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Psychological and biochemical strain in firemen's work

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KALIMO R, LEHTONEN A, DALEVA M, KUORINKA I. Psychological and biochemical strain in firemen's work. *Scand j work environ health* 6 (1980) 179—187. Mental load and strain in the work of firemen and fire alarm center operators were studied in a group of 260 firemen and 6 female full-time operators from three fire brigades. The firemen proved to be satisfied with their work, and signs of chronic psychological problems were uncommon. Situational work load and related strain may, however, be extreme during active operations. A large proportion (42 %) of the firemen suffered from strain after the 24-h long daily work period. Those who had recently worked as paramedics in the ambulance service or in the alarm center were under more strain than ordinary fire fighters. Biochemical stress indicators revealed a high activation of firemen at the alarm center. The difference found between firemen and full-time female operators may be due to a variation in the adaptive functions of the two sexes.

Key terms: alarm center, ambulance paramedics, job satisfaction, mental strain, psychophysiological stress.

Work-related load and psychological stressors are possible risks to the general well-being of people in various occupations. Congruence between work and man's general needs, expectations, and wishes has proved to be particularly important. A sufficient fit between work demands and man's natural way of functioning is a prerequisite of well-being. It is obvious that work demands may exceed or remain below man's capacity, ie, they may overstimulate or understimulate the working man. On the other hand, suitably challenging and stimulating work offers possi-

bilities for developing one's abilities, skills, and personality in a wider sense (2, 7, 11).

The special tasks of firemen and their work conditions involve certain particular stress factors, the impact of which on mental and general health has only been scarcely studied (5). Supposedly, firemen might be under considerable stress in their work due to the great responsibility for others' lives, the suddenly occurring rush periods with monotonous intermittent periods on watch, and the fact that it is shift work.

In Finland the firemen's labor union took the initiative in studying firemen's work conditions, the mental and physical load of the work, and its effects on the workers' health. Two parts of the project (13) are reported in this communication, namely, the results of a general questionnaire survey covering the total study sample and a more specified study on stress reactions of operators at an alarm center.

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QUESTIONNAIRE STUDY

Materials and methods

The subjects of the questionnaire study were 260 firemen from three fire brigades. One of them was the largest in Finland (Helsinki), the second was middle-sized, and the third small. All of the men on duty at the time of the survey, representing 80 % of the total work force of the three brigades, were included in the sample. The mean age of the subjects was 34 a (range from 20 to 53 a), and their length of work experience as a fireman averaged 11 a.

Firemen's work includes three main types of tasks, which differ considerably from each other, namely, firefighting and rescue work, ambulance service, and service in the alarm center. The men rotate these tasks. The general work schedule is 24 h on duty and 48 h off.

The questionnaire used for gathering the data contained items on stressors in work, job satisfaction, fatigue, and stress symptoms. In more detail the questions covered the following topics:

Mental load and psychological stressors

- work content
- work organization
- participation in the planning and decision making of one's own work
- information efficiency
- responsibility
- social contacts

Job satisfaction

Expectations concerning the work

Subjective symptoms

The questions were partly related to the fireman's work in general and partly to the special subtasks already described. The general questions were to be answered by everyone. Responses to items related more specifically to either firefighting and rescue tasks, ambulance service, or work done in the alarm center were given according to the main work placement during the last six months. Those who had worked mostly in ambulance service answered the specific questions on that subtask and not on firefighting, rescue, or alarm work, and vice versa. Many firemen had however worked in various subtasks and thus could not define any of the tasks as the main one. They then answered questions covering several subtasks. The questionnaires were filled out during a rest period at work under the guidance of someone from the research team.

Results

Strain at work

About half of the firemen considered both the mental and physical load of their work as average. The other half rated the mental load higher than average. At the end of a work shift 42 % of the firemen felt quite tired. Ambulance service and shifts in the alarm center were perceived as particularly fatiguing in comparison to firefighting and rescue tasks.

The determinants of strain in work were studied in two ways. First, from a list of 13 given items, the respondents were asked to choose those four perceived as the most

Table 1. Perceived reasons of strain in fireman's tasks — Percentage of respondents mentioning each factor.

