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Evaluation of Environmental Heat Exposure, Heat-related Symptoms, and Acute Physiological Changes among Farmers in Pasir Puteh and Bachok, Kelantan

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Abstract

Prolonged or intense exposure to heat can lead to a range of health effects. This study evaluated environmental heat exposure, heat-related symptoms, and acute physiological changes among 39 farmers in Kelantan, Malaysia. During the end of the monsoon season in February to Mac 2019, wet bulb globe temperature (WBGT) was collected in the farm environment to assess heat exposure. Blood pressure, heart rate, and body core temperature were measured pre-, mid and post-shift to measure the physiological response of farmers towards environmental heat. Sociodemographic, occupational information and heat-related symptoms that subjects had experienced were gathered using a questionnaire. The WBGT outdoor showed a high risk for heat stress and strain (> 28.0 °C) based on the American Conference of Governmental Industrial Hygiene (ACGIH) threshold limit values (TLVs). More than half (50%) of farmers reported heat-related symptoms including fatigue, lethargy, dizziness, rashes, and cramps. Significant physiological changes including heart rate, body temperature, and systolic blood pressure occurred across the work shift ($p < 0.05$). However, no significant association ($p > 0.05$) was found between the Acute Health Symptoms score (AHSS) with associated factors, thus no statistical model was further developed. In conclusion, farmers experienced significant psychological changes across the work shift. Preventive and control measures for heat stress are needed to reduce the risk of heat strain.

Keywords: heat exposure, physiological changes, blood pressure, body core temperature, farmers.

1.0 INTRODUCTION

Environmental health hazards faced by farmers such as exposure to extreme heat stress are growing concerns due to global climate change, particularly in tropical developing countries. In such environments, farmers are at risk of environmental heat exposure with increased vulnerability to climate-sensitive health outcomes such as heat-related illnesses. Acute physiological changes depend on several parameters including an increase in skin temperature, body core temperature, blood pressure, and heart rate [1]. Continual exposure to high temperature and heat extremes may cause several Heat-Related Illnesses (HRI) including heat rash, heat syncope, heat cramps, heat exhaustion, and heat stroke [2].

Occupational heat exposure may also lead to adverse health effects and contribute to a work-related injury, illness, or even death. The predicted increase in the frequency and the intensity of extremely hot weather at workplace heat exposure shows a growing challenge to workers' health and safety [3]. However, there is inadequate information about the extent of heat exposure to such farmers at the farm level from a local perspective. This situation is exacerbated due to their farming methods that involve heavy exertion with the use of primitive equipment and hard manual labor conducted in full sunshine under hot and humid conditions [4].

Therefore, this study assessed the environmental heat exposure and acute physiological changes on rural smallholder farms in Desa Alam Shah, Pasir Puteh and MARDI Bachok, Kelantan. The heat stress burden to the workers was increased, thus the outdoor environment temperature increased due to climate changes. The continuous exposure leads to heat stress and affects their physical and psychological condition. This study was conducted to support the previous database of heat stress exposure from a local perspective.

2.0 METHODOLOGY

2.1 Study Design and Subject Recruitment

A cross-sectional study was conducted at Desa Alam Shah, Pasir Puteh and MARDI Bachok which comprised environmental heat monitoring and physiological measurement of the workers including body core temperature, blood pressure, and heart rate. Purposive sampling was utilised by targeting farmers who fulfilled the inclusion criteria; aged 18 years and above, exposed to environmental health through observation and worked for more than 6 months on the selected farm. The period of 6 months was chosen as the optimal acclimatisation period for the workers to be exposed to the hot environment [5]. The sample size was determined using a single mean formula based on a previous study [6]

$$n = (\mathrm{Z}\sigma/\mathrm{E})^2$$

where Z is a standard score at a specific interval, i.e. 1.96 for 0.95 CI,
θ is the estimated population standard deviation and E = σ / sqrtn (n), the desired margin error (prevision value).

