

**A STUDY OF THERMAL COMFORT PERCEPTION TO
LOCAL RESIDENCE OF TROPICAL COUNTRY OF
MALAYSIA**

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MALAYSIA**

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**THESIS SUBMITTED IN PARTIAL FULFILMENT OF
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Field of Study: Environment

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A STUDY OF THERMAL COMFORT PERCEPTION TO LOCAL RESIDENT OF TROPICAL COUNTRY OF MALAYSIA

ABSTRACT

The emphasis on field surveys from around the world, which focuses on hot and humid countries, enables us to understand thermal perception and evaluate outdoor thermal comfort conditions. Focusing on the thermal comfort perception level between individuals, it tries to explain how this influences the outdoor activities time and their actions to improve their comfort level at outdoor area. This research function is to identify the thermal comfort perception acceptance level, best condition for thermal comfort and future improvement of thermal comfort perception. Beyond acclimatization and behavioral adaptation, through adjustments in clothing and changes to the metabolic heat, psychological adaptation plays a critical role to ensure thermal comfort and satisfaction with the outdoor environment. Such parameters include recent personal experiences and expectations; personal choice and perceived control, more important than whether that control is actually exercised, and the need for positive environmental stimulation suggesting that thermal neutrality is not a pre-requisite for thermal comfort. This study has been done on cohort in Petaling Jaya. By using surveys form to verify the difference of thermal comfort perception between individuals. Different individual have different thermal comfort perception level. Some of it is due to physical difference, other either psychological difference. Thermal comfort level is varies but still have similarities for majorities of respondent. The consistent low correlations between objective microclimatic variables, subjective thermal sensation and comfort outdoors, internationally, suggest that the difference in individual thermal perception brings us to search for ideal outdoor thermal comfort perception.

Keywords: Comfort, thermal, outdoor, perception

**UNTUK MENGENAL TANGGAPAN KESELESAAN TERMA KEPADA
PENDUDUK TEMPATAN NEGARA TROPICAL MALAYSIA**

ABSTRAK

Penekanan terhadap tinjauan lapangan dari seluruh dunia, yang memberi tumpuan kepada negara-negara yang panas dan lembap, membolehkan kita memahami persepsi terma dan menilai keadaan keselesaan terma luaran. Memfokuskan pada tahap persepsi keselesaan termal antara individu, ia cuba untuk menjelaskan bagaimana ini mempengaruhi masa aktiviti luar dan tindakan mereka untuk meningkatkan tahap keselesaan mereka di kawasan luaran. Fungsi penyelidikan ini adalah untuk mengenal pasti tahap penerimaan persepsi keselesaan terma, keadaan terbaik untuk keselesaan termal dan peningkatan masa depan persepsi keselesaan terma. Selain menyesuaikan diri dan penyesuaian tingkah laku, melalui penyesuaian pakaian dan perubahan kepada haba metabolik, penyesuaian psikologi memainkan peranan penting untuk memastikan keselesaan termal dan kepuasan dengan persekitaran luar. Parameter tersebut termasuk pengalaman dan harapan peribadi baru-baru ini; pilihan peribadi dan kawalan yang dirasakan, lebih penting daripada sama ada kawalan itu sebenarnya dilaksanakan, dan keperluan untuk rangsangan alam sekitar yang positif menunjukkan bahawa neutraliti termal bukanlah prasyarat untuk keselesaan terma. Kajian ini telah dilakukan terhadap kohort di Petaling Jaya. Dengan menggunakan borang tinjauan untuk mengesahkan perbezaan persepsi keselesaan terma antara individu. Individu yang berbeza mempunyai tahap persepsi keselesaan terma yang berbeza. Sesetengahnya adalah disebabkan oleh perbezaan fizikal, yang lain pula perbezaan psikologi. Tahap keselesaan haba berbeza-beza tetapi masih mempunyai kesamaan untuk majoriti responden. Korelasi rendah yang konsisten antara pembolehubah mikroklimatik objektif, sensasi termal subjektif dan keselesaan di luar, di peringkat antarabangsa, menunjukkan bahawa perbezaan

persepsi terma individu membawa kita untuk mencari persepsi keselesaan terma luaran yang ideal.

Keywords: keselesaan, terma, luar bangunan, tanggapan.

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LIST OF SYMBOLS AND ABBREVIATIONS

For examples:

°C : Degree Celcius

% : Percentage

UHI : Urban Heat Island

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CHAPTER 1: INTRODUCTION

1.1 Overview

The possibility of job opportunities and prosperity, among other factors, makes people want to migrate to cities. Fifty percent of the total global population already lives in cities, and based on forecast by 2050 sixty five percent of the world's population are expected to live in urban areas. Although there are many problems arising in the city, the two major most critical problems faced by the world today is poverty in cities and environmental degradation.

Based on Malaysia Bureau of Statistic (2017 website), Malaysia is currently one of the most urbanized countries in comparison with other nations in East of Asia region, and also one of the most rapidly urbanized regions around the world, over the last ten years, the urban population in Malaysia has increased from around 66% in 2004 to 74% in 2014. The growth is expected to increase, as people from rural areas keep on migrating to urban developed areas due to the improvement of economy and high employment opportunities which is higher compared to rural areas and continuing to shift from agriculture based nation to industry and services nation. Figure 1 shows the urban population ratio compare to total residents in Malaysia from 2007 to 2017. Currently, the biggest and most developed city in Malaysia in terms of population ratio is Kuala Lumpur, where 1.31 million residents consider this city as their home which is still can be consider quite small, considering that the total population of Malaysia is almost approaching to 31 million. Malaysia also have several smaller urban areas and there are three different urban area which have population of over 500,000 residents.

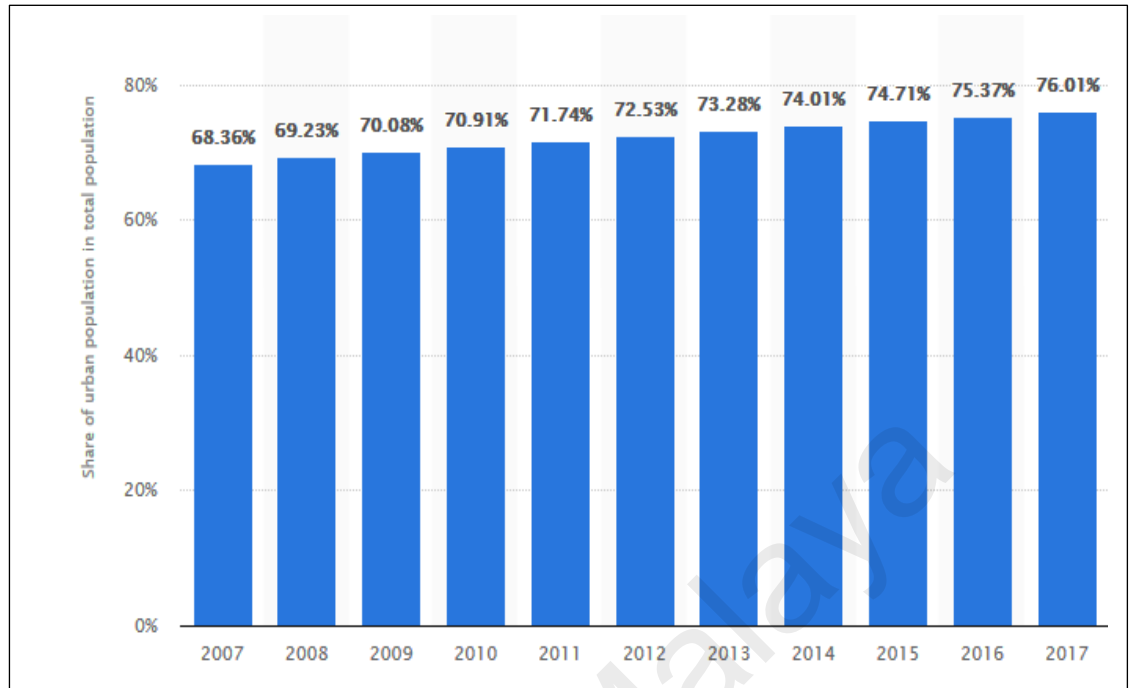


Figure 1 : Urban population ratio from 2007 to 2017
 (<https://www.statista.com/statistics/455880/urbanization-in-malaysia/>)

Poor air quality which is composed of potentially harmful gases and degradation of water quality, insufficient clean water availability, waste-disposal problems due to increasing rate of waste, and high energy consumption per individuals are exacerbated due to the increasing density of population and the increase of demands of developed and urban areas .

Urban heat island (UHI) is an area of metropolitan or urban that has temperature significantly higher compare to surrounding rural areas due to human activities such as reduction of green area, increasing of thermal absorption by manmade structure such as glass buildings, pavement roads and others. In Figure 2 is the simplification of the explanation in picture form. The difference in temperature is significantly larger at night compared to day time, and is most apparent when there is weak or no air movement. The modification

of land surfaces is the main cause of the urban heat island effect (William D et al 2005 ; EPA , Urban Heat Island Basic). Energy usage by local residents and industries generates waste heat which is the secondary contributor (Li,Y et al ,2012) . As a population center at the area grows exponentially, the heat tends to expand its area and size and increase its average temperature compare to previous temperature.

Malaysia is a tropical climate country which means the temperature is almost the same all around the 12 months and have mean temperature at least 25°C. For tropical climate, there is only two season ; wet season and dry season. Tropical climate is frost-free, and the temperature remains relatively constants hot throughout the year. This is based on Koppen climate classification.

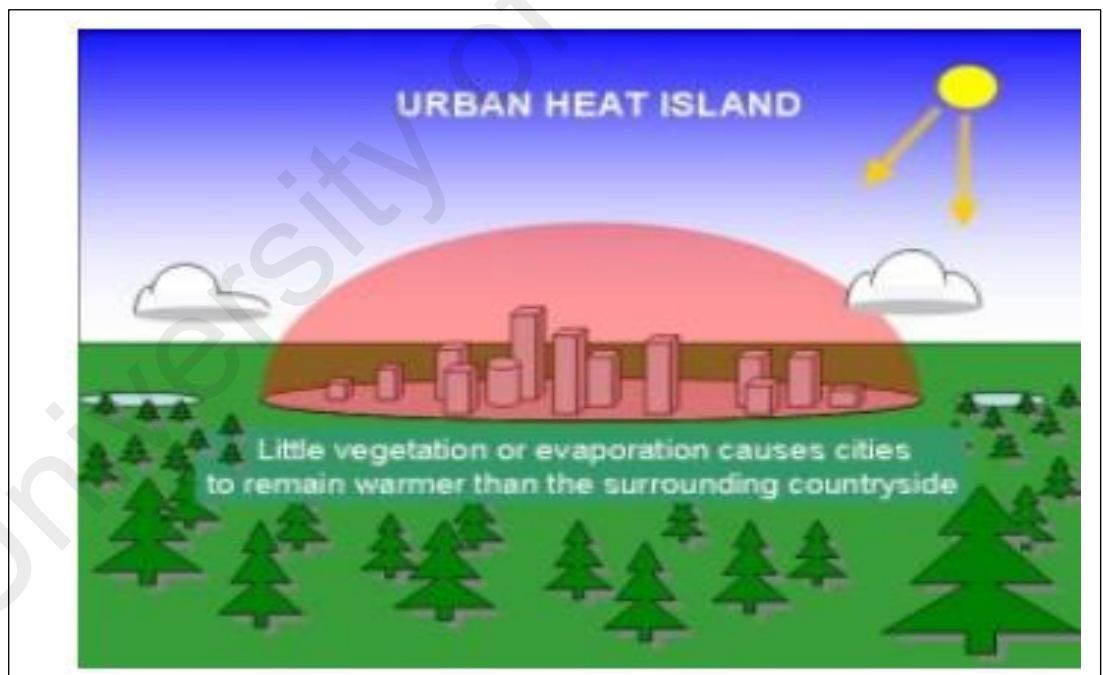


Figure 2 : Urban Heat Island Concept

(http://www.weatherquestions.com/What_is_the_urban_heat_island.htm)

According to the ANSI/ASHRAE Standard 55-2010, the definition of thermal comfort is the expression of satisfaction with environmental thermal and assessed by evaluation subjectively which affect the condition of mind". We understand that human comfort includes thermal comfort. Thermal comfort is subjected to the surrounding thermal conditions being satisfied and to monitor which have more effect in the comfort of in open area. When the body is overheated a cold sensation will be pleasing, but when the core is already cold it will be unpleasant. At the same time, the temperature of the skin is not uniform on all areas of the body. There are variations in blood flow and subcutaneous fat which reflect the variations parts of the body. The insulated clothing quality also has a marked effect on the level and the skin temperature distribution. Thus, the skin sensation from any particular part of the skin will depends on location, clothing types and difference in time, as well as the surrounding temperature.

The determination of thermal comfort between subjective and objective and the finality of this work is to manage and evaluate the thermal comfort by using various parameters of qualitative and quantitative. There are many factors that will have effect in thermal comfort such as the air temperature, the humidity, radiant temperature, air velocity, metabolism rates, and closing levels and each individual experience this sensation differently based on their on psychological states. Approach is been done by focusing on the subject perception by using surveys and current temperature values by using thermometer and humidity meter. With this also include the time stay in open area and also the zoning area which will have significant difference in order to reduce the discomfort in open area.

