

# THE EXCRETION RATES OF STRESS HORMONES UNDER MENTAL WORK

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## SUMMARY

The aim of the study was to assess stress on the basis of the excretion rates of stress hormones in occupational groups under mental stress. The investigation includes 293 persons, working in power engineering, education, public health and information sector. The stress hormones adrenaline, noradrenaline and 11-oxy corticosteroids (11-OCS) were followed during the working day using spectrofluorimetric methods. Very high excretion rates of adrenaline, noradrenaline and/or 11-OCS were found with leading radio editors, responsible engineers and operators in nuclear power station (NPS), teachers in secondary schools, designing engineers. In conclusion our data indicate high stress in occupational groups working under high psychological demands, high responsibility, making important managing decisions, low job control and are discussed with regard to the health risk.

**Key words:** occupational stress, adrenaline, noradrenaline, 11-oxy corticosteroids, health risk

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## INTRODUCTION

Stress at work is an increasing problem in our society. Nowadays it spreads all over 28% of the working population, and the data show that about 8–10% of the people work under high occupational stress. The systems responsible for the stress reaction are the hypothalamic-pituitary-adrenal axis and sympathetic system. The activation of the stress system helps the adaptation to the environmental demands. However, the long term effect of the increased activity of the stress system, or changes in the circadian rhythm of stress hormones are associated with increased risk of depression and cardiovascular diseases (1, 2). Stress may influence also the onset and/or course of infectious, autoimmune/inflammatory, allergenic and neoplastic diseases (3, 4).

The activity of the stress system is affected by a number of psychosocial factors such as working conditions, job content and control, social support, etc (5–8). It is well known that concentration of adrenaline is increased in situations involving mental load (6, 7), while the major determinant of high noradrenaline concentrations is the physical activity. The 11-oxy corticosteroids (11-OCS) or their main component cortisol are increased in stressful situations, involving elements of cognitive and behavioral insecurity, heightened attention load and loss of or threat to control (5, 9).

The levels of stress hormones during work present objective and highly informative data and can be used in risk assessment. This approach is especially appropriate for occupational groups with mainly mental load and high demands, where high occupational stress could be expected. Moreover the high sensitivity of the stress system gives ability for early risk identification.

The aim of the study was to assess stress on the basis of the excretion rates of stress hormones in occupational groups under mental work.

## MATERIAL AND METHODS

The study covers 293 persons of age between 20 and 50 years, working in the power engineering, education, health care and information sector. Age means ( $\pm$  SD) of male and female subjects were  $36.2 \pm 6.3$  years and  $38.7 \pm 6.2$  years respectively.

The excretion rates of catecholamines adrenaline and noradrenaline and 11-OCS were followed during two periods: morning (period 1) and afternoon (period 2). The samples were divided into subsamples for analysis of 11-OCS and catecholamines and stored at  $-20^{\circ}\text{C}$  until the analysis. The subsamples for catecholamine assay were acidified to pH 3 with 3N HCl prior the refrigeration. The free adrenaline, noradrenaline and 11-OCS were measured by fluorimetric methods (10, 11).

The data were analyzed with analysis of variance and stress was assessed using the developed criteria for risk assessment using the activation of the stress system during work, based on the data from 1200 subjects, stratified by sex, age and type of work (12). The mean shift value of adrenaline and noradrenaline is used. Adrenaline values above 2.31 nmol/h for male subjects and 2.09 nmol/h for female subjects are considered as high, and adrenaline values above 2.73 nmol/h for male subjects and 2.47 nmol/h for female subjects as very high. Noradrenaline values above 8.25 nmol/h and 7.55 nmol/h for male and female subjects respectively are considered as high and noradrenaline value above 9.58 nmol/h and 8.68 nmol/h for male and female subjects as very high. The excretion rates of 11-OCS during both periods of time (morning and afternoon) were used because of the distinct circadian changes of the hormone. Morning 11-OCS values above 5.81 nmol/h for male subjects and 5.26 nmol/h for female subjects were considered as high and morning values above 6.86 nmol/h for male subjects and 6.19 nmol/h for female subjects as very high. For the afternoon period 11-OCS values above 4.74 nmol/h for male subjects and 4.45 nmol/h for female subjects were considered as

high, and afternoon values above 5.61 nmol/h for male subjects and 5.30 nmol/h for female subjects as very high.

## RESULTS

The excretion rates of adrenaline and noradrenaline in the studied male occupational groups are presented on Fig. 1. According to our criteria the data show very high adrenaline excretion rates with the nuclear power station (NPS) engineers and operators, teachers and leading radio editors, high with sound engineers and moderate in TV-montage engineers, surgeons and designing engineers. The excretion rates of adrenaline in NPS engineers, leading radio editors and teachers were significantly higher ( $p < 0.01$ ) than that in TV-montage engineers, surgeons and designing engineers, and with significance of  $p < 0.05$  in comparison with adrenaline excretion rates in NPS operators and sound engineers. The noradrenaline concentrations were very high with the NPS engineers and operators and teachers, high with the leading radio editors and sound engineers and moderate in the rest of the investigated groups. The NPS engineers' noradrenaline excretion rate was significantly higher in comparison with all other studied groups ( $p < 0.01$  for TV-montage engineers and designing engineers and  $p < 0.05$  for leading radio editors, NPS operators, sound engineers and surgeons).