The standard deviation for diastolic blood pressure among farmers was 14.90 with E =5, therefore the estimated sample size was 34. After considering 20% of dropouts and non-response, the total sample size was 41. The study was approved by the Human Research Ethics Committee (HREC) of USM (reference: USM /JEPeM/18110652). The permission letter was sent to the respective organisation for study approval. After a week, the subjects were briefed on the aim of this research regarding their participation as well as their privacy and confidentiality). All the subjects were provided with research information and voluntarily signed the research and publication consent forms before data collection.

2.2 Questionnaire

A self-administered and validated questionnaire in Bahasa Melayu was used [7]. The structured questionnaire comprised of six sections about background information, occupational data, the prevalence of heat stress and health information, and social and lifestyle information was used to collect the baseline information of the subjects. This questionnaire was completed within 10 to 15 minutes. The internal consistency of the questionnaire was examined by calculating Cronbach's Alpha with showed good reliability (0.730). A reliability coefficient of 0.70 or higher was considered "acceptable" [8].

2.3 Environmental Heat Monitoring

A workplace walkthrough survey was conducted in identifying the environmental heat in the farm area. The environmental temperature was measured using a Wet Bulb Globe Temperature Index (WBGTin) QUESTemp°34 Thermal Environmental Monitor (Figure 1). The WBGT monitor measures four parameters which were dry temperature (DB), natural wet bulb temperature (NWB), globe temperature (GB), and relative humidity (RH).

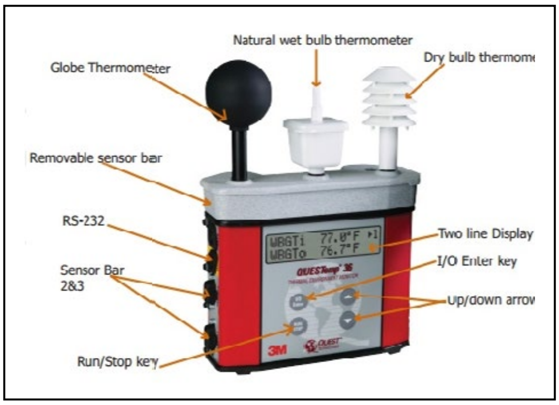

Figure 1: Wet Bulb Globe Temperature model QUESTemp°34

The WBGT monitor was fixed on a tripod at 3.5 feet (1.1 meter) in a stand position equipped with a photographic tripod at the center of the farm field, the natural wet bulb (NWB) thermometer cotton wick was moistened and immersed in a reservoir containing distilled water for ten minutes to stabilize the readings and then the machine was programmed to record and monitor the WBGT with a one-minute logging interval [9] The measurement was taken for eight hours of working shift from 8.00 a.m. until 5.00 p.m and the data were recorded automatically in the data logger. The results of the WBGT index were stored in the WBGT monitor and were printed out directly from the WBGT monitor. The WBGT values for outdoor with the presence of solar load were calculated as [9]

$$WBGTout = 0.7\,\mathrm{T}nwb + 0.2\,\mathrm{T}g + 0.1\,db \qquad (1)$$

WBGT = Wet Bulb Glob Temperature Index

T*nwb* = Natural Wet Bulb Temperature

T*db* = Dry-Bulb Temperature

T*g*=Globe Temperature

The calculation of average WBGT*out* was based on equation (2) as follow:

$$\text{Average WBGT} = \frac{\text{WBGT}_1 \times t_1 + \text{WBGT}_2 \times t_2 + \ldots.. \text{WBGT}_n \times t_n}{t_1 + t_2 + t_n} \qquad (2)$$

Where:

$\text{WBGT}_1 \times t_1 + \text{WBGT}_2 \times t_2 + \ldots\text{WBGT}_n \times t_n$ = WBGT values per hour

$t_1 + t_2 + t_n$ = duration of exposure per hour

2.4 Physiological Changes Monitoring

Three physiological parameters were monitored; body core temperature, blood pressure, and heart rate while anthropometric measurements include weight and height.