1.2 Problem Statement

The condition of mind that expresses satisfaction with thermal environment is known as thermal comfort. The human body can be assumed as an engine which generate heat where the food is the main source of energy. In order to operate normally, human body will generate excess heat. Based on Thermodynamics : An Engineering Approach (1995), the heat generated is proportional to temperature difference. When the environment is cool, the body loses more heat to the environment and when the environment is hot the body cannot exert enough heat. This scenario leads to discomfort.

Malaysia is a Tropical country which means that the environment is hot which lead to less exert heat by human body. Current average temperature is increasing yearly in urban area. Figure 3 shows the Malaysia average temperature from 1919 to 2014. Standard individual is defined on a whole of standardized criteria, and the interaction between Man and its thermal environment which rest on physical and/or physiological considerations.

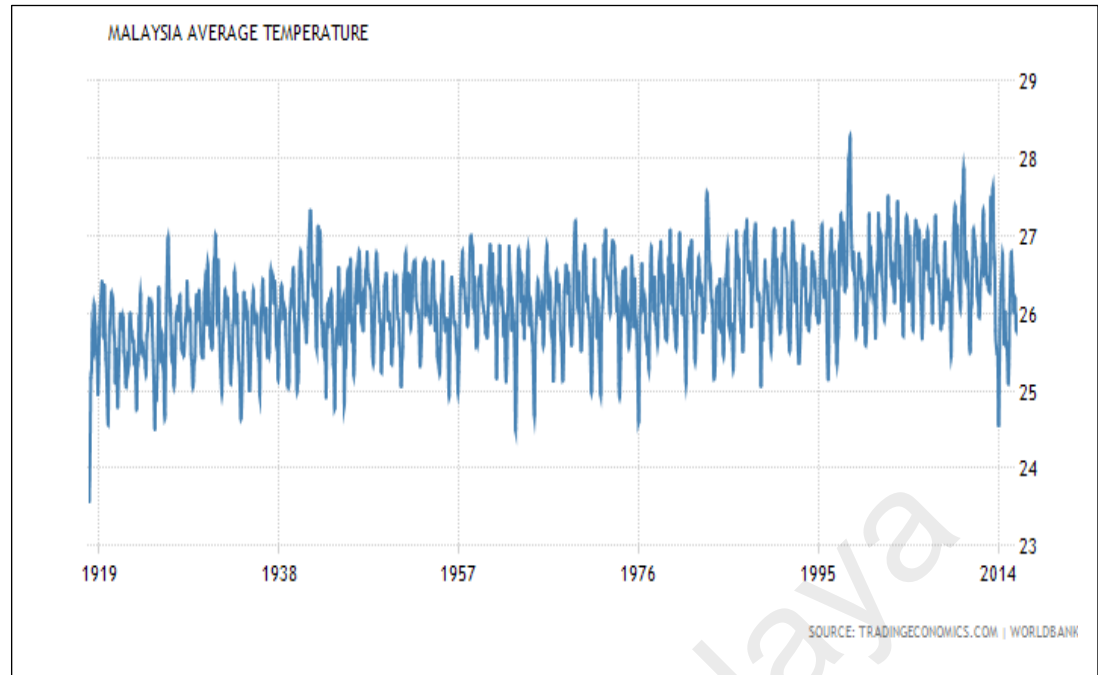


Figure 3 : Malaysia average temperature from 1919 to 2014

(tradingeconomics.com)

Current average temperature is increasing yearly which effect to all area in Malaysia. Malaysia will need strategies in order to improve and reduce current average temperatures at its major cities and at the same time increase thermal comfort and the perception of individuals.

1.3 Objectives

- i. To determine the average level of thermal comfort perception acceptance level of the respondent.
- ii. To identify highest thermal comfort perception limit rating based on the main factors contributes to the best condition met.
- iii. To evaluate the effectiveness of the action to take based on the differences for future regarding to improve the thermal comfort perception outdoor.

1.4 Scope of Study

In this study, the target is to identify contributing factors regarding individual thermal comfort. It is based on questionnaire regarding the understanding the meaning of thermal comfort and respondent plan to improve their comfort during their activities at outdoor area such as walking, picnic and doing sports.

It consists of 3 categories of questionnaire which focus on the individual information, their current condition and their preferred condition for outdoor area. The area of study is in Petaling Jaya which is an urban city because most of respondents are from the working class and have better education back ground.

1.5 Thesis Outline

This thesis follow 5 outline an as per arrangement

Chapter 1 Introduction

In this chapter it focus on what is the main research objective and scope. It acts as guide line and give roughly idea regarding the main research purpose.

Chapter 2 Literature Review

For literature review it more focus on the research in Internets, Reading articles, Journals and previous studies which either same or almost the same with current research objectives. Also it can give direction on how and why need to do the research.

Chapter 3 Methodology

Methodology is a process used to collect information and data in order to get the actual result of the thesis result. In this project it is based on deriving questionnaire and suggestion by previous studies.

Chapter 4 Result and Discussion

After completing the data collection, here is the place to verify all data collected and is it answers the objectives. Here listing questions regarding difference in opinion and the reason of each answers by correspondent

Chapter 5 Conclusion and Future Work Recommendation

Here is the summary of total thesis result and the answer to the objectives. Also in future where does this studies can implement in order to improve the current status based on the objectives.

CHAPTER 2: LITERATURE REVIEW

Introduction

Comfort and wellbeing are today the major focus of concerns of each consumer, user or prescriber of products or services, and the external environment which is the surroundings does play major parts in this issue. The absence of discomfort, “*an absence of feelings*” or with “neutrality inside thermal environment” is usually associated with comfort.

Natural environment encompasses all living and non-living entities occurring in natural manner without the disturbance of human. The environment encompasses the interaction of all living species in current condition, the climate and weather of the area and natural resources that effect the human survival and economy activities (Johnson and Nelson 1997). Due to uncontrolled human intervention to natural environment, the world environment is degrading day by day as the over usage of natural resources and failure to manage the waste generated.

In recent decades, the world has experienced a rapid growth in urban area. In 2015 alone 54% which is closed to 4 billion people will live in cities. This rapid growth of urbanization has brought multiple challenges, include the growth of populations, increase in air pollution, inadequate basic services and infrastructure which make cities vulnerable to disaster based on the Report of Secretary-General regarding Progress towards the Sustainable Development Goals 2017. Sustainable development goals were created in order to improve this condition which more specific is SDG 11 which is to make cities and human settlements inclusive, safe, resilient and sustainable.

According to the report titled East Asia's Changing Urban Landscape: Measuring a Decade of Spatial Growth, in between countries of East Asia, Malaysia is one of the most urbanized countries, and its population in urban area will continue to increase rapidly. Based on statistic data (share of urban population Malaysia 2007 - 2016), the rate increase from 2007 which is 68.36% to year 2016 which is 75.37% compare to total population of Malaysia.. However, compared to other countries, Malaysia is considered the most least dense urban areas in East Asia. The one of the largest in the region not as measured by population but measured by area is Kuala Lumpur.

Research has shown that the differences between parts of Kuala Lumpur and its neighboring rural areas has been found to be as high as 10°C and the gaps of temperature keeps widening. Based on Prof Datuk Dr Azizan Abu Samah (2017), this was due to the “urban heat island” effect, where the cities getting warmer compared to surrounding rural areas due to rapid developments. For tropical countries, the increase of temperature and the different temperature gaps between day and night will effect the thermal comfort of local resident in this area.

2.2 Definition

Many of the International Standards produced are found to be inadequate and hard to how best identify tropical climate comfort condition. The majority of the field studies conducted discovered that the international set up of comfort condition in this climate is either overestimating or underestimating (Nicol, 2004). This is partly due to the standards of derivation that are mainly based on the studies conducted in the moderate environmental condition which not

include the harsh environment which having too cold or too hot in certain region of the world.

The measurements recorded, especially in air temperature and velocity are frequently are beyond the limitations in many case studies conducted in the tropical countries. The air temperature of 30°C is considered normal and common and the air movement of more than 1 m/s is desirable for this climate to relieve the heat and give comfort sensation during reduction of body temperature. Another reason that may have an effect to the result is the conducting method of the experiment which has been focused on each researcher. Most of the measurement is based on the close-lab environment with control temperature, wind speed, humidity, heat radiation and other factors which effect in actual result in uncontrolled environment such as outside the buildings or open walk away. Such environment is rarely available in reality, especially in open environment. The factor which is not in the environment that is fully controlled is the adaptability part . In addition to this, the outside climate plays a very influential role in thermal comfort perception for a free-running building. For example is the difference between direct sunlight which the subjects exposed to heat radiation compared to the subject under the shaded area.

2.3 Thermal Comfort at Outdoor Area

The outdoor condition of a building especially the climate influences the indoor climate of the building in many cases. When the air temperature rises, the relative humidity will decreases for the outdoor condition normally.

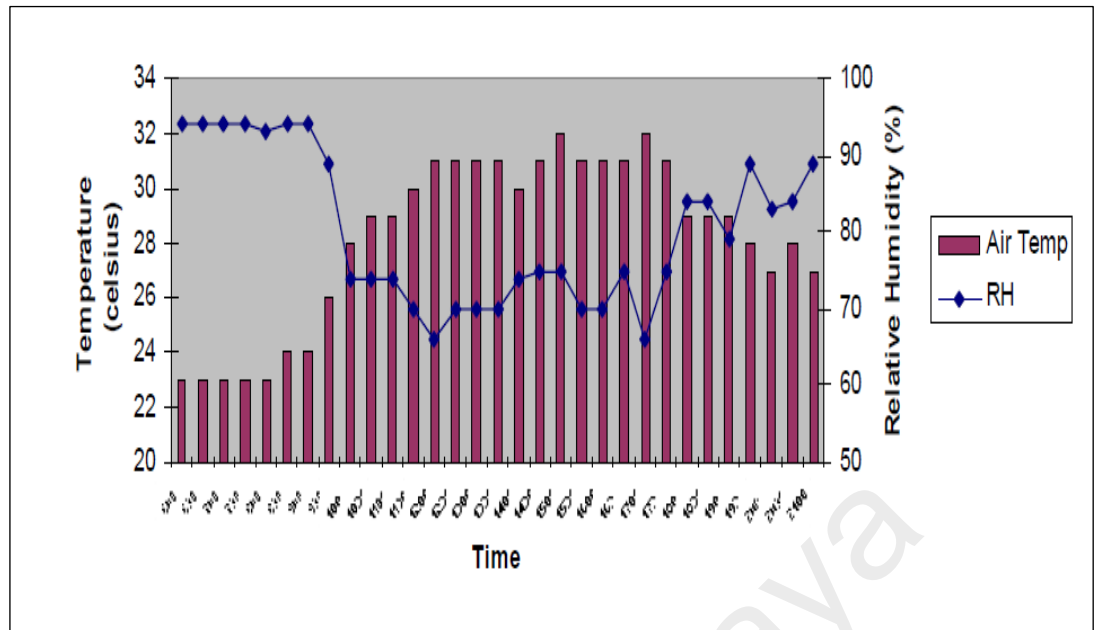


Figure 4 : Outdoor Relative Humidity Vs Air Temperature

The important factors in determining the comfort level in the hot and humid country is the air temperature and relative humidity. Based on Figure 4, increase air temperature reduce the humidity in environment. The hot and humid country typical climate is the high air temperature at an average of 28°C with an average of 80% of relative humidity. These factors have become the biggest challenge for improving and identify the thermal comfort perception individually. The hot air and high relative humidity have become very problematic in determining the best location for outdoor resting area with the least thermal discomfort. Due to these extreme conditions, many of the residentst prefer to move during night rather than during day time. There is scare available knowledge on the effect of these variables to the thermal comfort condition. A field study has been conducted to investigate how comfort condition been influence by these parameters.

2.4 Sources Affecting the Thermal Comfort at Outdoor Area

Regarding the thermal comfort in outdoor space, there are different sources which contribute to the thermal comfort at outdoor area. These are called microclimate. Microclimate plays major roles because the user will experience an outdoor area or space directly in contact with elements of the microclimate such as temperature, humidity, solar radiation, and wind speed. Many studies revealed that the microclimate parameters greatly affect the thermal sensation, but approaches or methods used have been only accounted for around 50% of the statistics and data variation between the objective and subjective comfort measurements. There is barely an approach or method to obtain the thermal comfort value by considering additional aspect, i.e., the physical, physiological, psychological, and social factors which play important roles in order to verify the individual perception of thermal comfort itself. The physical aspect that is considered as extremely influential is the environmental condition of the outdoor space itself, e.g., the configuration of the 'void', closing materials, building types, landscapes, the traffic as well as other elements such as plants for coverage areas and others physical form that available in the area. Factors mentioned above affect microclimate conditions. The microclimate characteristics then influence the thermal comfort value, especially physiologically which related on how the individual understand and feel regarding how their action will affect their body. The human body is quite sensitive to environmental conditions and changes such as rise of temperature since there is a need to maintain body temperature and to prevent overheat which will result in health itself.

