Health Complaints, Sicknesses and Accidents of Workers Employed in High Environmental Temperatures

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This paper summarizes the results of a study concerning the health of workers exposed to chronic occupational heat stress. The prevalence of elevated blood pressure and coronary heart disease was observed among these workers in comparison to a control group. The results suggest that there was an interdependence between the influence of heat stress and noise in promoting hypertension. Also a time related distribution of occupational accidents has been observed, similar for both groups, with the peak around noon.

Cet exposé résume les résultats d'une étude sur l'état de santé d'ouvriers exposés à la chaleur. Ceux-ci sont caractérisés par une forte tension et un taux élevé de maladies cardiaques, par rapport à un groupe de contrôle. Ces résultats indiquent l'interdépendance de l'exposition et la chaleur et au bruit comme causes d'hypertension. On a également observé la répartition chronologiques des accidents pendant la journée, chez les deux groupes. Le point culminant se trouve à midi.

Among occupational hazards, heat stress is considered one of the most harmful.[1-6] Apart from heat illnesses, heat stress can aggravate or promote development of some diseases.[5-9] However, there are few data concerning long-term health effects of chronic occupational heat stress.

Another problem related to heat stress is industrial accidents:[1,5,10] workers exposed to heat are more prone to accidents. This is in agreement with the general concept of accident risk that "the more energy present at a workplace, the greater the accident potential."[11]

The study summarized below is focused on workers under chronic occupational heat stress. The aim of the study was: (1) to gather information concerning health complaints and chronic diseases of these workers, and (2) to analyse — using a chronohygienic method[12] — the accident rates.

MATERIAL AND METHODS

The data collected have been based on medical documentation from the Health Department of a glass factory. The information regarding work organization, sh rotation and environmental circumstances has been base

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on supervisors' reports. Only those workers were chosen for the study who had been employed at least 3 years at a hot workplace (H-Group, 200 workers). This included the jobs carried out continuously in heat (identified generally as close to or exceeding permissible limits) or the activities performed occasionally in extreme heat where the work was only possible in protective clothing.

The reference group (R-Group, 144 workers) was chosen to match the H-Group with respect to age, physical load, shift rotation, workers' habits (most of the workers in both groups were "current drinkers"[13]) and other occupational hazards (except heat stress). In each group, three following age-related subgroups were distinguished: (a) 21-34 yrs., (b) 35-49 yrs. and (c) 50-65 yrs. The matching was not complete: a little higher percentage of people of R-Group was exposed to noise in comparison to H-Group (92%, 96%, 92% and 89%, 88%, 86%, respectively for a, b and c subgroups). For statistical analysis only extreme noise was taken into account.

Almost all chronic complaints, symptoms and disorders specified in the medical documentation have been considered. However, in this paper, only those which seemed to be typical for a given group or subgroup have been included. For distinguishing between "normal" and "elevated blood pressure" (EBP), the criteria accepted by the World Health Organization[14] were adopted and two stages of EBP have been specified: stage I (S_I), if the systolic blood pressure fluctuates between 140 and 160 mmHg or diastolic blood pressure varies between 90 and 95 mmHg, but occasionally there are normal values; and stage II (S_{II}), when the systolic or diastolic blood pressure exceeds 145 and 95 mmHg, respectively, and there are no evident normal values (except if treated).

In the statistical analysis, the following methods have been used: 1) to detect an association between health variables (disorders, symptoms, complaints) and possible risk factors (heat stress, noise, shift rotation), the goodness of fit of chi- squared test for independence was applied; 2) to compare the strength of association, Cramer's measure of associated V was determined for each contingency table; 3) to present the time-related distribution of accidents, the data concerning the frequency of accidents were collected for each hour around the clock (2344 accidents). For smoothing the empirical 24-h curves, a nonlinear regression was used. The regression model applied was the sum of two exponential density-like functions.