2.4.1 Body Core Temperature

A digital ear thermometer (Citizen CTD 504, Japan) was used to measure the body core temperature of the subjects. Body temperature was recorded three times pre-shift (8.00 a.m.), mid-shift (noon), and post-shift (5.00 p.m.).

2.4.2 Blood Pressure and Heart Rate

A blood pressure monitor (OMRON HEM-7111, China) was used to measure the blood pressure and heart rate of the subjects. Systolic, diastolic blood pressure and heart rate were recorded three times for pre-shift (8.00 a.m.), mid-shift (noon), and post-shift (5.00 p.m.). Respondents were asked to have a rest for about five minutes and sit down in a quiet place, preferably at a desk or table, with their arm resting on a firm surface and feet flat on the floor while their blood pressure and heart rate were taken. For each time interval measurement, triplicate data was recorded.

2.4.3 Body Weight and Height.

A digital weighing scale (OMRON Karada Scan HBF-361, Japan) was used to measure the weight of subjects, while a seca body meter was used to measure the body height. Both weight and height were taken to calculate the body mass index (BMI) and body fat percentage.

2.4.4 Determination of Acute Heat Symptom Score (AHSS)

Acute Health Score (AHS) is the total scoring derived from the seven acute health symptoms experienced by the subjects.

Thirteen symptoms were asked for their occurrence and frequency of acute health symptoms. It was adapted from The American College of Sports Medicine WBGT Index Risk Chart [10] which computed the score of seven healthrelated symptoms experienced by the subjects. The symptoms were profuse sweating extreme fatigue, heat collapse, dizziness, heat cramp, heat rashes, and heat stroke. The presenting symptom was one score, and the absent symptom was zero scores.

Thus, the highest score was listed as a high risk of health problems (See Table 1).

Table 1: The Distribution of Acute Heat Symptoms Score (AHSS)

Total Acute Health Symptoms	Acute Health Score	Classification of Acute Health Symptom Score (AHSS)
7/7	1.0	Very Severe
6/7	0.86	Severe
5/7	0.71	Severe
4/7	0.57	Moderate
3/7	0.43	Moderate
2/7	0.29	Low
1/7	0.14	Low
0/7	0	None

Source: American College of Sports Medicine WBGT Index Risk Chart [10]

2.5 Data Analysis

There were two types of measurements variable involved in this study; the dependent variable and the independent variable. For the dependent variable, Acute Health Symptom Score (AHSS) was used, meanwhile while the independent variables were core body temperature, blood pressure, and heart rate was used. All data acquired from the questionnaire and measurements of the parameters were analysed using software IBM SPSS Statistics 22. Normality test by using Kolmogorov-Smirnov was used to identify the data type distributions which were normally distributed. Descriptive data analysis which is the frequency, mean, range, and standard deviation of each variable of core body temperature and blood pressure was utilised. ANOVA Repeated Measures were utilised to compare the mean difference of acute physiological changes (body core temperature, blood pressure, and heart rate) between pre-shift, mid-shift, and post-shift. Multiple Linear Regression (MLR) analysis was used to measure associations of Acute Health Symptoms Score (AHSS) with associated factors. A method enter was used in which all variables in a block were entered in a single step. The modeling procedure was started after collinearity between the independent variables was measured using the variance inflation factor index (VIF). The cut-off point for VIF was set at 10. For all the independent variables, the VIF was below 10 which was acceptable. The statistical analysis with a p-value of less than 0.05 was set as significant.

3.0 RESULTS AND DISCUSSION

3.1 Sociodemographic Characteristics and Work Description

Thirty-nine subjects who participated in this study and the response rate was 95.12%. Table 2 shows the socio-demographic and works description of the subjects. All were Malay men with a mean age of 43.14 years and 51.3% were smokers. Agriculture was dominated by males above 30 years old with 81% being between 20 and 60 years old [11]. More than half of the subjects were overweight in BMI as compared to normal BMI. The majority were in middle age and overweight possibly due to the farming process which contributes to less physical activity [1]. Ninety-two percent had secondary education and have been working for more than 5 years at the current farm with more than 6 hours working on the farm per day.

