



Study of Comfort Temperature for Gym Activities at UTHM Gymnasium

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Abstract: Comfort temperature is a condition which expresses satisfaction with the temperature of the surrounding. The indoor surrounding temperature of the building affects the health of the human. Health damage such as heat strokes if people carry out an activity under too high temperature for a long time while getting flu if the temperature too low. Objective of this study is to determine the comfort temperature for gym activities at UTHM Gymnasium. Physical measurement method and human response method applied to determine the comfort temperature. The Predicted Mean Vote (PMV) values obtained from the physical measurement and human response data. From the data, the correlation and regression analysis were carried out to determine the relationship between the air temperature and PMV value. Based on the calculation, the cubic polynomial with the highest correlation and regression value were chosen to determine the range of comfort temperature for gym activities. The PMV values of -0.5 and +0.5 used to determine the minimum and maximum value of comfort temperature. The results found that the range of comfort temperature for physical measurement method were between 20.1°C and 25.6°C while the range of comfort temperature for human response method was between 21.33°C and 25.20°C. The acceptable discomfort level for gym activities where the acceptable temperature was 30°C which set by Beijing Chinese Olympic Committee as well as according to the Europe Standard. The acceptable discomfort PMV values for physical measurement method and human response method were 1.79 and 1.92 respectively.

Keywords: Comfort temperature, Indoor surrounding temperature, Gym activities, Predicted Mean Vote, Acceptable discomfort level

1. Introduction

Comfort temperature is a condition which expresses satisfaction with the temperature of the surrounding. The comfort temperature is very important to make sure the temperature of the surrounding just right and suitable for the human especially in the building. A comfortable environment is still one of the significant aspects to be considered when designing a building. The people inside the building will feel extremely hot if the surrounding temperature is very high. This will lead to health damage such as heat strokes if the users carry out an activity under that temperature for a long time [1]. On the other hand, the people inside the building will get flu if the temperature too low. Furthermore, a standard is needed to determine the comfort temperature in a space that is necessary to

satisfy the people in the building. There are six main factors or parameters that need to be addressed when determining the comfort temperature of the indoor space. The parameters obtained from the equipment are air temperature, air speed, relative humidity and mean radiant temperature while metabolic rate and clothing insulation are calculated and obtained via observation and survey [2]. To know the comfort temperature for a certain environment, Predicted Mean Vote (PMV) can be applied. The ASHRAE thermal sensation scale dimensional CFD code [6-8] have used to investigate the coupled cooling process involved in fluid flow and heat transfer between the solid plate and the coolant flow. After PMV calculation, SPSS software is applied to determine the regression and correlation for estimating the relationship among the variables.

1.1 Indoor Air Quality

Indoor air quality (IAQ) is a measure of the building's interior air in term of the occupant's potential health and comfort [3]. The evidence of the impact that IAQ on people makes compelling consideration for its enhancement to mitigate against adverse health consequences, improve quality of life and the work environment with consequential benefits to wellness and performance [4]. Enough air filter and ventilation will increase the air quality. Acceptable indoor air quality is determined by the competent authority at harmful concentrations and most people exposed are not dissatisfied. ASHRAE Standard 62-2001 is the standard of the ventilation for acceptable indoor air quality. ASHRAE Standard 62-2001 establish IAQ-related guidelines for the design, construction, start-up, operation and maintenance of heating, ventilation and air conditioning (HVAC) systems [5]. This standard aims to specify the minimum acceptable ventilation rate and indoor air quality for occupants. It is intended to minimize the potential for adverse health effects [6].

1.2 Thermal Comfort

Thermal comfort describes the condition of the human body in the ideal state of a thermal environment. From a practical perspective, thermal comfort can define as three methods which are physical, psychological and rational [7]. When the heat generated by the body's metabolism is dissipated, thermal neutrality is maintained, thereby maintaining thermal balance with the surrounding environment. To determine the comfort temperature, there are six parameters that can promote a person's thermal comfort. The parameters are air temperature, air speed, relative humidity, radiant temperature, metabolic rate and clothing insulation.

