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EXTREME HEAT EVENTS: PERCEIVED THERMAL RESPONSE OF INDOOR AND OUTDOOR WORKERS

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ABSTRACT

Background: With the changing climate in the tropical regions, millions of people in indoor and outdoor occupational situations are vulnerable to frequent heat episodes with health implications.
Methodology: The study refers to behavioral responses of the men folks (N=999) to hot environment in indoor (iron work N=287, ceramics and pottery N=137, power loom N=143, pulp and paper mill N=31) and outdoor (stone quarry N=401) working conditions.
Result: Wet bulb globe temperature (WBGT) values in power loom was highest (35.2 ± 1.1^{0}C), followed by other respective occupations. The behavioral responses of workers differed significantly ($p<0.0001$) between the indoor and outdoor working conditions. The subscales of four principal components (PC-1 to PC-4), explained total cumulative variance of 44% in case of iron works, 47% in case of ceramic and pottery work and ~49% in powerloom and stone quarry works.
Conclusion: The stone quarry workers faced greater risk, as compared to the workers in indoor work. Perceived response might provide indication of risk mitigation to combat heat-related emergencies.
Keywords: WBGT, heat stress, ceramic and pottery, power loom, pulp and paper mill, stone quarry workers.

INTRODUCTION

Growing incidences of extreme heat events demonstrate the vulnerability to humankind with increased morbidity and mortality in different geographical regions[1,3]. Epidemiological research from case-control[4], case-only and case-crossover studies[5,6] elucidates susceptibility of the exposed population with reference to physiological and behavioral implications[7]. Despite projection that teeming millions in the tropics are expected to experience unprecedented extreme heat events in the coming years[3,8]. The public recognition of the community calamity in the vast Indian subcontinent remains subdued. The workers in informal occupations, farmers, construction workers, street venders, rickshaw pullers and others, including urban and rural poor dwellers in slums and pavement have daunting challenge to face impacts of heat events. Risks of heat induced human illnesses prevail with relative vulnerability to children, elderly, pregnant mothers, and those with pre-existing medical conditions such as obesity, cardiovascular and neurological diseases[9]. The workers in physically demanding jobs are also at increased risk of heat induced illness[10]. Since people with low adaptive capacity and lack of mitigation measures are at greater risk of morbidity and mortality[11], the occupational characteristics, physical habituation to work, working capacity and state of heat acclimatization are the critical determinants to influence physiological and behavioral adaptations of population exposed to hot environment. This study targeted high heat exposed population to analyze their physiological and behavioral response as regard to perception of heat related stress and strain, and the possible differences of response among different occupational groups.

MATERIALS AND METHODS

The study focused on indoor and outdoor informal working groups, such as ceramics and pottery, and iron works, power loom, pulp and paper mill and stone quarry works (Figure I). The iron works involve cutting of iron sheets, tubes, flats of desired size, folding, bending, drilling, punching, welding, riveting, assembling and spray painting. The ceramic and pottery works include manufacturing of products, such as ceramic tiles, sanitary ware, crockery items. Power looms are small scale textile manufacturing units in semi-urban environment. The workers in informal pulp and paper mill are engaged in making packaging materials, card board boxes, etc. Stone quarry works involve the process of excavation (digging, blasting or cutting) of rocks and minerals from open-pit mines.

The habitual perception of heat related stress and strain of nearly one thousand workers of rural and semi-urban environment were examined during the summer months (May and July), when the ambient temperatures reached to 45 to 50^{0}C, with relative humidity in the range between 50 to 80%. Direct measurements of the thermometric parameters ambient dry bulb (DB) and wet bulb (WB) temperatures, WBGT index were undertaken by Thermal Environment Monitor (QUESTemp, USA) and Relative Humidity/Temperature data logger (Lascar EL-USB-2-LCD, Sweden) throughout several hours of observation period, and continued for a number of days at each workplaces. Taking into account of WB and globe temperatures, the environmental warmth were expressed in terms of WBGT index.

The prevailing climatic conditions indicate that these occupational groups are potentially at risk of high heat exposures due to the work processes, in addition to thermal load during the peak summer months. During occupational engagement, as evident from the pictures shown in Figure I, the workers wore light clothing – shorts, trouser, or lungi / dhuti (a loose fabric wrapped around at the ankle length), and half-sleeve banian or t-shirt with insulation values ranging within 0.4 to 0.6 clo. Health risk surveillance was introduced among the men folks in the age range between 18 to 60 years, and their informed consent to participate in the study were taken, as per the ICMR (2000)[12] ethical guidelines.