3.2 Environmental Heat Exposure Index

Environmental heat exposure monitoring was conducted on each farm to identify an environmental condition that significantly contributed to heat stress. Both farms are open spaces, and the sun was a major contributor to the high WBGT outdoor index. Table 3 shows that both farms have a WBGT out index that exceeded the permissible threshold level (29.66 ± 0.8 ºC) according to the ACGIH threshold limit value for WBGT index of >28.0 ºC for moderate workload and when workers doing 75% work and 25% rest for each hour [12]. The increase in WBGT outdoor index was due to its local climate which increases hot temperatures and gives an effect on farmers experiencing heat-related illnesses. For the short-term effect, that might experience acute heat symptoms such as fatigue, lethargy, and dizziness. The actual weather temperature for the 2 days in Bachok was 31 ºC and 32 ºC while Pasir Puteh was 33 ºC for both days [13]. It showed that climate change and extreme weather affected the temperature in the agricultural farms in both Pasir Puteh and Bachok. The incidence of high stroke in open space will be like the climate in Malaysia due to higher ambient temperature and increased solar radiation [14]. In comparison, the environmental heat exposure from both farms was much higher than the finding reported in greenhouse farms which reached 28.9 ºC [5]. The greenhouses were roofed to protect the farm and workers from direct exposure to heat from the sunlight.

Table 2: Sociodemographic and work characteristics of the workers

Variables	Frequency (%)	Mean ± SD
Age Category (Years)		
20-30	3 (7.7)	
31-40	15 (38.5)	43.41 ± 8.86
41-50	12 (30.8)	
51 and older	9 (23.0)	
Body Mass Index (kg/ms^2)		
Normal	19 (48.7)	26.04 ± 3.88
Overweight	20 (51.3)	
Education Level		-
Primary education	2 (5.1)	
Secondary education	36 (92.3)	
No formal education	1 (2.6)	
Smoking Status		
Yes	19 (48.7)	
No	20 (51.3)	
Duration of Employment		
1-5 years	14 (35.9)	8.97 ±7.28
6-10 years	25 (64.1)	
Duration of Working per day (hours)		
1-5 hours	12 (30.8)	
6-10 hours	27 (69.2)	
Water Intake Per day (L)		
0 to 1.0 L	22 (56.4)	
More than 1.0 L	17 (43.6)	

Table 3: The environment heat exposure index (WBGT outdoor) of the farm area

Location	WBGT out values (ºC)	Mean ± SD
Mardi Bachok		
Farm 1	29.14	29.66 ±0.74
Farm 2	30.18	
Desa Alam Shah		
Farm 1	29.73	30.57 ±1.19
Farm 2	31.41	

TLV WBGT = 28.0 ºC exceeding the limit

3.3 Reported Heat-related Symptoms and Acute Health Symptoms Score (AHSS)

Figure 2 reports information on the reported heat-related symptoms of the subjects. All of them reported having fatigue. More than 70% showing reported symptoms of heat-related illness such as lethargy, dizziness, rashes, and cramps. Similarly, sugarcane workers experienced Heat-Related Illness (HRI) symptoms including fatigue (91.1%), rashes (52.2%), and cramps [15]. Heat fatigue, dizziness, muscle cramps, and heat rashes were also reported to be the highest prevalence of HRI among maize farmers [16]. Table 4 reports the Acute Health Symptoms Score (AHSS) of the subjects. Most subjects had a score of 0.57 for AHSS (having four health symptoms) followed by 0.43 for AHSS having three health symptoms) and 0.71 of AHSS (having five health symptoms) by 43.6%, 28.2% and 17.9% respectively. In comparison, rockmelon farmworkers [5] reported of having AHSS for 0.71, 0.57, and 0.43 by 40.8%, 22.2%, and 18.5% respectively.

