HEAT EXPOSURE AND PHYSIOLOGICAL CHANGES AMONG COOKS IN KUBANG KERIAN, KELANTAN

by

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LIST OF ABBREVIATIONS AND SYMBOLS

%	Percentage
>	Greater than
<	Less than
ACGIH	American Conference of Governmental Industrial Hygienists
a.m.	ante meridiem
BBC	British Broadcasting Corporation
BMI	Body Mass Index
°C	Celsius
DI	Discomfort Index
E_{max}	Evaporation is maximal
et al	et alia: and others
F	Fahrenheit
HSI	Heat Stress Index
IBM	International Business Machines
JEPeM	Jawatankuasa Etika Penyelidikan (Manusia)
K	Kelvin
L/min	Litre per minute
n.d	No date
OSHA	Occupational Safety Health Administration
p.m.	post meridiem
TLV	Threshold Limit Value
t_{sk}	skin temperature
t_a	air temperature
USMKK	Universiti Sains Malaysia Kubang Kerian
VO^2 max	Volume Oxygen maximum
WBGT	Wet-Bulb Globe Temperature
SPSS	Statistical Package for Social Sciences

PENDEDAHAN HABA DAN PERUBAHAN FISIOLOGI DALAM KALANGAN TUKANG MASAK DI KUBANG KERIAN, KELANTAN.

ABSTRAK

Kajian ini bertujuan untuk menentukan hubungan antara tahap pendedahan haba kawasan dengan perubahan fisiologi termasuk suhu teras badan, tekanan darah dan kadar denyutan nadi tukang masak. Kajian keratan rentas ini menggunakan kaedah persampelan bertujuan untuk memilih 24 orang tukang masak dari kafe Murni, Nurani dan kedai makan di luar Kampus Kesihatan Universiti Sains Malaysia. Untuk pengukuran haba persekitaran, Suhu Glob Bebuli Basah (WBGT) dipasang pada tripod di ketinggian 1.1 m dan diletakkan berhampiran sumber haba selama 8 jam. Pengukuran perubahan fisiologi melibatkan pengambilan suhu teras badan, tekanan darah dan kadar denyutan nadi sebanyak tiga kali sehari pada sebelum, pertengahan dan selepas syif. Borang soal selidik digunakan untuk mengumpul maklumat individu, sejarah perubatan, butir-butir pekerjaan dan simptom penyakit ketegasan haba. Empat kawasan persampelan mempunyai nilai WBGT melebihi tahap ambang yang dibenarkan. Terdapat perbezaan yang bererti pada suhu teras badan ($p=0.016$) dan kadar denyutan nadi ($p=0.004$) antara permulaan syif dan selepas selesai kerja. Tiada hubungan yang bererti ($p>0.05$) di antara indeks WBGT dengan teras suhu badan pada sebelum dan pertengahan syif, tetapi ada hubungan yang sedikit bererti untuk selepas selesai syif ($p=0.053$, $r=0.399$). Peningkatan tersebut mungkin disebabkan oleh pendedahan haba. Tiada hubungan yang bererti di antara suhu teras badan dan tekanan darah (sistolik dan diastolik) dan kadar denyutan nadi ($p>0.05$). Bagi faktor sosiodemografi, hanya umur menunjukkan perkaitan yang bererti dengan suhu teras badan. Kajian ini mencadangkan langkah pencegahan tekanan haba di tempat kerja seperti pakaian yang sesuai dan minum air dengan banyak.

HEAT EXPOSURE AND PHYSIOLOGICAL CHANGES AMONG COOKS IN KUBANG KERIAN, KELANTAN

ABSTRACT

This study aimed to determine the association between area heat exposure levels with the physiological changes that include body core temperature, blood pressure and heart rate of cooks. This cross-sectional study design utilised purposive sampling method to select 24 cooks from café's namely Murni, Nurani and food stall outside the Health Campus Universiti Sains Malaysia. For area heat measurement, Wet Bulb Globe Temperature (WBGT) was mounted on a tripod at height of 1.1 m and was placed near the source of heat for 8 hours. For physiological changes measurement, body core temperature, blood pressure, and heart rate were taken three times per day at pre-shift, mid-shift and post-shift. Respondents' personal information, health history, work description, and symptoms of heat related illness were asked using questionnaire. Four sampling sites had exceeded the permissible threshold WBGT level of 28.0 ° Celsius. There was a significant different of body core temperature ($p=0.016$) and heart rate ($p=0.004$) between pre-shift and post-shift. There was no significant correlation ($p>0.05$) between WBGT index with body core temperature at pre-shift and mid-shift, but there is a marginal significant association for post-shift ($p=0.053$, $r=0.399$). Such increase may be attributed by heat exposure. There was no significant association between body core temperature and blood pressure (systolic and diastolic) and with heart rate ($p>0.05$). For sociodemographic factor, only age showed significant association with the body core temperature. Preventive measures of heat stress at work such as suitable personal clothing and drink more fluid is highly recommended.