Reason	Firefighting and rescue work (N = 220)	Ambulance service (N = 122)	Alarm center (N = 55)
Busy work pace	67	58	
Physical heaviness of work	52		
Bad work postures	50		
Continuous attentiveness	40		
Duration of work period		64	
Unequal distribution of work load		58	41
Shift work			67
Work conditions (underground)			62
High responsibility			42

important subjective causes of fatigue. Second a correlation analysis was made to determine the relations of a large number of work characteristics to the different levels of perceived strain in work.

The subjective reasons for strain related to active operations in work are given in table 1. While the occupation in general was evaluated, discontinuousness of sleep was rated as the most severe cause of strain. It was also the factor with the highest correlation to fatigue ($r = 0.46$). The other work characteristics correlating the highest with perceived strain were factors indicating mental pressure in work (table 2).

Subjective reasons for strain and fatigue seemed to be related primarily to the quantitative overload in work, ie, to an extreme situational load or the long duration of the load. On the other hand, qualitative mental overload was characteristic of factors correlating the highest with strain.

Job satisfaction

Job satisfaction was measured with six items, of which a sum scale was formed. In spite of some criticism concerning the organization of the work, firemen seemed to be satisfied with their work. The questionnaire data indicate that job satisfaction was higher than average for 89 % of the respondents. A corresponding level of reported satisfaction has been found in many studies of this kind (16). The reasons for job satisfaction were studied with direct questions to respondents, and a correlation analysis was made between the work characteristics and indicators of job satisfaction.

The work characteristics perceived as

the basis of job satisfaction were those related to satisfaction of the "higher human needs" (table 3). The same types of factors also had the highest correlations with satisfaction (table 4).

Subjective symptoms

Answers to the questions on perceived psychological symptoms were factor analyzed to determine the basic dimensions of the stress symptoms. The symptoms were clustered around the following three factors: anxiety, depression and avoidance behavior.

Psychological symptoms were rare among the firemen. Very few respondents often or sometimes perceived any of the depressive symptoms and avoidance reactions inquired about. Anxiety symptoms were also perceived often only by a small percentage of the respondents. The prevalence of symptoms was lower than that of the Finnish population (19). However, a fairly large proportion of the firemen reported having these symptoms every

Table 2. Significant correlations ($p < 0.001$) between work conditions and perceived strain.

Variable	r
Discontinuousness of sleep	0.46
Mental load in work	0.45
Continuous excitement	0.39
Continuous being on guard	0.35
Behavior of the public	0.30
Insufficiency of information	0.28
Possibility to influence work organization	0.26
Risk of accident	0.26
Inconsistent instructions	0.25
Unforeseen situations	0.24
Physical work load	0.22
Momentary exertions	0.22

Table 3. Perceived reasons for job satisfaction — Percentage of respondents mentioning each category.

Reason	Firefighting and rescue work (N = 220)	Ambulance service (N = 112)	Alarm center (N = 55)
Social significance of work	56	75	75
Variation of work	55	69	
Interesting nature of work	53	81	60
Autonomy at work		58	
Responsibility at work			75
Secure work contract			50

Table 4. Significant correlations ($p < 0.001$) between job satisfaction and work conditions.

Variable	r
Variation of work	0.43
Possibility to use one's knowledge and skills	0.36
Correspondence between work demands and education	0.33
Social significance of work	0.31
Possibility to participate in decision making	0.28
Mental activity in work	0.25
Possibility to influence work organization	0.24
Possibility to advance	0.22

Fig 1. Symptoms of anxiety — Percentages of responses other than "every now and then."

now and then (fig 1). The latter result is probably related to the fireman's type of work with its uneven load and its sometimes high situational mental pressure. The work is thus apt to evoke state anxiety which has not developed into a chronic symptomatology.

Discussion

Mental load in the work of firemen could be regarded generally as favorable for the well-being of the workers. The work contains variation and demands quite a lot of the mental functions and abilities of the men.