The highest 11-OCS excretion rates (Fig. 2) were found with NPS engineers and operators and leading radio editors, high with the teachers, TV-montage engineers and designing engineers. The 11-OCS excretion rates in NPS engineers and leading radio editors were significantly higher during both studied periods (morning and afternoon) in comparison to the other studied groups, while in the NPS operators were higher only during the morning period ( $p < 0.05$ ). We would like to point out the high 11-OCS excretion rates among the TV-montage engineers and designing engineers during the afternoon period, even exceeding the morning excretion rates with the designing engineers.

With the investigated female groups (Fig. 3) high adrenaline values according to our criteria are found with teachers in secondary school, leading radio editors and designing engineers. In these three groups the adrenaline excretion rates were significantly higher than that in pharmacists ( $p < 0.05$ ), while the differences with the other studied groups did not reach significance. High noradrenaline values with the investigated female groups were found only with the secondary school teachers, significantly higher in comparison to all other groups ( $p < 0.05$  for leading radio editors, designing engineers, sound engineers and TV-montage engineers and  $p < 0.01$  for pharmacists).

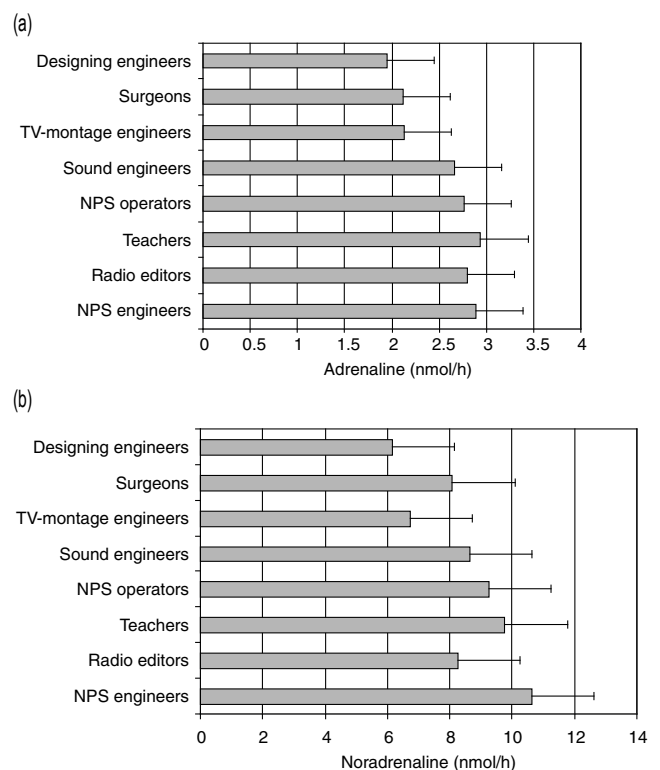
Our data show high 11-OCS excretion rates (Fig. 4) during both studied periods with teachers, leading radio editors, designing engineers and TV-montage engineers, significantly higher ( $p < 0.05$ ) during both studied periods in comparison to sound engineers and pharmacists.

## DISCUSSION

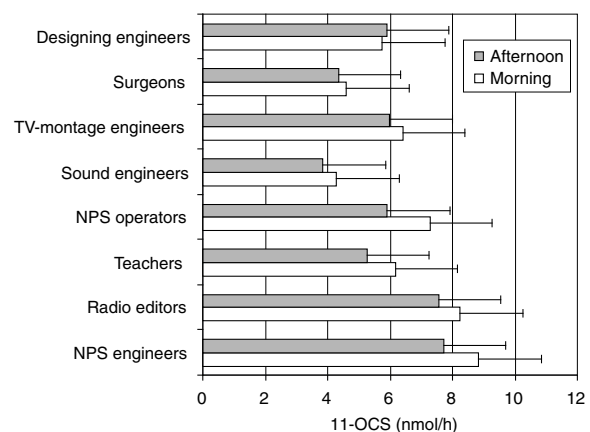
Our data show very high excretion rates of adrenaline and 11-OCS and consequently high occupational stress with the NPS engineers and operators, leading radio editors and teachers. The job of the

**Table 1.** The investigated occupational groups under mental work

Sector/indices	Occupational group	n	n men	n women
Power engineering (n = 107)	nuclear power station (NPS) responsible engineers	8	8	–
	NPS operators	30	30	–
	designing engineers	39	23	16
Education (n = 65)	secondary school teachers	65	16	49
Health care (n = 49)	surgeons	32	32	–
	pharmaceutists	17	–	17
Information sector (n = 72)	leading radio editors	17	8	9
	sound engineers	30	18	12
	TV-montage engineers	25	11	14