CHAPTER 1

INTRODUCTION

1.1 Research Background

Heat stress can be defined as the amount of physical work which contributes to the overall heat load to the body (Nurul & Shamsul, 2011). This occurs when individuals are exposed to hot environment condition during their working hours. Hot environments can be defined as a high surrounding condition which exceed the normal room temperature if the working condition is in indoor room.

There are various terms used to describe the forms of heat-related illness such as heat rash, heat stroke, heat cramps, and heat syncope which invites discomfort to workers (Nurul & Shamsul, 2011). Continuous exposure to high heat also causes a negative reaction to the body systems such as cramps and recirculation of inadequate blood to the heart and the vital organs in the body. This may further contribute to the occurrence of the before-mentioned thermal stress disorders. Hot workplace environment can increase the body temperature as it has direct relationship with the surrounding temperature. When the condition of body temperature is less than 38 degree Celsius, it is considered as safe.

A number of human factors contribute to a worker's susceptibility to heat stress, such as medical conditions, increasing age, overall level of fitness, presence of other metabolically stressful illnesses, use of medications, dehydration, alcohol intake, and individual ability to acclimatise to extreme temperature (Rampal, 2000). A previous study conducted among mining workers had shown that increased Body Mass Index (BMI) and depressed Volume Oxygen maximum (VO^2 max) are risk factors for heat exhaustion (Donoghue & Bates, 2000). While the environment factors that can contribute to heat stress are ambient temperature, low convection currents, high humidity, low evaporative loss, and high insulation levels around the body (Rampal, 2000).

1.2 Problem Statement

Occupational heat stress is one of the major issues in tropical countries such as Malaysia which may affect workers' health and performances. However, it is still most neglected occupational hazard in tropical countries (Diyana *et al.*, 2014). In addition to that, there are lack of study in Malaysia on the heat stress at kitchen workplace. One of the problems faced by cooks when working at kitchen is getting thermal stress due to heat produces from stove. Hot environment and low ambient humidity can increase the heat stress level. Other factors that may affect them are human physiological factors such as increase of heart rate, sweat production, blood pressure.

Therefore, this study will focus on heat stress level and the physiological effects among the cooks and workers at kitchens in the area of Kubang Kerian, Kelantan. They are several stalls that only open their business during the day and also food stalls that operated only at night. Nowadays, food stalls are important source of eateries among students and the public for their daily busy schedule and at cheap price. Students who stayed in hostel are not allowed to cook own food at dormitory and have less time to prepare foods usually eat in restaurants or food stalls place near the university. Restaurants and food stalls serve good food at reasonable prices may get attention for their regular customers. Increase in demand of food by customer may increase the production of food thus will lead to the heat exposure when cooks working in kitchen.

1.3 Research Question

1. How much the level of heat stress on workers that working in the food stall kitchen?

2. What is heat related illness present among cooks?

3. What are the physiological changes of heat stress that present among cooks?

1.4 Research Objectives

1.4.1 General Objective

The general objective for this study was to determine the association between area heat exposure levels and the physiological changes among cooks.

1.4.2 Specific Objectives

The specific objectives for this study were:

1. To determine the area heat exposure levels at food stalls.
2. To determine the physiological changes such as body core temperature, blood pressure and heart rate for pre-shift, mid-shift and post-shift among cooks at food stalls.
3. To compare the mean difference of physiological changes between pre-shift, mid-shift and post-shift among cooks at food stall.
4. To determine the association between sociodemographic, work and physiological factors with body core temperature among cooks at food stall.

1.5 Hypothesis

1. There is significant relationship between area heat exposure levels with physiological changes among cooks at food stall.
2. There is significant difference of physiological changes between pre-shift, mid-shift and post-shift among cooks at food stall.
3. There is significant association between body core temperature with blood pressure and heart rate among cooks at food stall.

1.6 Significance of the Study

The concern of this study was to measure and determine the area heat exposure level by using WBGT index. From the monitoring using WBGT equipment, the heat exposure and percentage of relative humidity at the kitchen can be evaluated. Such values can further be associated with the physiological changes among cooks in the kitchen.
This study also can identify heat related illness associated to heat stress when cooks and workers at food stall are exposed to thermal stress at kitchen. The examples of heat related illness are heat stroke, heat exhaustion, heat cramps, and heat rash. These can be detected and identified through the physiological changes shown by each related illness such as increase in body core temperature, heart rate and blood pressure. As for examples of symptoms, when workers are detected to have the symptoms of confusion, fainting, seizures, excessive sweating, hot and have very high body temperature they are suspected to have a heat stroke.