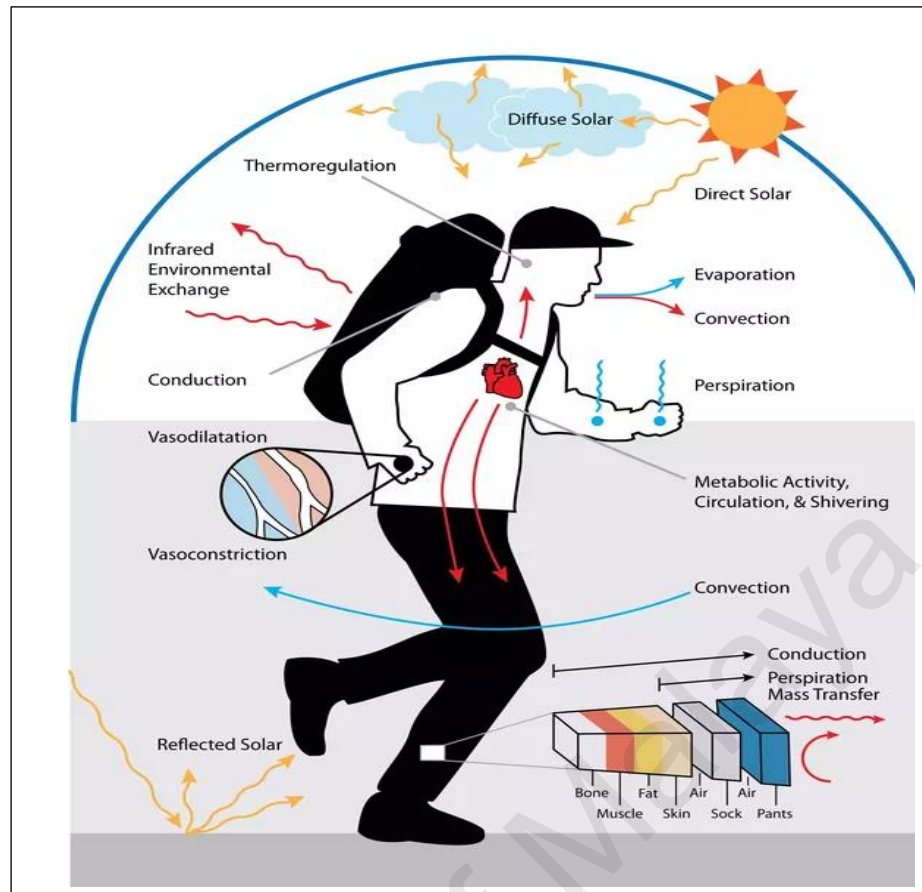


Figure 5 : Thermal Interaction between Human and Environment

(<http://www.thermoanalytics.com/products/human-thermal>)

2.4.1 Outdoor Temperature

There are many factors regarding thermal interaction between human and environment based on figure 5. Outdoor temperature is usually based on the heat from sun which then heat surrounding area. For human being, there are difference between the surrounding temperature which measured by thermometer compared to what we actual feel. We sense heat flux which the heat radiation through our skin and because of that for example during rainy season we tend to feel much cooler compare to hot time because of the difference in ambient temperature tends to affect our thermal comfort. For a human body to remain healthy, the body needs to maintains its internal temperature around 37°C . Usually of less

than 1°C variation occur with the time of the day, emotional state or level of physical activity play roles in the temperature fluctuation. A change of body temperature of more than 1°C occurs only during illness when we have no control of our body such as fever or when the body is unable to cope with extreme heat of environmental for example during high temperature outdoor area or during noon time. The body tends to warm-up as the environment warms-up, as well follow according external temperature. The body's internal "thermostat" maintains a constant inner body temperature by increasing sweat production and pumping more blood to the skin in order to cool down the body. In this way, the body balance the heat burden by increases the rate of heat loss by the body. In a very hot environment, the rate of "heat loss" is less than the rate of "heat gain" and the body temperature starting to increase. Heat illness results in the increase of body temperature.

2.4.2 Humidity

The amount of water vapor present in the air at any temperature is known as humidity. Water vapor is the gaseous state of water and is invisible to the human eye. Humidity indicates the likelihood of precipitation, dew, or fog which depends on the quantity per are and the environment temperature. The effectiveness of sweating in cooling the body reduced due to higher humidity which reduced the rate of evaporation of moisture from the skin because the environment vapor air is already saturated. This will affect the thermal perception by individuals. The amount of water vapor that is needed to achieve saturation increases as the temperature increases. It will eventually reach the point of saturation

without adding or losing water mass as the temperature of a parcel of air becomes lower. The amount of water vapor in a parcel of air differences can be quite large. For example, a parcel of air that is near saturation may contain only 8 grams of water per cubic meter of air at 8 °C but 28 grams of water per cubic meter of air at 30 °C. The important thing to understand is humidity because it affects weather and climate as well as global climate change.

2.4.3 Greenery Area

Most of the urban cities have issue regarding the increasing of heat surrounding. This phenomenon are know as Urban Heat Island. Urban Heat Island occur when natural land cover are replaced with dense concentration of buildings, pavement, roads and other surface that absorb or store heat This event often affected to local surroundings and the most vulnerable is the local residents at that area.

Greenery area is an area where the high quantity of vegetation which is cultivates to act as blanket to reduce the heat absorption. For this method it focus on plant trees and other vegetation in limited space area. Target area at the middle of road divider, retaining old trees and modify new construction in order to retain trees in the cities. Create top roof garden or increase quantity by using pots and integrate small green infrastructure practices into grassy or barren areas, vacant lots, and street rights-of-way.

2.4.4 Wind

Wind is air in moving state. Wind happens when the sun heats the earth surface. As the sun heat the earth surface, the atmosphere also heated. Some parts of the earth receive more heat compare to others. As the temperature increase the molecule become warmer and the molecules rises. As the molecule rises, the area become less dense. The cool area which is much dense will move to the less dense area. This cycle is what causing the wind. For urban area, the temperature is higher because of the buildings, pavements and other man made surface that absorb heats. Green area stored more cool air compare to this area. The probability of wind occur is much higher if the cities have green areas. Wind helps to control the temperature surrounding the area and at the same time helps to improve human thermal perception and comfort. For this studies, the wind area is not taken figuratively but more focus on the opinion of the participants regarding the most expected area to have high frequency of wind blowing.

2.4.5 Dressing code

Dress or clothing apparel is a necessity for all individuals. The clothing have power to show the wearer status, rank and other positional post for it. In 4 season countries there is garment for different seasons. This is focus on the comfort of the wearer during that seasons. In hot and humid climate area the garment suppose to reflect more heat radiations and at the same time able to increase cooling efficiency of the wearer so that the body will not over heat.

For the color of the clothing, the color and texture of an object dictates the absorption and reflection light characteristics of an object. Leaves appear green to the eye as they contain a pigment 'chlorophyll', which reflects green color but absorbs all other colors. So if the cloth wore by the individual is of light color, the surface of the cloth would reflect most of the light which reduce the heat absorption whereas a black cloth may absorb all of the light incident upon it which makes the wearer feels much hotter. The temperature difference between the two aforementioned conditions 'light vs black' depends upon the weather conditions. For examples previous studies at 4 season region (Schiavon, S.; Lee, K. "H. (2012)), in the summers when the Sun is setting on the top of a person, which is the increase of the magnitudes of the temperature difference. The end result would be the temperature of the outer body surface of a person being much higher in the latter 'black' than in the former. As a result, the person sweats rates increases to control the inner and outer temperature of his body. As far as the size of the shirt is concerned based on the body to shirt ratio, the long T-shirt means more surface area of the body is being covered by the clothes. So there is an increase in the radiation transfer to the body by the surroundings for the long sleeved shirt. The temperature at the outer surface of the body thus increases because the clothing traps the heat on the surface body and at the same time increase the sweating quantity. As opposed, the shorts may get you some comfort as long as its comfortable and the heat wave is not irritating your skin.

2.4.6 Metabolic Rate

Physical and psychological have impacts regarding the perception of the thermal comfort itself. Physical more focus on the condition of the body itself. Metabolic rate is one of the examples of the physical contribution to the thermal comfort. Different people have different metabolic rates. Metabolic rate is defined as the level of transformation of chemical energy into heat energy and energy for mechanical activities such as walking, playing lifting, throwing and other activities that required movement of physical body. This is based in ASHREE 55-2010 Standards. Metabolic rate is expressed in met units, which can be defined as follows:

1 met = 58.2 W/m² (18.4 Btu/h·ft²), which is equal to the energy produced per unit surface area of an average person seated at rest. The surface area of an average person is 1.8 m² (19 ft²) which is based on ANSI/ASHREE Standard 55-2013.

For a variety of activities, ASHRAE Standard 55 provides a table of met rates. Some of the common values are for example 0.7 met for sleeping, 1.0 met for a seated position and quiet position, 1.2-1.4 met for light activities such as standing, 2.0 met or more for activities that involve physical movement, walking, lifting heavy loads or operating machinery. The Standard states that is permissible to use a time-weighted average metabolic rate for intermittent activity if individuals are performing activities that vary over a period of one hour or less. Different metabolic rates must be considered for longer periods.

Based on ASHRAE Handbook of Fundamentals (2010), metabolic rates estimation is complex, and for levels above 2 or 3 met especially if performing such activities in various ways the accuracy is low. Therefore, average level higher than 2 met is not applicable for activities is not applicable with the Standard. Met values can also be determined more accurately than the tabulated ones, using an empirical equation that takes into account the rate of respiratory oxygen consumption and carbon dioxide production. , There is a relationship between the latter and oxygen production is another physiological yet less accurate method related to the heart rate.

2.4.7 Psychological

Psychological aspect of the thermal comfort perception is during when the individual focus on their activities such as sports or playing which result in the ignorance of physical heat and the them same time improve their thermal adaptation and comfort. Based on the research title The Compendium of Physical Physicians used activities to record physical activities done by individuals. It has a different definition of met that is the ratio of the metabolic rate of the activity in question to a resting metabolic rate. *Szokolay, Steven V. (2010)* said that drinks and food consumption habits may have an influence on metabolic rates, which indirectly influences thermal preferences. Depending on food and drink intake either types or frequency of intake these effects may change. Another factor that affects thermal comfort is the body shape. Body surface area depends on heat dissipation. A tall and skinny person has a

larger surface-to-volume ratio, can tolerate higher temperatures and can dissipate heat easily more than a person with a rounded body shape.

2.5 Previous studies regarding temperature cities in tropical countries

The hot and humid areas are generally located close to the equator and known as the tropical countries. These countries experience constant temperature all year around and the temperature ranging between 27°C at night which is quite rare until 33°C during the days. Among the countries that are included in the criteria are located at the Asian continent which is more specifically in the Southeast region which including Malaysia, Singapore, Indonesia and Thailand. The earliest investigation regarding the thermal comfort was conducted by Webb in 1949 which led to the derivation of the Equatorial Climate Index (ECI). The ideal air velocity is 0.2 m/s with the relative humidity of 70% and the ideal temperature of 28.86 Celsius based on index. However, the prediction is only focused on the dry and wet bulb temperature and wind speed but excluded other external activity level and clothing value in the derivation. These two factors are important parameters and will give more results compared to other factors since they are closely related to social and cultural influence.

Mallick (1996) in his investigation had also discovered that people who lived locally in this area are highly adaptive to the surrounding environment conditions although it seems quite harsh compared to other areas by changing the behavioral patterns and lifestyle preferences to reduce the discomfort feeling regarding the thermal comfort. The process of acclimatization also had a strong influence in the comfort preferences study. The study also found that the estimated comfort temperature is estimated between the range of 24°C at night and 33°C during the day under still-air condition which mean no movement of

air and with the movement of air such as wind or normal air-fan at 0.3 m/s, the range increased by 24°C for the lower count and 20°C for the upper limit. The air movement was a contributing factor in providing thermal comfort environment by reducing the temperature both to surrounding and the participant, however, according to this study, despite a wide range of recorded relative humidity which ranged from 50% to 95%, the humidity had little influence to the thermal comfort level due to the long term conditioning which effect to the perception of the subject itself which already feel like common status (Mallick).

The study also found that there is a strong correlation between the thermal comfort perception and wind sensation. This project will focus on the humidity and the surrounding temperature which will be surveyed for different types of subjects and search their common perception regarding the thermal comfort.

Another country in the Southeast Asia region which is Indonesia is currently active conducting research pertaining to the comfort level in the hot and humid climate. In 2004, Feriadi and Wong conducted an investigation regarding the thermal comfort perception, evaluation of the thermal comfort prediction and the behavioural action that influence thermal comfort perception in naturally ventilated houses in Indonesia. The study concluded that the prediction using the ASHRAE and Bedford Scale is irrelevant in predicting the thermal comfort condition for tropical climate because of the uncontrollable changes and climate itself. The finding also suggested that adaptive behaviour of the local community which already stayed in the area for long period of times may influence the neutral temperature to be higher than it was supposed to, however, if possible cooler temperature is still preferable. Earlier, Karyono conducted a field study on the thermal comfort, which samples are divided into various categories and

groups, for a multi storey office building in Jakarta, Indonesia. The groups are categorized by gender, age, ethnic background and physical characteristics. The study concluded that it is statistically insignificant between the neutral temperature between male and female, subjects under 40 and over 40 years old and between different ethnic backgrounds as well as between thin and normal subjects. The study also revealed that the neutral temperature is increased in the late afternoon compared to the early morning by 30 Celsius. For this problem, it can more focus on internal cooling system and air flow system of the building itself. This review shows that there is still difference in the subjects perception of thermal comfort regarding in closed area or open area.