Human physiological and behavioral responses to environmental warmth manifest depending on the personal characteristics and other modifying variables. For example, heat stress and disorders are specific to one's state of acclimatization and ability to respond to the level of heat exposure. Based on the WHO ICD-10 code T69, a checklist enquiry incorporated examining heat-related signs and symptoms. These were rated by the individual workers in a five point Likert's attitude scale, referred to as strong disagreement (1) to strong agreement (5), the low score being the positive indicator of the absence of a problem. The self-reporting of perception of heat related symptoms has limitation, since the illiterate workers might not be much conversed with the relative Likert scoring method. Therefore, appropriate indoctrination of the workers and consistent recording by the field investigators are essential in order to establish the relationship between the perception of workers to stress symptoms and heat exposures.

Data analysis was performed using SPSS 16.0. Analysis included treatment of data for descriptive statistics, in addition to test of normality of distribution. The distribution characteristics of thermometric variables might serve as indicators to ascertain vulnerability of population to heat stress, and therefore, these variables were treated for statistical normality distribution in terms of kurtosis and skewness tests. Further, the behavioral responses were treated for one-way

ANOVA to compare responses among the occupational groups. Also, the principal components analysis was applied to allow grouping of the behavioral responses into subscales, and to elucidate the component loading of the heat stress signs and symptoms.

RESULTS

Table I includes the average physical characteristics of the workers. Different occupational groups had similar anthropometric dimensions. The sample size of workers selected from the pulp and paper mill (N=31) was small, in comparison to other groups. The workers in ceramic and pottery works were relatively younger, and older age groups were in power loom. Most other working groups were in the range of 30+ years of age.

The ambient temperature conditions recorded during the study (Table I) indicated that the DB temperatures exceeded 40^0C in all observations of powerloom, $3/4^{th}$ in case of iron works, $1/4^{th}$ in ceramic and pottery, and pulp and paper mill, and over $1/3^{rd}$ of observations exceeding 40^0C of DB in case of stone quarry works. The WBGT index in power loom (35.2 ± 1.1^0C) was highest, followed by ceramic and pottery (33.8 ± 1.9^0C), stone quarry (33.1 ± 2.4^0C), pulp and paper mill (32.7 ± 1.1^0C), and iron works (31.6 ± 1.5^0C) respectively. The thermometric variables treated for Kolmogorov-Smirnov test with Lilliefors significance correction indicated that the dimensions are normally distributed, with test statistics varied from 0.116 to 0.416 ($p<0.001$). The distributions of DB and WB temperatures, and WBGT in indoor occupations were less outlier prone, and the distribution appeared flatter. The skewness values of WBGT indoor in case of ceramic and pottery, and pulp and paper mill works remained symmetric around the sample mean. For stone quarry works, the distributions of WB temperature and WBGT were more outlier-prone, however, the positive kurtosis indicated a relatively peaked distribution. Since the ambient temperature conditions vary during the working day, a sample time trend of WBGT values of an indoor (ceramic and pottery works) and outdoor (stone quarry) situation is shown in Figure II.

The occupational groups selected in the study were naturally acclimatized due to their habitual engagement in the respective jobs. The questionnaire survey essentially looked into the relative behavioral responses as perceived by the workers during the combined work-and-heat exposures. Figure II illustrates the heat strain indicators, as responded on Likert's 5-point scale, midpoint being taken as 3. The responses scored greater than 3 were taken as indication of high strain, and the percentage of workers having responded to high strain is presented in Table II. Behavioral responses, such as heavy sweating, excessive thirst / dry mouth, elevated heart rate, muscle pain / cramps, and elevated body temperature were predominantly rated by the workers however, one way ANOVA indicated that these responses were significantly different ($p<0.0001$) among the occupational groups.

Among all indoor occupations, over 70% of the workers responded of heavy sweating and excessive thirst/dry mouth. About $2/3^{rd}$ of the workers of the iron, ceramic and power loom complained of loss of working capacity, and nearly half of the workers reported feeling of elevated body temperature. Whereas, the stone quarry works are extremely arduous in nature, and a large number of these workers responded for dizziness & nausea, headache, skin tanning, blurring vision, and confused/irritated, in comparison to other occupational groups. Feelings of chill/shivers, dryness of skin and loss of appetite were reported by nearly $1/3^{rd}$ of these workers. Complaints of skin tanning and itching / prickly sensation were highly evident among stone quarry workers, which might be indicative of possible sun burn effects. A larger number of stone quarry workers (63%) reported loss of working capacity during the summer months.

Due to repeated exposure to high heat load and strenuous physical activity, even the habitual workers were subjected to thermal instability. The workers' perceptions were aggregate response over time, including the peak loads. Corresponding to observations of heat related responses to heat illnesses, the relative vulnerability to heat stress were higher among workers in outdoor stone quarry works. Among the indoor occupational groups, the power loom workers had higher heat stress that corresponded to higher WBGT values recorded in power loom works.