CHAPTER 2

LITERATURE REVIEW

2.1 Mechanisms of Heat Transfer

Thermal energy is related to the temperature of matter. Heat transfer is a study of the exchange of thermal energy through a body or between bodies which happens when there is a temperature difference. When two bodies are at different temperatures, thermal energy transfers from the one with higher temperature to the one with lower temperature. Heat transfer in human body involves the mechanisms of conduction, convection, radiation and evaporation. Any energy exchange between bodies occurs through one of these modes or a combination of them.

2.1.1 Conduction

Conduction is the transmission of heat between two solids in contact. Such exchanges are observed between the skin and clothing, footwear, pressure points (seat, handles), tools and so on. In practice, in the mathematical calculation of thermal balance, this heat flow by conduction is approximated indirectly as a quantity equal to the heat flow by convection and radiation which would take place if these surfaces were not in contact with other materials (Malchaire, n.d). The motion of warm material that rises, cools off, and sinks again, producing a continuous circulation of material and transfer of heat. Some examples of processes involving convection are boiling water, in which heat is exchanged from the stove to the air.

2.1.2 Convection

Convection is the transfer of heat between the skin and the air surrounding it. If the skin temperature, t_{sk}, in units of degrees Celsius (°C), is higher than the air temperature (t_a), the air in contact with the skin is heated and consequently rises. Air circulation, known as natural convection, is thus established at the surface of the body. Increase of the speed of ambient air that passes over the skin make this exchange to be more prominent (Malchaire, n.d).

2.1.3 Radiation

Radiation is a process in which energy is emitted as particles or waves. It is a complete process in which energy is emitted by one body, transmitted through an intervening medium or space, and absorbed by another body. Thermal radiation is electromagnetic radiation generated by the thermal motion of charged particles in matter. The skin, whose temperature may be between 30°C and 35°C (303K and 308K), emits such radiation, which is in the infrared zone (Malchaire, n.d). Sunlight is the example that emits natural radiation.

2.1.4 Evaporation

Evaporation is one of the heat exchange mechanism that is need to be considered. Every wet surface has on it a layer of air saturated with water vapour. If the atmosphere itself is not saturated, the vapour diffuses from this layer towards the atmosphere. The layer then tends to be regenerated by drawing on the heat of evaporation (0.674 Watt hour per gram of water) at the wet surface, which cools. If the skin is entirely covered with sweat, evaporation is maximal (E_{max}) and depends only on the ambient conditions

(Malchaire, n.d). Evaporation required energy comes from our body in the form of heat (heat loss).

2.2 Occupational Heat Exposure

Occupational heat exposure threatens the health of a worker not only when heat illness occurs but also when a worker's performance and work capacity is impaired. Occupational contexts that involve hot and humid climatic conditions, heavy physical workloads and/or protective clothing create a strenuous and potentially dangerous thermal load for a worker (Lucas *et al.,* 2014).

Climate change and increasing global temperatures will exacerbate occupational heat exposure in many places around the world. The geographical position of Malaysia which is placed near to the equator line making the country experienced hot and humid conditions throughout the year. Hot weather and bad working conditions will raise the temperature of the workplace environment. Working in conditions that are too hot may result to workers to feel uncomfortable, tired and lost focus due to loss of salt and fluid in the body.

Occupational heat exposure can be fatal if not treated early. Person who are exposed to excessive heat and high temperature can get heat related illness such as heat cramps, heat exhaustion or heat stroke. Heat stroke can be fatal if not properly treated. In order to minimise the risk of getting heat related illnesses exposure limits are introduced (Table 2.1).

Table 2.1: The permissible heat exposure threshold limit value by the America Conference of Governmental Industrial Hygienists

	Work Load		
Work/rest regimen	Light	Moderate	Heavy
Continuous work	30.0°C (86°F)	26.7°C (80°F)	25.0°C (77°F)
75% Work, 25% rest, each hour	30.6°C (87°F)	28.0°C (82°F)	25.9°C (78°F)
50% Work, 50% rest, each hour	31.4°C (89°F)	29.4°C (85°F)	27.9°C (82°F)
25% Work, 75% rest, each hour	32.2°C (90°F)	31.1°C (88°F)	30.0°C (86°F)

Source: OSHA Technical Manual (1999)

These TLV's are based on the assumption that nearly all acclimatised, fully clothed workers with adequate water and salt intake should be able to function effectively under the given working conditions without exceeding a deep body temperature of 38°C (100.4° F). They are also based on the assumption that the WBGT of the resting place is the same or very close to that of the workplace. Where the WBGT of the work area is different from that of the rest area, a time-weighted average should be used (Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices (OSHA Technical Manual, 1999).