2.6 Gaps And Measures of Outdoor Thermal Comfort Perception

For thermal comfort perception, the main idea is to understand and analyze the current status of individuals and their understanding regarding thermal comfort. The perception is to find the difference regarding each individual about their ability and adaptation with outdoor thermal. Different individual tends to give different answer. In order to implement improvement, the search for similarities between each individual is compulsory. In tropical hot and humid country such as Malaysia, the average temperature is quite high compare to other different climate countries. The search of the minimum average temperature for this country can be compare with average temperature of different rural areas. To reduce the average temperature, multiple supports and actions need to be taken both from individuals to government agencies in order to improve the thermal comforts each individuals in Malaysia.

CHAPTER 3: METHODOLOGY

The overall methodology involves all the steps in order to achieve the objectives of the research.

3.1 Introduction

The method section describes actions to be taken to investigate a research problem and the rationale for the application of specific procedures or techniques used to identify, select, process, and analyze information applied to understanding the problem, thereby, allowing the reader to critically evaluate a study's overall validity and reliability. The methodology section of a research paper answers two main questions: How was the data collected or generated? And, how was it analyzed? The writing should be direct and precise and always written in the past tense (Kallet, Richard H, October 2004). For this study, the data is collected using questionnaire which is link with the objectives.

3.2 Flow Chart

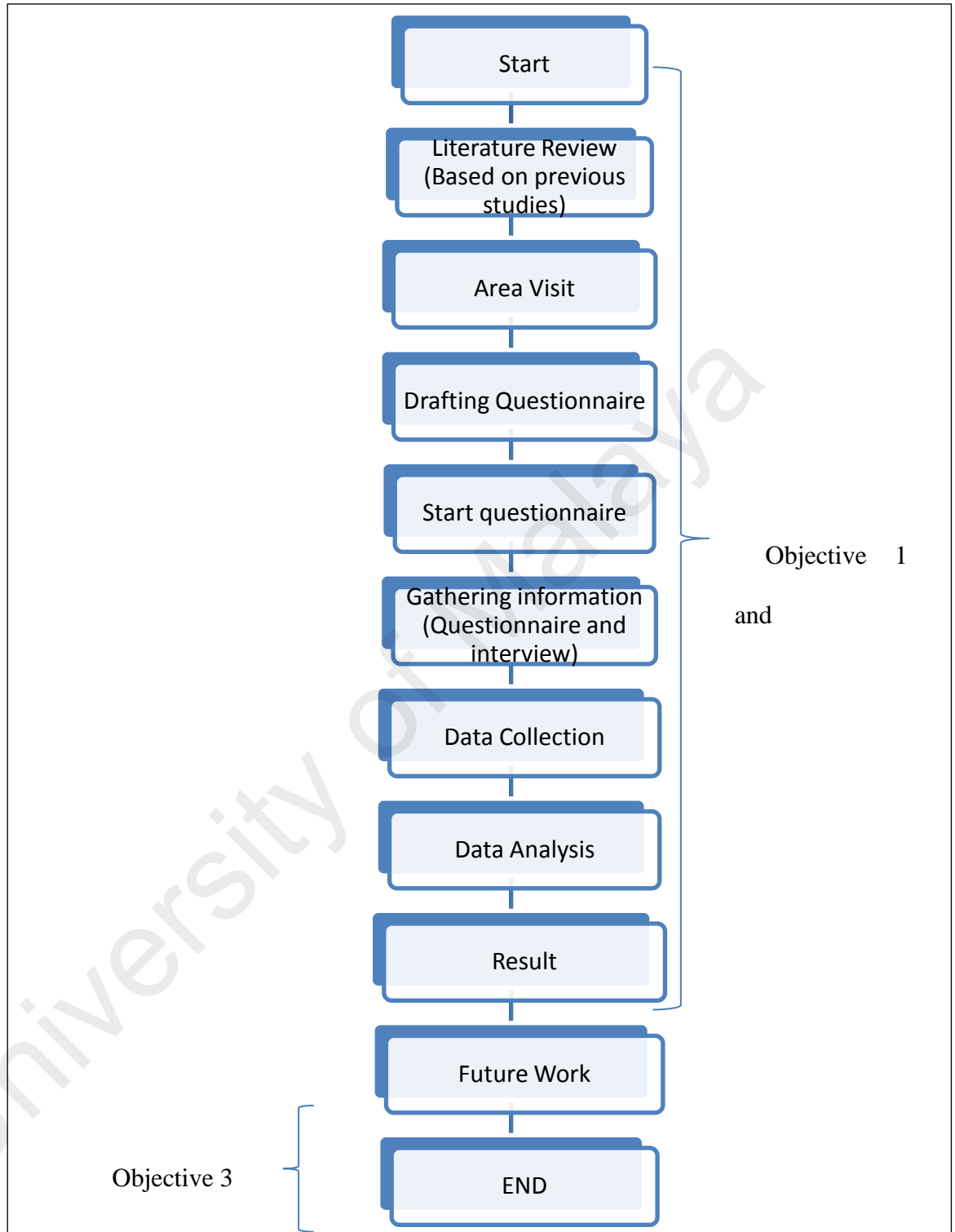


Figure 6 : Research Flow Chart

3.3 Study Area

This study focus on open urban area which is in this study is in Petaling Jaya, Malaysia.

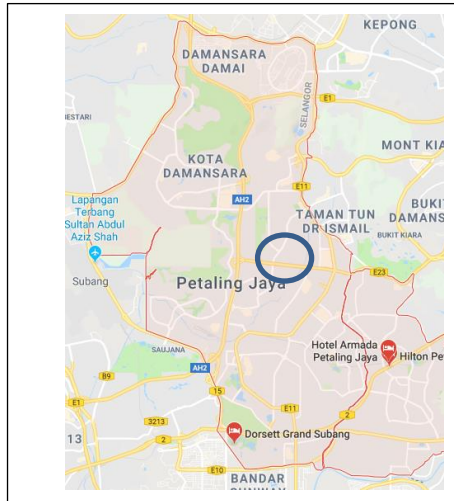


Figure 7 :Petaling Jaya Map Area

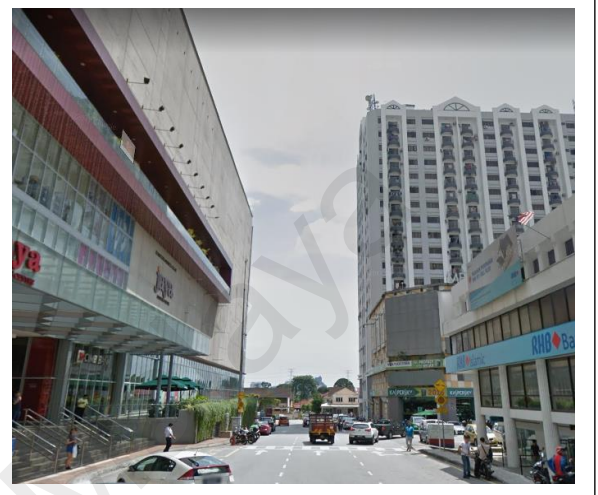


Figure 8 : Surveyed area location

3.4 Study Instrument

For this study, we use survey method and at the same time using thermometer and humidity meter to measure current temperature during survey is done.

3.4.1 Identify the possible candidate

Candidate will be selected randomly and be done at the outdoor environment. The method of candidate identification is based on the following criteria;

- Local residence in the area to do survey. The survey will focus on

which area it been taken and also current temperature and humidity. It can be done by using thermometer and humidity meter as figurative comparison regarding the feedback from the candidate itself.

- Survey must focus on different aspect to monitor. For this it focus on the gender, age, status, dressing, and their perception regarding current temperature surround them. It also focus on their method of suggestion to cool down their body to reduce the thermal discomfort.
- Population quantity and current status about the surveys. This focus on the local population and estimate population at the area that survey is done. This quantity based on perception of area such as the size of effected area and also the current quantity of people in the area. It will be decide by range of population.
- Previous studies done by researcher in order to identify the ideal thermal comfort for local residence. This has been elaborate at previous topic. The studies encompass of external thermal perception and internal thermal perception. It also focus on the environmental factors that play roles in the thermal comfort.

3.5 Method of Data Collection

3.5.1 Data Collection

The information will cover the aspects such as the location of the data taken and also the current temperature and humidity as followed;

- The current humidity of the surveyed area. Focus on the data collected by humidity meter. The value will be put by actual

reading meters and estimated by the targets.

- Support by the qualitative result (temperature). This using thermometer to measure the temperature during the survey session and at the same time the estimated temperature by the targets itself.
- Open area or shaded area. This focus on the field which the target subject do gathering and also open shaded area such as under roof with no walls and also under the trees which have shaded area.
- Activities for example walking, running, sports, or other activities that need it to be done externally. For this the target area is near the shopping complex or the open field.
- Safety and Health Aspects for example the body condition, the physical constraint such as the skin color, the background of the target and also the most preferred area to hang out if the target doing external activities.

3.6 Questionnaire Design

The questionnaire as per figure 9 is a multiple choice question which consist of 3 different categories, Current status of the survey participants, their current thermal condition and their prefer thermal condition perception. Every question will include their opinion regarding the chosen answer.

QUESTIONNAIRE FOR OUTDOOR THERMAL COMFORT PERCEPTION BY MALAYSIAN RESIDENCE

Objective : To evaluate the outdoor thermal comfort perception level by Malaysian residence and the people experience regarding improving their comfort.

Date : Time : Estimate Temp & Humidity :
 Actual Temp & Humidity (Measuring Device) :

Personal Information

Current Location (outdoor) :

Residence Area (State) : Sex : Male / Female

Age : < 15, 15-25, 26-35, 36-45 46-55 56-65 > 66

Activity : Walking, Sitting, Standing.

Clothing Color : Light / Dark

Individual Perception Condition

Preferred waiting area :	Shaded under tree	1	2	3	4	5	6	1 - Less likely
	Shadow of building	1	2	3	4	5	6	6 - Most likely
	Open Area	1	2	3	4	5	6	

Maximum ability to stay direct sunlight : Minutes (Estimate)

Previous location before survey ?

Car	Public Transport	Outdoor (Work)	Outdoor (Sports)	Indoor (Work)	Indoor (Sport)
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Preferred Condition

What time do you prefer doing outdoor activities ?

Morning	Noon	Evening	Night
---------	------	---------	-------

Please describe preferred thermal temperature :

<16°C	16°C-20°C	20°C-24°C	24°C-28°C
28°C-30°C	30°C-35°C	35°C-40°C	40°C>

In your opinion what is the best thermal comfort condition?

Humidity	Low/High		
Sunlight	Sunny	Neutral	Cloudy
Cloth	Light	Dark	

Figure 9 : Survey form

The study is conducted using survey format is divided into 3 sections. The first section is focus on personal information of the participants. It compromise 6 questions. Residence area is more focus on where the participants currently staying which in this case focus on Selangor state. The gender also play roles in this surveys due to the tolerance is different as how the body build itself. Height and weight allows the heat radiates either faster or slower taking effect to the participants, for example of this survey, we focus on the roughly estimate according to range regarding their perception of this temperature difference. Age is segregated according to stages starting from below 15 years old to above 66 years old. This study also want to verify if the aging effect to the thermal perception difference to the publics. Activity that has been done which is before taking a survey, for this it more focus on walking, standing or seating to see that which activities resulting in the most comforting activities been done in the same place. Their clothing focus on the color, either light or dark because can it be effect either mentally or physically because previous studies have been done regarding effect of clothing and heat absorption to body itself.

The second part of the questionnaire focuses on their current condition during the survey is taken. For preferred waiting area, 3 different locations are given which is shaded under tree, shadow of building and direct sunlight. For this survey, we do the most likely and least likely which to prevent the answer to be in the middle, we do scale from 1 to 6 which 1 is the less likely to 6 which is most likely. From this, we can derive if the correspondent focus which there prefer more. Also we do survey regarding how long they able to stand under direct sunlight based on their own perception. This is by using range scale using minutes as measurement unit. The next question is where have the target candidate have been in the last 1 hour. For this we do the multiple choice

question which related either the participant have been either in door area which have proper temperature control and better heat control or at outside buildings which have exposed to environmental temperature and heat.

The third section in this survey is to check what is the preferred and ideal condition that the participant want. For the first question is regarding the preferred time to do outdoor activities. This breaks into 4 category, morning, afternoon, evening and night which have different temperature and sun radiation. In this survey, participant can declare their ideal working temperature which we put according to specific range for the participant to choose. From this survey, participant awareness can be tested and are they able to identify the difference in temperature or just focus on other peoples opinion regarding their choose answer. Final question in this survey is to understand the participant perception regarding the best thermal comfort condition for outdoor area. This question is multiple choice question which is divided into 3 segments, humidity which to understand if they understand the roles of humidity in order to get best thermal condition and relationship to the temperature itself, the sunlight to check either the participant have knowledge regarding radiated heat from the sun and the last is the effect of their dress color according to the heat and temperature the participant percept either it have any effect or not to thermal comfort condition itself.