TABLE I
Cardiovascular Related Complaints
(% of Workers)

Complaints	H-Group a	H-Group b	H-Group c	R-Group a	R-Group b	R-Group c
Palpitation	1.7	6.5	21.0	2.1	4.9	12.0
Substernal (chest) pain	5.0	17.4	31.0	5.2	5.9	12.0
Short of breath	3.4	19.4	41.0	4.2	9.8	20.0

RESULTS AND DISCUSSION

1. Cardiovascular diseases

The number of workers who reported the complaints listed in Table I increased with increasing age. In almost all age-related subgroups (a, b and c) there were more complaints in H-Group than in R-Group. The same refers to EBP and CHD (Table II). On the contrary, the percentage of workers with heart murmurs was higher in R-Group. This was probably an effect of medical preselection before admission to hot jobs.

Statistical analysis showed that the hypothesis of independence had to be rejected for both pairs of variables: heat stress and EBP, and heat stress and CHD (Table III). The values of Cramer's V indicate that the association between the elements of both pairs of variables increased progressively with age and was highest for the oldest group of workers (subgroup c). Most of these workers had also the longest period of work experience in heat (up to 32 yrs., 19yrs. on average). The results confirm the observations of other authors[5,15] that hypertension can be found more often among workers exposed to occupational heat than among their colleagues not exposed to heat stress. Also the pathological changes in ECG were recorded more often in people exposed to intense heat.[5,6]

The statistical analysis has shown that the association between the elements of both pairs of variables was still higher if the workers were exposed to both heat stress and noise together (Cramer's V higher for "Ns", Table III). This result confirms the suggestion[16-19] that intense noise can be a risk factor for hypertension. The results strongly suggest that there is an interdependence between the influence of noise and heat stress in promoting EBP. The percentage of workers with EBP, who had been exposed to both hazards together, was much higher than could be expected assuming that the effect of both agents were independent (Table IV).

There was no significnt association between cardiovascular complaints or diseases and work in a 3-shift system

TABLE II
Cardiovascular Diseases
(% of Workers)

Diagnosis (Symptom)		H-Group a	H-Group b	H-Group c	R-Group a	R-Group b	R-Group c
CHD		0 (0) [0]	7.7 (1.9) [0.7]	24.0 (9.0) [10.0]	0 (0) [0]	0 (0) [0]	2.0 (0) [0]
EBP	S_I	10.9	15.5	22.0	6.3	11.8	18.0
	S_{II}	12.6	36.1	55.0	2.1	7.8	24.0
Heart Murmurs		0.8	1.9	3.0	5.2	4.9	6.0

(infarction), [coronary by-pass]
EBP — elevated blood pressure
CHD — coronary heart disease

TABLE III
Analysis of Independence

Pairs of variables	Age-related groups		χ^2	υ	n
Heat stress	a	H	10.277**	0.218	215
and		Ns	11.180***	0.239	195
EBP	b	H	30.687****	0.346	257
		Ns	34.301****	0.382	235
	c	H	19.209****	0.358	150
		Ns	24.865****	0.434	132
Heat stress	b	H	8.284***	0.180	257
and		Ns	12.007****	0.226	235
CHD	c	H	11.616****	0.278	150
		Ns	10.677****	0.284	132

χ^2 — Chi-squared statistic, υ — Cramer's contingency coefficient, Ns — heat and noise together, H — heat only.
*$p < 0.05$, **$p < 0.01$, ***$p < 0.005$, ****$p < 0.001$

although this has been observed by some authors.[20] This lack of association might be because our workers were relatively often transferred from 3-shift rotation to a day-shift system.

2. Gastrointestinal tract related complaints

There was a higher percentage of young workers (subgroup a) who complained of gastric irritation or indigestion in R-Group in comparison to the corresponding subgroup of H-Group ($p < 0.001$). This was presumably an effect of self- or medical selection concerning peptic ulcer during the first years of working in heat. Nevertheless, in H-Group, the percentage of workers with these complaints progressively increased with age (14%, 32%, 64% and 34%, 32%, 54% for H and R, respectively). There were no other significant differences between the groups regarding gastrointestinal tract.