The problems found are connected mainly with the organization of the work. In the ambulance service the demand for continuous attention and the high mental load in general indicates a need for reconsidering the duration of the work period (currently 12 h) and the tasks to which the men are put after ambulance service.

The situational periods of extreme work load in firefighting and rescue operations are so keenly connected with the work itself that it could be diminished only with an increase in the number of firemen.

The weaknesses of the shift work arrangement is particularly obvious at alarm centers. Men working as alarm center operators have to stay awake the whole night through, which is not usually the case in the other tasks of firemen. The shift work problems are related with the uneven distribution of work load as the number of operators varies during different hours of the day. Naturally also the work itself has situational peaks, eg, during the daily rush hours.

To the surprise of many administrators, the work at the alarm center and that of the ambulance service were found to be more burdening than the most traditional tasks of firemen. This finding motivated a more thorough investigation of the work of firemen as operators at the alarm center. A report of this investigation follows.

BIOCHEMICAL ASPECTS OF STRAIN IN OPERATORS AT A FIRE ALARM CENTER

Introduction

Many sources indicate that the degree of adrenal activity parallels the response to both physical and psychological stressors (10, 14). The adrenal reaction, including elevated catecholamine and corticosteroid excretion, can thus be an important indicator of strain due to work. This type of

strain is probably general or nonspecific, ie, common to all types of stressors.

In field studies of psychophysiological strain related to work there are many additional factors which may modify the adrenal functions in the same way as response to stressors and which should therefore be taken into account, eg, diet, alcohol, coffee, etc (14). Also the possible combined effect of two or more factors and the normal diurnal rhythm of adrenal activity should be recognized (4, 18). Interindividual differences in response can also be considerable (8).

The aim of the present study was to investigate biochemical indicators of strain in relation to work at the fire alarm center, which was perceived as highly loading by the firemen. The work at the alarm center includes receiving and processing information concerning fires and other emergencies, sending out rescue teams and detailed record keeping. The work is divided into the following three subtasks in which the operators rotate: firefighting, ambulance, and other emergency service.

The work is characterized by highly responsible decision making. The operators have to decide whether each message from outside involves a real need for rescue and what kind of help is needed. The decision must also be quick. For example in the case of a fire alarm, the rescue engines with teams of firemen leave the fire department on the average of 1 min after the message is received at the alarm center. The orders to the firemen are thus mediated by the operators at the alarm center in a fraction of a minute. Depending on the severity of the emergency, one or several operators are involved in continuous contact and information processing with the men in the field for several hours. With this work and the detailed record keeping the mental load on the operators is obviously high during these periods. There are, however, periods with no fires, the occurrence of which varies seasonally and diurnally. For this reason there are sometimes quiet hours with feelings of monotony and boredom. The work related to ambulance service is, instead, usually regular throughout the day and seasons.

The operators have no systematic

schedule of breaks during their workshifts. They are not allowed to go out of the center, which is located 16 m under ground and has no windows or daylight.

Materials and methods

Subjects

Group I (men). Group I comprised firemen working as operators at the alarm center on either the 0900—1700 or 1700—2300 shift on rotation during their normal 24-h shifts. The mean age of this group was 28 a (range 21—40 a).

Group II (women). Women operators working at the alarm center of the fire department on either the 0700—1500 or the 1500—2300 shift formed group II. The mean age of these women was 30 a (range 26—33 a).

Methods

Urine samples were collected during a two-week period. The work load, estimated on the basis of the annual statistics of the alarms, was slightly lower than the average for the same time of year. All the women and firemen on the morning and evening shifts were studied except those who were on medication or who had not followed the instructions concerning the intake of coffee and alcohol preceding the workshifts. Morning and evening shift samples were obtained from all the women except one, who participated in the study only during the afternoon shift. Two women participated twice on both shifts. Four men participated on both shifts. Only morning shift samples could be obtained from two men, and only evening shift samples from one man.

The periods represented by the samples are indicated in tables 5 and 6. The urine samples were taken at approximately the beginning, the middle, and the end of the workshifts.

Because of the early hour, the first period of the morning shifts began as the subjects arrived for work. The first period of the afternoon shift began, instead, 2 h before the subjects came to work. So that the conditions could be standardized,

those firemen were excluded who had had any field activity during the 2 h preceding their shift at the alarm center.

