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COMBINED EFFECTS OF HEAT STRESS AND SHIFT WORK ON PHYSIOLOGICAL PARAMETERS IN FOUNDRY WORKERS

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ABSTRACT

In order to investigate the combined effects of shift work and heat stress on the physiological parameters,such as heart rate (HR) and body temperature (BT),a hot-dry working environment was investigated for 53 workers in foundry workshops. In this study Wet Bulb Globe Temperature index (WBGT) was measured and along with that simoultanously heart rate and oral temperature were checked in 3 shifts.

The results indicated that the physiological responses of workers changed whenever the shift changed and the responses were increased by a corresponding increase in heat stress' index.

INTRODUCTION

Millions of people are doing shift work around the world and the propertion of shift workers to total workforce is increasing each year. It has been estimated that since World War II there has been 1 percent growth per year in this respect.

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Virtually every function in the body takes place according to a day-night cycle. There is not only a circadian rhytm in an obvious process such as sleep but also in the internal states of the body such as body temperature, digestion and hormone levels in the blood. Many shift workers are exposed to hazardous agents in their working environment such as heat stress (4,7). The physiological effects due to shift work and heat stress have already been studied separately.

The objective of our investigation was to study the effect of heat stress combined with shift work on physiological parameters of workers at a foundry.

MATERIALS AND METHODS

This study was conducted at a certain foundry in North East of IRAN during the summer of 1988. Those who participated in this study were 53 workers of Electric and Gas Furnace who worked at a rotating 3 shift schedule, (under test group, UT). The control group consisted of 20 workers for each shift including guards, power and foundry maintenance personnel who worked in different environmental conditions. All the subjects filled out a short questionnaire (6). They were also checked to see whether they had any problems or used any kind of drugs. The results revelead that all of them were healthy.

The Physical Characteristic of the Subjects are as follows:

Their average age, height and weight are shown in Table 1. The majority of workers were young, 26-35 years old; on the other hand, the history of their job (3.47 ± 4.08 years) indicated that they were heat acclimatized workers. They were dressed in routine work coverings and their nutritional conditions were similar.

Physiological factors such as heart rate (HR) and oral temperature as well as environmental parameters, including natural wet bulb and globe temperature were checked. Measurements were made at ankle, abdomen and head heights (8). WBGT index was calculated as the mean weighted index (1). All the measurements were carried out over 3 consecutive weaks where a 3 shift system

was in operation and the shifts changed at 06.00 am, 14,00 and 22.00 pm. The whole process was repeated 3 times: at the beginning, at the maximum activity time (during peak hour) and at the end of each shift according to the recommended guildlines discipline (IS07243).

TREATMENT OF DATA: The data was treated by the two-way analysis of variance with unequal sample sizes, and regression analysis and confidence interval using the SPSS programme.

RESULTS AND DISCUSSION

Table II indicates the mean and standard deviation of WBGT index in 3 shifts. The measured WBGT indexes were divided into the four following groups: WBGT $\leqslant$ 21C°, 21C° $\leqslant$ WBGT $\leqslant$ 25C°, 25C° $\leqslant$ WBGT $\leqslant$ 29C° and WBGT $\geqslant$ 29 C° and on the basis of the above classification, the subjects were distributed into the groups previously mentioned in each shifts (3). Heart rate and body temperature data in 3 shifts in relation to 4 WBGT groups are presented in Tables III and IV. The work rate in this job is estimated to be a moderate one.

According to Tables III and IV, the physiological responses were changed by a corresponding variation in relation to environmental parameters and shifts. The levels of strain for the two parameters (H.R & B.T) imposing during heat stress and shift changes were investigated by analysis of variance. The results demonstrated that the interaction between the two above variables is significant and it means that their effects are not additive. The effects of the change in the working - hours in connection with the body temperature and heart rate are highly significant ($P < 0.001$); on the other hand, the above physiological factors do not show any statistically significant difference under various levels of heat stress. However, since the interaction term is significant, it could be concluded that heat stress should be considered as an affecting factor. A clear comparison of the shifts shows that the effects of day and night shifts on the alteration of the

physiological responses appear to be similar but the afternoon shift indicates a highly significant effect ($P < 0.05$).

The relationship between heart-rate and body temperature among workers under a wide range of environmental heat stress was investigated by regression equation and it was concluded that there is a linear correlation between H.R and BT in the 3 shifts (2). The heart rate-body temperature relationship observed in this study was quite similar to that reported by KUHLEMEIER AND MILLERL (5).

The study of the data revealed that the BT & HR were elevated during the day and reached the peak value during the afternoon, then dropped during the night. This circadian rhytm was more significant in the «under test group» rather than the control group($P < 0.05$). This finding may be due to an increased rate of metabolism in the UT because of working in other shops or elsewhere out of the plant during day. Therefore the results of the study indicate that the afternoon shift workers were more subjectet to work stress than the rest.

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Table 1. Characteristics of the subjects

	Age (Yrs)	Height (cm)	Weight (kg)
Mean	31.33	171.79	65.59
Standard deviation	10.95	5.70	11.58

Table II. Mean value and standard deviation of WBGT index in 3 shift.

WBGTC°	Day	Afternoon	Night
$\bar{X}$	27.08	28.35	25.70
S	8.07	3.80	3.70

Table III: Variations of the Body Temperature of Workers Versus WBGT Index During 3 Shifts

WBGT C° \ Shift		Day	Afternoon	Night	Total
WBGT ⩽ 21	$\bar{X}$	36.90	37.00	36.34	36.76
	S	0.22	0.28	0.20	0.34
	n	11	2	5	18
21 ⩽ WBGT ⩽ 25	$\bar{X}$	36.75	36.91	36.79	36.81
	S	0.26	0.91	0.35	0.27
	n	11	9	13	33
25 ⩽ WBGT ⩽ 29	$\bar{X}$	36.98	36.88	36.83	36.85
	S	0.20	0.32	0.22	0.24
	n	5	7	28	40
WBGT ⩾ 29	$\bar{X}$	36.78	37.13	36.64	36.94
	S	0.31	0.21	0.22	0.32
	n	26	35	7	68
Total	$\bar{X}$	36.82	37.05	36.74	36.87
	S	0.28	0.24	0.29	0.30
	n	53	53	53	159
Control	$\bar{X}$	36.70	37.00	36.6	
	S	0.15	0.32	0.24	
	n	20	20	20	

Table IV: Variations of the Heart Rate of Workers Versus WBGT Index During 3 Shifts

WBGT C° \ Shift		Day	Afternoon	Night	Total
WBGT ⩽ 21	$\bar{X}$	76.6	80.5	71.6	75.5
	S	6.3	19.1	4.2	7.71
	n	11	2	5	18
21 ⩽ WBGT ⩽ 25	$\bar{X}$	77.9	73.3	72.1	74.4
	S	7.2	10.8	5.7	8.0
	n	11	9	13	33
25 ⩽ WBGT ⩽ 29	$\bar{X}$	76.0	75.4	76.6	76.32
	S	7.6	5.9	10.5	9.4
	n	5	7	28	40
WBGT ⩾ 29	$\bar{X}$	75.9	83.7	64.1	78.7
	S	10.4	8.3	3.9	10.7
	n	26	35	7	68
Total	$\bar{X}$	76.5	80.7	73.3	76.8
	S	8.6	9.7	9.3	9.8
	n	53	53	53	159
Control	X	77.3	73.2	68.4	
	S	5.0	5.9	5.3	
	n	20	20	20	

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