3. Other diseases and complaints

There were no significant differences between the groups regarding kidney stones, chronic bronchitis, sinusitis, allergy and skin disorders (there was medical preselection concerning skin diseases). However, more workers of R-Group complained of headaches (33% and 22% for R and H, respectively, $p < 0.05$), which could be attributed to the fact that more workers of R-Group were exposed to intense noise. There were also more complaints, in R- Group, regarding "joint problems", including arthritis, rheumatism, back pain, shoulder pain, etc. (62% and 46% for R and H, respectively, $p < 0.005$). This was probably connected with the fact that the workers of the R-Group were often exposed to a large variety of changes in surrounding temperatures and draughts while, for instance, performing some works in the yard.

Further analysis involved the workers who were currently working under heat stress as well as the employees who had worked in heat in the past. It has been shown that the percentage of overweight workers was higher among these workers in comparison to the workers of R-Group (38% and 21%, respectively, $p < 0.001$). In addition, almost all workers who suffered from diabetes were working or had worked for several years in the past under heat stress (5.5% and 1.4% for H and R, respectively). Although the hypothesis of independence for the pair of variables heat stress and diabetes has been rejected ($p < 0.05$; $\chi = 3.891$;

TABLE IV
Workers (in %) With EBP Who Were Exposed To:

agent \ subgroup	a	b	c
Heat but no noise	0	27.8	50.0
Noise but no heat	9.0	19.4	39.1
Heat and Noise together	26.4	54.7	81.4
	(9.0)	(41.8)	(69.6)

(in brackets — expected values)

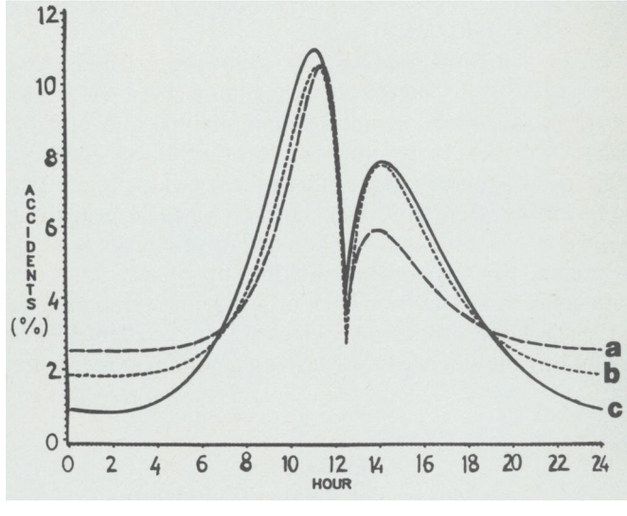

Figure 1. 24-h distribution of occupational accidents that happened:
(a) in hot departments (758 departments)
(b) to all workers together (2,344 accidents)
(c) in the whole of Ontario in 1983 & 1984 (268,21 accidents).

n = 344), any conclusions can only be speculative without further research. Nevertheless, these observations — the prevalence of both overweight and diabetes, among the vorkers who were for several years exposed to extreme heat — may lead to the hypothesis that extreme heat could affect some mechanisms responsible for carbohydrate metabolism.

4. Accidents

24-h distribution of occupational accidents for 3-shift workers employed in hot departments was similar to that for R- Group as well as for the whole plant and for the whole of Ontario in 1983 and 1984 (Fig. 1). The timing of accidents followed the fluctuations of some hygienic and social factors discussed previously[12] which seemed to play an essential role in determining the level of accident risk. Also the effect of workers' own health on their performance and consequent safety at work was taken into account as a risk factor.

CONCLUSIONS

1. The majority of health problems of the workers exposed to occupational chronic heat stress referred to the cardiovascular system. The percentage of workers with EBP and CHD was much higher among these workers than their colleagues not exposed to heat.

2. Alongside of heat stress, extreme noise was the other important harmful agent. There was an interdependence between the influence of noise and heat stress in promoting EBP.

3. There was a prevalence of overweight and diabetes among the workers who were working or had worked for several years in the past under heat stress.

4. The 24-h fluctuations of occupational accidents were recorded with a peak just before noon and a trough occurring at night. A special strategy of prevention is recommended that could help to identify the circumstances in which the probability of being involved in accident is increased.

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