The survey results of the behavioral responses were analyzed by using principal component analysis (PCA) and presented in Table III. Due to the small sample size, the pulp and paper mill group was excluded from component analysis. The PCA using a varimax rotation (Kaiser normalization), with convergence to a maximum of 10 iterations, allowed elucidation of the behavioral responses, determining the component structure of the heat related perceptive dimensions and grouping them into subscales of four components (PC-1 to PC-4). Each component had an eigen value greater than 1 and the items with loading beyond 0.40 were retained.

Analysis of clustering of behavioural dimensions yielded its relative difference in the loading; however, there was substantial commonality in clustering of the behavioral dimensions in each of the components among the occupational groups, however, the relative loading of the variables were influenced by the cumulative heat stress of the workers. The general feelings of painful cramping of muscles, elevated heart rate, loss of work capacity, headache, dizziness & nausea, blurring vision were commonly clustered in PC-1 in different occupational groups. These symptoms are probably indicative of "heat exhaustion" with potential risk to cause a more serious form of heat-related illness. In power loom group, sensation of heavy sweating as well as hot or dry skin (no sweating) clustered together, suggesting probable fatigue of the sweat glands. The total variance explained by PC-1 in iron works, ceramic and pottery works, power loom and also in stone quarry works ranged from 14.2 to 17%. The thermal stress response, such as elevated body temperature clustered in PC 2 prevailed among all the occupational groups. The heavy sweating, an evident symptom of heat cramp clustered in PC 1 (ceramic and pottery, and power loom), PC 2 in (stone quarry) and PC 3 in (iron works). The response of hot or dry skin (no sweating), which often indicates sweat gland fatigue spread over in different components, e.g., PC 1 in power loom, PC 2 in (iron works and, ceramic and pottery) and PC 3 in (stone quarry). The thermoregulatory parameters such as excessive thirst (dry mouth) and decreased urine output are clustered in PC 2 in (power loom and stone quarry) and PC 4 in (iron works, and ceramic and pottery). Abdominal spasms clustered in PC 4 (ceramic and pottery, power loom), PC 3 in stone quarry and PC 1 in iron works. The identified four principal components explained about a half of the total cumulative variance, i.e., ~44% in iron works, 47% in ceramic and pottery works and ~49% in case of power loom and stone quarry works. The first three stronger components represented ~40% of the total variance.

DISCUSSION

The present study focused on examining physiological and behavioral responses of workers in indoor and outdoor occupations, who are exposed to high hot environment. The basic premise is that the physiological parameters and behavioral adaptations are critical to manifest ones thermal environmental perceptive responses in a given occupational situation[13,14]. With impending heat wave phenomena in the region, the surveillance data on felt perception of workers might provide indication of their vulnerability.

The habitual occupational involvement makes the workers naturally acclimatized to hot environment[15]; however, even the habitual workers during peak summer months are at potential risk of developing heat-related illness[16].

As regard to environmental warmth, in all occupational groups, it is clearly indicated high heat load even at the minimum level during the working period. All ambient DB temperatures recorded in power loom, and 3/4th observations in iron works exceeded 40^0C. It was noted that in stone quarry works, 35% of observations of DB temperatures exceeded 40^0C. The reference of ambient DB temperature of 40^0C was taken with the view that consecutive days of ambient conditions exceeding this level, often referred to as situation of heat wave[17]. With reference to the temperature condition prevailed during the summer day both indoor and outdoor, the ACGIH (2008)[18] and ISO (1989)[19] guidelines do not match to the ambient conditions of the tropical environment reported in this contribution. Distributions of DB and WB temperatures, and WBGT indoors in case of iron, ceramic and pottery works, and pulp and paper mill were less outlier prone, whereas the distributions in case of stone quarry works were more outlier-prone. Asymmetry in the distribution of WBGT values was relatively larger in iron works (indoor) and stone quarry works (outdoor). Data that spread out more to the right from the proximity of mean indicated a component in heat vulnerability to the population concerned.

One way ANOVA revealed that the behavioral responses differed significantly ($p<0.001$) between the indoor and outdoor working conditions. Also, the PCA yielded that there was a considerable commonality in the behavioral dimensions that are clustered in each of the components among the occupational groups, however, the relative loading of the responses were influenced by the cumulative heat stress of the workers. Since the total variances explained by the four principal components are moderate (44 to 49%), this indicates relative interpretive powers of the workers to perceiving heat stress and strain.

The indoor work environment appeared to cause relatively less severity of heat strain. Among the indoor occupational groups, the power loom workers had higher heat stress. About 2/3rd of the workers of the iron, ceramic and pottery, and power loom complained of feeling of elevated body temperature and loss of working capacity. The power loom workers were much older, who might be sluggish in response of sweat glands[20], in comparison to other workers who were in the range of 30+ years of age. Indications of neurologic impacts to heat stress are headache, dizziness & nausea, feel collapse/mental disorientation, or recurrence of seizure. Over 1/3rd of the workers in different groups indicated feeling of collapse and mental disorientation.