CHAPTER 4: RESULT AND DISCUSSION

4.1 Personal Information

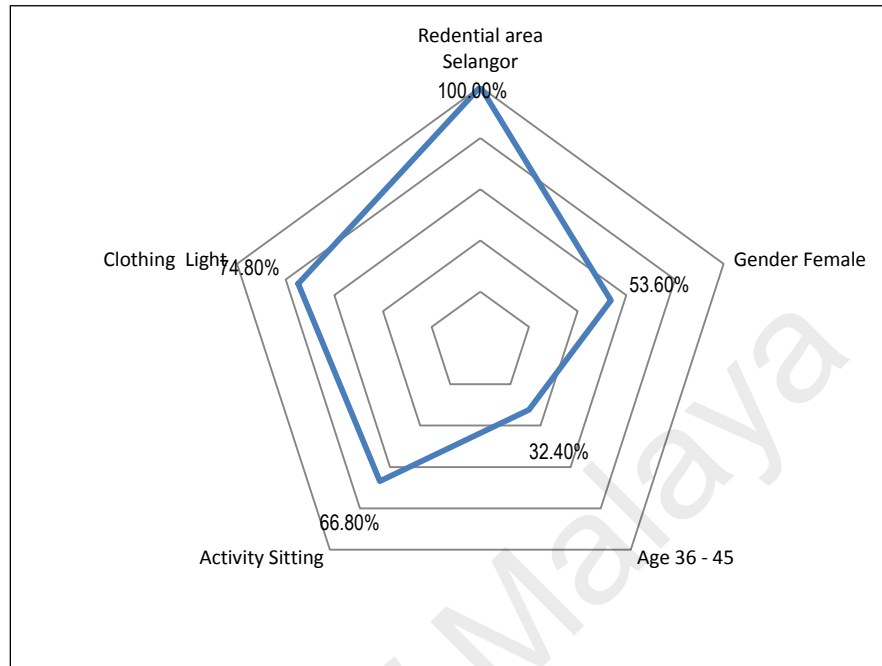


Figure 10 : Summary Result for first section

4.1.1 Current location

The survey took place in Petaling Jaya, more specifically near the shopping complex in Petaling Jaya area. The main reason is to focus in this area because the location itself which is near to the UM campus and at the same time is a local center of attraction. Most people in this area understand regarding the concept of thermal perception and at the same time able to give their opinion and support related to this survey. Figure 10 is the summary of Current Location category based on highest percentage.

4.1.2 Gender

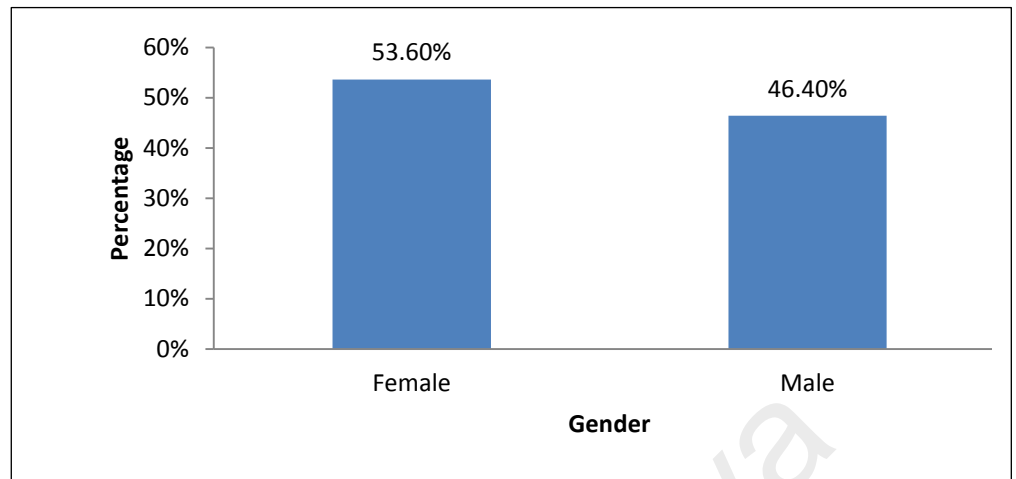


Figure 11 : Gender ratio respondent

Total survey respondents are 250 persons. From this the respondent is segregated to 134 female and 116 male respondent based on figure 11. From this the ratio between male and female is 46.4% male and 53.6% female. It is not based on target gender but mostly the female ratio is much higher compare to male ratio. Also from this survey, female respondent tend to give support regarding surveys compare to male respondent. In future, the target respondent needs to increase in order to get better accuracy and more reliable data for this studies.

4.1.3 Age

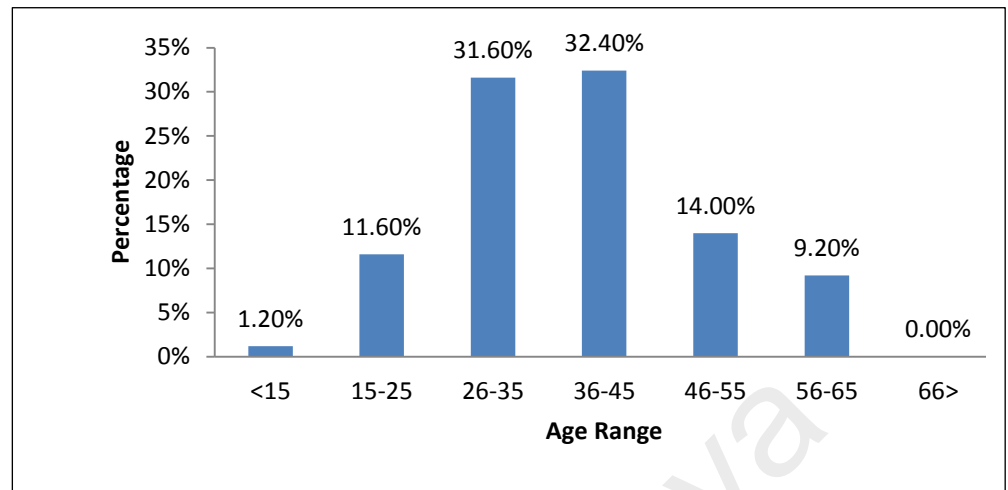


Figure 12 : Age Range

The age is segregated according to range. Figure 12 is the summary of the age range. For this survey, the age is segregated into 7 categories which have range of 10 years starting from less than 15 years old to over than 66 years old. The target respondents are approached selectively regarding their outer looks. The result based on percentage is less than 15 years old consist of 1.2%, 15 years old to 25 years old 11.6%, 26 years old to 35 years old 31.6%, 36 years old to 45 years old 32.4%, 46 years old to 55 years old 14%, 56 years old to 65 years old 9.2 % and no respondent above 66 years old. From the graph we can see that most of the target respondent is at the age between 26 years old to 45 years old which consist mostly of workers while other is student of higher degree. Based on this age distribution, the majority of people in this area can be assume to have basic understanding regarding thermal comfort perception and able to give proper survey and answer for this questionnaire because of their background of studies and already exposed to working environments. In future, to understand the difference

regarding thermal comfort perception between children and elders, the survey must be done for specific target groups such as the respondent must be at the age of either less than 15 years old or above 60 years old which can be done at old folks homes, primary or secondary schools or other gathering place for this age category.

4.1.4 Activity

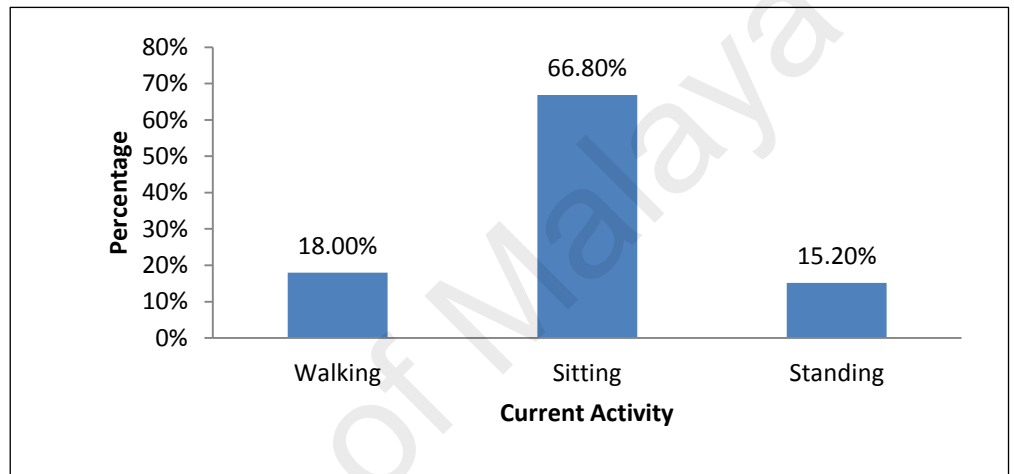


Figure 13 : Activities during survey taken

The activity is mainly focus on what the target respondent in this survey is doing before the survey takes place. For this the activities are divided into 3 categories as per figure 13, walking which consist of 18%, sitting which consist of 66.8% and standing which consist of 15.2%. Based on this survey, most of the respondent is sitting. Based on the observation, the reason why most the respondent in sitting position because it is much easier to explain regarding the research objectives and at the same time increase their interest in order to do the survey. This is based on assumption by surveyor during the survey is taken. While walking become the second highest which can be assume that they have

things that they need to do but some of them willing to do it maybe because it peek their interest regarding their understanding of thermal comfort perception. The smallest group is standing. This question is focus on the willingness of respondent to do questionnaire so that the percentage of the survey result is better. Also based on this questionnaire we can assume that in order to reduce heat generated from body, most of the respondent is in seating position because the seating position is a rest position which will reduce the metabolic rate of the body. By reducing the heat generated, thermal comfort can be achieved. The study based on ergosource.com suggest that sitting for an hour burn almost 0 calorie but standing for an hour burn 47 calories which shows that the difference in metabolic rate between standing and sitting.

4.1.5 Clothing

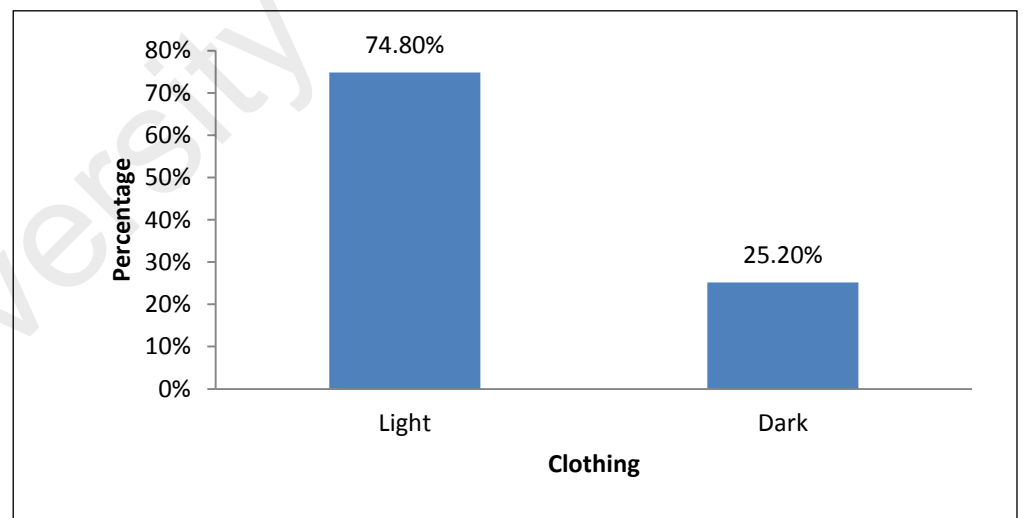


Figure 14 : Clothing Color

The final question in the personal information category is the clothing color. Based on figure 14, the comparison is not based one the fabric types, clothing design or the clothinging style itself because if these

variables are compared, the data pool will become larger and at the same time will increase the time require to analysis the relationship of each clothing with the thermal perception of the individuals. Instead we focus on the clothing color tone of the respondent. This questionnaires is focus on which tone color clothing is choose by the respondent during their outdoor activities. From the graph we can said that light color clothing is mostly worn during outdoor activities which consist of 74.8% of total target surveyed and the dark color clothing consist of 25.2% of the total surveyed target. When the respondents were asked regarding their choice of clothing color, majority said that the reason they were wearing light color cloth is because it feels less hot and more comfortable compare to wearing dark color clothes. When the respondents wear dark color cloth were asked, their answer is they feel hot but still tolerable indicate that they maybe have higher tolerance to thermal compare to the light color cloth respondent. To identify that is this really logically or not, next survey category will have answer regarding their tolerance under heat stress.