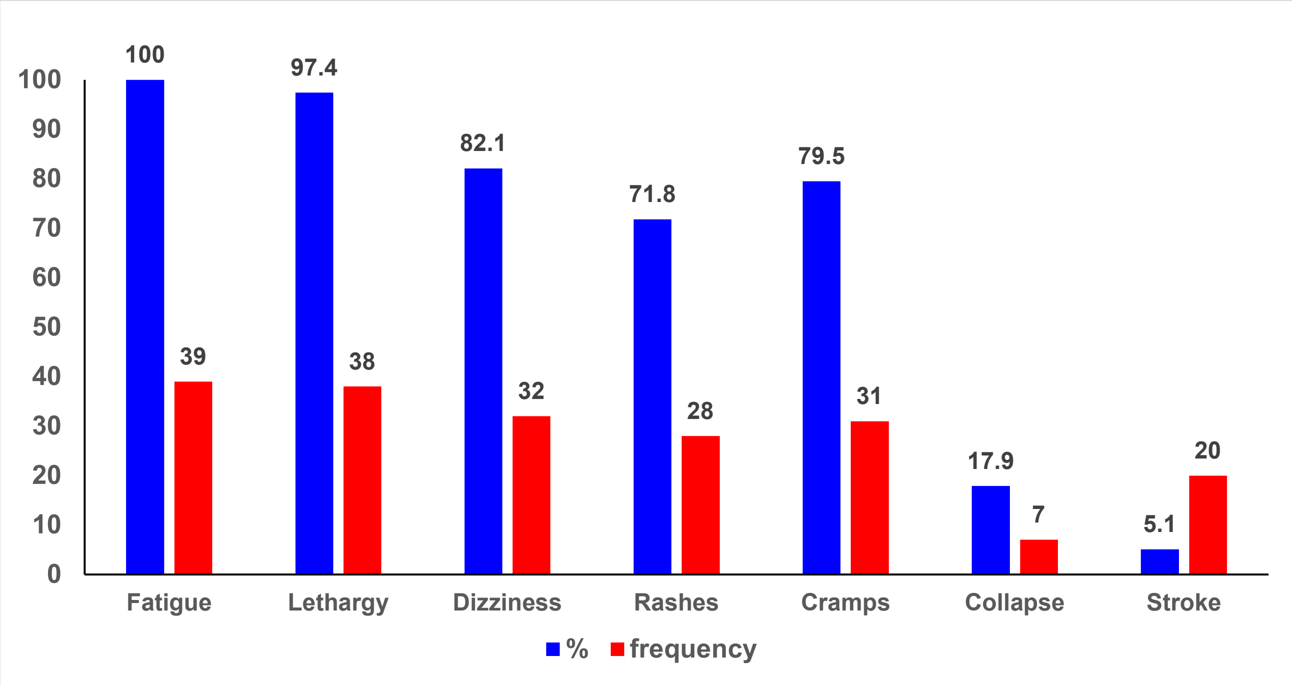

Figure 2: Reported heat-related symptoms

Table 4: Acute Health Symptom Score (AHSS)

Acute Health Symptom Score	Frequency	Percentage
1.0	0	0
0.86	4	10.3
0.71	7	17.9
0.57	17	43.6
0.43	11	28.2
0.29	0	0
0.14	0	0
0	0	0

3.4 Differences of Acute Physiological Changes (pre, mid-, and post-shift)

The physiological changes of the vital parameter in humans to sustain life functions are; core body temperature, blood pressure, and heart rate were monitored. A one-way repeated measure analysis of variance (ANOVA) was conducted to evaluate the difference in physiological changes of the farmers when measured at pre-, mid-,and post-shift. Comparisons indicated that there was a significant difference between 3 pairs core body temperature pre-shift (35.4 ± 0.55 ºC), mid-shift (35.8 ± 0.51 ºC) and post-shift (36.2 ± 0.36 ºC) ($p< 0.001$) (Table 5).