The outdoor stone quarry workers indicated much higher signs and symptoms of heat strains, such as excessive sweating and thirst, elevated heart rate, elevated body temperature, muscle pain/cramps (arms/legs). A large number of these workers responded to dizziness & nausea, headache, skin tanning and blurring vision in comparison to other occupational groups. Increased complaints of skin responses might indicate of possible sun burn effects among the stone quarry workers. The behavioral response of seizure like activity was reported by 10% of the stone quarry workers. About 39% of the workers in this group also reported response of hot or dry skin (no sweating), thereby cautioning to identify susceptible individuals. These serious heat effects will have inevitably affect the hourly productivity of the workers[10], as evident that 63% of stone quarry reported loss of working capacity. The incidences of kidney stones remain a common observation among the stone quarry workers, however, it was not within the scope to elucidate the association of the prevalence of renal diseases and the level of hypohydration to heat exposed workers[21]. Prolonged dehydration aggravates the disease pattern related to renal failure[22,23]. Data gathered from the stone quarry workers indicated their profuse sweating and scare availability of potable water in difficult terrain, and therefore, their long term dehydration cannot be ruled out.

CONCLUSION

Extreme heat events are fast happening across the states of western India where the study was undertaken. The people are regularly confronted with extreme heat emergencies, with great risk of heat related mortality and morbidity. Perceived response might provide indication of risk mitigation to combat heat-related emergencies. The study on selected informal occupations in indoor and outdoor environment amply indicated the felt perception of risk of workers to health and performance. Even the habitual workers were at potential risks of developing heat-related illness in peak summer exposures. At similar environmental warmth, the workers in outdoor environment e.g., stone quarry works, faced a much greater risk, as compared to those in indoor environment in power loom, iron works, and ceramic and pottery works. As a matter of fact that the stone quarry works were strenuous in extreme hot environment and also, the other indoor occupations such as iron works and power loom were inevitably hot workplaces. The present analysis has provided direction that such data on felt perception of heat stress and strain would ascertain the relative vulnerability of different occupational groups to extreme heat eventuality.

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Table I. Physical characteristics of the workers and ambient conditions during the study

		Iron works (N=287)	Ceramic & pottery (N=137)	Power loom (N=143)	Stone quarry (N=401)	Paper mill (N=31)
Physical characteristics of workers						
Age (yrs)	Mean	32.3	25.3	47.6	30.9	30.9
	SD	12.6	7.6	10.9	9.7	11.0
Body height (cm)	Mean	155.3	159.8	161.1	163.0	160.8
	SD	31.3	16.0	10.5	14.2	6.1

Body weight (kg)	Mean	57.9	53.1	59.6	53.6	57.5
	SD	13.7	7.4	11.7	9.4	9.2
BMI	Mean	22.2	20.6	23.0	20.0	22.2
	SD	5.8	2.9	4.1	3.5	3.3
Body surface area (sqm)	Mean	1.5	1.5	1.6	1.6	1.6
	SD	0.2	0.2	0.2	0.2	0.1
Ambient conditions during the study						
DB temp(^{0}C)	Mean	39.5	39.2	40.5	38.4	39.0
	SD	1.5	3.3	1.7	3.3	1.5
	Kol-Sm test*	0.416	0.229	0.366	0.116	0.284
	Skewness	-1.5	1.0	-0.2	-0.2	0.9
	Kurtosis	1.0	-0.4	-2.0	-1.2	-0.5
	Exceeding 40^{o}C (%)	**74.2**	**24.1**	**100.0**	**35.4**	**22.9**
WB temp(^{0}C)	Mean	27.5	30.3	32.2	28.0	28.9
	SD	1.7	1.3	0.9	2.8	0.8
	Kol-Sm test*	0.380	0.159	0.238	0.150	0.366
	Skewness	0.9	-0.1	0.2	2.3	-0.4
	Kurtosis	-1.1	-1.1	-1.5	8.0	-1.8
WBGT (^{0}C)	Mean	31.6	33.8	35.2	33.1	32.7
	SD	1.5	1.9	1.1	2.4	1.1
	Kol-Sm test*	0.374	0.271	0.342	0.179	0.328
	Skewness	1.2	0.3	-0.2	1.0	0.1
	Kurtosis	-0.2	-1.5	-2.0	3.6	-0.7

