

Work load, psychophysiological strain and coping of innovation project management in industry

by Raija Kalimo, PhD,¹ Arto Harju, MA,¹ Jukka Leskinen, MA,² Erkki Nykyri, ScL¹

Planning and implementing innovations are distinct processes which differ greatly from a regular industrial work regime. A project model is becoming more and more common for work in the industrial planning and implementation of innovations. This type of work abounds with competition and high economic interests. Novelty and lack of previous experience cause great demands on time management and competence. Project groups are usually formed of people who do not work together in their ordinary duties, and this lack of familiarity may create unexpected problems.

Quantitative work demands are typically very high, and the responsibility and know-how are centralized. There is a risk that incentives and productivity pressures will lead to ignorance of the limitations of the resources of the employees. Occupational health problems related to this trend and means for intervention are poorly known.

Threats on the well-being of persons involved in innovation projects can be conceptually analyzed on the basis of the framework of the general stress theory. Accordingly, lack of balance between work demands and human resources on one hand and between human aspirations and job opportunities on the other cause stress, which in turn has negative consequences with respect to psychological, physiological, and behavioral functions. An individual's internal and external resources and coping strategies modify the intensity of stress and its consequences.

Stress has been shown to increase activation of the sympathoadrenomedullary and adrenocortical systems (1-4). Repeated exposure to mild stressors, common in daily work, without periods of recovery is thought to cause a destabilization of the system. As a result, the organism reacts increasingly strongly to the same stressors, and the heightened response pattern may gradually become chronic. Overtime at work aggravates the pattern (1). Differences in the excretion rates of the catecholamines have been reported between occupations (5). Views and findings on the differential sensitivity of catecholamines and cortisol to different types of stressors vary (2, 6, 7). There is an indication that cortisol excretion increases in stressful situations

that cause helplessness (8) or problems in coping in general (9).

In a previous prospective study (Kalimo & Olkkonen, unpublished) work demands, resources, and strain were monitored with psychological and physiological methods during one year in a project management group (N=27) of a technological development program and a reference group (N=9) in industry. The excretion of adrenaline, noradrenaline, and cortisol did not differ significantly between the groups. The differences between the individuals were great. The highest individual levels of cortisol were measured in the project group. Time pressure, work-related worries, and frequent symptoms of exhaustion characterized the project group more than the referents. During the peak periods of project work, normal work-hours were greatly exceeded. This excess had a major impact on leisure activities and private life as a whole. Case analysis of those with the highest catecholamine excretion indicated a connection between high excretion, high work load, and strain.

The objectives of the present study, based on the previous one, were to investigate the accumulation of work load and strain in the managers of an innovation project group and to analyze the role of coping and the integration of the group in this process. A further goal was to develop support strategies for the control of the periods of high work load and strain.

Subjects

The subjects were two groups of project managers (N=16), each responsible for a major industrial construction project. Each subject was in charge of a broad sector of the total undertaking, some with several hundreds of employees. Their organizational and work roles corresponded to each other, but the groups, called the cohesive group (N=8) and the disjointed group (N=8), had differences in their structure and function. The cohesive group was formed by its leader, while the management of the company nominated the members of the disjointed group. Two of them were nominated several months after the others. The cohesive group worked more as a group, while the disjointed group was characterized by a division into sub-projects, and the group served them primarily as a basis for the distribution of information. The mean age was

¹ Institute of Occupational Health, Helsinki, Finland.

² Suomalainen Työterveystaito Oy, Helsinki, Finland.

48.6 years in the cohesive group and 41.2 years in the disjointed group. All of the group members were men.

Methods

Collection of data. The subjects and the work situation have been monitored during the first 17 months of the total follow-up period of about three years, which lasts from the early planning phase to the beginning of production.

For the determination of noradrenaline and cortisol all urine was collected on two successive workdays each month. The catecholamines were assessed with a radioenzymatic assay and the cortisol with a radioimmunochemical technique.