Thermal regulation is an important mechanism for the gain and loss of heat through the autonomic nervous system. The hypothalamic thermoregulatory center receives the information from thermal receptors in the body and provides input and resultant signal thermoregulatory effector then triggers the responses of sweating and increasing core temperature [17]. In general, body temperature will increase when the workers work in a high heat temperature. A body temperature greater than 37.5 ºC was considered excessive for an eight-working period. The human bodies always working to regulate body core temperature even in extreme conditions when the external air is greater than 37.0 ºC but the body core temperature was not exceeded 37.0 ºC [18]. However, the effects of body core temperature still existed with significant changes across the work shifts.

Heart rate plays an important physiological measurement in extreme heat exposure [19]. Heart rate reacted to the ambient temperature and oscillated synchronously with the temperature surrounding the person and increased while working in heat stress conditions [14,15]. A significantly increased heart rate was recorded during pre with mid-shift (71.6 ± 9.38, $p=0.002$) and post-shift (75.4 ± 9.83, $p=0.001$) respectively. However, the heart rate found was not exceeded the ACGIH TLV (180 bpm) due to acclimatisation. Heat acclimatisation act as a temporary adaptation that improves tolerance and dissipation when expose to heat for a certain extended period [20]. Moreover, the subjects were acclimatised to a hot environment by working there for more than one year. Blood pressure is a vital indicator for physiological changes when working in a hot environment [21], which could lead to an increase in blood pressure [22]. Only systolic blood pressure showed a significant increase across the shift (pre-and mid-shift) while other pairs showed no significant differences across shifts. Carotid baroreflex is important to regulate blood pressure. The high environmental temperature causes the blood pressure to increase as the cardiac output rises and the total vascular conductance decreases and the cutaneous vasolidates [23, 24].

Table5: Difference in physiological changes (pre-, mid-, and post-shift)

Variables	Mean ± SD	Mean Difference ± SE.	95% Confidence Interval	p-value
Body Core Temperature (°C) [a]				
pre-shift - mid shift	35.4 ± 0.55	-0.43 ± 0.04	-0.56, -0.31	<0.001**
mid-shift - post shift	35.8 ± 0.51	-0.36 ± 0.07	-0.54, -0.19	<0.001**
pre-shift - post-shift	36.2 ± 0.36	-0.77 ± 0.08	-0.99, -0.61	<0.001**
Diastolic Blood Pressure (mm Hg) [b]				
pre-shift - mid shift	79.2 ± 11.50	-1.46 ± 0.83	-3.535, 0.612	0.257
mid-shift - post shift	80.6 ± 10.57	1.87 ± 1.18	-1.070, 4.813	0.358
pre-shift - post-shift	78.7 ± 10.92	0.41 ± 1.25	-2.720, 3.541	1.000
Systolic Blood Pressure (mm Hg) [c]				
pre-shift - mid shift	130.9 ± 11.74	-3.88 ± 0.95	-6.28, -1.5	<0.001**
mid-shift – post-shift	134.8 ± 12.09	3.23 ± 1.44	-0.37, 6.83	0.091
pre-shift - post-shift	131.6 ± 13.31	-0.67 ± 1.50	-4.43, 3.09	1.000
Heart Rate (bpm) [d]				
pre-shift - mid shift	71.6 ± 9.38	-3.54 ± 0.98	-5.98, -1.10	0.002*
mid-shift – post-shift	75.2 ± 11.51	-0.23 ± 1.15	-3.10, 2.64	1.000
pre-shift - post-shift	75.4 ± 9.83	-3.77 ± 0.98	-6.23, -1.31	0.001*

SD – Standard Deviation, SE –Standard Error

Statistical test - One-Way ANOVA Repeated Measures using Bonferroni correction, Significant at *p<0.05, ** p < 0.001