4.2 Individual Perception Condition

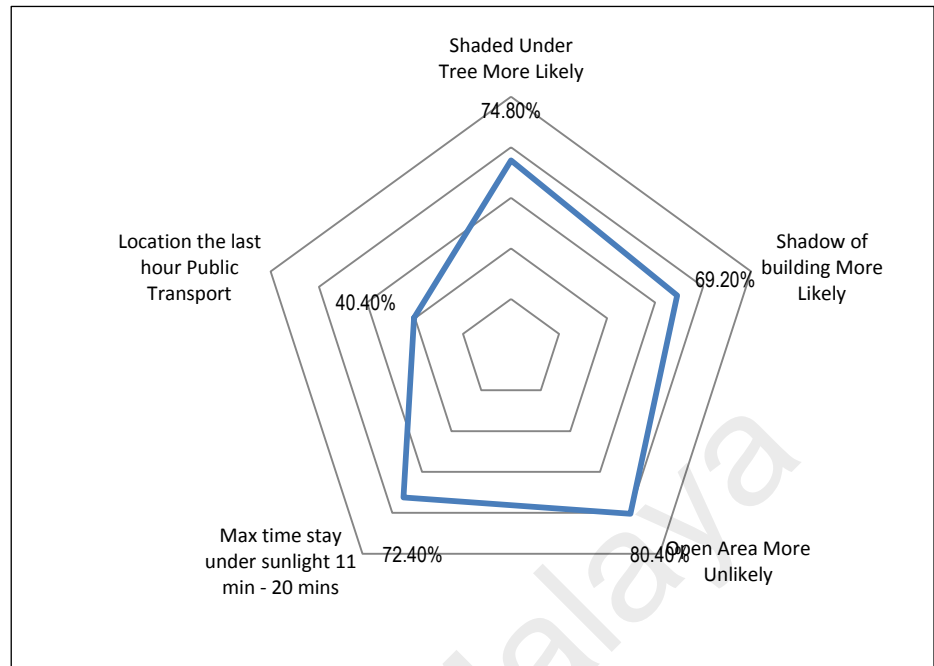


Figure 15 : Summary Result of Second Section

4.2.1 Preferred waiting area

Preferred waiting area is the location where respondents want to wait in order to rest and reduce the body temperature and at the same time increase their thermal comfort level. This questionnaire is more focus on their perception about thermal comfort in their own perspective. In order to understand their level of likeliness scale based selection is done. The scale is range from 1 to 6. 1 is for less likely and continues to 6 which are most likely. Figure 15 is the summary result of second section.

4.2.1.1 Shaded Under Tree

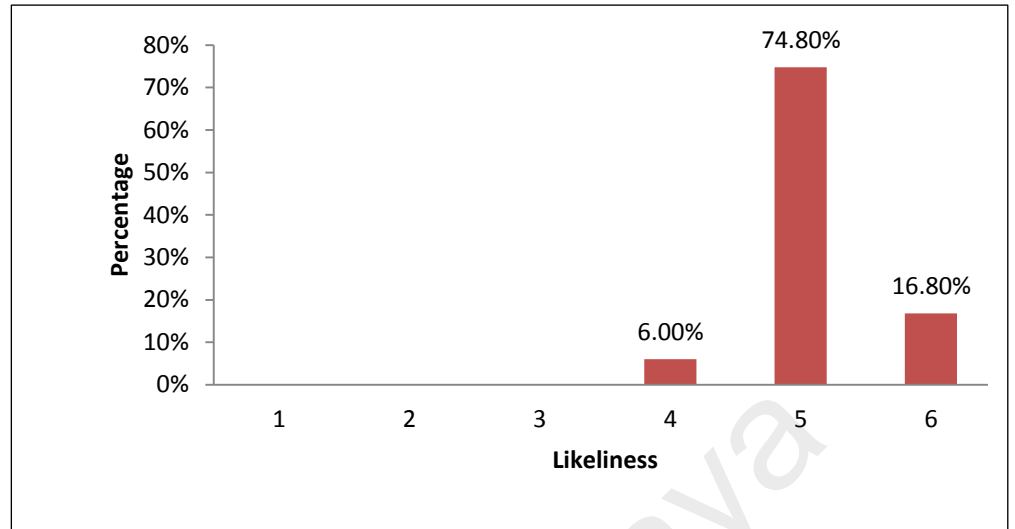


Figure 16 : Likelihood waiting under tree shade

Based on Figure 16, the scales at x-axis indicates that the level of likelihood start from 1 which is most unlikely to 6 which indicate most likely. From the graph, we can identify that all the respondent choose to wait under the tree shades. For scale 4 which is likely, 6% of the respondents choose this scale. For scale 5 which is more likely, 74.8% of the respondents choose this scale and balance of the respondent which contribute to 16.8% of the respondent choose most likely. Based on this survey, we can conclude all respondents will wait under tree shades if given chance to do so. The difference is why the respondent didn't choose most likely if they prefer to wait under tree shades. After interview, the respondent which choose scale 4 and 5 said that they will look the seating position first before waiting under the tree shades. Also they will look if there is risk of falling tree branches or other unsuspected hazard before waiting under the tree. In some cases, they will follow the crowd for example if the crowd waiting under the tree, they tend to

follow with the crowd itself. They want to reduce heat absorb by their body from sun rays.

4.2.1.2 Shadow Under Building

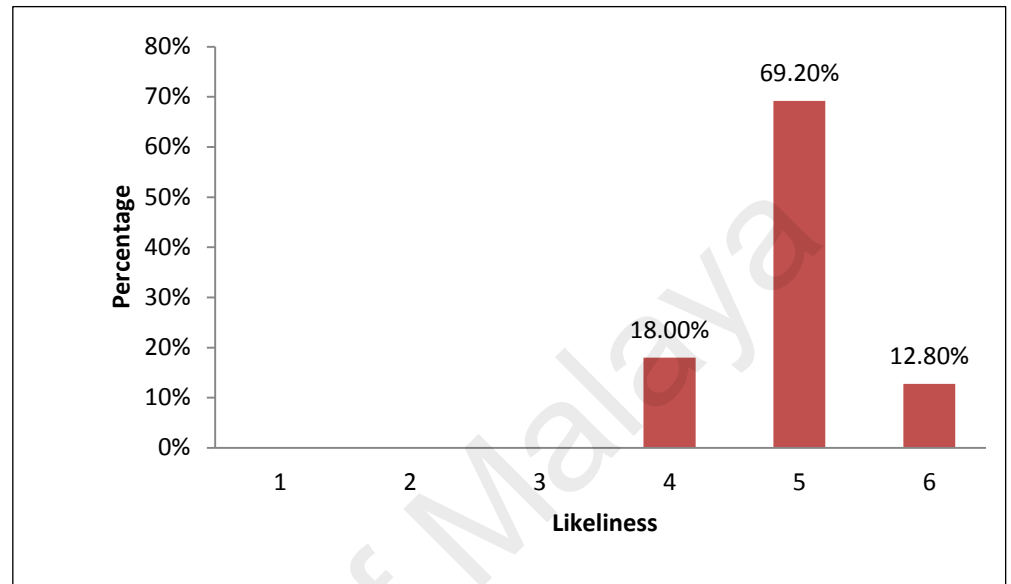


Figure 17 : Likeliness waiting under building shadow

This is the result regarding the range of likeliness of preferred waiting area. For the shadow under the buildings, it include shaded walking area which been built at outside of the buildings, bus stops, and other types of buildings, the result is almost the same as waiting under the shades of tree. All of the will likely waiting under the tree compare to waiting under direct sunlight. From refer to Figure 17 we can said that 18% will likely waiting under the shadow of building, 69.2% will more likely to do so and another 12.8% most likely to do it. To compare between waiting under the tree and waiting under shadow of the building, we compare the likeliness based on scale 4 to 6. For scale 4 which is likely, waiting under a tree 6% compare waiting under shadow of building which is 18%. For scale 5, waiting under a tree shade consist of 74.8%

compare waiting under the shadow of building which is 69.2%. While for scale 6, waiting under the tree 16.8% compare to waiting under shadow of the building which is 12.8%. Why there is difference in this survey. After verbally check with the respondent based on their answer they said that waiting under the tree will feel much cooler and more comfortable compare to waiting under shadow of the building. Some of the answer is the probability of wind is much higher compare to the building itself and although waiting under the shadow of the building, heat radiated from the building still can be felt by the respondent compared to waiting under the tree which not radiate any heat. Also the respondent said the coverage of tree shadow much bigger compare to coverage by buildings. For this new additional parameters conclude there is more in identify and improving thermal comfort of each individuals at outdoor environment.

Further studies can be done regarding this additional parameters. For wind, how can it reduce the heat receive by the respondent and the probability the wind come and cool down the respondent. For the heat radiated from buildings, we can check regarding the design, material types, exposure level and time for the heat to dissipate from the wall building itself. Also how long the exposure time needed for building to radiate heat for one hour as an examples based on different types of wall structure for examples, concrete, brick walls, glasses etc. For the third question, how big is a building can cover and how does trees able to make bigger shades compare to building? For this studies, we can do to identify detail parameters in order to make multipurpose buildings which

can act as shades and at the same time reduce the heat absorption to the building .

4.2.1.3 Direct Sunlight

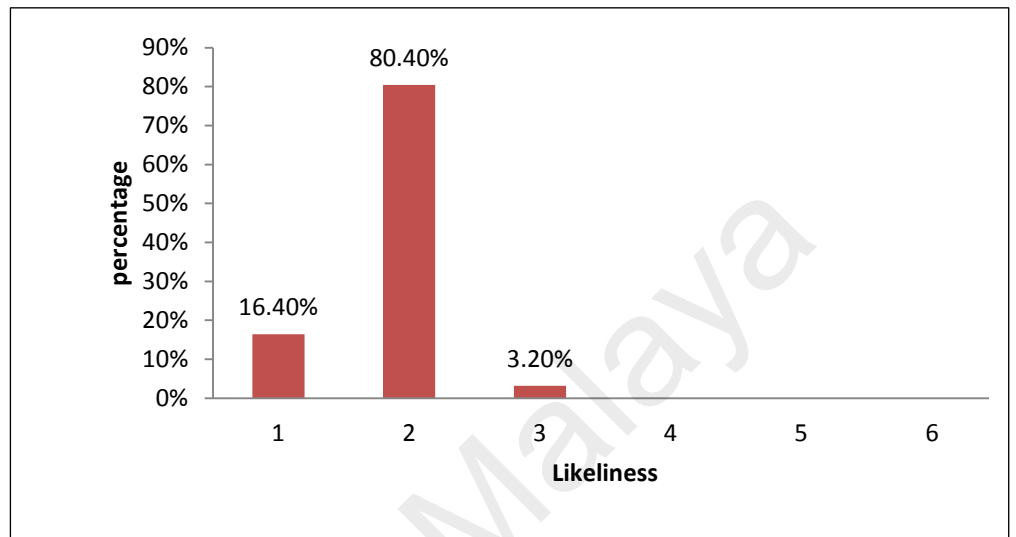


Figure 18 : Likeliness waiting under sunlight

Compared to previously surveyed waiting area, waiting under direct sunlight is the most unlikely area to wait at outdoor area. From Figure 18, we can say that all prefer not to stay under the sunlight. The probability increase as the time approaches noon when the sun position is directly above the ground. When interview with the respondent, 96.8% of the respondent said that the heat from the sun makes them feel uncomfortable and will find nearest shaded area even need to walk a little bit of distance. From this we can say that heat radiated from sun have effect regarding the thermal comfort. To improve the thermal comfort of individual, less exposure of sun rays. During this studies, after verbally interview to target respondent, most of them will said that rays feels hotter as it approach noon. In future we can do studies

regarding how much heat is generated based on time the sun ascending to position interval.

4.2.2 Maximum Ability To Stand Under Direct Sun Light

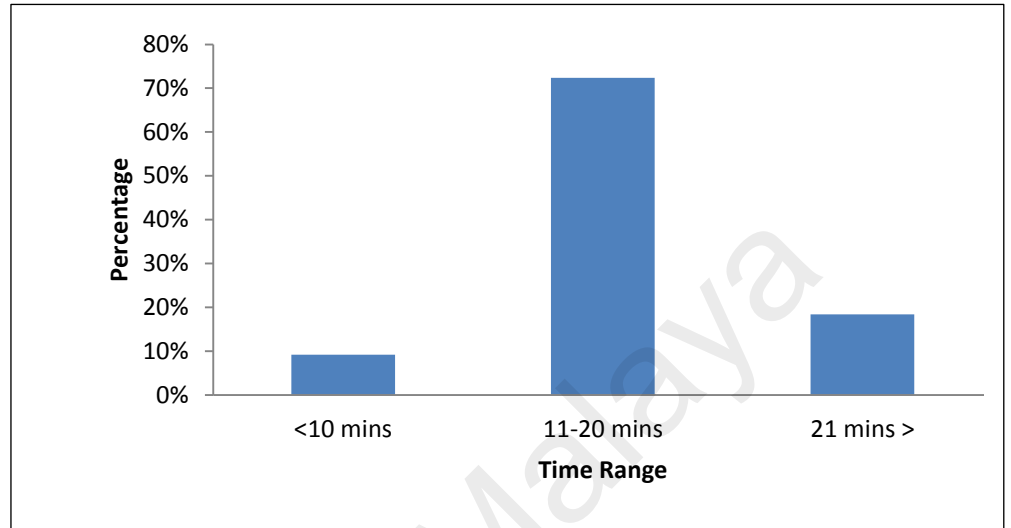


Figure 19 : Tolerance with heat rays from the sun

For this question survey, it focuses on the individual ability to withstand in uncomfortable environment if in emergency situation. For this survey, it is based on what the respondent feel about their maximum ability to stand under direct sunlight. For this survey we focus on when the sun is at brightest which is from 10 in the morning until 5 in the evening. As per Figure 19, 72.4% of the respondents selected range time from 10 minutes to 20 minutes. After asking based on their perspective they said that the reason is they are able to cope with this time due to their exposure time itself during activities mostly work related that require them to stand under the heat from sun rays. For above 21 minutes which is accumulated 18.4% of the respondents said they already have high tolerance regarding standing under the sun. For the respondents which can stand under 10 minutes under the rays which is 9.2% said

most of their time is in either confine office space with air condition or inside of building. Roughly survey regarding their physical attribute shows that darker skin persons are able to tolerate heat rather than lighter skin persons.