2.3 Physiological Effects of Heat Stress

The characteristics of the body's physiology may reflect the existence of physiological effects of high temperature exposure (Fawziah, 2002). However, physiological changes of the body alone is not enough to confirm the occurrence of thermal stress. This is because it also requires a specific clinical examination of the expert or doctor. For example blood pressure measurement can only measure cardiac output needs and it fails to show the specific thermal stress. Moreover there are various factors that influence the increase and decrease of blood pressure for example exercise, nutrition, alcohol, stress and smoking (McKinley Health Center, 2008).

A study conducted by Nurul and Shamsul (2011) at an automotive industry had found that body temperature and average of pulse reading does not indicate level of heat strain at work section even though elevated reading of WBGT had exceeded the ACGIH level. This study had shown individual factors had a significant relationship with body core temperature readings such as medical conditions, increasing age, overall level of fitness, presence of other metabolically stressful illnesses, the use of certain medications, dehydration, alcohol intake, and individual ability to acclimatise to extreme temperatures.

2.3.1 Blood Pressure

Heat causes an increase in blood flow to the skin and pooling of blood in the legs, which can lead to a sudden drop in blood pressure. There can be a feeling of light-headedness before fainting occurs (Better Health Channel, 2015). Aside from redirecting blood to areas in greater need, vasoconstriction in the viscera serves to increase total peripheral resistance in response to the heat exposure. In this way, arterial blood pressure would be maintained during exercise in the heat. In addition to vascular adjustments, the dissipation of metabolic heat during exercise in a hot environment is almost totally dependent upon the cooling effect of sweat evaporation. This however places extra demands on the body's fluid reserves and a relative state of dehydration may occur (Physiological Response to Heat Exposure, n.d).

The mean systolic blood pressure showed an increase during the last three readings taken after the automotive worker finish their work. It occurs due to the exposure of the respondents to the thermal environment resulted from acute exposure to heat. This further causes increase in blood circulation, especially in the skin and promoted the muscle to contract (Nurul & Shamsul, 2011).

2.3.2 Hydration

Dehydration by less than 3–4% of body weight may cause insignificant hyperthermia or impairment of physiological function and performance. It was recognised that dehydration by more than 4% is dangerous to health (Wyndham & Strydom, 1969). Factors such as duration and intensity of the exercise, dehydration, nutrition, fitness and motivation can effects the level of body core temperature (Nielsen *et.al*, 1993). Reading of core temperature depends on the area of measurement. During exercise, heat is stored at certain part in our body such as muscles or body fluid. It had been shown that oesophageal temperature is lower compared to muscles temperature since heat is liberated in the muscles and then distributed via the circulation.

A previous study on heavy physical exertion in heat resulted in sweat rates of about 1 litre per hour (Leveritt, 2004). Sweat rates of up to 2.2 litres per hour are sustainable over periods of one to two hours in fit, healthy individuals with plenty of access to water. However, the limit of the stomach and gut to absorb water is about 1.6 to 1.8 litres per hour on a continuous basis, so sweat rates in the order of 2.2 litres would be extremely dangerous to the individual's health if allowed to continue for the duration of the shift. Dehydration of 3 to 4% of body weight may result in as much as a 50% reduction in the work rate in hot environments, while dehydration of only 2% in the same environment will cause retardation of mental performance. Thus, working in heat, when accompanied by dehydration affects safety performance either directly or indirectly. Any diuretic, including alcohol and beverages containing caffeine is likely to adversely affect dehydration levels (Brake *et,al.*, 1998).

2.3.3 Heart Rate

Normal resting heart rate for adults' ranges from 60 to 100 beats a minute. Heart rate can be influenced by individual fitness. Generally, a lower heart rate at rest implies more efficient heart function and better cardiovascular fitness. Medline Plus also states a normal pulse should be 60 to 100 beats per minute for adults (Lynn, 2014). As age increases, changes in the pulse rate and regularity can change and may signify a heart condition or other condition that needs to be addressed (American Heart Association, 2015).Table 2.2 shows the recommended target heart rate for different ages.