The following hormones were analyzed: urine 17-ketogenic steroids (17-KGS), adrenaline, and noradrenaline. The content of the 17-KGS in urine was determined with the method of Norymberski & Stubbs (15), as modified by Appleby et al (1) and Jørgensen (12).

The urine samples used for the determination of adrenaline and noradrenaline were acidified to below pH 3 and were kept frozen (-20°C) until the analyses. The urinary adrenaline and noradrenaline concentrations were measured with the fluorometric method of Crout (3) and von Euler & Lishajko (6).

Results

The results of the 17-KGS, adrenaline, and noradrenaline analyses of groups I and II

are presented in tables 5 and 6, respectively.

17-Ketogenic steroids

Group I. The excretion of 17-KGS followed the normal diurnal pattern in group I during the first hours of the morning shift (fig 2). In the middle of the shift, around noon, the 17-KGS excretion slowed down, perhaps because of the relative quietness of these hours. During the last period of the shift there was a considerable rise in the excretion of 17-KGS. This phenomenon was a deviation from the normal diurnal pattern, and it may have been due to the increase in the activity of the alarm center during the afternoon rush hours, with their higher risk of, eg, road accidents.

At the beginning of the evening shift of group I, the excretion of 17-KGS was on a relatively high level in comparison with the mid-shift value. The level of excretion

Table 5. Mean ($\pm$ the standard error of the mean) urinary concentration of 17-ketogenic steroids (17-KGS), adrenaline (A), and noradrenaline (Na) in group I.^a

		Morning shift				Evening shift		
		N	0900—1059	1100—1359		1400—1700	N	1500—1659
17-KGS (mg/h)	7	0.41 ± 0.04	0.34 ± 0.07	0.43 ± 0.12	4	0.42 ± 0.07	0.38 ± 0.03	0.37 ± 0.08
A (μg/h)	7	0.68 ± 0.13	0.50 ± 0.10	0.68 ± 0.18	4	0.49 ± 0.17	0.41 ± 0.14	0.28 ± 0.10
Na (μg/h)	7	1.99 ± 0.34	1.47 ± 0.22	1.88 ± 0.23	4	1.50 ± 0.23	1.36 ± 0.08	1.29 ± 0.34

^a To determine the micromole equivalents of the A and Na results, divide the given values (expressed in micrograms) by the pertinent molecular weight (A: 183.20, Na: 169.18). For the micromole equivalents of 17-KGS (expressed in milligrams), divide the given value by the molecular weight of 17-KGS (288.41) and multiply the total by 1,000.

Table 6. Mean ($\pm$ the standard error of the mean) urinary concentration of 17-ketogenic steroids (17-KGS), adrenaline (A), and noradrenaline (Na) in group II.^a

		Morning shift				Evening shift		
		N	0700—0859	0900—1159		1200—1500	N	1300—1459
17-KGS (mg/h)	7	0.47 ± 0.10	0.36 ± 0.07	0.31 ± 0.05	8	0.35 ± 0.06	0.27 ± 0.04	0.22 ± 0.03
A (μg/h)	7	0.30 ± 0.08	0.26 ± 0.05	0.29 ± 0.07	8	0.41 ± 0.08	0.33 ± 0.07	0.29 ± 0.04
Na (μg/h)	7	1.38 ± 0.27	1.13 ± 0.11	1.30 ± 0.24	8	1.43 ± 0.22	1.14 ± 0.26	1.21 ± 0.16

^a To determine the micromole equivalents of the A and Na results, divide the given values (expressed in micrograms) by the pertinent molecular weight (A: 183.20, Na: 169.18). For the micromole equivalents of 17-KGS (expressed in milligrams), divide the given value by the molecular weight of 17-KGS (288.41) and multiply the total by 1,000.

corresponded to that of the morning. This finding deviated from the circadian pattern of 17-KGS, which tends to be lower at this time of the afternoon. The hypothesis constructed on the basis of these results is that, while coming to the alarm center, the firemen are already under considerable strain. As 17-KGS are especially sensitive to physical load, the high excretion was perhaps related to it in spite of the preceding 2-h period of only being on standby duty. The relatively high level was maintained during the whole shift without any expected lowering towards the end of the shift at 2300.