[a] Mauchly's W = 0.789, df=2, p=0.007, Wilks's Lambda assumed: df=2, p <0.001

[b] Mauchly's W = 0.805, df=2, p=0.0018, Wilks's Lambda assumed: df=2, p =0.126

[c] Mauchly's W = 0.767, df=2, p=0.007, Wilks's Lambda assumed: df=2, p =0.001

[d] Mauchly's W = 0.951, df=2, p=0.395, Wilks's Lambda assumed: df=2, p <0.001

3.5 Acute Health Symptom Score (AHSS) and Associated Factors

Table 6 reports the Multiple Linear Analysis of Acute Heat Symptom Score (AHSS) with associated factors (age, BMI, duration of employment, smoking status, duration of working per day, and water intake). The acute health score expresses the symptoms of heat fatigue, lethargy, dizziness, heat rashes, heat cramps, unstable movement, and heat stroke experienced by the subjects was used as the dependent variable. No established model revealed the AHSS with associated factors (p>0.05). Age capacities with more older workers increase the risk of heat collapse [25]. Most of the subjects were more than 40 years old. In general, middle-aged men between 45 to 64 years old are more susceptible to physiological strain as compared to younger people [26]. Similarly, Harshal et al. [27] reported no significant difference in the age group with a slight increase in the prevalence of heat-related disorders in the age group between 31 to 45 years old as compared to younger workers. Anna et al. [28] also reported that age did not have a significant relationship with the thermal strain which indicated that older and younger workers can tolerate excessive hot conditions. In addition, continuous sweating leads to manifestations of heat illness such as headache, fatigue, heat exhaustion, light-headedness, heat syncope as well as a reduction in plasma volume [29]. In contrast, Inoue and Shibashaki [30] found that older men experienced greater strain during heat stress conditions as compared to younger men.

Individuals with higher BMIs had a greater chance of developing a heat-related illness [31]. A trend of increasing BMI had been observed in recent decades as more than half of the subjects were overweight. However, no significant association was found. This could be explained by inadequate body composition, particularly the percentage of body fat. Therefore, indicators of body composition specific to the Asian populations such as body frame size should be explored in future studies [32,33].

The Majority of the subjects have worked for more than 6 years which might increase the chances to get heat-related illnesses, especially in the outdoor workplace. Excessive heat exposure is a well-known occupational health hazard that causes illnesses ranging from cramps to death. Exposure to intense or prolonged heat and humidity reduces workers' enthusiasm and work concentration increases their irritability and leads to heat-related illnesses [34]. Smoking has a thermogenic effect and is associated with the low physical performance thus increasing the physiological strain [35]. Exposure to nicotine during harvesting exacerbated the heat strain effect among agricultural workers [36,37,] No significant relationship was found in this study. The current study was not designed to examine the body heat loss responses or smokers' ability to dissipate heat during active heat stress (e.g exercise). Therefore, a detailed examination of the whole-body transfer in smokers and non-smokers (e.g., during exercise heat stress) would give a significant result. This could provide insight as to whether the local alterations in smokers' thermoregulatory responses translated to differences in body heat gain and heat loss.

Generally, the duration of heat exposure (hours per day) increases the risk of heat exhaustion for outdoor workers [38]. This study found no significant association between the duration of heat exposure with acute heat symptoms score. A similar finding was revealed by Harshal et al. [27], no significant differences between duration of heat exposure and health effects. Outdoor workers experienced severe physiological distress such as chronic depression or chronic anxiety disorders [39,40]. Daily water intake was associated with dehydration conditions in an individual. As the dehydration condition increased, the level of fatigue also increased. There was a significant relationship between dehydration and heat stress. Those who are exposed to high levels of heat stress revealed that dehydration leads to a decrement in cognitive performance such as fatigue, depression, confusion, and vigor. Furthermore, strenuous task during heat stress condition was correlated with a high sweat rate and led to dehydration.

