Heat Stress and its Effect in Glass Factory Workers of Central India.

AUTHORS
1. Kishor P Brahmapurkar, M.D. (PSM)
Assistant Professor,
Department of Preventive and Social Medicine,
S. V. N. Government Medical College, Yavatmal(M.S) India

2. Ashok G. Lanjewar, M.D. (PSM)
Professor, Department of Community Medicine,
Raichur Institute of Medical Sciences, Raichur (Karnataka), India

3. Sanjay P Zodpey, PhD, M.D. (PSM)
Director, Public Health Education
Public Health Foundation India (PHFI), New Delhi, India

4. Vaishali K. Brahmapurkar, M.D. (PSM)
Assistant Professor,
Department of Preventive and Social Medicine,
S. V. N. Government Medical College, Yavatmal(M.S) India

5. Gautam M Khakse, M.D. (PSM)
Associate Professor and Head of Department,
Department of Preventive and Social Medicine,
S. V. N. Government Medical College, Yavatmal (M.S) India

6. Subhash B. Thakre MD (PSM).
Associate Professor,
Department of Preventive and Social Medicine,
Government Medical College, Nagpur (M.S) India

7 Vivekanand C. Giri, M.D. (PSM)
Assistant Professor cum Epidemiologist,
Department of Preventive and Social Medicine,
S. V. N. Government Medical College, Yavatmal (M.S), India

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ABSTRACT

INTRODUCTION:

Heat stress is still the most neglected occupational hazard in tropical and subtropical countries. Intense hot environments are prevalent in the iron, steel, glass and ceramics units and many other industries. Physical work under heat stress impairs the health and efficiency of workers.

AIM:

The aim of present study was to compare heat stress and its effect between the group of glass factory workers and the comparison group.

METHODS:

Present study focuses on effects of heat stress recorded between 263 Glass factory workers and comparing findings with 263 study subjects from comparison group not working in similar environment. These were seen in different age groups , section wise effect of heat stress in raw, furnace, manufacturing, lehr and other (sorting and dispatch), duration of exposure and seasonal comparison(Summer Vs No summer). Thermal Environment Study at the workplace various sections was carried out using "Questemp^{0}34" (Quest technologies 2002) the Thermal Environment Monitor in the month of June 2004 by using predesigned, pretested and structured proforma.

RESULTS:

The results revealed that a total of 77 (22.3%) workers had effect of heat. 61(40.1%) workers from manufacturing section are affected .The effect of heat was more in the summer season compared to other seasons.

The globe temperature reading at all sections except sorting was higher than dry bulb temperature, therefore radiant heat was a major contributor to heat stress.

CONCLUSION:

Overall, significant occurrence of effect of heat stress among glass factory workers and provision of cooling devices may be preventive measure.

Key words: Heat stress, Heat exhaustion, Heat cramps, Glass Factory.

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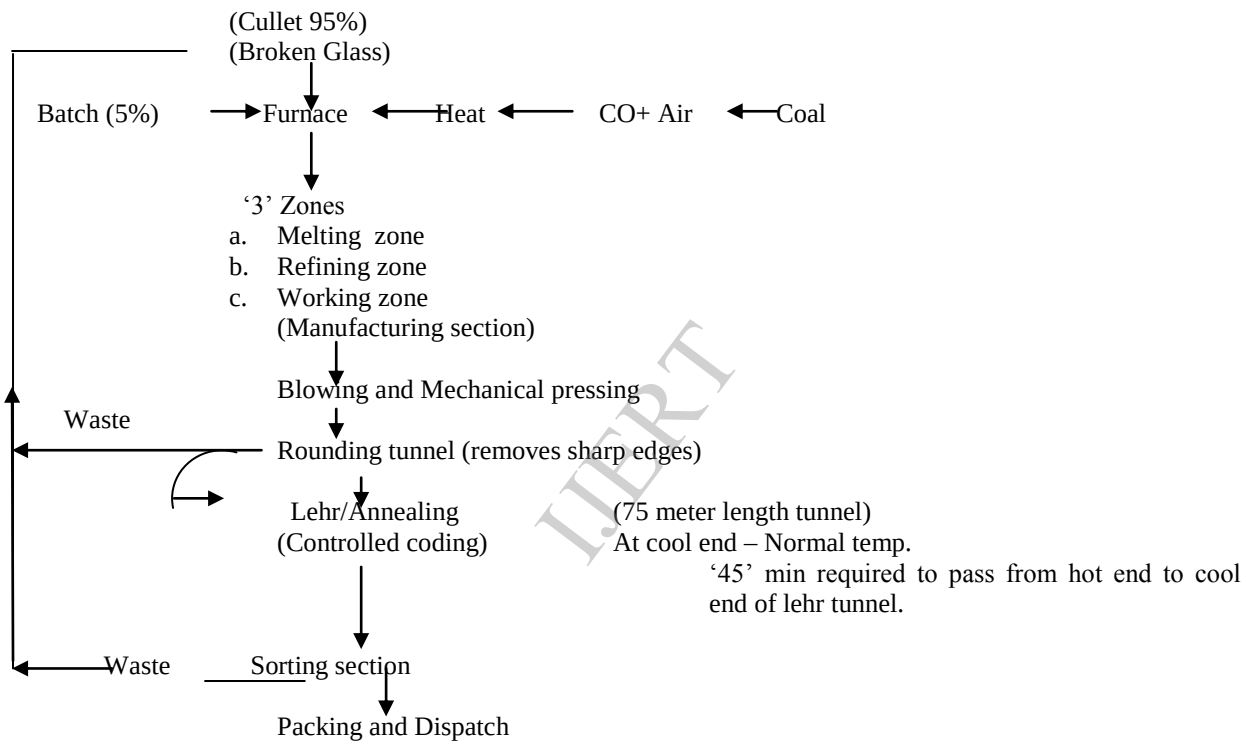
INTRODUCTION

