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Original Article

Physiological Implications of Occupational Heat Stress for Maintenance Workers in a Residential Complex in Chennai – An Exploratory Intervention Trial

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Abstract

Introduction: Workers who are working in various industries are at increased risk of heat related illnesses. They experience an additional heat load on the body from their work environment apart from the external environmental temperature. Heat stress is one of the important risk factor affecting workers health at work place which leads to severe health impairments.

Aim: To assess the heat stress and heat strain among residential complex maintenance workers in Chennai.

Materials & Methods: Area Heat stress assessments were measured using Quest Temp Wet Bulb Globe Temperature (WBGT) monitor. Questionnaire was administered to procure information about occupational heat exposure, personal history, and medical history of the subjects. Core body temperature and heart rate was collected before the start of work (Pre) and 2 hours after the work (post). Sweat rate was calculated using Canadian sports association formula. An intervention study (nutritional) was conducted in a subset of population.

Results: Area heat stress measurements (WBGT) ranged from 24.7°C to 30.2°C. 90% of the workers gave history of excessive sweating during work in hot environments and 78% of the workers gave history of excessive thirst. There was a significant increase in core body temperature and heart rate during the post work session compared to the pre work measurement (P value < 0.05). About 58.8% of the workers had high sweat rate.

Discussion & Conclusion: This study has demonstrated statistically significant increase in body temperature, heart rate and sweat rate after work in excessive heat stress conditions. This study indicates that heat exposure is perceived as a significant problem by the workers affecting both physical and mental health.

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Introduction

The global and local climate is getting altered due to climate change that is taking place in earth due to various reasons. It is expected to make hot regions further hotter because of Global climatic change as per predictions (1). The causes for climate change are multi factorial. Recently it has been identified that some of the human activities have also been an important cause of climate change, often referred to as global warming. Pollution exhaust from industries, deforestations etc are some of the reasons. Scientists who are working in this context have concluded that global warming is occurring undoubtedly. It is predicted that in future, extremes of temperature may lead to frequent heat waves which are more frequent, more intense and longer lasting (2). There is substantial evidence of relationship between global warming and human health either directly or indirectly. Increase in level of heat pose significant risk to individuals especially to the workers, the elderly, the very young and the chronically ill. Workers who are working in various industries where heat production is more are at increased risk of heat related illnesses. They experience an additional heat load on the body from their work environment apart from the external environmental temperature. Specific heat wave events in the Northern hemisphere have been associated with marked short term increases in mortality, with reported excess mortality ranging from 4% to 142%. It has been estimated that in Australia 4,336 people died between 1803 and 2002 as a consequence of heat waves, twice the number of fatalities caused by cyclones or floods over the same period of time (3). 1.6 billion Workers across the world falling under the vulnerable employment category. Indoor & Outdoor work without air conditioning is already a major human heat strain in India. Physical labour and poor working conditions have a huge impact on the working population in India. The combination of heat stress, dehydration and physical activity impose challenge for physical adjustment, with potential risk of ensuing heat related injuries and disorders, e.g., heat cramp, heat exhaustion, heat syncope (4). The risk of heat stroke amongst working people is well known and explained by the limits of human physiological adaptability (5). Apart from clinical health effects, work capacity is affected by excessive heat exposure and hourly work output is reduced. A substantial amount of body water may be lost as sweat, including loss of fluid through respiration, gastrointestinal tract as well as kidney (6). A rise in the body temperature results in heat related illness[7]. The heat related illnesses includes heat rash, heat exhaustion and heat syncope which can lead to heat stroke if not treated properly. Although there are some studies about heat stress, the health impacts due to heat stress among workers who are more prone for adverse health outcomes is not well documented in India especially in southern India. Therefore it is very much essential in the current scenario to study the health impacts due to heat stress among workers which may provide valuable information to protect their health through planning and implementing suitable interventions to reduce morbidity and mortality which subsequently increase the productivity.

AIM:

To assess the heat stress and heat strain among residential complex maintenance workers in Chennai.

Materials and Methods

This cross-sectional study was done on 20 housekeeping maintenance workers (age group 20-60 years) belonging to a residential complex in Chennai. All the workers from the complex were included in this study and none of them were excluded, which eliminated selection bias. This study was carried out during winter (month of January).

