong significant acute effect of systolic blood pressure compare to the high outdoor temperature.

The mean value for blood pressure was 117.26 ± 8.65 mm Hg (before shift), 130.58 ± 14.92 mm Hg (after 2 hours working) and 130.40 ± 15.60 mm Hg after 8 hours working. Post hoc tests showed that the mean value was increase significantly ($p<.001$) between before shift and after 2 hours working but slightly reduce after 8 hours working. This can be related to the facts that the workers were involved with high intensity of work in early shift. This will results the workers to start more sweating and heat in the body due to the change of normal environment to the hot environment during the early work hours.

However, this results was contradict with the previous studied which there is an increase significant differences in between before shift and after 8 hours working (Muznita, 2004; Hidayah, 2005; & Durbashini, 2004). Roine et al. (1992) stated that during high temperature, peripheral vascular resistance is reduced and blood volume shifts from the central body to the periphery to facilitate heat exchange which it can lead to increase in blood pressure. However, these symptoms will be decreased over time depends on individual which known as acclimatization or body adaptation.

5.2 Conclusion

As a conclusion, the workers in these palm oil mills are exposed to high level of heat stress. However, the mean value of heart rate and core body temperature were still in the acceptable range which represent the acclimatization of the workers. The air velocity in the mill indicates less air circulation which contribute to the no significant correlation with WBGTin. However, there was a significant differences in all physiological parameters between three difference periods of time. The high prevalence of heat related illness among workers were heat exhaustion, dehydration, and heat cramps. Overall, the majority of the workers had reported high prevalence in heat related illness since all the work sections had recorded high level of environmental temperature.

5.3 Recommendation

The findings of this study shows that the production area in palm oil mills have high value of WBGTin than suggested standard value by ACGIH which below 28°C. This automatically make the workers exposed to the high level of heat stress which can lead to the heat related illness. Therefore, several control measures have been suggested in order to minimize the exposure of heat among the workers.

i. Engineering control

Engineering control is the effective way to control the heat if they handled systematically with good maintenance. Firstly, every work section should have at least two fans since one fan was not enough in helping the good circulation of air in the work section. By increase the number of fans, the air movement will also increase which it can help the air movement to circulate well in the entire area. Besides, every work section should have one air-conditioned rest room to help employee to cooling down their body temperature when the temperature is too high which it can lead to fatigue, excessive dehydration and fainting. This also directly help in reducing the duration of exposure to the heat among employees.

ii. Administration control

The employer should provide heat stress training and program to train the employees on knowledge related with heat stress and controls. This program also will make the employees familiar with any symptoms and signs related with heat stress which it may prevent any worst case from happened. The training may cover the description of heat stress including symptoms of heat related illness and the procedure of first aid measures for each disorder.

Besides, the employer should conduct medical surveillance on heat stress to evaluate and identify the individual risk when exposed to heat as well as provide treatment for heat related illness. This surveillance should be conducted at least once a year by licensed physician. In addition, the management also should ensure safety environment in the workplace by putting the alert safety board at the particular area. The safety board should mentioned the level of dangerous and temperature at every work section to aware the workers with the hazard that they are exposed during working hours.

iii. Heat stress hygiene practice

Heat stress hygiene practices are the actions taken by the exposed employee to reduce the risks of a heat disorder. The individual should responsible for practicing good heat stress hygiene such as drink less quantities of water as frequently as possible to avoid excessive of water lost from the body. Plus, the employees should not skip meals because food will replace the minerals lost in sweat as well as calories.

A healthy lifestyle is also important to lowering the risk of a heat related illness. A worker should have adequate sleep and a good diet to increase the job performance when working in high environment temperature.

A healthy lifestyle also means no abuse of alcohol or drugs, which have been implicated and have strong related with heat strokes.

Most important thing to be taken into consideration is commitment from the top management itself and all the employees in order to maintain productivity and health of the workers from excessive exposure to the heat.

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JAWATANKUASA ETIKA UNIVERSITI UNTUK
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UNIVERSITI PUTRA MALAYSIA,
43400 UPM SERDANG, SELANGOR, MALAYSIA

BORANG B1: PENERANGAN DAN PERSETUJUAN RESPONDEN

Sila baca maklumat berikut dengan teliti. Sekiranya anda mempunyai sebarang pertanyaan, sila kemukakan kepada penyelidik.