Heat stress is still the most neglected occupational hazard in tropical and subtropical countries. Intense hot environments are prevalent in the iron, steel, glass and ceramics units, rubber, foundries, coke ovens, mines and many other industries.

Heat stress naturally occurring due to the hot climate is augmented for the workers involved in work close to furnaces. Glass manufacturing is one such work environment, where some workers are exposed continuously to high temperatures during the 8 hour shift. Convective of radiant heat gains by the human body can lead to heat disorders [1].

The common physical hazard in most industries is heat. The direct effects of heat exposure are burns, heat exhaustion, heat stroke and heat cramps; the indirect effects are decreased efficiency, increased fatigue and enhanced accident rates. Many industries have local "hot spots"-ovens and furnaces, which radiate heat [2].

In the Glass factory the processes and materials involved were as follows:



"The processed and materials involved."

In Glass Factory', the raw material used is 95% cullet i.e. waste glass and 5% batch (mixture of sand, sodium and chemicals).The raw material was added to furnace (400-500 kg/hr depending upon the order). The coal is used for heat generation purpose. When all the substances in the mixture have melted the temperature of mixture is raised to around 1500^0C. The operations, involve increased heat levels and possibility of exposure of heat to workers. The furnace presents a dominant source of radiant heat.

As Nagpur is located at centre of Indian peninsula far from Bay of Bengal and Arabian Sea, Nagpur has a tropical wet and dry climate with dry conditions prevailing for most of the year. Summers are extremely hot lasting from March to June, with maximum temperatures occurring in May. (More than 42^0 C)

Limited information is available to estimate the combined effect of climate as well as industrial heat exposure. Consideration of the factors contributing the total heat stress and knowledge of how people need to respond to different work conditions and climate will greatly help.

One of the hazard in the glass industry as mentioned in International Labour Organization Encyclopedia of Occupational Health and Safety is heat stress due to heat and radiant energy [3].

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It was with this background that the present study was undertaken to compare heat stress and its effect between the group of glass factory workers and the comparison group from general population of adjacent area not working in similar working environment.

MATERIAL AND METHODS

Study design

The study design was cross-sectional study with comparison group, which was matched for age, sex and socio-economic status, unexposed to similar working environment i.e. Glass Factory.

Study Setting

The Glass Factory is situated at Uppalwadi, Piwdi Nadi, Kamptee Road, Nagpur in the Maharashtra State (M.S.) at 12 km. from Government Medical College, Nagpur.

Comparison group was selected from general population of adjacent area, Piwdi Nadi, Kamptee Road, Nagpur in Maharashtra.

Study Population

It includes workers of Glass Factory [study subjects]. Total number of employees of the factory was 295. After excluding the administrative staff and office employees (n=27), total 268 workers were enrolled for the study. Of these '05' did not co-operate. Hence 263 workers were studied along with 263 comparison group. A written consent was obtained from study subjects before data collection. The worker on leave more than 15 days was exclusion criteria along with those who do not co-operate. An inclusion criterion was workers on pay roll and those giving written consent. The actual of study subjects started after the approval of Institutional Ethics Committee Government Medical College, Nagpur.

Methodology

To start with a list of glass factories was obtained from 'Sub-Regional Employees State Insurance Corporation' (E.S.I.C.) Office, Ganeshpeth, Nagpur. The Glass Factory was selected by Convenience sampling Technique for the study purpose as necessary permission to carry out the study was given by the owner and general manager of the factory and they assured co-operation for performing the study. The permission was obtained from the concern Government official i.e. Deputy Director, Industrial Safety and Health, Nagpur

The purpose of the study was discussed with workers. The time schedule was prepared, so that workers could participate in the study conveniently.