Table 2.2 Estimated target heart rates for different ages

Age	**Target HR Zone 50-85%**	**Average Maximum Heart Rate, 100%**
20 years	100-170 beats per minute	200 beats per minute
30 years	95-162 beats per minute	190 beats per minute
35 years	93-157 beats per minute	185 beats per minute
40 years	90-153 beats per minute	180 beats per minute
45 years	88-149 beats per minute	175 beats per minute
50 years	85-145 beats per minute	170 beats per minute
55 years	83-140 beats per minute	165 beats per minute
60 years	80-136 beats per minute	160 beats per minute
65 years	78-132 beats per minute	155 beats per minute
70 years	75-128 beats per minute	150 beats per minute

Source: American Heart Association (2015)

2.4 Wet-bulb Globe Temperature Index.

Wet-bulb Globe Temperature (WBGT) is an evaluating index in which wet temperature, dry temperature, radiant temperature and working metabolism are composited and it is displayed in the form of a number. One of the main measurement parameters to evaluate the thermal stress is measuring the radiant heat using WBGT index. When radiant heat exists in the environment, WBGT can be a better indicative of thermal environment (Brief & Confer, 1997).

Heat stress assessment is usually conducted using valid tools like heat stress indices (Monazzam *et.al*, 2012). For over a century attempts have been made to construct an index in which to describe heat stress satisfactorily. Sophisticated indices can integrate environmental and physiological variables while the simple indices are based on the measurement of basic environmental variables. "Wet-bulb globe temperature" (WBGT) index and the "discomfort index" (DI) are indices that have been used for over four decades till now (Brief & Confer, 1997).

WBGT limitation is the restriction of sweat (by high humidity or low air movement) when evaporation is free it can make the index level of environments are more stressful. WBGT requires careful evaluation of people's activity, clothing, and many other factors, all of which can introduce large errors into any predictions of adverse effects (Budd, 2007).

2.5 Heat Related Illness

Heat-related illness is a problem for many types of workers: metal smelters, outdoor construction and law enforcement workers, plastics manufacturing workers, landscaping and recreation maintenance personnel, staff in warehouses without air conditioning, cooks and kitchen workers, and athletes (Rampal, 2000). When staying out in hot temperature for too long it can lead the body to encounter heat related illnesses. The body temperature can rise to dangerous levels thus develop a heat illness. Heat related illness can be categorised from a severe to low effect of health begins with the heat rash up to heat syncope, heat cramps, heat exhaustion and heat stroke.

2.5.1 Heat Rash

Heat rash is less severe type of heat related illness. Heat rash or prickly heat occurs when the sweat ducts in the skin become blocked or swell, causing discomfort and itching. It may results skin irritation from a production of excessive sweating (Kenny, 2013).

2.5.2 Heat Syncope

Heat syncope, or orthostatic dizziness, can occur when a person is exposed to high environmental temperatures. This condition is attributed to peripheral vasodilation, postural pooling of blood, diminished venous return, dehydration, reduction in cardiac output, and cerebral ischemia (Casa, 2003). Heat syncope usually occurs during the first 5 days of acclimatisation, before the blood volume expand (Hubbard, 1995).

2.5.3 Heat Cramps

Exercise-associated muscle (heat) cramps represent a condition that presents during or after intense exercise sessions as an acute, painful, involuntary muscle contraction. Proposed causes include fluid deficiencies (dehydration), electrolyte imbalances, neuromuscular fatigue, or any combination of these factors (Rich, 1997). Sweat contains a large amount of sodium, and drinking fluids with inadequate sodium content after sweating profusely may result in a serious low sodium condition called hypernatremia.

According to Cunha (2015), those who are at most risk for heat cramps are infants and young children, elderly, individuals who live by themselves or who cannot afford air conditioning in hot environments. The list continues among those who consume alcohol, individuals who work or exercise in a hot environment, those taking certain prescription medications and who abuse the drug Ecstasy.

2.5.4 Heat Exhaustion

Exercise (heat) exhaustion is the inability to continue exercise associated with any combination of heavy sweating, dehydration, sodium loss, and energy depletion. It occurs most frequently in hot, humid conditions. At its worst, it is difficult to distinguish from exertional heat stroke without measuring rectal temperature. Other signs and symptoms include pallor, persistent muscular cramps, urge to defecate, weakness, fainting, dizziness, headache, hyperventilation, nausea, anorexia, diarrhoea, decreased urine output, and a body-core temperature that generally ranges between 36°C (97°F) and 40°C (104°F) (Binkley, 2002)

2.5.5 Heat Stroke

Exertional heat stroke is an elevated core temperature (usually > 40°C [104°F]) associated with signs of organ system failure due to hyperthermia. The central nervous system neurologic changes are often the first marker of exertional heat stroke. Exertional heat stroke occurs when the temperature regulation system is overwhelmed due to excessive endogenous heat production or inhibited heat loss in challenging environmental conditions (Cabanac, 1995). This condition is life threatening and can be fatal unless promptly recognised and treated. Signs and symptoms include tachycardia, hypotension, sweating (although skin may be wet or dry at the time of collapse), hyperventilation, altered mental status, vomiting, diarrhea, seizures, and coma (Binkley, 2002)

2.6 Risk Factors for Heat Related Illnesses

There are some factors that influence the heat index value. It includes of acclimatisation, thermoregulation, age and personal clothing (Binkley *et. al*, 2002). All these factors need to be considered when investigating the heat related illness. These factors show that an environment temperature is not the only cause to heat related illness.