Group II. The women's excretion of 17-KGS (group II) did not show any special deviation from the normally expected circadian pattern (fig 2). The excretion was lower at the beginning of the afternoon shift than at the beginning of the morning shift. This result was different from that of the men, whose excretion in the afternoon corresponded to that in the morning, possibly due to the preceding work as firemen before the evening shift at the alarm center.

Adrenaline and noradrenaline

Group I. During the first 2 h of the morning shift the excretion of adrenaline and noradrenaline was considerably higher than expected in group I (17, 18) (fig 3 & 4). The highly negative attitude of the

firemen towards their work at the alarm center, as was indicated by the questionnaire data, may be related to this reaction.

After the first hours there was a decline in the excretion of both adrenaline and noradrenaline. This result coincides with the less busy period at the center around noon. The absolute levels of the catecholamine excretion were, however, high when compared to those of some other groups (17, 18), especially for adrenaline. The later increase in excretion was possibly related to the rush hours of the late afternoon.

In the beginning of the evening shift the excretion of adrenaline and nor-

Fig 2. Urinary 17-ketogenic steroids (17-KGS) concentration of the women (group II) and men (group I) during the morning (—) and evening (-----) shifts.

Fig 3. Urinary adrenaline concentration of the women (group II) and men (group I) during the morning (—) and evening (-----) shifts.

Fig 4. Urinary noradrenaline concentration of the women (group II) and men (group I) during the morning (—) and evening (-----) shifts.

adrenaline was on a fairly high level. It is however important to note that the excretion of adrenaline in particular was higher at the end of the morning shift at the alarm center than during the corresponding period at the beginning of the evening shift, which was preceded by a period of standby at the station. This finding indicates that the firemen had problems in adapting to work as alarm operators. Because of the small number of subjects and the interindividual differences this result did not however show statistical significance. Dutton et al (5) found a difference of about 30 % in the adrenaline excretion of days off and on duty.

The levels of adrenaline and noradrenaline followed the normal diurnal pattern, but the absolute values were still relatively high at the end of the evening shift at 2300. The strong decline in the excretion of adrenaline especially at the end of the shift may have been due to the fatigue of the firemen, who had already served in field work before their shift as alarm operators.

Group II. The level of adrenaline and noradrenaline excretion did not show any strong variation during the workshifts of group II (fig 3 & 4). At the very beginning of the afternoon shift especially the level of adrenaline was, however, relatively high. This result includes the excretion during the 2 h preceding the afternoon shift. Thus, the period under consideration includes, eg, traveling to the place of work and some housework. It was probable that traveling to work had some effect on the excretion of adrenaline in particular, as all of the women lived fairly far from the fire department. In the interview they also indicated that they worry quite a lot about being late.

Compared to those of the men, the absolute levels of the excretion of both adrenaline and noradrenaline of the women was considerably lower. The comparison was made only for the morning shift, which was preceded by a period of rest in both groups without any other differing influences. On the other hand the firemen in this study strongly disliked their work at the alarm center. In addition they were not so familiar with this work

because they work only occasionally at the alarm center. The women, instead, work continuously as alarm operators and enjoy their work as such. They only complained about the lack of scheduled breaks, the length of the shifts, and the underground work conditions.

Discussion

This report is based on a preliminary study of the work of alarm operators. The groups of subjects were small, and there were considerable interindividual differences (8).

It would be important to continue with research concerning the work of firemen at the alarm center, since the present data indicate a high activation of the adaptive functions of these persons. The great variation found may be due to the difference in the adaptive resources of men and women, as shown in other studies (9).

On the basis of these data and the perceived work load measured with the questionnaire, a need for a reorganization of the workhours and the tasks done within the daily work periods is indicated. With respect to the work in the alarm centers, training is another means with which to increase the operators' ability to cope with the stressful situations. The same could be said regarding duty in the ambulance service.

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