Air temperature is the temperature of the air around the occupants at a location. The air temperature is a measure of hotness and coldness of the air. Major parts of the body respond to temperature changes as the temperatures can vary from head to toe and change over time. The air temperature also affects almost all other weather parameters [8]. According to MS 1525:2019, the normal comfort room temperature is 24°C to 26°C [9]. Temperature can be measured in a variety of ways including thermistors, thermocouples and mercury thermometers. The air velocity is the rate at which air passes over a given distance over time. Air movement affects people's comfort because too much air can be considered "draft" or "cold" and too little air can feel stuffy [10]. The combination of low temperature and air flow will cause discomfort. The instruments used for quantitative air velocity measurements include air velocity meters, rotating vane anemometers and the multi-parameter ventilation meters [10, 11].

The radiant temperature is called the Mean Radiant Temperature (MRT) which is defined as the uniform temperature of the imaginary shell where the radiant heat transfer from the human body is equal to the radiant heat in the actual non-uniform shell [7]. In most buildings, the

temperature range is relatively small. Therefore, the fourth power law of radiant heat exchange can be approximately calculated, so that the radiant heat loss is approximately proportional to the temperature difference between the surface of the clothes and the radiant temperature [12, 13]. Furthermore, MRT has a large impact on thermo-physiological comfort indices such as Predicted Mean Vote (PMV). The importance of radiant temperature can be quickly understood when entering a room with heated surfaces on a spiny summer or a cold winter [14]. In buildings without thermal insulation, the internal surface temperature of the building wall is affected by external environmental conditions especially solar radiation [15].

Clothing insulation is the insulation material provided by clothing. Clothing insulation can help to keep the body warm in the cold season by wearing suitable clothing on the skin. The effect of changing clothing insulation on optimal surgical temperature is approximately 6°C per clone for near-steady-state activities with a metabolic rate of approximately 1.2 [16]. The concept of clothing insulation indicates that the transfer of heat is not fabric but clothing. The concept also considers the effects of air movement inside the garment. The microclimate temperature of clothing can be used to evaluate the effectiveness of clothing. Clothing microclimate refers to the layer of air that exists on the surface of human skin when wearing clothing. This layer can be used as a simple method to determine comfortable of the wearing of the people [17].

2. Previous Work

Previous research is of reference and comparative significance to this research. A lot of research has been done based on comfort temperature research, but it has been applied to different situations and conditions related to the problem statement. Razman *et al.* [18] had carried out a field study in UTHM hostel building. The purpose of this study was to determine the thermal comfort of the hostel building and to determine whether the thermal comfort of the hostel building can be achieved through natural ventilation. As a result, the comfort temperature for both mechanical ventilation room and natural ventilation room was 26.4°C-28.99°C and 27.78°C-29.51°C which were not in the range of comfort temperature proposed by ASHRAE Standard and ISO 7730-7784. Furthermore, Haron *et al.* [19] conducted a study to determine the thermal comfort level of the UTHM mosque. The results of this study show that the air temperature exceeds the range of ASHRAE Standard 55-2004 which was around 25.6°C to 30°C.

Bafana [20] also conducted a study to determine the human comfort temperature in the UTHM lecture room. The range of the comfort temperature for human respond method and physical measurement method was almost the same with the range of the comfort temperature of ASHRAE Standard which were 22.47°C -26.03°C and 23.31°C -26.12°C respectively. Huang *et al.* also conducted a field study to assess the thermal conditions during the lecture session in six lecture halls DK1-DK6 of

the Faculty of Engineering at the University of Malaya, Kuala Lumpur. As a result, 25.3°C was recommended for the optimal operative temperature of the lecture hall to make the occupants feel comfortable [21]. Kwok *et al.* had conducted a field study in Japanese schools to assess the thermal conditions during the lecture. The main purpose of this research was to study the application of thermal comfort standards in the cultural and climatic environment of Japan [22]. The result showed that the air temperature for natural ventilation (26.9°C) was not within the range of comfort temperature of ASHRAE Standard but the air temperature for air-conditioning (24.2°C) was within the range of comfort temperature of ASHRAE Standard. The method of data collection, number of data collection session, parameters, measurement equipment, the standard of comfort zone such as ASHRAE Standard and Malaysian Standard as well as the method of analyzing data were applied to study the comfort temperature for gym activities at UTHM Gymnasium.

3. Methodology

In this study, there are two methods has been applied to determine the comfort temperature for UTHM Gymnasium based on the PMV index. The methods are physical measurement method and human response method. For the data collection of the physical measurement method, it is carried out during the gym activities is in progress. The location of instruments and equipment for conducting the physical measurement method is taken at location 'X' as shown in Fig. 1.