Personal interviews for gathering information about work, stress, and coping were carried out three times by two interviewers who made separate assessments on that basis. A questionnaire was also used.

Analysis of data. Sum scales were made of the questionnaire items and some of the interview items, for which a mean value of the two interviewers was first calculated. The differences between the group means were divided into two categories in regard to whether or not the direction of the difference was in accordance with the hypothesis or in the opposite direction. The binomial one-tailed test (10) was used to determine whether the number of the differences in the hypothesized direction differed statistically significantly from

the value expected at random. The latter was calculated on the assumption that the probability of the difference between the two groups being in the hypothesized situation at random was 0.5.

A monthly indicator of noradrenaline and cortisol was determined for each individual from calculations of the means of the two successive samples. The differences between the group means were tested with the t-test.

The determinants of the trends of the excretion of the hormones during the 17-month follow-up period were analyzed with linear regression models for repeated measurements.

Results

The work situation was, as expected, more positive, and there were fewer signs of strain, in the cohesive group than in the disjointed group according to the self-reports and the interviewer assessments ($P < 0.01$) (table 1). Personal resources did not differ significantly in the two groups.

The mean levels of cortisol during the entire follow-up period did not differ between the groups, while the excretion of noradrenaline was higher in the disjointed group ($P = 0.05$).

The general pattern of the excretion of both hormones differed significantly between the individuals (general linear model, $P < 0.001$). Interindividual variance explained 55% of the variance for cortisol and 47% of the variance for noradrenaline. When the time

Table 1. Means of self-reported and interviewer assessed work-related factors, indicators of job satisfaction and strain, and resources for coping by group. (+ = in direction of hypothesis, - = not in direction of hypothesis, NS = not significant)

	Source of information	Mean		Group expected to have higher score	Observed direction of difference
		Cohesive group (N = 8)	Disjointed group (N = 8)		
Work-related factors ^a					
Commitment to work (5)	Self-reported	4.1	3.9	Cohesive group	+
Commitment to project (4)	Self-reported	4.4	3.9	Cohesive group	+
Commitment to project (1)	Interviewer assessed	4.7	3.9	Cohesive group	+
Quality of project group (8)	Self-reported	4.3	3.3	Cohesive group	+
Integration into group (1)	Interviewer assessed	4.2	2.5	Cohesive group	+
Ability to cooperate (1)	Interviewer assessed	4.2	3.6	Cohesive group	+
Awareness of total (1)	Interviewer assessed	4.7	3.6	Cohesive group	
Job stressors (31)	Self-reported	2.3	2.5	Disjointed group	+
Job satisfaction and strain ^a					
Job satisfaction (5)	Self-reported	3.7	3.6	Cohesive group	+
Psychological symptoms (9)	Self-reported	2.0	2.2	Disjointed group	+
Symptoms of burnout (7)	Self-reported	2.3	2.4	Disjointed group	+
					p < 0.01 ^b
Resources for coping ^a					
Self-satisfaction (5)	Self-reported	3.0	3.0	Disjointed group	—
Sense of coherence (13)	Self-reported	5.6	5.1	Disjointed group	+
Social support (6)	Self-reported	4.0	3.6	Disjointed group	+
Personal resources (1)	Interviewer assessed	3.8	3.6	Disjointed group	+
Effectiveness of coping 1990 (3)	Interviewer assessed	3.2	3.2	Disjointed group	—
Effectiveness of coping 1991 (3)	Interviewer assessed	3.0	3.4	Disjointed group	—
Overall control of stress (1)	Interviewer assessed	3.4	3.1	Disjointed group	+
					NS ^c

^a Number of items in each scale (classes from 1 to 5) are given in parentheses.

^b Probability of observing 11 expected differences at random.

^c Probability of observing four expected differences at random is greater than 0.05.

variable (month of assessment) was added to the model with the person variable, the explanatory power of the model did not increase. This result indicates that the excretion of the hormones did not vary systematically with time. The interaction parameter of time and membership in the groups increased the explanatory power of the model for noradrenaline ($P = 0.045$) but not for cortisol. This finding indicates that the excretion of noradrenaline in the disjointed group increased with time.