1. TAJUK KAJIAN

Penilaian Perubahan Fisiologi dan Penyakit Berkaitan Haba dalam Kalangan Pekerja Kilang Minyak Sawit Dibawah Tekanan Haba

2. PENGENALAN

Kajian ini bertujuan untuk mengenalpasti tegasan haba dan kesannya dalam perubahan fisiologi terhadap pekerja kilang kelapa sawit. Ini kerana pendedahan kepada tahap tegasan haba yang melampau boleh mengatasi mekanisme didalam badan yang membawa kepada keadaan yang serius seperti strok haba dan mungkin boleh membawa maut. Tegasan haba boleh berlaku apabila badan manusia gagal dalam mengawal dan mengekalkan suhu dalaman yang membawa kepada peningkatan dalam suhu teras badan, kadar degupan jantung dan tekanan darah kepada individu yang terdedah. Kesannya ia boleh menyebabkan strok haba, kelesuan haba, kekejangan haba, atau pengsan haba. Oleh itu, bagi meningkatkan keselamatan dan kesihatan pekerja, kajian ini perlu dilakukan agar status kesihatan pekerja dapat ditingkatkan dan dilindungi daripada tegasan haba.

3. APAKAH YANG PERLU ANDA LAKUKAN?

Anda dikehendaki menandatangani borang penyertaan yang menyatakan minat anda untuk menyertai kajian ini selepas anda membaca dan memahami segala penerangan yang diberikan. Anda diminta untuk menjawab soal selidik untuk mendapatkan maklumat mengenai kajian ini. Borang penyertaan dan borang soal selidik perlu dikembalikan kepada penyelidik sebelum ujian tekanan darah, kadar degupan jantung dan suhu badan dijalankan.

4. SIAPAKAH YANG TIDAH BOLEH MENYERTAI KAJIAN INI?

Pekerja yang bekerja kurang daripada 3 bulan dan telah disahkan menghidap tekanan darah tinggi dan penyakit jantung.

5. APAKAH FAEDAH MENYERTAI KAJIAN INI?

a) KEPADA ANDA SEBAGAI PESERTA?

Melaui kajian ini, peserta akan dapat menjalani ujian kesihatan dan mengetahui status kesihatan diri secara percuma.

b) KEPADA PENYELIDIK?

Ia akan membantu penyelidik untuk menentukan tegasan haba dan kesannya dalam kalangan pekerja di kilang minyak kelapa sawit.

6. ADAKAH IA BERISIKO?

Tiada risiko didalam kajian ini.

7. ADAKAH MAKLUMAT DAN IDENTITI SAYA KEKAL RAHSIA?

Maklumat dan identiti yang digunakan dalam kajian ini akan kekal sulit.

8. **SIAPA YANG SAYA PERLU HUBUNGI SEKIRANYA SAYA MEMPUNYAI SOALAN TAMBAHAN SEMASA MENGIKUTI PENYELIDIKAN INI?**

Jika anda mempunyai sebarang soalan tambahan, anda boleh menghubungi Dr Karmegam Karrupiah, Penyelia kajian penyelidikan di 013-5818331 atau Nur Athirah Diyana binti Mohammad Yusof, penyelidik di 017-2799049.

Sila tandatangan di sini sekiranya anda telah membaca dan memahami kandungan halaman ini

9. PERSETUJUAN

Saya…………………………………………… No Kad Pengenalan. ……………………………

beralamat…………………………………………………………………………………………

………………………………….dengan ini bersetuju untuk mengambil bahagian secara sukarela dalam penyelidikan yang tersebut di atas *(kajian klinikal/percubaan ubat-ubatan/rakaman video/kumpulan sasaran/temuduga/ soal selidik).

Saya telah diberi penjelasan secara menyeluruh mengenai penyelidikan ini dari segi metodologi, risiko dan komplikasi (seperti tertulis pada Helaian Penerangan Responden). Saya memahami bahawa saya berhak menarik diri dari penyelidikan ini pada bila-bila masa tanpa memberi sebarang alasan.Saya juga memahami bahawa sebarang maklumat yang berkaitan identiti saya akan dirahsiakan.