The pilot study was carried out in the month of December 2003 with predesigned, pretested and structured proforma. Interview technique, general observation and investigation were used for data collection.

The pilot study was carried out on 30 workers and 30 from comparison group. Depending upon the findings of the pilot study, suitable corrections were made in the proforma.

This predesigned, pretested proforma was used for data collection. The data was collected in the following manner.

After collecting data for 30 to 40 workers, the comparison group was selected from the community area of Piwdi Nadi. Initially age and sex matching was done and then matching was done for socioeconomic status. The data was collected on the similar proforma, which was used in study subjects and comparison group.

The heat stress study at workplace of the factory was carried out using 'QUESTemp^{0}34' [manufactured in USA], the thermal environment monitor [4] with the cooperation of "National Institute of Miners Health" (Central Laboratory) Wadi, Nagpur. The QUESTemp^{0}34 has three sensors; one at head level, one at abdomen level and one at ankle level. The data of previous three years (Maximum temperature, relative humidity etc.) was collected from the Metrological Department, Nagpur.

The following parameters were recorded at raw, furnace, manufacturing, lehr and sorting section.

- WBGT IN,WBGT OUT, Dry bulb temperature, Wet bulb temperature, Globe temperature, Heat Index and Relative Humidity.

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STATISTICAL ANALYSIS

Percentages, chi-square and chi-square for linear trend used for statistical analysis purpose with Epi Info 2002.

RESULTS:

The effect of hot environment in study subjects[glass factory workers] and comparison group is summarized in [Table 1], it reveals 212 episodes of effect of heat stress in 77(29.3%) glass factory workers and 6(2.3%) in comparison group. Heat exhaustion was observed in 74 (28.1%) and 4 (1.5%) of workers and comparison group respectively. The effect of heat in relation to age of study subjects and comparison group showed in [Table 2] revealed that age group more than 50 years was more affected.

Section wise distribution of glass factory workers with effect of heat as in [Table 3] it was seen that majority of workers 61 (40.1%) of 152 from manufacturing section and furnace (37.5%) section were affected. [$\chi^2$for linear trend=14.252, p=0.00016].Out of total 263 workers, 77 (29.3%) had effect of heat stress. The Effect of heat in relation to length of exposure in [Table 4] it was found that 19 (55.9%) out of 34 workers with length of exposure more than 20 years had effect of heat. [$\chi^2$for linear trend=17.445, p<0.00003] .Study subjects were significantly more affected from effect of heat than comparison group as seen from Table 5 [χ^2 =70.10, df=1, p<0.000000] and odds ratio is 17.7.

Heat stress parameters at various sections measured using Questemp-34^0 at Sensor 1(abdomen level) and Threshold Limit Values (TLV) respectively. It was observed that as WBGT was higher at raw, furnace, manufacturing and lehr section while it was within permissible limit in sorting and packing section.The globe temperature reading at raw, furnace, manufacturing and lehr section is higher than dry bulb temperature; therefore radiant heat is a major contributor to heat stress in these sections.

DISCUSSION

The prevalence of effect of heat stress in the present study i.e. heat exhaustion (28.1%), heat cramps (22.0%), heat hyperpyrexia (2.6%) were similar to that reported by Patel Harshad C et al [5]., i.e. Heat exhaustion 48 (18.3%), heat cramps 16 (6.1%) and heat pyrexia 11 (4.2%) were reported among firefighters. This indicates occurrence of heat stress among glass factory workers. Similarly 15.9% of workers in Iron industry and 20.3% Ceramic workers experienced heat cramps [6].

Bazroy et al, studied magnitude of injuries in glass bottle manufacturing plant. They found burns 7.1%. , in our study we found burns 27.7% as a direct effect of heat exposure [7]. Elderly population is Vulnerable to heat stress due to reduced ability to acclimatize to changing temperatures and higher likelihood of pre-existing chronic health conditions. Thermoregulatory mechanisms in older adults often do not function optimally, even when the individual is relatively healthy. In present study 76.9% of workers in the age group more than 50 years were affected.

Rathod et al, studied thermal stress and physiological strain in the glass bangle industry [8].They noted workers are exposed to severe degree of heat stress during various operations in the manufacturing process. In our study we found 40.1% workers from manufacturing section were affected. They also carried out a detailed study in eight glass bangle units to make quantitative estimates of heat stress on exposed worker in summer season. In present study out of total 99 episodes of heat stress in 77 workers, 96 episodes occur in summer (March to June) and 3 in other season.