Table II. Heat strains, as expressed by the workers

	Iron worker (N=287)	Ceramic workers (N=137)	Power loom (N=143)	Stone Quarry (N=401)	Paper mill (N=31)	ANOVA F (p value)
	Percentage(%) of workers expressed heat strain					
Heavy sweating	66	80	81	92	81	41.7 (p<0.0001)
Elevated heart rate	44	53	45	82	45	41.1 (p<0.0001)
Dizziness & nausea	17	18	18	37	10	18.7 (p<0.0001)
Headache	29	28	25	47	29	14.2 (p<0.0001)
Confused & Irritated	17	22	6	38	10	16.3 (p<0.0001)
Skin tanning	14	18	5	33	3	17.5 (p<0.0001)
Excessive thirst/dry mouth	89	88	90	94	71	22.9 (p<0.0001)
Decreased urine output	7	12	6	21	10	19.0 (p<0.0001)
Loss of appetite	14	20	13	34	39	17.5 (p<0.0001)
Blurring vision	23	16	29	40	16	9.7 (p<0.0001)
Hot or dry skin (no sweating)	7	12	14	39	19	82.9 (p<0.0001)
Chill feeling/shivers	3	6	3	27	16	40.2 (p<0.0001)
Seizure	1	1	1	10	0	14.0 (p<0.0001)

Feel collapse/Mental disorientation	28	31	24	40	3	9.5 (p<0.0001)
Abdominal spasms	9	16	8	33	19	25.4 (p<0.0001)
Muscle pain/cramp(arms/legs)	37	39	24	66	45	30.0 (p<0.0001)
Elevated body temperature	53	54	55	36	10	16.3 (p<0.0001)
Itching skin/prickly sensation	34	40	48	45	39	3.6 (p<0.001)
Loss of work capacity	25	31	24	63	19	38.4 (p<0.0001)

Table III. Principal Component loading of behavioral responses

	Principal components			
Iron works	**PC-1**	**PC-2**	**PC-3**	**PC-4**
Eigen Values	21.2	9.0	7.2	6.3
% of Variance	16.6	10.1	9.2	7.8
Cumulative % of Variance	16.6	26.7	35.9	43.7
Confused & Irritated	0.67			
Loss of work capacity	0.64			
Elevated heart rate	0.63			
Headache	0.60			
Dizziness /nausea	0.53			
Feel collapse/Mental disorientation	0.53			
Muscle pain/cramps(arms /legs)	0.53			
Blurring vision	0.49			
Decreased urine output	0.45			
Abdominal spasms	0.43			
Hot or dry skin (no sweating)		-0.65		
Elevated body temperature		0.56		
Chill feeling/shivers		-0.55		
Heavy sweating			0.52	
Loss of appetite			-0.44	
Skin tanning			0.43	
Excessive thirst/dry mouth				0.50
Seizure				0.46
Ceramic and pottery works				
Eigen Values	21.6	11.0	7.7	6.7
% of Variance	14.2	12.3	11.6	9.0
Cumulative % of Variance	14.2	26.5	38.0	47.1
Elevated heart rate	0.65			
Dizziness /nausea	0.61			
Heavy sweating	0.59			
Blurring vision	0.58			

Feel collapse/Mental disorientation	0.53			
Decreased urine output	0.52			
Confused & Irritated	0.48			
Headache	0.42			
Loss of work capacity	0.40			
Elevated body temperature		0.65		
Chill feeling/shivers		-0.62		
Hot or dry skin (no sweating)		-0.50		
Seizure		-0.41		
Skin tanning			-0.57	
Muscle pain/cramps(arms /legs)			0.52	
Loss of appetite			0.47	
Abdominal spasms				-0.52
Excessive thirst/dry mouth				0.44
Power loom				
Eigen Values	22.0	11.8	8.4	7.0
% of Variance	17.0	12.9	10.3	8.9
Cumulative % of Variance	17.0	29.9	40.2	49.1
Elevated heart rate	0.64			
Heavy sweating	0.60			
Headache	0.58			
Loss of appetite	0.57			
Muscle pain/cramps(arms/legs)	0.57			
Hot or dry skin (no sweating)	0.53			
Loss of work capacity	0.52			
Dizziness /nausea	0.52			
Blurring vision	0.47			
Itching skin/prickly sensation	0.45			
Elevated body temperature		0.67		
Skin tanning		0.60		
Excessive thirst/dry mouth		0.46		
Confused & Irritated		0.40		
Chill feeling/shivers			0.66	
Feel collapse/Mental disorientation			0.52	
Seizure			0.50	
Decreased urine output				0.74
Abdominal spasms				0.64
Stone Quarry				
Eigen Values	21.5	13.5	8.3	6.1
% of Variance	16.0	13.1	13.1	7.2
Cumulative % of Variance	16.0	29.1	42.2	49.4
Blurring vision	0.61			
Dizziness /nausea	0.60			

Chill feeling/shivers	0.59			
Headache	0.58			
Confused & Irritated	0.55			
Elevated heart rate	0.53			
Seizure	0.53			
Muscle pain/cramps(arms/legs)	0.50			
Loss of appetite	0.49			
Loss of work capacity	0.44			
Skin tanning		0.67		
Elevated body temperature		0.66		
Excessive thirst/dry mouth		-0.61		
Feel collapse/Mental disorientation		0.55		
Heavy sweating		-0.52		
Hot or dry skin (no sweating)			-0.48	
Abdominal spasms			0.43	
Decreased urine output				-0.53
Itching skin/prickly sensation				0.50