4.2.3 Previous Location before survey

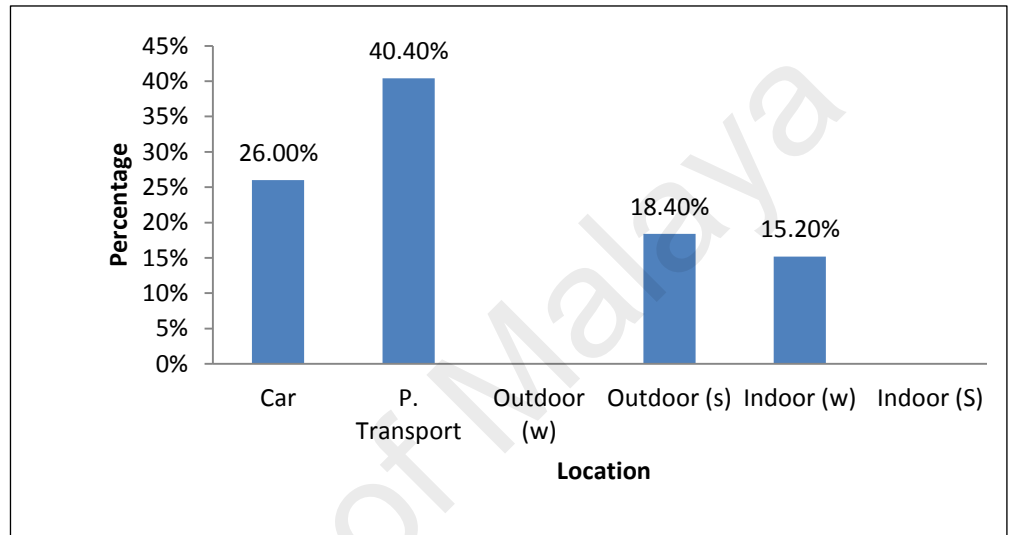


Figure 20 : Location respondents before survey is taken

This is the last question regarding current condition that has been given to respondent is their location in the last hour. This one we divided into 6 multiple choice answer. We have cars, public transport, outdoor doing work stuff, outdoor doing sports, indoor doing work and indoor doing sports. Based on the survey results as per Figure 20, the highest is in the public transport which is 40.4% of the total respondent. It includes in trains, buses, taxis and even application based transport. The second highest is in cars which is either car pool or personal cars which is 26% of the total respondent. The third is outdoor doing sports 18.4% and indoor doing work 15.2%. This is just to collect data for which most of the people prefer to be rather than outdoors. It turns out that majority of

the respondent prefer to location which is contained and have controllable temperature because it is more comfortable than at outdoor area which the temperature is uncontrollable. From this question we can conclude that normally they prefer around room temperature. Usually room temperature is around 24°C and it can either been control by using air conditioner or normal fan. The reason is the temperature is not based on the room itself but what the skin feels regarding the temperature.

4.3 Preferred Condition

This is the last category of the questionnaire. This question focus on what the respondent want and feel regarding the thermal comfort perception. Also, this questionnaire will get them to compare is the thermal perception is based on what the respondent really feel throughout their body or just the way they interprets what is the thermal comfort itself. In this category there is 3 questions that need answer from correspondents. The first one is the preferred outdoor activities time. This question mainly focus on what the respondent feel the most comfortable time to do outdoor activities, either working or doing sports or just strolling. The second question is the preferred thermal condition mainly focuses on the temperature itself. In this question the respondents will be test with their understanding and is there any difference regarding temperature they feel and temperature they want. The third question is about the best thermal condition. It breaks into 3 question, humidity which for low is 50% less and high which is 50% more, Sunlight which either sunny which is bright light, normal which is a bright sky with no direct rays or cloudy which a little bit dark in day time. This is based on their perspective regarding the best thermal comfort they want for

outdoor environment. Figure 21 is summary for third section of this questionnaire.

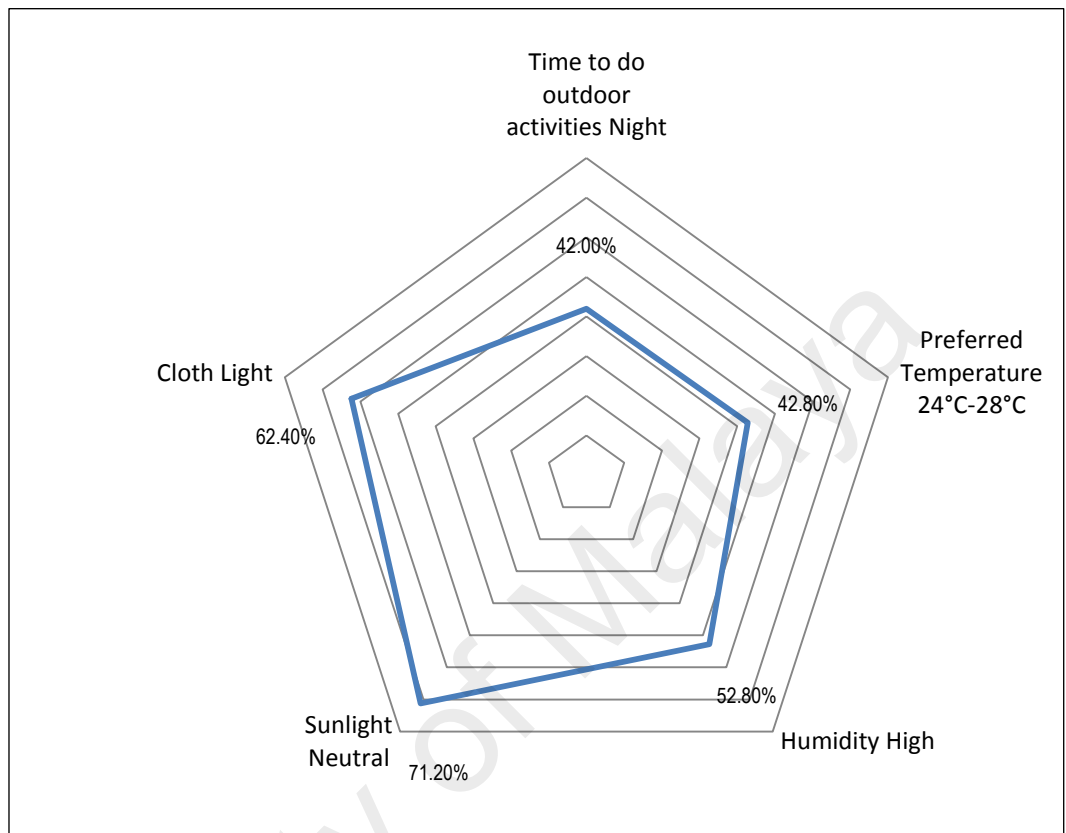


Figure 21 : Summary result for third section

4.3.1 Preferred Outdoor Activity Time

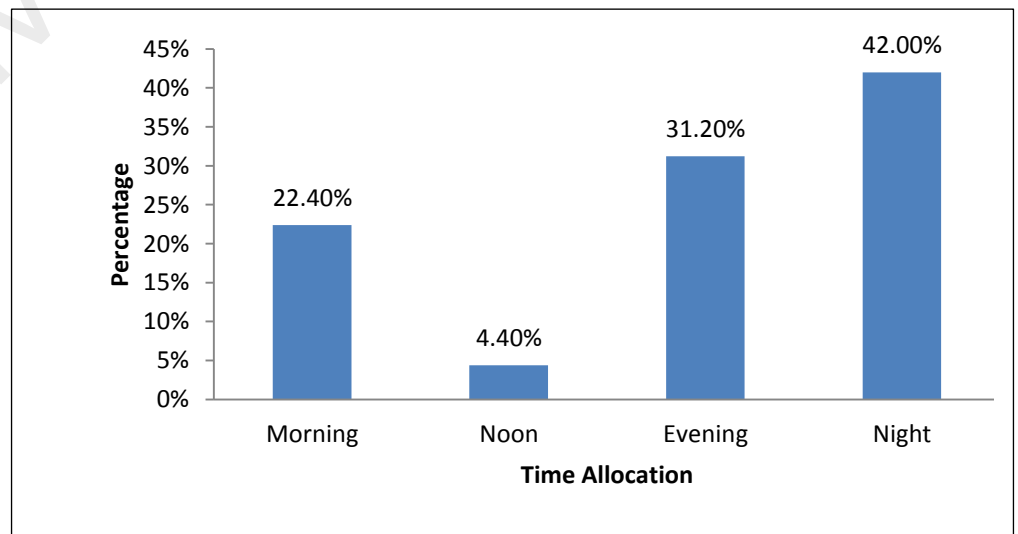


Figure 22 : Preferred time for outdoor activities

For preferred outdoor activity time we segregate the time into 4 categories, morning, noon, evening and night as per Figure 22. Morning is defined from 6 am until 10 am, noon starts after 10 am until 4 pm which is most of the time the sun already shine brightly, evening is between 5 pm until 7 pm while night is 8 pm until 5 am before morning. This cycle is explained to the respondent before they start to answer the survey sheet. Based on their answer given, 42% of the respondent chose to do outdoor activity at night. Their reason is the night is much cooler compare to day because of no sun during day time. This question shows that rays from sun play roles in the thermal comfort and not based on perception individually itself. Second highest is activity done during evening which accumulate 31.2% of total survey respondent. Based on their answer regarding their thermal comfort, the respondent said that the uncomfortable only feel when they start to get bored or tired when doing outdoor activities. Based on this question we can said that the individual thermal comfort perception differs based on their energy and how they enjoy what they were doing. If they find it enjoyable, they can tolerate thermal much higher and at the same time doing their activities. The third is activity done during early morning. It consisted of 22.4% of the total respondents. The reason why they prefer to do activity at this time is because of they feel fresher and the air is much cooler compared to other time. So they can do more activity especially jogging for longer period of time and greater distance. The reason is they felt less strain to the body due to heat absorb from the sun. It can be concluded that time of day play a role for the individual thermal comfort perception itself. The least chosen time to do outdoor activity is during noon which consisted only

4.4% of total respondent. All of the respondent that chose this activities in around age 15 to 25 based on the survey age. After investigate regarding this chosen time, the respondent said that the reason they do the activity at this time because they can tolerate regarding the heat and thermal issue.

4.3.2 Preferred Comfortable Temperature

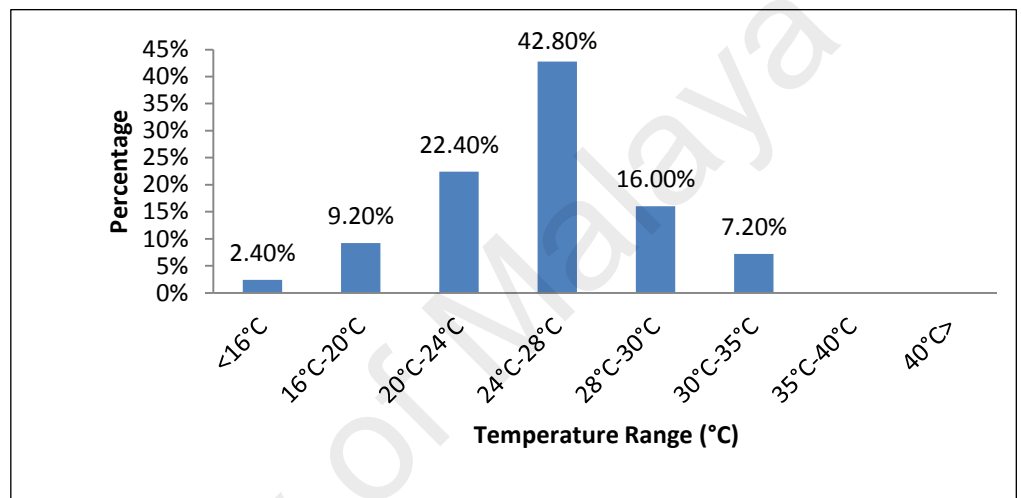


Figure 23 : Comfortable temperature perception by respondents

For preferred comfortable temperature, the selection is based on temperature range. It starts from less than 16°C which is based on the lowest setting allowable by household air conditioner. The next scale is 16°C until 20°C. The next is 20°C to 24°C and continue with 24°C to 28°C, 28°C to 30°C, 30°C to 35°C, 35°C to 40°C and finally above 40°C. For this question we focus on what the ideal temperature the respondents feel comfort based on their individual perception. The highest chose range is 24°C to 28°C which consist of 42.8% of the total respondents. The second highest is temperature between 20°C to 24°C which consist of 22.4%. Based on roughly observe range, we can assume that the

respondents prefer room temperature. Because of the respondents is a local tropical country residence, they prefer slightly higher than normal room temperature. It shows that the ideal temperature preferred by the residence for outdoor area is based on where they are staying and in this studies it focus on tropical country which have slightly higher temperature compare to other 4 climate countries. Even though they stay on tropical country, no respondents choose temperature above 35°C because the temperature itself is too high to tolerate. Thermal comfort perception is different between individual. Environment condition also able to change their level of comfort tolerance and perception based on the location of residence and the exposure of the environment climate themselves.

4.3.3 Best Thermal Condition

For best thermal condition, we segregate into 3 parts which is humidity, the sunlight intensity and the clothing color they are wearing. For humidity we do segregation, low and high based on what the respondents said. The sunlight intensity segregate into 3 types, sunny, neutral and cloudy and the last is the clothing color which is either light color or dark color.