This study was approved by Institutional Ethics Committee of Sri Ramachandra University. Informed consent was obtained from study participants. A walk through survey was conducted in the residential complex to identify the potential high heat exposure areas. This study includes environmental heat assessment with the help of WBGT monitor, Questionnaire administration for assessment of perception of workers regarding the occupational heat stress and Health assessment which includes core body temperature, heart rate and sweat rate were collected in data collection form. Area Heat stress

assessments was conducted by Quest Temp WBGT (Wet Bulb Globe Thermometer) monitor (8). A validated HOTHAPS (High occupational Temperature Health And Productivity Suppression) questionnaire was administered to procure information about occupational heat exposure, personal history, and medical history of the subjects (9). Height was measured using a measuring tape and weight was recorded using Omran digital body weight scale HN-283. Personal heat stress (core body temperature) was collected using Quest Temp Personal Monitors before the start of work (Pre) and 2 hours after the work (post) to check the increase in temperature after exposure to heat. Heart rate was recorded using pulse oximeter before the onset of the work (resting heart rate) and 2 hours after work (Working heart rate) to evaluate the difference in heart due to exposure to heat during work. Sweat rate was calculated using Canadian sports association formula (10). In addition, an intervention study (nutritional) was conducted in a subset of population (n=10). Nutritional Intervention included provision of buttermilk. Participants were monitored for the physiological parameters such as sweat rate, heart rate, core body temperature at the beginning of the shift and at the end of the shift for two consecutive days. On day one workers were monitored without intervention and day two with intervention. Statistical analysis was done using SPSS software version 11.6. Data is represented as mean±SD. Paired't' test was used to compare the variables before (pre) and after exposure (post). Statistical significance was taken at 5% significance level.

Results

The age group of our study participants was in the range of 20-60 years with mean height ranging 145±11 cms and mean weight ranging 58±10 kgs. Heat stress measurements (WBGT) ranged from 24.7°C to 30.2°C. The maximum WBGT recorded was in the construction site which had direct exposure to sun light. Based on the ACGIH guidelines threshold limit values (TLV) were calculated in all the sites and classified into light (30°C), moderate (26.7°C) and severe (25°C). Based upon this the workers were divided in to two groups. Most of the workers (> 50%) were working in areas with above TLV (Threshold Limit Values) values which reflect that these workers are under direct heat impacts which may affect the health in later stages of work and increase the morbidity and mortality (Table I). 75% of the workers were exposed to direct heat source. 90% of the workers said that the work place was well ventilated (Table II).

TABLE II: Work place Description.

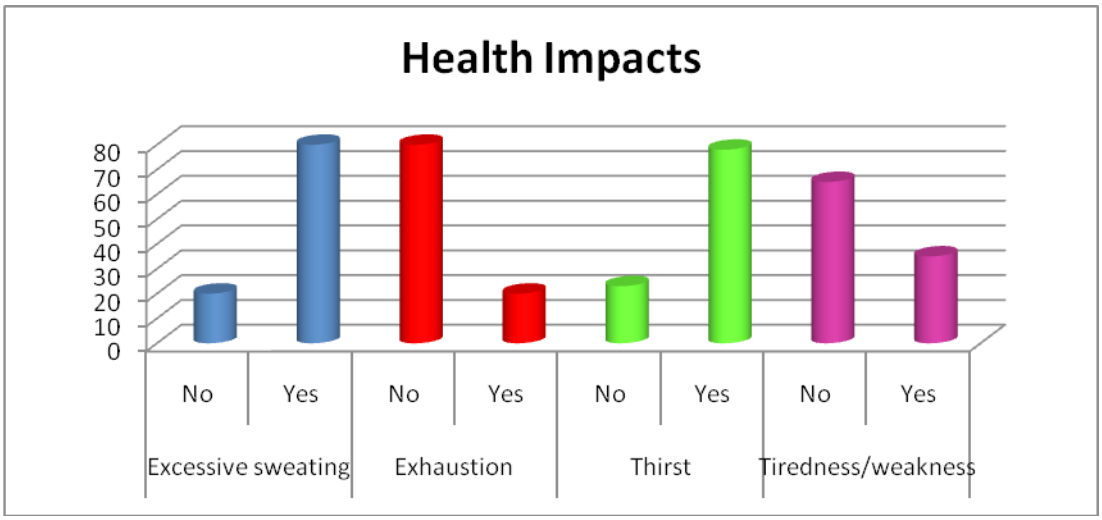
Variable		*Frequency*	*Percentage (%)*
Work near direct heat source	No	10	25
	Yes	30	75
Work place ventilated	No	4	10
	Yes	36	90

90% of the workers gave history of excessive sweating during work in hot environments and 78% of the workers gave history of excessive thirst. 38% of workers gave history of tiredness/ weakness due to excessive heat exposure (Graph 1).