Figure I: Indoor and outdoor occupations. (a)Iron casting (b) Ceramic & pottery works, (c) Iron molding work, (d) Powerloom, (e) Breaking stone with hammer, and (f) cutting stone slab

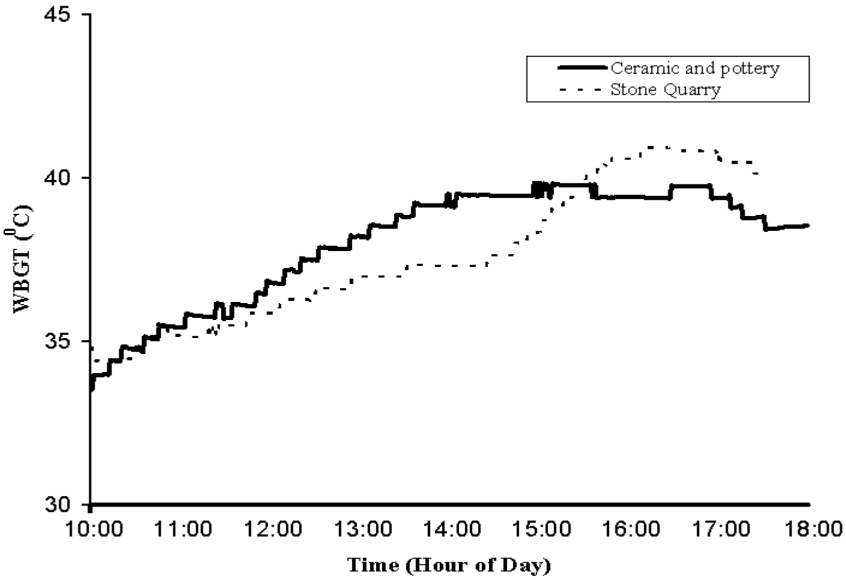
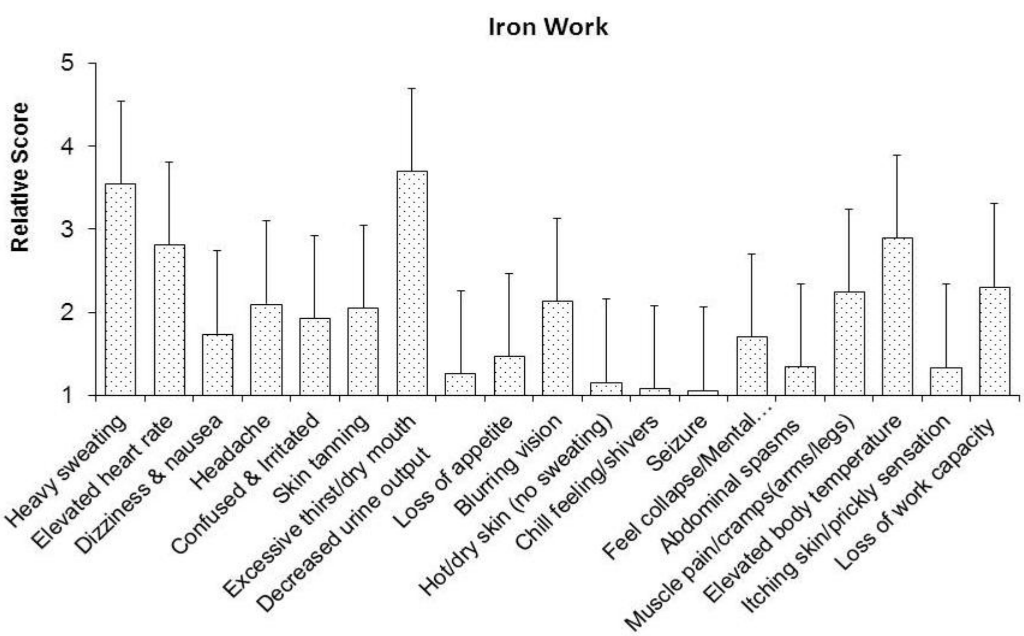
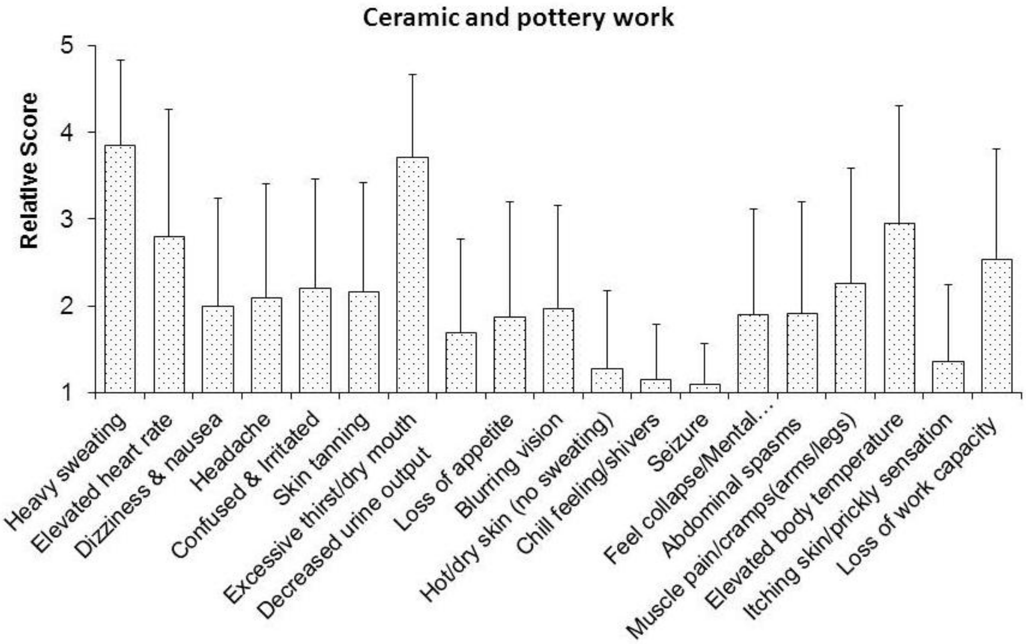
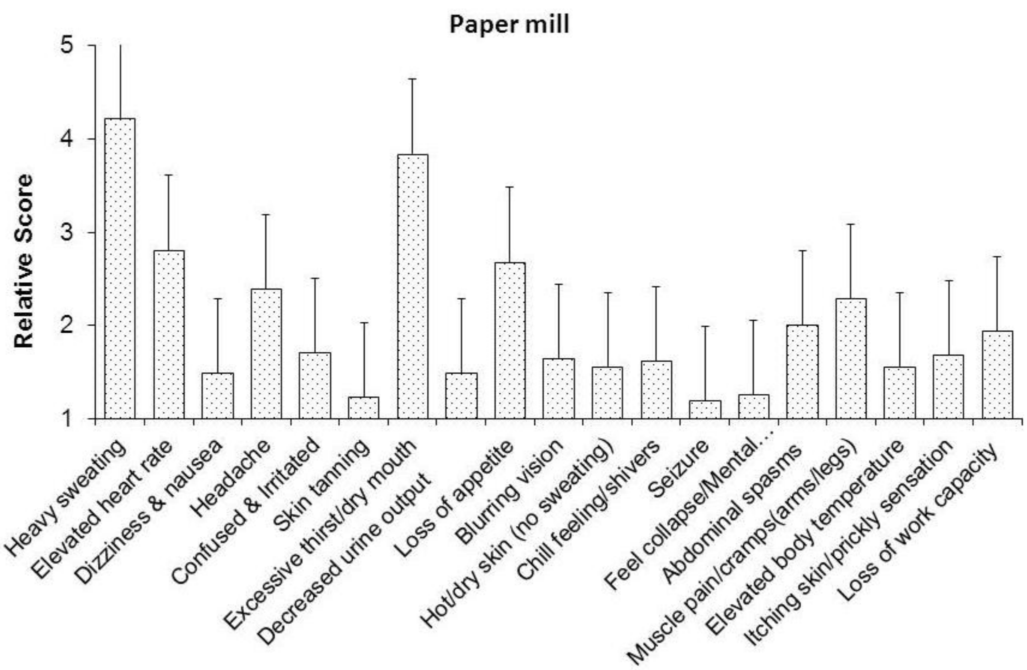
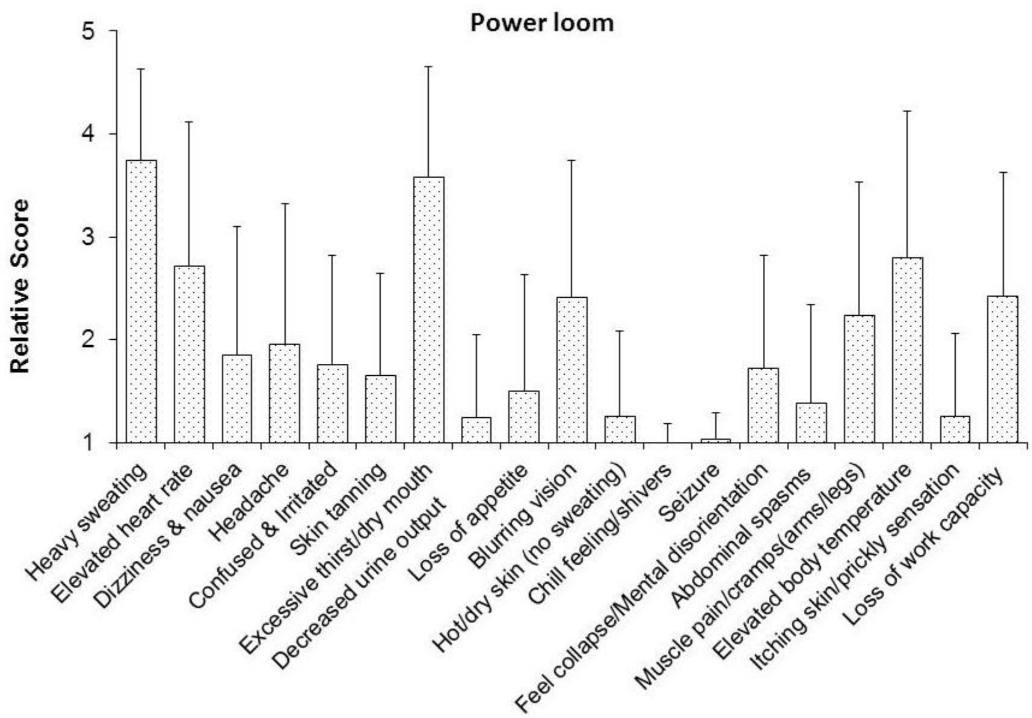