2.6.1 Acclimatisation

Acclimatisation is defined as the time needed for physiological adaptation to extreme temperature changes. An average individual takes about 1 to 2 weeks to adapt to extreme cold or hot temperatures. Successful acclimatisation occurs if the physiologic mechanisms of the cardiovascular, pulmonary, and renal systems interrelate effectively to adjust the body's core temperature by using evaporative heat loss or conservation. The process of acclimatisation requires intact and responsive cardiovascular and renal systems (Rampal, 2000).

Workers that work for many years at hot environment can acclimatise and suit well to the temperature. Their body can regulate the temperature very well because they have been through the average temperature at workplace. In fact new workers may experience heat stress compared to senior workers because their body thermoregulation still new to the hot environment.

2.6.2 Thermoregulation

Exposure of healthy individuals to a hyper thermic environment causes a series of physiological responses that are critical for thermoregulation. One of the more pronounced and physiologically important responses is an increase in skin blood flow. In thermal neutral conditions, skin receives 5% to 10% of resting cardiac output, whereas in conditions of heat stress skin blood flow can reach 50% to 70% of resting cardiac output, approaching 8 L/min. To maintain blood pressure, cardiac output must increase; in normal subjects up to 13 L/min during whole-body heating (Cui, 2005).

Thermoregulation is a process where body maintains its core internal temperature. Homeostasis is where body maintain an even internal temperature to the surrounding. A healthy, safe temperature has a very narrow range of between 98°F (37°C) and 100°F (37.8°C). Within a few degrees of that range, signs related to body temperature changes may be noticed. For example, if the body temperature falls just 3 degrees to 95°F (35°C), you might experience hypothermia occurs. Hypothermia can cause cardiac arrest, stroke, or even death. Brain damage occur at 107.6 °F (42 °C) as a result of temperatures that are too high (Holland, 2013). Figure 2.1 shows the thermoregulation process in human body.