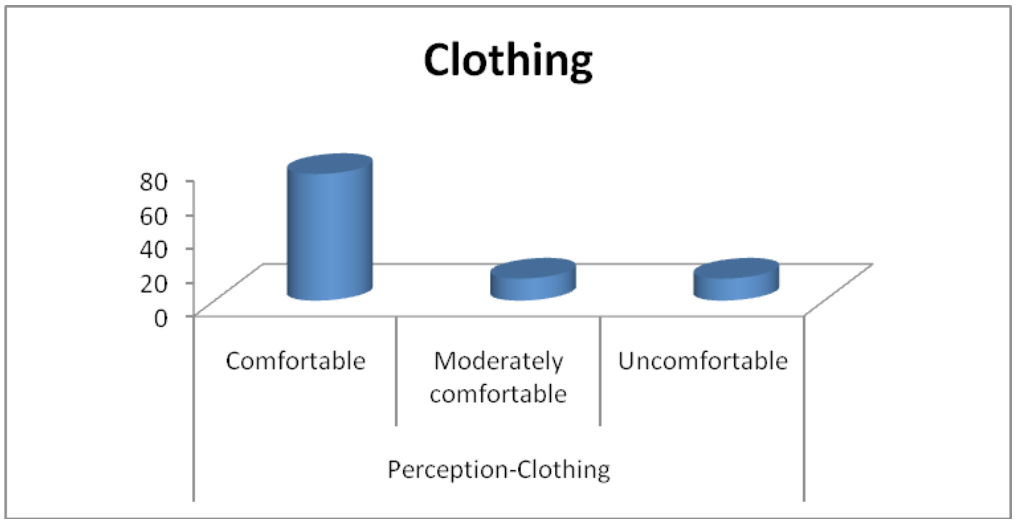
About 75% of the workers felt that they were comfortable with the clothing since they had already got used to such kind of clothing (Graph 2). 70% of

TABLE I: Heat Stress (WBGT Values) across different work locations.

No.	*Location*	*Work category*	*Measured WBGT (°C)*	*ACGIH-TLV*	*Comments*
1	Construction Workers (Exposed to Sun Light)	Heavy	30.2	27.5	Above TLV
2	Security Main Gate (Direct Sun Light)	Moderate	29.6	28.0	Above TLV
3.	D2-Block (Out) Construction workers (Sunlight Exposed)	Heavy	29.9	27.5	Above TLV
4	G-Block (Ironing room)	Moderate	27.1	28.0	Above TLV
5.	D2-Car Parking Security (Shade)	Heavy	24.7	27.5	Below TLV
6	Security Office (Main Gate)	Light	26.2	31.0	Below TLV



Graph 1 : Impacts of occupational heat stress on health.



Graph 2 : Impacts of clothing.

the workers follow taking rest in between the work while 60 % of the workers drink water. 3% of the workers prefer to change clothing (Graph 3).

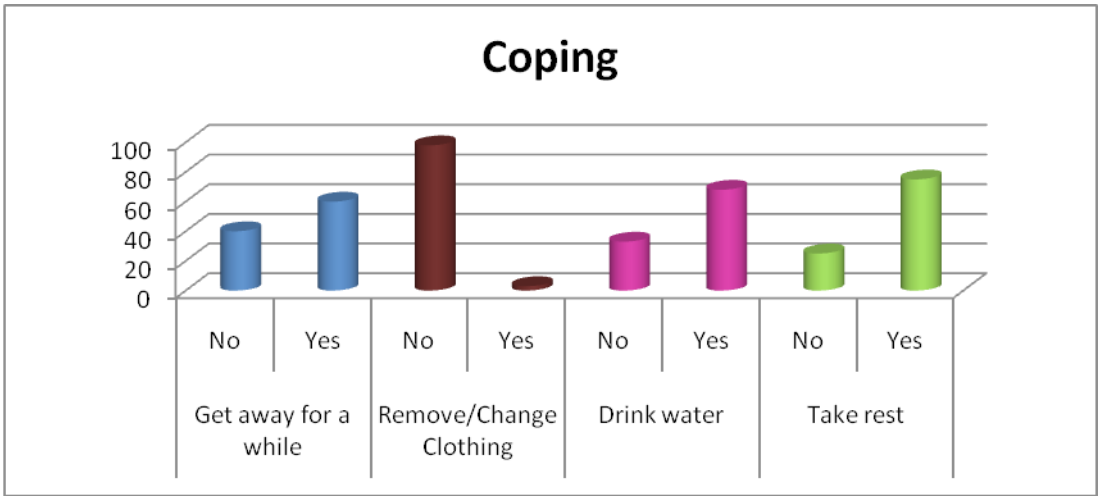
There was a significant increase in core body temperature and heart rate during the post work session compared to the pre work measurement. Post work measurement was taken after 2 hours of work (P value < 0.05) (Table II).