Discussion

The small number of subjects available in innovation project management sets limits on a study of their work conditions and stress. Although the project model is relatively common in industry, the projects are usually unique and cannot be compared. External controls are therefore not available. The analysis of the variation of strain in time and its relation to job stressors usually remains as the main possibility for study. The temporal pattern of job stress among project managers may greatly vary between individuals, and consequently strain levels may vary. This possibility limits the usefulness of the data on the group level. The situation is further complicated by the fact that the general levels of individuals vary.

In this study noradrenaline excretion was higher in the disjointed group with more negative features in the work situation, weaker group integration, and higher psychological strain. The mean age of the disjointed group was lower, and on this basis their catecholamine excretion would be expected to be lower because catecholamine excretion has been shown to increase with age (11). The excretion level of cortisol rose with time in the disjointed group, a finding which also indicates a higher accumulation of stressors and strain in this group. The study of physiological strain among the project managers with time was limited by the difficulty of obtaining reliable base-line data. The project managers became involved in the project gradually, and some of them had a demanding work situation in the same type of tasks before the beginning of the project. First measurements that were supposed to reflect a "before" situation thus did not fully fill the requirements of a base line.

Coping resources and the effectiveness of coping did not vary systematically between the groups. Therefore

the managers were not selected into the two projects according to these factors. Coping resources and strategies are expected to be high in persons selected into project management roles. There were, however, clear differences between the individuals.

The accumulation of stressors and strain in the disjointed group may be based on a weaker coordination and integration of their work with less cooperation, and on resulting lower group support. The analysis of data on the group level was, however, not sufficient to reveal connections between job stress, physiological indicators of strain, and coping in project management. Further analyses will be made to study the connections between the individual patterns of these factors. Such a preliminary analysis has already been used as the basis for supportive interventions by the consulting psychologist involved in the research team.

References

1. Frankenhaeuser M. Psychoneuroendocrine approaches to the study of emotion as related to stress and coping. In: Howe HE, Dienstbier RA, ed. Nebraska symposium on motivation. Lincoln, NB: University of Nebraska Press, 1978:123-61.
2. Panksepp J. The neurochemistry of behavior. *Annu Rev Psychol* 1986;37:77-107.
3. Brantley PJ, Dietz LS, McKnight GT, Jones GN, Tulley R. Convergence between the Daily Stress Inventory and endocrine measures of stress. *J Consult Clin Psychol* 1988;56:549-51.
4. Dimsdale JE, Ziegler MG. What do plasma and urinary catecholamines tell us about human response to stressors? *Circulation* 1991;83 Suppl 4:1136-42.
5. Jenner DA, Reynolds V, Harrison GA. Catecholamine excretion rates and occupation. *Ergonomics* 1980;23:237-46.
6. Jorgensen LS, Bonblokke L, Christensen NJ. Plasma adrenaline and noradrenaline during mental stress and isometric exercise in man: the role of arterial sampling. *Scand J Clin Lab Invest* 1985;45:447-52.
7. Delahunt JW, Mellors G. Hormone changes in stress. *Stress Med* 1987;3:123-34.
8. Dembroski TM, Schmidt TH, Blümchen G, ed. Behavioral bases of coronary heart disease. New York, NY: Krager, 1983.
9. Bohnen N, Nicolson N, Sulon J, Jolles J. Coping style, trait anxiety and cortisol reactivity during mental stress. *J Psychosom Res* 1991;35:141-7.
10. Siegel S. Nonparametric statistics for the behavioral scientists. New York, NY: McGraw Hill, 1956.
11. Meijman TF, Mulders HPG, Kompier MAJ, van Dormolen M. Individual differences in adrenaline/noradrenaline reactivity and self-perceived health status. *Z Gesamte Hyg Ihre Grenzgeb* 1990;36:413-17.