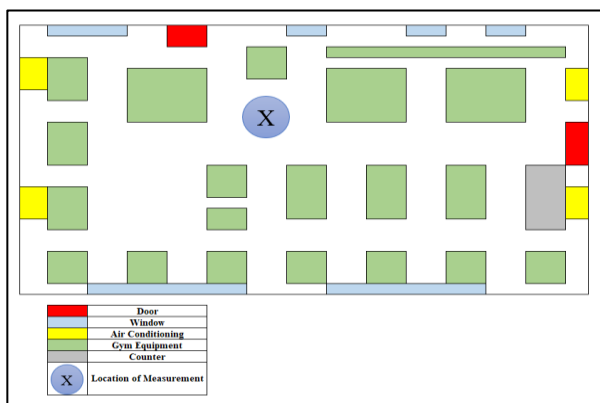


Fig. 1 - Layout of UTHM Gymnasium

The procedure of human response method is established by surveying to the users of UTHM Gymnasium. The surveys are distributed during the period of gym activities or after the users had done the gym activities to avoid the effect of the outside temperature on the users as well as allow the users to adapt the thermal conditions inside the gymnasium. The number of respondents is followed by the ASHRAE Standard which is at least 16 occupants. The survey form contains personal information of gymnasium users and information related from the users in order to obtain clothing insulation and Predicted Mean Vote (PMV). The value of PMV is obtained by the average response of the users on the thermal sensation scale.

Before full data collection, the pilot testing is carried out to test whether the survey achieves the target of the study. This test figured out the suitability of the questions for the respondents and the time to complete the survey in real time. The full data collection is carried out once the pilot testing success. The data collection consists of data from the physical measurement method and data from the human response method. The data collected is 20 sets to make sure the data more accurate which is carried out in 3 sessions which are morning session, the afternoon session and the evening session. The morning session is started from 8 a.m. until 10 a.m., the afternoon session began from 11 a.m. until 1 p.m. as well as the evening session started from 5 p.m. until 7 p.m. The data collection for the physical measurement method and human response method is conducted at the same time. The data collected from the physical measurement method and human response method are analyzed. The results of the PMV index are obtained and analyzed after using these two methods.

The difference of the PMV index is obtained after comparing the PMV index of both methods. There is an alternative method to calculate the PMV value based on the data of the physical measurement method which is CBE Thermal Comfort Tool. In addition, correlation and regression analysis are carried out by using SPSS software to determine the relationship between the variables. The highest R value shows that the polynomial trendline is better and used. To obtain the range of comfort temperature, regression analysis is used to estimate the relationship strength among the variables. AR^2 value from the regression analysis is obtained by squaring the value of R obtained from the correlation analysis. The graphs of the physical measurement method and human response method are plotted. From the graphs, an equation is formed. The equation is used to determine the minimum temperature and maximum temperature of the surrounding temperature of UTHM Gymnasium by inserting -0.5 for minimum value and 0.5 for maximum value. The PMV range of -0.5 to 0.5 is applied as it is the comfort zone which is outlined in the ASHRAE Standard.

3.1 Predicted Mean Vote (PMV)

Predicted Mean Vote (PMV) matches the human experience of thermal comfort. The PMV index includes four physical parameters namely air temperature, air speed, relative humidity and radiant temperature and two personal parameters namely metabolic rate and clothing insulation. It predicts the average vote of a large group of people with a seven-point thermal sensation level which are cold(-3), cool (-2), slightly cool (-1), neutral (0), slightly warm (+1), warm (+2) and hot (+3).

3.2 Statistical Package for the Social Science (SPSS)

SPSS Statistic is a software package designed for interactive or batch statistical analysis. The program can perform correlation analysis and regression analysis. Correlation analysis is used to study the strength of the relationship between two continuous variables measured numerically. Pearson's product moment coefficient is a measure of correlation, R and ranges between +1 and -1.

The value of strongest possible positive correlation is +1 while the strongest value of possible negative correlation is -1. 0 means no correlation, so values closer to zero are weaker than values closer to +1 / -1. The value of R should be greater than 0.5 because it indicates the strength of the relationship between them. Regression is used to estimate the relationship between the dependent variable and one or more independent variables [21]. Regression analysis mainly used for prediction and forecasting. Regression analysis is used to infer relationships between independent and dependent variables.