Table 6: Acute Health Score with Associated Factors

Factors	SLR ^{a}		MLR^b		
	β (95% CI)	**p-value**	**Adj β (95% CI)**	**t-statistic**	**p-value**
	Acute Health Score (AHS)				
Constant	0.320 (-0.121,0.761)				
Age (years)	0.002 (-0.002,0.070)	0.317	0.001(-0.004, 0006)	0.446	0.658
BMI (kg/ms^2)	0.003 (-0.009, 0.014)	0.633	0.004 (-0.008,0.015)	0.633	0.531
Duration of Employment (year)	0.007 (0.001,0.012)	0.021*	0.005 (-0.002,0.011)	1.492	0.146
Smoking Status (Yes/No)	-0.073 (-0.158,0.011)	0.088	-0.053 (-0.142,0.036)	-1.214	0.234
Duration of Working per day (hours)	0.021 (-0.009,0.051)	0.166	0.017 (-0.014,0.048)	1.121	0.271
Water Intake (Litre)	-0.001 (-0.074, 0.071)	0.968	0.005 (-0.070, 0.080)	0.138	0.891

SLR*a* = Simple Linear Regression, MLR*b* = Multiple Linear Regression

*Significant at $p<0.05$

$R^2 = 0.215$

3.7 Limitation of Study

The first limitation is the health status of respondents' heat-related illness symptoms. The possibility of bias happened since all the heat-related illness symptoms were based on self-reported without any further clinical and expert examination. The possibility of recall bias occurs in respondents' thoughts about answering the questionnaire. The second limitation of this study was also referred to types of heat stress monitoring. In this study, there was no personal heat stress monitoring conducted which provides a more accurate reading than environmental heat monitoring. The use of personal heat monitoring and sweating rate allows better results on which workers were likely to be exposed to heat conditions and the environment. Furthermore, the lack of equipment needed for monitoring the environmental heat at the same time prevents effective data collection for the need of this study. Further monitoring like personal heat measurement, air velocity, humidity, wind speed, and radiation should be added.

The Healthy Workers Effect (HWE) was a type of selection bias and explanation for some non-significant results in this study. Some farmers were possibly not included in this study because they might be transferred to other non-agriculture jobs or resign from their current job due to illness caused by their susceptibility. Lastly, the limitation in this study also referred to the present study was conducted only in two locations, and it is difficult to represent the agricultural farm in Kelantan as a whole. Therefore, future research should be examining many different locations to see if the higher-order analysis would be appropriate. Such research would also provide better confirmation of the initial conclusion presented in the study

4.0 CONCLUSION

From this study, it could be concluded that overall WBGT out at both farms exceeded the TLV set by ACGIH (28.0 ºC). This condition causes farmers to experience acute health symptoms score (AHSS) of 0.43 and above with at least 3 acute health symptoms. There was a significant increase in body core temperature across the shift (from pre, mid-, and post-shift). However, no significant association (p>0.05) was found between the Acute Health Symptoms score (AHSS) with associated factors, thus no statistical model was further developed. This suggested that the increase in AHSS might be attributed to other occupational factors (e.g., rating perceived exertion and metabolic workload) and environmental factors (e.qg. relative humidity and air velocity) which were not fully investigated in this study.

Farmers exposed to direct sun exposure might be at higher risk of getting heat stroke, heat exhaustion, and heat cramps. Therefore, few control measures should be taken into consideration by the management**.** It was recommended for workers that were exposed to long hours in heat stress to adjust their working schedule and shift by limiting of hot environment, increasing recovery time spent in a cool environment, adequate amounts of cool potable water near the work area, and drinking frequently. Employers should also provide a heat stress training program for all workers about recognition of the sign and symptoms of heat-related illnesses and administration of first aid. The employer should explain the importance of immediately reporting to a work buddy or supervisor for any symptoms or signs of heat-related illness in themselves.

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