Figure II: A sample trend of WBGT varying during the working day in indoor (ceramic and pottery) and outdoor (stone quarry) works.




Ceramic and pottery work
Relative Score
5
4
3
2
1
Heavy sweating
Elevated heart rate
Dizziness & nausea
Headache
Confused & Irritated
Skin tanning
Excessive thirst/dry mouth
Decreased urine output
Loss of appetite
Blurring vision
Hot/dry skin (no sweating)
Chill feeling/shivers
Seizure
Feel collapse/Mental…
Abdominal spasms
Muscle pain/cramps(arms/legs)
Elevated body temperature
Itching skin/prickly sensation
Loss of work capacity


Paper mill
Relative Score
5
4
3
2
1
Heavy sweating
Elevated heart rate
Dizziness & nausea
Headache
Confused & Irritated
Skin tanning
Excessive thirst/dry mouth
Decreased urine output
Loss of appetite
Blurring vision
Hot/dry skin (no sweating)
Chill feeling/shivers
Seizure
Feel collapse/Mental…
Abdominal spasms
Muscle pain/cramps(arms/legs)
Elevated body temperature
Itching skin/prickly sensation
Loss of work capacity



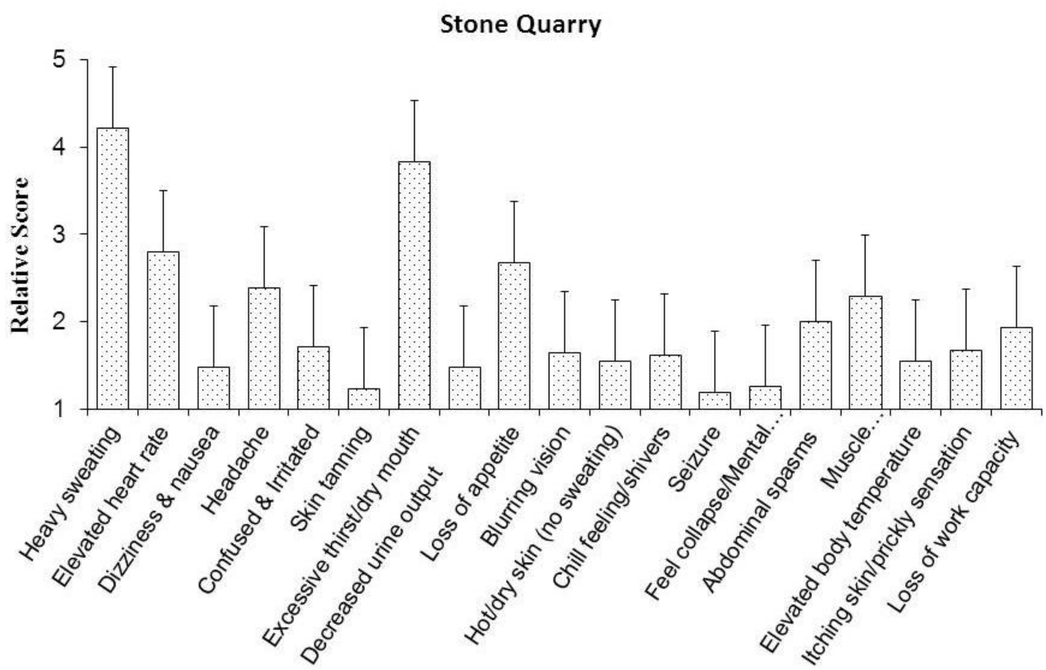


Figure III: Relative severity of signs and symptoms of heat related responses in different occupational groups (a) Iron work, (b) Ceramic and pottery work, (c) Paper mill, (d) Powerloom and (d) Stone Quarry.