3.3 Instruments and Equipment

Instruments and equipment used for collecting the values of the parameters involved consists of two instruments which is specially used for measuring the parameters required in this study. The instruments are Velocicalc Plus Multi-parameter Ventilation Meter 8386 and KIMO AMI 310 with Black Globe Thermometer. Velocicalc measures air velocity measures air temperature, air velocity, relative humidity and differential pressure as well as calculate and display volumetric flow rates. Measurements are achieved using constant temperature anemometry. It is a multipurpose instrument which can be used for many applications including indoor air quality, HVAC measurements and bio-safety cabinet certification.



Fig. 2 - Velocicalc Plus Multi-parameter Ventilation Meter 8386 (left) and KIMO AMI 310 with black globe thermometer (right).

Besides, it can determine fume hood face velocity and capture velocities for industrial hygiene control studies. Furthermore, direct calculation of dew point and wet bulb temperature no psychrometric chart needed as well as the heat flow function calculates heat transferred after a heating or cooling element. When measuring fluctuating flow, it also has a stable digital display. In the case of insufficient light, it is easy to read the backlight display. The operating temperature for this instrument is from -10°C to 60°C and data storage capabilities up to 1394 samples. KIMO AMI 310 is known as a multifunctional instrument because it can measure six simultaneous parameters according to the applications which are pressure, temperature, humidity, air quality (CO/CO₂), air velocity and air flow as well as tachometry. This instrument can record up to 500 campaigns of 20000 points a day on a SD card and can restore on a PC via USB. To

identify the radiant temperature, a black globe thermometer is connected to this instrument. Fig. 2 above showed the Velocicalc Plus Multi-parameter Ventilation Meter 8386 and KIMO AMI 310 with black globe thermometer.

3.4 Standard

Standards are important to ensure that research results remain within the scope of existing standards and meet the requirements of the standards. If the results or data obtained from the study do not meet the standard requirements, the data obtained are considered unacceptable. The standard is referred to ASHRAE Standard 55: Thermal Environmental Conditions for Human Occupancy. The study is based on criteria to be followed such as metabolic rates for typical task lists, clothing insulation values for common clothing, location of measurement, measuring period, sample size, adaption time and number of sampling point and positioning. Different activities performed by different occupants should be considered separately. Time-weighted average metabolic rate can be used for individuals whose activities change over an hour or less. This standard also does not apply to occupant activities with an average metabolic rate exceeding 2.0 met.

Furthermore, the amount of thermal insulation material worn by people has an important impact on thermal comfort. The insulation from the clothing can be determined by a variety of means. When such information is not available, three methods can be used to estimate the thermal insulation of clothing. Based on the ASHRAE Standard, the first method is referred to the list of insulation effects provided by various common clothing combinations. For the second method, it is referred to the list of thermal insulation effects of various garments. These garments can be added to or subtracted from the garments in the list of the first method to estimate the thermal insulation of garments. For the third method, there is a list of complete clothing collection. The collective insulation estimate is the sum of the individual values of the list.

The thermal environment survey is used to conduct research to assess the thermal comfort of the occupants. The survey used can refer to the standard survey questions provided by ASHRAE 55. The question about health is to determine whether the user's answers can be considered. The general estimates for an alcoholic beverage to metabolize are around one to three hours which vary depending on the type of alcoholic beverage and the amount of alcohol in the beverage. Hence, it is better to consider the data of the occupants who drink alcoholic beverages acceptable if the last time of the occupants drinks the alcoholic beverages more than three hours before doing the gym activities. For the occupants who are smokers, the data would be affected if the effect of smoke still in the body which may influence the thermal comfort of the occupants. Generally, nicotine and carbon monoxide start to leave the body and oxygen levels to return to normal eight hours after the person smoke.

The measurement location should be in an area of the building where the occupants are known to or are expected to spend the time. For this study, the measurement location is in the UTHM Gymnasium. Measurements will be made in the center of the crowded area. The measurement should be sufficiently far from the boundary of the occupied area and any surface to allow proper circulation around measurement sensors. For the height of the instrument on the floor, the instrument must be flush with the height of the occupant when performing activities. For this study, the occupants are seated when doing most of the gym activities. According to the standards provided by ASHRAE Standard 55, the seated occupant shall measure the height of the measuring instrument from the ground to 0.6 m.

Besides that, the sample size of people who must respond to a survey is based on the number of people in the room according to ASHRAE Standard 55. If the number of occupants is less than 20, it should be at least 80% or 16 occupants must respond. For adaptation time, there is no clear standard stating the time for the human body to respond and adapt to the change of temperature of the environment. This study will use 30 minutes to let the instruments to adapt to the new environment before starting the data collection of the thermal environment and then the occupants will answer the survey form.