**Fig. 1.** The excretion rates of adrenaline (a) and noradrenaline (b) in male occupational groups under mental work.



**Fig. 2.** The excretion rates of 11-OCS in male occupational groups under mental work.

first two groups can be characterized with high responsibility and important managing decision making under pressure of time. The NPS engineers are responsible for the work and safety of the NPS. The NPS operators, the other studied group in the NPS, are responsible for monitoring and controlling the nuclear power process. The job of leading radio editors is associated with high psychoemotional stress, while that of teachers with high responsibility and involvement. With the NPS engineers and operators together with the very high adrenaline and 11-OCS excretion rates very high noradrenaline concentrations were found, too. These high noradrenaline values most probably are due to sustained high psychological arousal. Miki and Sudo (13) reported that prolonged exposure to mental work produces a marked increase in noradrenaline excretion and it can be regarded as an indicator of considerable overload of the adaptation systems.

With the TV-montage engineers and designing engineers, whose task required intense concentration, moderate activation of the sympathetic system and high excretion rates of 11-OCS

were found. In the latter group the 11-OCS concentrations were high during the period 1 and very high during the second half of the working day, opposite to the circadian rhythm of the hormone. This stress model can be defined as negative coping and indicates health risk (5). The high sympathetic activity and moderate secretion rates of corticosteroids with the sound engineers can be considered as a positive coping and corresponds to emotional stability, good performance, activation of the immune system and health.

As a whole the activation of the stress system of the investigated female occupational groups is less expressed in comparison with the male groups. However, high stress was found with leading radio editors, secondary school teachers, designing engineers and TV-montage engineers.

The excessive and sustained levels of stress hormones rise health concerns (14, 15), and it is especially so in occupational groups working under high stress and lack of physical exercise (16). In this case the high cortisol concentrations limit the entrance of the free fatty acids in the  $\beta$ -oxidation, and result in higher production of triacylglycerols and very low density lipoproteins (VLDL). The high cortisol levels decrease the catabolism of low density lipoproteins. And these two processes lead to increase in LDL-cholesterol and consequently higher cardiovascular risk.

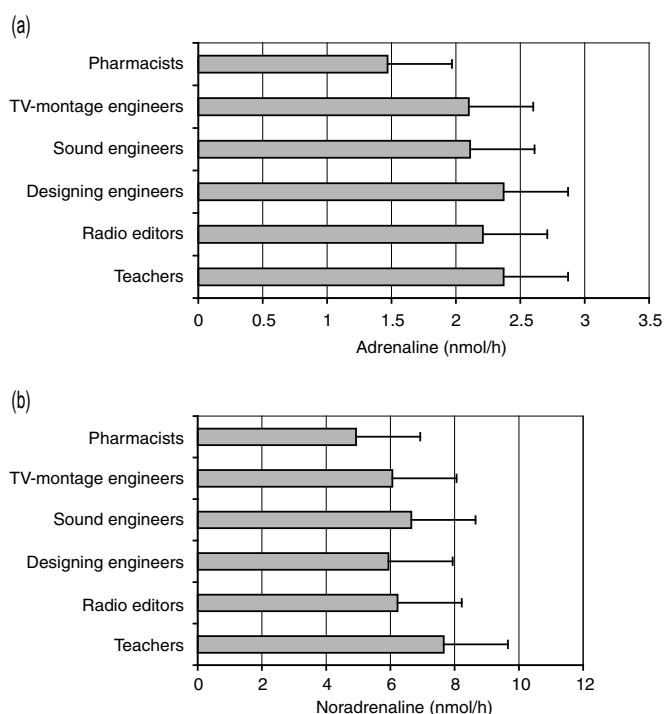
In conclusion our data show high stress in occupational groups with high responsibility, high demands, low control, decision making, time pressure. The activity of the stress system gives early and objective indications for increased health risk and it can help in risk assessment. It is especially appropriate for occupational groups with mainly mental load, high demands and presence of subjective data for high occupational stress.

# Acknowledgment

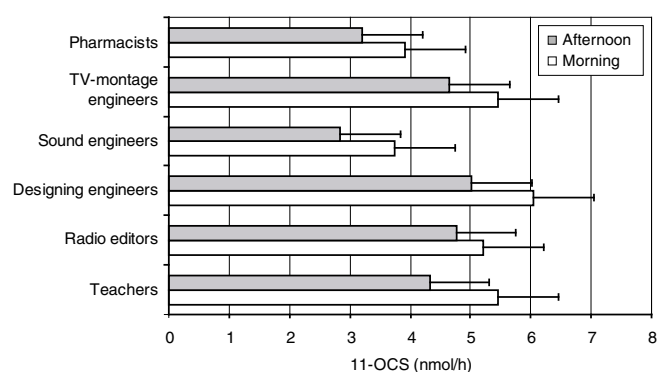
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**Fig. 3.** The excretion rates of adrenaline (a) and noradrenaline (b) in female occupational groups under mental work.



**Fig. 4.** The excretion rates of 11-OCS in female occupational groups under mental work.

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