Our findings of globe temperature more than dry bulb temperature at various sections such as raw, furnace, manufacturing, lehr (hot end) in glass factory confirm radiant heat as a major contributor to heat stress in these sections. In present study heat index was higher in all sections except sorting and packaging and it was not recordable at furnace (Sensor 2 and 3), manufacturing (Sensor 1 and 3) [i.e. outside the range of 21 - 49^{0}C and RH 30 – 99%] or the temperature is outside its allowable range.

Srivastava et al, studied heat exposure in the workplace in glass manufacturing unit, found that globe temperature observed at all locations except the compressor room was higher than the dry air temperature, indicating that all the surfaces which surround the globe are warmer than the air thereby radiating heat to atmosphere [9]. They found furnace as a dominant source of radiant heat. They observed WBGT (^{0}C) peaked 40^{0}C against the American Conference of Governmental Industrial Hygienists (ACGH) [10], Threshold Limits Values (TLVs) of 26.7^{0}C in front of IS machine. At all parts in the manufacturing section WBGT exceeds the TLV limits. They concluded that in view of high ambient temperatures prevalent in tropical and sub-tropical countries, it is felt that ACGIH standards would not suit local conditions leading to higher WBGT indices for the same type of work performed in cooler climates. A revision of these standards to suit tropical and sub-tropical conditions would be in older.

Gode found that the radiant heat was comparable throughout the shift and said that the mean radiant temperature was much higher and was responsible for major heat load at the workplace [11].

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Rastogi et al, studied wet bulb globe temperature index: a predictor of physiological strain in hot environments [12]. They conclude that radiant heat seemed to make most significant contribution to the environmental stress in these glass bangle industries.

CONCLUSION

The results indicate that the heat stress is prevalent in the present glass factory workers working in the manufacturing section and near furnace. Elderly populations working in such environment are at risk to effect of heat stress. In addition the occupational heat stress, the workers are exposed to climatic heat in summer season. The results of thermal environment assessment at the workplace in glass factory reflect radiant heat as major contributor to heat stress.

RECOMMENDATION

As there are two big table fans in the manufacturing and furnace sections; cooling devices be provided during summer season as preventive measure as the workers are at risk of heat stress due to combined effect of occupational (radiant heat) and climatic hot environment.

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Table 1: Distribution of effect of hot environment in the study subjects and comparison group

ICD Code	Morbid Condition	Study subjects No. (%)	Comparison group No. (%)
T 67.5	Heat exhaustion	74(28.1)	04(1.5)
T 67.2	Heat cramps	58(22.0)	02(0.8)
T 67.0	Heat hyperpyrexia	07(2.6)	0(0.0)
T 30.1	Burns	73(27.7)	0(0.0)
	Total	212(80.6)	6(2.3)

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Table 2: Age wise distribution of study subjects and comparison group with effect of heat during last one year

Age group (years)	Total no study subjects	Study subjects with effect of heat No. (%)	Total no of comparison group	Comparison group with effect of heat No. (%)
<20	37	13(35.1)	37	00(0.0)
20-29	108	24(22.2)	108	00(0.0)
30-39	80	21(26.2)	80	00(0.0)
40-49	25	09(36.0)	25	02(8.0)
>50	13	10(76.9)	13	04(30.8)
Total	263	77(29.3)	263	06(2.3)

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Table 3: Section wise distribution of study subjects with effect of heat during last one year

Type of work	Exposure score	Study subjects with heat effect	Study subjects without heat effect	OR***	Level of significance
Raw	0.33	1	29	1.00	Chi Square for linear trend 14.252 p:0.00016
Other	0.12	5	38	3.82	
Lehr	0.23	7	23	8.83	
Furnace	0.38	3	5	NA*	
Mfg**	0.40	61	91	19.44	

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*NA as cell value is less than five.

**Mfg. – Manufacturing

*** OR Odds Ratio

Table 4 Distribution of Study subjects with effect of heat in relation to length of exposure

Length of Exposure (Years)	Exposure score	Study subjects with heat effect	Study subjects without heat effect	OR	Level of significance
<5	0.2	25	98	1.00	Chi square for linear trend = 17.445, p=0.00003
5-9	0.28	13	33	1.54	
10-14	0.3	9	21	1.68	
15-19	0.37	11	19	2.27	
20-24	0.59	13	09	5.66	
>24	0.5	06	06	3.92	

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Table 5: Effect of heat in the study group and comparison group

Group	Effect of heat		Total
	Yes	No	
Study group	77	186	263
Comparison group	06	257	263
Total	83	443	526

X^2=70.10 (With Yate's correction), d.f. =1, p<0.000000

Odd Ratio=17.7

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