In addition, the number of standard sampling points and standard height positions of the device sensors must be determined to ensure that the data obtained is within acceptable limits before collecting the required data in this study. The floor area of UTHM Gymnasium is 91.2 m² which is less than 3000 m². Therefore, the minimum number of sampling point is equal to one. The height of positioning for the device sensor to measure air temperature and air velocity shall be measured at 0.6 m from the ground as the gym users are seated most of the time when doing the gym activities. The location of study that has been chosen is UTHM Gymnasium which is located at the UTHM Stadium. UTHM Gymnasium is one of the popular recreational facilities preferred by UTHM students and staffs to carry out gym activities.

4. Results and Discussion

The pilot testing was conducted at 5:15 p.m. This test involved 16 respondents which consist of 16 males. All the respondents were given a brief explanation about the survey form before the pilot testing start. The predicted mean vote for physical measurement method and human response method were calculated using the data collected. The parameters needed in calculating the PMV value for physical measurement method were air temperature, air velocity, relative humidity, mean radiant temperature, metabolic rate and clothing insulation. All the readings of the parameters were obtained from the data except the value of metabolic rate and clothing insulation which were obtained by observation.

The value of metabolic rate obtained by observing each session of gym activities carried out by the gymnasium users. The gym activities of walking for exercise, standing, seated, reclining, weightlifting as well as warming up. The warming up exercise included walking for exercise, standing or relaxed and light weightlifting. In order to determine the metabolic rate of the gymnasium users, a time-weighted average metabolic rate was used for individuals with activities that vary in a period of one hour or less. The time taken for one person doing gym activities for one session was normally about 29.47 minutes or 1768 seconds which included 88 seconds for walking, 330 seconds for reclining, 345 seconds for standing, 495 seconds for seated and 510 seconds for weightlifting. According to the activity level listed in ASHRAE Standard 55 and past researches, the metabolic rate for walking for exercise (on a level surface) was 1.8 met, reclining was 0.8 met, standing was 1.2, seated was 1.0 met and weightlifting was 3.0 met.

The time-weighted average metabolic rate for gym activities was 1.62 met. For the clothing insulation, the majority of clothing ensemble wore by the gymnasium users was short sleeves T-shirt, sweatpants, ankle-length athletic socks and shoes. According to the ASHRAE Standard 55, the clothing insulation of short sleeves T-shirt was 0.08 clo, sweatpants was 0.28 clo, ankle-length athletic socks was 0.02 clo and shoes was 0.02 clo. The clothing insulation for gym activities was 0.40 clo. The CBE Thermal Comfort which complies with ASHRAE Standard 55-2017 was applied to calculate the PMV value as it was easier and faster than using the equations. The PMV value of pilot testing for physical measurement method was 1.20. For human response method, the PMV value of human response method was calculated by taking the average of all the PMV rating voted by the gymnasium users on that session. The PMV value of pilot testing for human response method was 1.34. A comparison was made between the PMV value from physical measurement method and human response method.

Based on the calculated PMV for physical measurement method and human response method obtained, the difference between the PMV value was 0.14. The results were verified since both PMV values were closer with an uncertainty value of ± 0.3 . The human response method using the survey form was validated and the full data collection proceeded. The data of pilot testing was considered as the first session of data collection.

4.1 Data analysis

The data analysis was conducted based on the physical measurement data and human response data. There were 20 sets of data for both methods which included 6 sets of data for the morning session, 6 sets of data for the afternoon session and 8 sets of data for the evening session. The physical measurement data and human response data were calculated to obtain the PMV value.

4.2 PMV value between physical measurement and human response method

Table 1 showed the comparison of the PMV values between the physical measurement method and human response method. The air temperature of both methods was the same but the value of PMV of both methods was different. The difference of PMV value between the physical measurement method and human response method for all sessions was not largely marginalized as the difference value was within an uncertainty value of ± 0.3 .