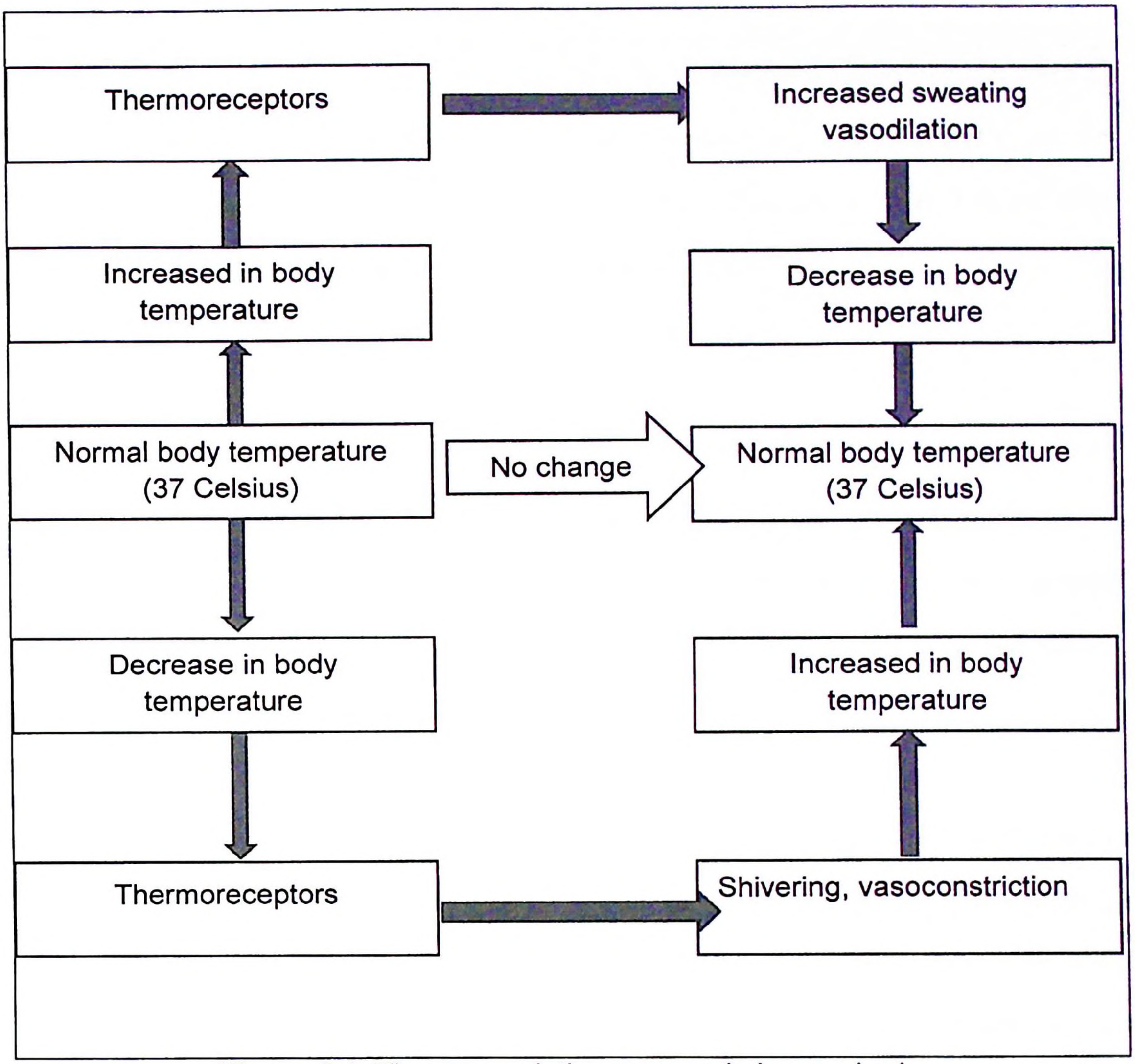

Figure 2.1: Thermoregulation process in human body.

Source: Holland (2013)

2.6.3 Age

Older adults (that is, people aged 65 years and older) are more prone to heat stress than younger people for several reasons that are older adults do not adjust as well as young people to sudden changes in temperature. They are more likely to have a chronic medical condition that changes normal body responses to heat and more likely to take prescription medicines that impair the body's ability to regulate its temperature or that inhibit perspiration.

During exercise, skin blood flow is typically 20-40% lower in men and women aged 55 and over (compared with 20-30 years old) at a given body core temperature. Yet criterion measures of heat tolerance (changes in core temperature, heat storage) often show minimal or no age-related alterations (Kenney, 1993).

2.6.4 Personal Clothing

Choices of suitable clothing is an important criteria when working in hot environment. Clothing act as insulator which it can trap temperature in between skin and canvas. Then when sweat are produced it will trap vapour thus make our body to change the temperature making body to feel comfort.

Even without any clothing, a thin layer of still air (the boundary layer) is trapped next to the skin. This external still air film acts as a layer of insulation against heat exchange between the skin and the ambient environment. Studies of clothing materials have led to the conclusion that the insulation provided by clothing is generally a linear function of its thickness. Differences in fibres or fabric weave have only very minor effects on insulation, unless these directly affect the thickness or the vapour or air permeability of the fabric. The function of the fibres is to maintain a given thickness of still air in the fabric and block heat exchange (Jacklitsch *et. al*, 2015).

Clothing of any nature creates a barrier for heat and vapour transport between the skin and the environment. For example, in India, women construction workers wear polyester shirts over their traditional sari for modesty reasons. This practice traps the sari beneath a less permeable fibre decreasing air movement, vapour permeability and increasing the clothing's insulation (Havenith, 1999). Clothing factors take a part as a unit to be considered when relate to heat exposure (Table 2.3).

Table 2.3: WBGT correction of TLV for clothing.

Clothing type	Clo* value	WBGT correction
Summer lightweight working clothing	0.6	0
Cotton coveralls	1.0	-2
Winter work clothing	1.4	-4
Water barrier, permeable	1.2	-6

Source: ACGIH (1992)

2.7 Prevention of Heat Related Illness

For prevention of heat related illness, it is recommended to drink water or other liquids frequently enough to never become thirsty (about 1 cup every 15–20 minutes). Hydration is the most important tool in preventing heat-related illness, and workers should try to be well-hydrated before arriving at work.

Eating during lunch and other rest breaks help replace lost electrolytes. Besides that, by wearing light-colored, loose-fitting, breathable clothing such as cotton may reduce heat. Exposure to heat (sun) should be avoided. If possible take breaks in the shade or a cool area when working in hot environments. Be aware that protective clothing or personal protective equipment may increase the risk of heat stress. Heat illness can be prevented by drink enough water, enough rest and take shade from heat (OSHA, 2011).

CHAPTER 3

METHODOLOGY

3.1 Research Design

The study design used in this research was cross-sectional study design aimed to identify the relationship between heat stress level with the physiological changes that include of blood pressure and body core temperature of cooks who work in kitchen. The quantitative component of this study comprises of environmental monitoring and data collection based on parameter that included in this research.