4.3.3.1 Humidity

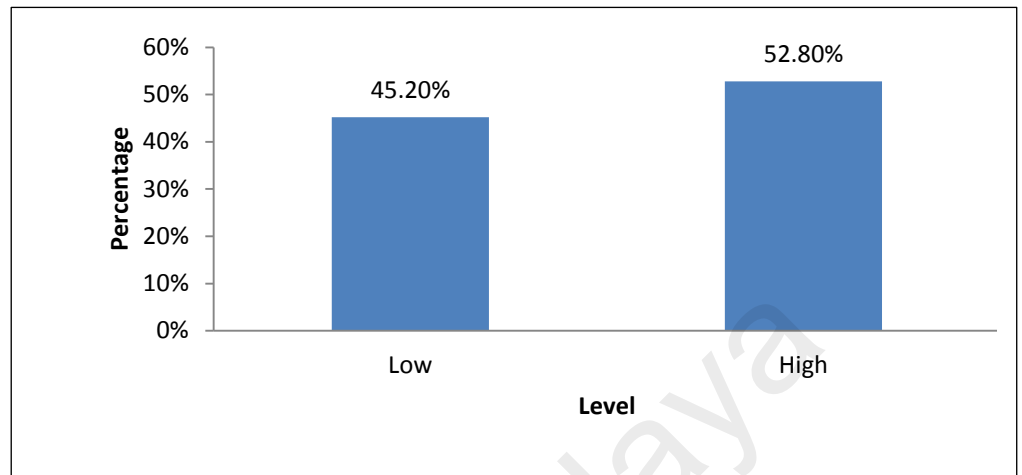


Figure 24 : Humidity level

For this survey first we do explain in simple term regarding how to determine the humidity level. We explain that if the respondent feel cool it means the humidity is low and when the respondent feel hot it means that the humidity is high. This explanation is based on the previously research regarding the temperature effecting the air humidity. Based on this result as per Figure 24, majority which is 52.8% of the total respondents chose high humidity and balance which is 47.2% of the respondent chose low humidity. After check verbally why they chose their answer, they just said that most of the time when the temperature is hot their skin moist and when temperature is cool their skin is dry. Based on this answer, the respondent did not really understand the concept of humidity and its link to temperature which will affect the thermal comfort perception of the individual themselves.

4.3.3.2 Sunlight

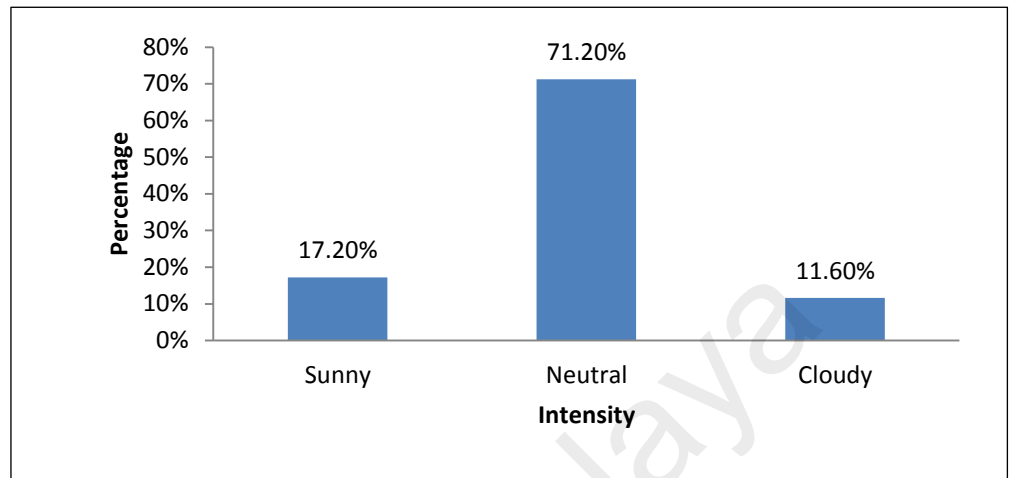


Figure 25 : Sunlight intensity

This question is much easier to understand compared to the Humidity survey. Figure 25 shows that the selection is break it into 3 available options, sunny which the sun shine brightly and directly, neutral which the sun not directly shine and cloudy which a little dark which is the cloud block the sun. Based on Figure 25 most respondents prefer to do activities outdoor on neutral day which they feel much cooler compare to sunny day. It consisted of 71.2% of the total respondent. Only 17.2% prefer sunny condition as their best thermal condition. The least is cloudy which consist of 11.6% of the total respondent. After asking verbally why they prefer neutral condition compare to cloudy condition because the probability the rain or storm occur is high due to accumulation of clouds. So they prefer to do things in door for safety purpose. From this survey we can understand that for thermal comfort perception individually at

outdoor area require so many factors which is uncontrollable by people and sometimes at the mercy of the weather itself. For this our body already able to tolerate because of repeating exposure of this temperature and humidity making our body able to tolerate higher temperature and at the same time able to improve our thermal perception individually.

4.3.3.3 Clothing

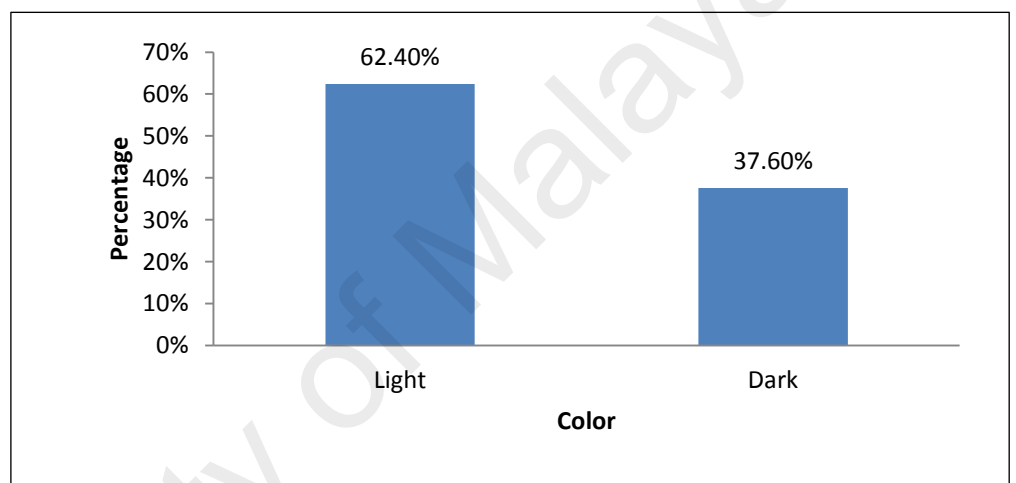


Figure 26 : Clothing Color

In this study the main focus is the color of clothing the respondents wear and not the fabric types or the clothing designs itself. This last question focuses what color of their clothing prefer to wear during their outdoor activities as per Figure 26. For this survey we segregate into 2 parts, light color clothing and dark color clothing. After finish survey although by visually most of the respondents of the survey wearing dark color cloth or clothing but they prefer to wear light color cloth. Based on what they explain, the reason is when wearing light color cloth they feel less hot much cooling

compare to dark color cloth although they stay under the sun for same period of time. The reason why they prefer dark color cloth to wear because the sweat is not clearly visible compare to light color cloth and the dark color cloth look much cleaner compare to light color cloth which easily stained. The question happen when one of the respondent said that he doesn't feel any difference between dark color cloth and light color cloth. After than we check back with previous question, the result is the respondent stay under shades for a period of time shows that dark color cloth cool much faster compare to light color cloth. This is just a theory can be elaborate for further studies.

4.4 Summary

After completion of the survey and analysis, there thermal perception varies between individuals. We already done surveys which we segregate between 3 categories such as personal information, individual perception condition and prefer ideal condition. From hear we will take the highest result from each of the questionnaire. First in the category is the personal information. For this survey we take random 250 persons which cooperate in making this survey successful. All respondent in this survey is Selangor resident. 54.6% of the respondent is female, 32.4% of the respondent is in middle age class which is 36 years old to 45 years old. 66.8% of the respondent is sitting or resting when the survey is taken and 74.8% is wearing light cloth or clothing. From this list is the reason why the total survey respondent is Selangor residents is because the survey is taken in Selangor state or in simple term currently staying in Selangor. Also this

survey is taken during working hours so most of the people is either working in Selangor or staying in Selangor.

The second question is most of the respondents is female because female gender tend to hear detail and easy to ask for cooperation compare to male respondent. This is maybe due to their gender or their want to know what people are during around them.

The third question is the respondent age. We can see the most categories is adult and working man which is around 36 years old to 45 years old. For this we can say that most of the people there is working which have either break or out of office work.

The forth is the activity which is done. The highest is sitting which accumulates of 66.8% of total respondents. One of the reason is because they are in relax mode and want to kill time. Some of the in waiting process. So they tend to support during this survey is taken.

The fifth is mostly based on visual judgments. Their clothing color. Light color is the highest which is 74.8% of total surveyed respondents. The reason is when they stay at open area they feel less hot which means that clothing color play roles for thermal comfort not just perception only.

Based on this questionnaire regarding personal information, we can conclude that this is the current action taken in order to improve their thermal comfort.

The second category is regarding their current condition. This one focuses what they feel regarding thermal comfort. For area waiting the respondent preferred under shade either from buildings or from trees more than standing out

in the open. But when given choices they prefer under the tree because of higher speed of wind compare to buildings. Mostly they can stay under sunlight in between 11 minutes to 20 minutes before start finding a shelter from the sun. In city, people prefer public transport because they can reduce the time to find parking and at the same time in city the public transport more efficient compare to other areas.

The third category more focus on what they prefer for thermal condition to achieve thermal comfort at outdoor area. Start from time they prefer to do activities. The time mostly prefer at night because of no heat from sun which make environment much cooler compare to day time. Because of the respondent is local tropical country residents, the temperature they prefer is between 24°C to 28°C which a little higher compare to room temperature which is around 24°C. For humidity they prefer higher because of high probability of wind coming, the sunlight in neutral which the heat rays is not visible and the clothing is light color which will reflect the sun and at the same time reduce heat absorption by their body.

CHAPTER 5: CONCLUSIONS AND FUTURE WORK RECOMENDATIONS

5.1 Conclusions

After selected study of Thermal Comfort Perception to Local Residence of Tropical Country of Malaysia, the average of thermal comfort perception acceptance level of the respondent results were acquired. Based on this result, the acceptance level is quite high. It is because rather than depending on weather only, the respondents more focus on improving themselves such as wearing light color clothing, finding shaded area and reduce direct exposure to heat rays from the sun. Although there is increase of average temperature which is more obvious during the night time, local residents is able to assimilate and tolerate by improving themselves. This study has been done in Petaling Jaya which is an urban area. Gender and aging play roles in the level of thermal comfort perception level. The result is in conclusive compare to the objective to determine the average level of thermal comfort perception acceptance level of respondent because the different in ration of male and female, age level will change the average acceptance level.

There are many factors contributing the highest thermal comfort perception limit rating. These factors include the outdoor temperature, the humidity in the environment, greenery percentage at the area, wind, dressing code, metabolic rate and psychological stats. In comparison of the individual, tall, skinny, dark skinned individual is able to tolerate higher temperature and thermal level compared to short, fat, light skinned individual. The difference in physical factors of the individual itself makes the limits of the highest thermal comfort perception level cannot be determined. For environmental condition which is the best in order to improve thermal comfort is the temperature of 28°C which is chosen by respondents, the sky is normal which the sun not shines so brightly and the respondents wearing light color clothing.

We focus on public traffic area for jaywalk such as shopping mall districts and at the same time do field observation with total of 250 participants with questionnaire and interviews. This questions more focus on their current behavior in order to improve thermal comfort and monitor either the answer is only based on their perception or more to how they feel about themselves. Results indicated that behavioral adaptation strategies were more frequently used to enhance thermal comfort, among which moving-oriented behaviors and material-aided behaviors were most frequently adopted. When behavioral adaptation could not be adopted, psychological adaptations were used, the most frequent being shift strategies, which included distraction or focusing attention on the ongoing activity to help tolerate thermal discomfort. Last, a simplified version and detailed version of the thermal adaptation evaluation procedure appropriate for urban plaza users in hot and humid Asia were proposed.

This evaluation procedure should be applied to analyze user's behavior at open space before landscape engineering. Information from the behavior analysis will be useful for landscape planner to design a comfort outdoor open space in urban areas. Moreover, the procedure could be applied to the post-occupancy evaluation while outdoor open space have been constructed for a few years. Results of the post-occupancy evaluation could offer practical insights to government for how to remodel outdoor open space.

5.2 Future Work Recommendations

After completion of this study, there are simple methods in order to improve the current thermal comfort perception by all individuals. The green area play important roles in order to improve the surrounding temperature. It helps to regulate temperature and at the same time act as shades which also agitate air movement. For this city planner can increase the number of trees and vegetation area. For individuals they can start planting small pot plant for example vegetables at their balcony. Also rooftop garden is a unique

approach to reduce temperature which can be practice at high rise buildings. Reduce the color absorbent paint and more focus on white color paints also helps in order to reduce the heat absorption and at the same time able to help regulate surrounding temperature.

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