Saya* berminat / tidak berminat untuk mengetahui keputusan kajian yang melibatkan saya.

Saya bersetuju/tidak bersetuju untuk imei/gambar/rakaman video/ rakaman suara digunakan dalam apa jua bentuk penerbitan atau pembentangan. (sekiranya berkaitan).

*potong yang tidak berkenaan

Tandatangan ………………………………… Tandatangan…………………………………
(*Responden*) (*Saksi*)

Tarikh :……………………………………… Nama :………………………………………

No.

K/P: ………………………………………

Saya mengesahkan bahawa saya telah menerangkan kepada responden ini sifat dan tujuan penyelidikan yang tersebut di atas.

Tarikh ……………………………… Tandatangan ………………………………
(*Penyelidik*)

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FORM B1: RESPONDENT'S INFORMATION SHEET AND CONSENT

Please read the following information carefully and do not hesitate to discuss any questions you may have with the researcher.

1. STUDY TITLE

The Evaluation of Physiological Changes and Heat Related Illness among Palm Oil Mill Workers under Heat Stress Condition

2. INTRODUCTION

Purpose of this study is to determine heat stress and its effect among workers in palm oil mill. This is because exposure to extreme heat stress level can overwhelm the body's coping mechanisms leading to a serious condition such as heat stroke and possibly fatal. Heat stress can happen when the body failed in controlling and maintaining its internal temperature which lead to increasing in body core temperature, heart rate and blood pressure of the exposed individual. These changes can result in heat stroke, heat exhaustion, heat cramps, or heat syncope. Therefore, this study need to be done so, it can improve the safety of workers and health status can be improved and protected from heat stress.

3. WHAT WILL YOU HAVE TO DO?

You must sign consent form which is stated that you interest to participate in this study after you read and understand all the explanation given. You will need to answer a questionnaire for obtaining information about this study. Then, consent form and questionnaires should be returned to the researcher before blood pressure, heart rate and body temperature test are carried out.

4. WHO SHOULD NOT PARTICIPATE IN THE STUDY?

Worker who work less than 3 months and has been diagnosed with hypertension and heart disease.

5. WHAT WILL BE BENEFITS OF THE STUDY:

a) TO YOU AS THE SUBJECT?

Through this participation, the subject will be able to undergo a health test and find out the status of health for free.

b) TO THE INVESTIGATOR?

It will help the investigator to determine the heat stress and its effect among workers in palm oil mill.

6. WHAT ARE THE POSSIBLE RISKS?

There is no risks available in the study.

7. WILL THE INFORMATION THAT YOU PROVIDE AND YOUR IDENTITY REMAIN CONFIDENTIAL?

The information and identity used in this study will remain confidential.

8. WHO SHOULD YOU CONTACT IF YOU HAVE ADDITIONAL QUESTIONS DURING THE COURSE OF THE RESEARCH?

If you have any additional questions, you may contact to Dr Karmegam Karrupiah, Supervisor of the study research at 013-5818331 or Nur Athirah Diyana binti Mohammad Yusof, the researcher at 017-2799049.

Please initial here if you have read and understood the contents of this page

9. CONSENT

I ……………………………………………… Identity Card No. …………………………………

address………………………………………………………………………………………………

……………..…………………………………………………….. hereby voluntarily agree to take part in the research stated above *(clinical /drug trial/video recording/ focus group/interview-based/ questionnaire-based).

I have been informed about the nature of the research in terms of methodology, possible adverse effects and complications (as written in the Respondent's Information Sheet). I understand that I have the right to withdraw from this research at any time without giving any reason whatsoever. I also understand that this study is confidential and all information provided with regard to my identity will remain private and confidential.

I* wish / do not wish to know the results related to my participation in the research

I* agree/do not agree that the images/photos/video recordings/voice recordings related to me be used in any form of publication or presentation (if applicable)

* delete where necessary

Signature ……..………………………… Signature ……..……………………………
(Respondent) (Witness)

Date :…………………………………….. Name :……………………………………….

I/C No. :……………………………………….

I confirm that I have explained to the respondent the nature and purpose of the above-mentioned research.