Table 1 - PMV values between physical measurement and human response method

Session	Air Temperature (°C)	PMV	
		Physical Measurement Method	Human Response Method
1	28.1	1.20	1.34
2	28.6	1.35	1.56
3	22.8	-0.12	-0.25
4	22.2	-0.31	-0.28
5	23.1	-0.07	-0.16
6	24.6	0.03	0.24
7	28.5	1.40	1.44
8	29.9	1.78	1.61
9	22.1	-0.08	-0.19
10	23.0	-0.18	-0.22
11	23.6	0.12	0.15
12	21.3	-0.24	-0.31
13	30.0	1.70	1.79
14	28.4	1.48	1.56
15	28.1	1.33	1.40
16	28.6	1.54	1.73
17	21.2	-0.35	-0.47
18	21.1	-0.38	-0.59
19	21.0	-0.40	-0.63
20	21.1	-0.31	-0.53

4.3 Correlation and regression analysis

Figure 3 to 5 shows the trendline of linear polynomial, quadratic polynomial and cubic polynomial for physical measurement method while figure 6 to 8 shows the trendline of linear polynomial, quadratic polynomial and cubic polynomial for human response method.

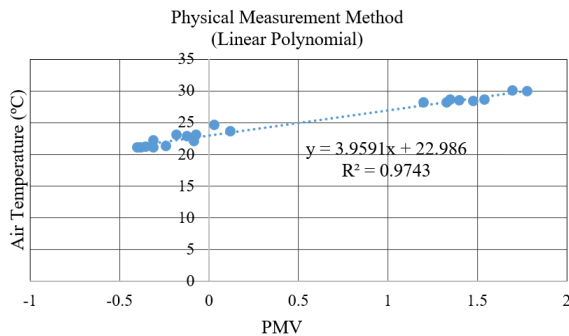


Fig. 3 - Trendline of linear polynomial for physical measurement method

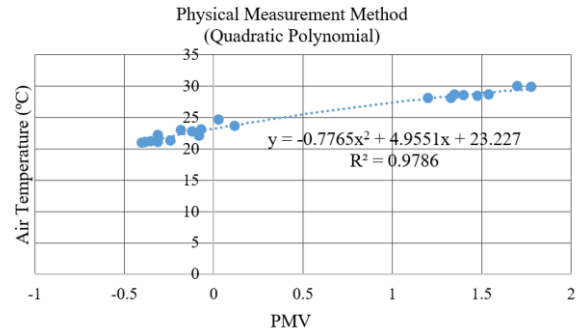


Fig. 4 - Trendline of quadratic polynomial for physical measurement method

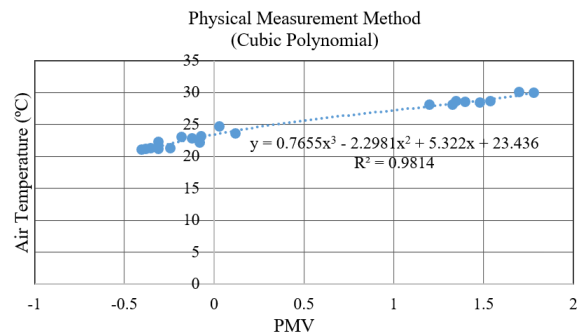


Fig. 5 - Trendline of cubic polynomial for physical measurement method

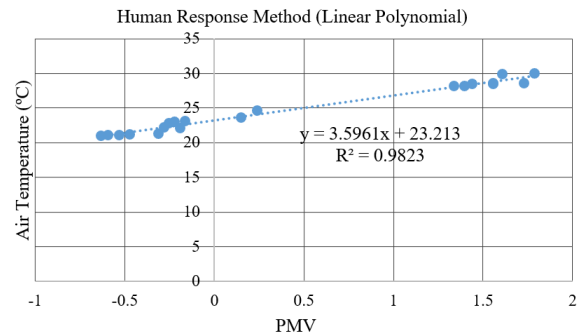


Fig. 6 - Trendline of linear polynomial for human response method

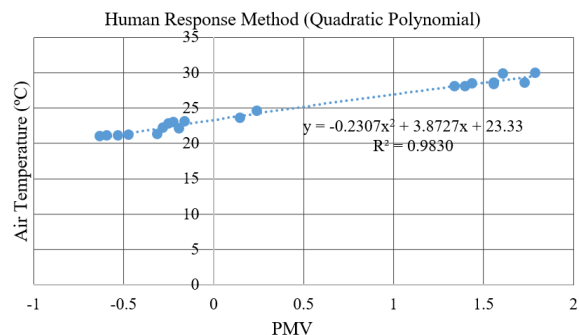


Fig. 7 - Trendline of quadratic polynomial for human response method

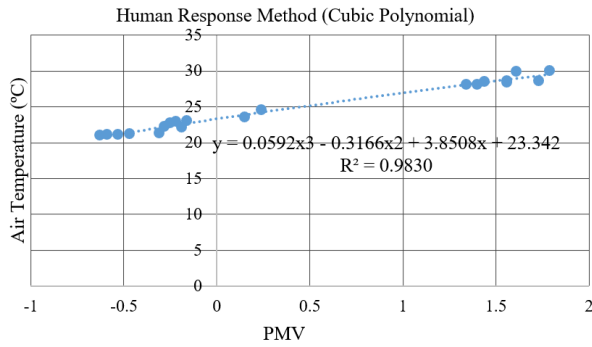


Fig. 8 - Trendline of cubic polynomial for human response method

The R and R^2 values for the physical measurement method and human response method were calculated and tabulated. Table 2 showed the summary of the correlation, R value while Table 3 showed the summary of the regression, R^2 value.

Table 2 - Summary of the correlation, R value

Polynomial	Correlation, R Value	
	Physical Measurement Method	Human Response Method
Linear	0.9871	0.9911
Quadratic	0.9892	0.9915
Cubic	0.9907	0.9915

Table 3: Summary of the regression, R^2 value

Polynomial	Regression, R^2 Value	
	Physical Measurement Method	Human Response Method
Linear	0.9743	0.9823
Quadratic	0.9786	0.9830
Cubic	0.9814	0.9830

Based on the results of regression analysis, it showed that the data has a strong relationship among the variables as the value were close to 1 as being a perfect model. Therefore, cubic polynomial with the highest R^2 value for both methods was used to determine the range of the comfort temperature.

4.4 Comfort temperature

The range of comfort temperature was determined through the graph of air temperature against PMV. The PMV range of -0.5 to 0.5 was applied as it was the comfort zone which was outlined in the ASHRAE Standard. Therefore, the range of comfort temperature was defined by using $PMV = -0.5$ as minimum comfort temperature and $PMV = +0.5$ as the maximum comfort temperature. As a result, the range of comfort temperature for physical measurement method was between 20.10°C and 25.62°C while the range of comfort temperature for human response method was between 21.33°C and 25.20°C.