3.2 Study Location

This study was conducted in area about 3 kilometres near Universiti Sains Malaysia, Kubang Kerian, Kelantan.

3.3 Scope of the Study

This study focused on heat stress monitoring among cooks who work at food stalls. The scope of measurement included evaluation of body core temperature and blood pressure.

3.4 Population and Setting

This study population focused and targeted among (n=24) cooks and chefs working at food stalls. There is no exclusion criteria for gender of the cooks. The selected sampling sites were kitchen area which has at least two or three walls surrounding the place for cooking.

The inclusion and exclusion for the respondents in this study were as follow:

Inclusion

1. Respondents must works as a chef or cooks was and are exposed to the high temperature in the kitchen.
2. Respondent have working experience 6 months and above.

Exclusion

1. Respondents involve are those who do not agree to participate in this research.
2. Respondents of 18 years old and below.
3. Respondent do not understand Malay or English language.

3.5 Sampling Method

The type of sampling method used in this study was purposive sampling. All cooks were invited into this study who had fulfilled the inclusion criteria and those who are not, were excluded from the study.

3.6 Sample Size Calculation

Sample size calculation was based on the standard deviation for the systolic blood pressure of the study by (Nurul and Shamsul, 2011) = 11.33. In this study where the plan was to estimate the mean of a continuous outcome variable in a single population, the formula for determining sample size is given as followed.

$$n = \left(\frac{Z\sigma}{E}\right)^2$$

Where **Z** is the value from the standard normal distribution reflecting the confidence level that will be used (e.g., Z = 1.96 for 95%), **σ** is the standard deviation of the outcome variable and **E** is the desired margin of error (precision value. The formula above generates the minimum number of subjects required to ensure that the margin of error in the confidence interval for μ does not exceed **E**.

Calculation: Blood Pressure = $(1.96 \times 11.33 / 5)^2$

= 19.726

= 20

At 20% dropout, the number of sample size would be 24 subjects.

3.7 Instrument of Data Collection

There are two types of instrument used in this study, which is for area monitoring and physiological monitoring. Wet-Bulb Globe Temperature was used for area monitoring.

3.7.1 Wet-bulb Globe Temperature

For calculation of WBGT value of Indoors, or when solar radiation is negligible, the following formula was used:

$$WBGT = 0.7T_w + 0.3T_g$$

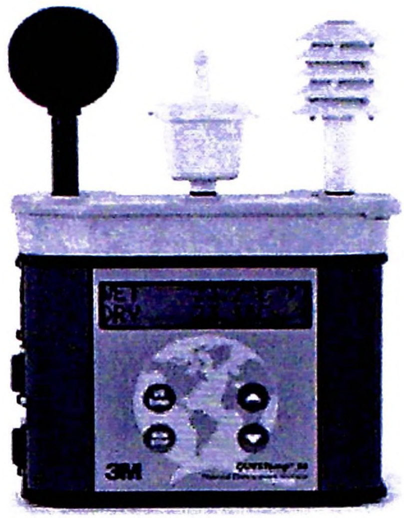

Figure 3.1: Wet-bulb Globe Temperature QUESTemp° 36

Source: Heatstress (2016)

3.7.2 Questionnaire

This study utilised questionnaire that was adapted from a validated questionnaire by Nurul (2011). It comprises of Section A, is about personal information of respondent, while Section B about health history, Section C is about job details and Section D related to acute sign of health problems (Appendix D).

3.7.3 Physiological Parameters Evaluation

The following Table 3.1 shows the list of study instruments that were used to measure the physiological parameter.

Table 3.1 Study instrument used to measure the physiological parameter.

Physiological Parameter	Study Instrument
Body core temperature	Ear Thermometer
Heart rate	Omron Blood Pressure Monitor
Blood Pressure	Omron Blood Pressure Monitor
Weight	OMRON Karada Scan HBF-361, Japan

3.8 Data Collection Process

This section is to explain about the way to conduct the study and the flow of this research.

3.8.1 Selection of Workplaces

Initial letter was given to the kitchen workers as an initial approach for them to become respondents (Appendix E). A week after that, they were given a call to confirm their willingness to participate in this research. Arrangement for data collection was made.

3.8.2 Environmental Monitoring

For the environmental monitoring, Weight-Bulb Globe Temperature tool was used. The WBGT was placed near the source of heat of range about 10 m away nearest to the kitchen (Nurul, 2003). When placing the WBGT, it was ensured that there were no other thing blocking the heat exposure. The WBGT was mounted on a tripod at height of 1.1m (3.5 feet). The monitoring of heat exposure was done for 8 hours of working time in which started at 8.00 a.m. until 5.00 p.m.