About 58.8% of the workers had high sweat rate and 35.2% of the workers had moderate sweat rate which was calculated using Canadian sports association formula (Graph 4). The results of the intervention study shows that there was a significant reduction in sweat rate during the second day following nutritional intervention as described in the methodology (Table IV). There was no significant

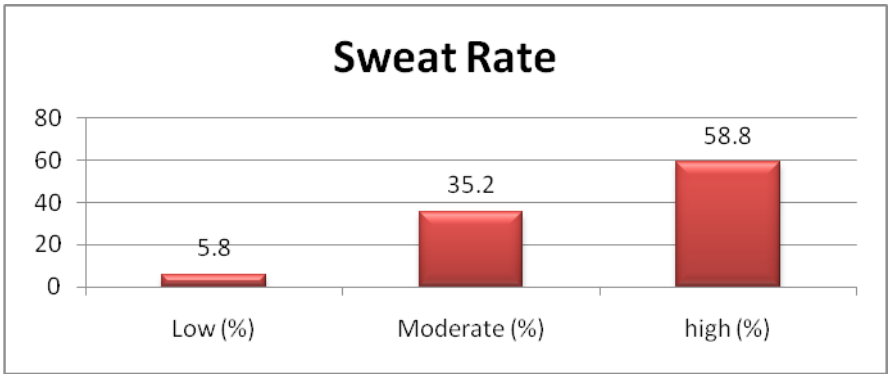
TABLE III : Comparison of Heat strain parameters before (Pre) and after (Post) work.

Variables	*Mean±SD*	*P Value*
Pre Core body Temperature (°C)	36.4±0.455	0.03
Post Core body Temperature (°C)	36.8±0.30	
Pre Heart Rate (Beats/Min)	81.5±8.06	0.00
Post Heart Rate (Beats/Min)	88.3±7.3	

Data expressed as mean±SD. The P<0.05 was considered significant. Analysis of data was done using paired t test.



Graph 3: Coping mechanisms followed by workers at work place.



Graph 4: Analysis of Sweat rate based on Canadian Sports formula.

TABLE IV: Comparison of sweat rate with and without Nutritional intervention.

	Day 1 (without intervention) Mean±SD	*Day 2 (with intervention) Mean±SD*	*P value*
Sweat Rate (L/hour)	2.13±0.95	1.13±0.77	0.026

Data expressed as mean±SD. The P<0.05 was considered significant. Analysis of data was done using paired t test.

change in heart rate and core body temperature with nutritional intervention.

Discussion

The study has demonstrated the effects of excessive occupational heat exposure in working population. Most of the workers were involved in moderate to severe work pattern. These workers are more prone for health impacts of heat related illness like heat exhaustion and syncope as they are directly exposed to sun rays which if continued for a long duration without any intervention may lead to serious health illness (5). Most of the workers (> 50%) were working in areas which had above TLV values which reflect that these workers were under direct heat impacts which may affect their health in later stages of work and increase the morbidity and mortality. The workers also expressed that it was very difficult to work continuously in hot environment which also affected their mental health. They also felt that the ability to perform work decreased with heat exposure. This study indicates that heat exposure is perceived as a significant problem by the workers affecting both physical and mental health (11). Excessive sweating was one of the important problems perceived by the worker which may lead to dehydration if not treated

properly (12). This study has demonstrated statistically significant increase in body temperature, heart rate and sweat rate after work in excessive heat stress conditions. When core temperature exceeds 38°C, the risks of heat strain increases substantially. If insufficient heat is lost, core body temperature will continue to rise to between 38°C and 39°C (where collapse may occur) and 41°C (where heat stroke may occur). A decrease in sweating may occur as the deep body temperature continues to rise and the skin is completely dry. Increase in core body temperature above normal range which may lead to heat disorders like heat stroke and may even lead to death if not treated properly (13). The Calculated sweat rate was high in more than 50% of the workers which if continued to progress would have lead to dehydration and other serious health disorders like renal failure etc (14). This is because of excessive heat exposure which increases the core body temperature which in turn causes increase in blood flow to skin to dissipate the excess heat from the body. As a result the sweat rate was increased. The work done by the heart to increase the cardiac output to meet the extra needs due to excessive heat exposure can increase the heart rate (15). The increase in heart rate due to thermal stress is further exacerbated by the loss of water through sweating because large sweat losses reduce the body's water content (hypohydration) and therefore reduces the blood volume and may lead to sympatho vagal imbalance (16). Dehydration is one of the serious complications due to excessive sweating. In this study there was a decrease in sweat rate among workers after intervention. Nutritional fluid intervention can maintain the fluid balance in workers who work in hotter areas and thereby prevent dehydration (17). Excessive skin hydration can occlude the sweat glands thereby decreasing the sweat rate. Currently there were no studies done in India to check about the effect of fluid replacement in workers working in hot environments. There was no statistically significant change in heart rate and core body temperature which might be due to smaller sample size.

Conclusion

The information generated in this study will help the management to implement certain interventional measures to protect the workers health. Engineering controls like by proving fan, adequate ventilation in working environment and by following work rest cycle as per ACGIH guidelines can protect the workers health. Similar studies have to be conducted in other occupational sectors to document the health impacts. Studies of such kind can improve the workers health condition which can thus reduce the morbidity.

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