Date ……..……………………… Signature ……..…………………………
(Researcher)

APPENDIX 5

PROJEK PENYELIDIKAN TAHUN AKHIR
B.S. KESIHATAN PERSEKITARAN DAN PEKERJAAN
FAKULTI PERUBATAN DAN SAINS KESIHATAN
UNIVERSITI PUTRA MALAYSIA
SERDANG SELANGOR

BORANG SOAL SELIDIK BAGI KAJIAN TEGASAN HABA DAN KESANNYA TERHADAP PEKERJA DI KILANG MINYAK KELAPA SAWIT

ARAHAN SOALAN:

1. Borang soal selidik ini mengandungi lima (5) bahagian iaitu:

   BAHAGIAN A: MAKLUMAT DIRI
   BAHAGIAN B: MAKLUMAT PEKERJAAN
   BAHAGIAN C: MAKLUMAT KESIHATAN
   BAHAGIAN D: MAKLUMAT GAYA HIDUP
   BAHAGIAN E: MAKLUMAT SIMPTOM PENDEDAHAN HABA

2. Anda diminta untuk menjawab semua soalan.
3. Untuk menjawab, sila tandakan jawapan di bahagian jawapan yang telah disediakan.
4. Borang soal selidik hendaklah dikembalikan kepada pengkaji setelah selesai menjawab semua soalan.
5. Semua maklumat yang diperoleh didalam kajian ini adalah rahsia dan hanya digunakan untuk tujuan pembelajaran semata-mata.

Sekian, terima kasih.

Untuk kegunaan penyelidik

BAHAGIAN A: MAKLUMAT DIRI

1.1 Tarikh lahir	:	☐☐ ☐☐ ☐☐☐☐	A 1.1
1.2 No. K/Pasport	:	☐☐☐☐☐☐☐☐☐☐☐☐☐☐	A 1.2
1.3 No. Telefon	:	☐☐☐☐☐☐☐☐☐☐☐☐☐☐	A 1.3
1.4 Umur	:	☐☐ tahun	A 1.4
1.5 Bangsa	:	1. ☐ Melayu 2. ☐ Cina 3. ☐ India 4. ☐ Lain-lain	A 1.5
1.6 Warganegara	:	1. ☐ Warganegara 2. ☐ Bukan warganegara	A 1.6
1.7 Status	:	1. ☐ Bujang 2. ☐ Berkahwin 3. ☐ Bercerai	A 1.7
1.8 Pendidikan	:	1. ☐ Tidak Bersekolah 2. ☐ Rendah/UPSR 3. ☐ Menengah/PMR/SPM/STPM 4. ☐ Sijil/Diploma/Ijazah	A 1.8
1.9 Gaji	:	RM ☐☐☐☐☐☐	A 1.9
1.10 Tinggi	:	☐☐☐ cm	A 1.10
1.11 Berat	:	☐☐ kg	A 1.11
1.12 Isi rumah	:	☐☐ orang	A 1.12

BAHAGIAN B: MAKLUMAT PEKERJAAN

2.1 Apakah jawatan anda sekarang? B 2.1

____

2.2 Di bahagian mana anda bekerja sekarang? B 2.2

1. ☐ Loading Ramp
2. ☐ Sterilization
3. ☐ Thresher
4. ☐ Digester
4. ☐ Press
5. ☐ Kernel Plant
6. ☐ Boiler Room
7. ☐ lain: ____________________

2.3 Berapa lamakah anda telah bekerja sebagai (pekerjaan seperti di atas)? B 2.3

_____________ tahun

2.4 Berapa lamakah anda bekerja di kilang sawit ini? B 2.4

_____________ tahun

2.5 Shift kerja: B 2.5

1. ☐ Normal
2. ☐ Shift

2.6 Berapa hari anda bekerja dalam seminggu? B 2.6

_________hari

2.7 Adakah anda bekerja lebih masa (OT)? B 2.7

1. ☐ Ya 2. ☐ Tidak

2.8 Jika Ya, secara purata, berapa kerap anda bekerja lebih masa? B 2.8

1. ☐ Tiada 2. ☐ 1-3 kali sebulan

3. ☐ 3-5 kali sebulan 4. ☐ Lebih dari 5 kali sebulan

2.9 Berapa harikan anda bekerja dalam seminggu? B 2.9

_______ hari

2.10 Berapa jamkah anda bekerja dalam sehari? B 2.10

_______ jam

2.11 Adakah anda menggunakan sebarang Peeralatan Perlindungan Diri (PPE)? B 2.11

1. ☐ Ya 2. ☐ Tidak

2.12 Tandakan jenis PPE yang digunakan: B 2.12

1. ☐ Kasut keselamatan
2. ☐ Topi keselamatan
3. ☐ Cermin mata keselamataan
4. ☐ Sarung Tangan
5. ☐ Pakaian perlindungan diri
6. ☐ Respirator
7. ☐ Lain- lain:_______________