4.5 Acceptable discomfort level

According to the Beijing Chinese Olympic Committee, the maximum temperature set in the sports hall was 30°C. This temperature was also the same as the maximum allowable indoor air temperature specified for constant use set by Europe Standard. Therefore, a temperature of 30°C was used to determine the acceptable PMV value for the gym activities. After the temperature was inserted into the cubic polynomial, the acceptable PMV value for physical measurement method was +1.79 while the acceptable PMV value for human response method was +1.92.

Based on the range of comfort temperature obtained, the difference between physical measurement method and human response method was 1.23°C for the minimum comfort temperature and 0.42°C for the maximum comfort temperature. The range of comfort temperature of the physical measurement method and human response method was almost the same. The range of comfort temperature for gym activities at UTHM Gymnasium was lower compared to the ASHRAE Standard (23.0°C-26.0°C) and Malaysian Standard 1525:2019 (24.0°C-26.0°C). It was logically and reasonable that the comfort temperature required for gym activities was lower as more heat was produced during the gym activities compared to the activities done by the past researches. The thermal sensation for acceptable discomfort level with an acceptable temperature of 30°C was approaching warm scale with a PMV value of +1.79 for physical measurement method and +1.92 for human response method.

5. Conclusion

In conclusion, the objective of this study which was to determine the comfort temperature for gym activities at UTHM Gymnasium has been achieved. The comfort temperature was determined by using both methods which were physical measurement method and human response method. Based on the result obtained, the range of comfort temperature for physical measurement method was between 20.10°C and 25.62°C while the range of comfort temperature for human response method was between 21.33°C and 25.20°C.

There was an additional finding of the acceptable discomfort level for gym activities where the acceptable temperature was 30°C which set by Beijing Chinese Olympic Committee as well as according to the Europe Standard. The acceptable discomfort PMV values for physical measurement method and human response method were +1.79 and +1.92 respectively. Several recommendations can be revised for improvements. The recommendations are increase the number of full data collection sessions so that more reliable and accurate data can be obtained to make an analysis, change or add more to the location of measurement, improve the questions in survey form so that can accurately express to the respondents, controlled respondents to reduce the dissimilarities of votes as well as controlled metabolic rate for all occupants to improve the accuracy of votes.

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