2.13 Adakah latihan penggunaan PPE diberikan? B 2.13

1. ☐ Ya 2. ☐ Tidak

2.14 Adakah anda terdedah kepada sebarang hazad seperti di bawah: B 2.14

1. ☐ Bahan kimia
2. ☐ Panas melampau
3. ☐ Habuk
4. ☐ Bunyi bising
5. ☐ Binatang berbisa
6. ☐ Lain- lain:_______________

BAHAGIAN C: MAKLUMAT KESIHATAN

3.1 Adakah anda mengidap penyakit berikut dan telah disahkan oleh doktor? C 3.1 (a-e)

Penyakit (a)	1. Ya (b)	2. Tidak (c)	Adakah anda pernah mengambil sebarang ubat-ubatan untuk penyakit tersebut?	
			1. Ya (d)	2. Tidak (e)
3.2.1 Darah Tinggi				
3.2.2 Kencing Manis				
3.2.4 Jantung				

BAHAGIAN D: MAKLUMAT GAYA HIDUP *(LIFESTYLE)*

4.1 Adakah anda mengambil sebarang jenis dadah? D 4.1

1. ☐ Ya 2. ☐ Tidak

4.2 Adakah anda merokok? D 4.2

1. ☐ Ya 2. ☐ Tidak

Jika ya, ________ batang sehari

4.3 Adakah anda mengambil minuman beralkohol? D 4.3

1. ☐ Ya 2. ☐ Tidak

BAHAGIAN E: MAKLUMAT SIMPTOM- SIMPTOM PENDEDAHAN HABA

5.0 Adakah anda mengalami sebarang simptom-simptom atau tanda-tanda seperti yang di bawah semasa atau selepas terdedah kepada suhu/haba yang tinggi (panas)? Tandakan.

	Simptom	1. Ya	2. Tidak	
5.1.1	Keletihan			E 5.1.1
5.1.2	Pening kepala			E 5.1.2
5.1.3	Kelihatan pucat			E 5.1.3
5.1.4	Sesak nafas dan nadi lemah			E 5.1.4
5.1.5	Berdebar-debar			E 5.1.5
5.1.6	Ruam dan kulit kemerah-merahan selepas terdedah kepada panas			E 5.1.6
5.1.7	Loya			E 5.1.7
5.1.8	Muntah			E 5.1.8
5.1.9	Kekejangan otot			E 5.1.9
5.1.10	Terasa lenguh dibahagian kaki atau lengan			E 5.1.10
5.1.11	Strok			E 5 .1.11
5.1.12	Pitam			E 5.1.12
5.1.13	Sawan			E 5.1.13
5.1.14	Kekeliruan			E 5.1.14
5.1.15	Pengsan			E 5.1.15
5.1.16	Dahaga			E 5.1.16
5.1.17	Kulit kering			E 5.1.17
5.1.18	Kulit lembap dan terasa sejuk			E 5.1.18
5.1.19	Peluh berlebihan			E 5.1.19
5.1.20	Kadar degupan jantung meningkat			E 5.1.20
5.1.21	Suhu badan yang sangat tinggi			E 5.1.21

5.2 Kategori waktu bekerja anda

E 5.2

1. ☐ Bekerja berterusan bagi setiap jam
2. ☐ 75% bekerja, 25% berehat
3. ☐ 50% bekerja, 50% berehat
4. ☐ 25% bekerja, 75% berehat

5.3 Berapa lama anda terdedah kepada haba dalam pekerjaan seharian.

E 5.3

1. ☐ Kurang dari 2 jam
2. ☐ 2-4 jam
3. ☐ 4-6 jam
4. ☐ 6-8 jam
5. ☐ Lebih dari 8 jam

-Terima kasih atas kerjasama anda dalam menjayakan kajian ini-