RELATIONSHIP BETWEEN PERCEIVED PSYCHIC WORKLOAD AND HEART RATE REACTIVITY IN INDUSTRIAL WOMEN MANAGERS

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Abstract. The paper presents the results of an investigation into the physiological cost of psychic load in the profession of industrial managers. The psychic workload was estimated on the basis of an evaluation of work requirements and the ability to meet them in terms of mental difficulty, monotony, risk, responsibility, interpersonal conflicts and time pressure. The physiological cost was estimated on the basis of heart rate at work, during leisure time and sleep. Heart rate at work indicated that occupational tasks carried significant psychic load. Notably, the analysis of requirements involving risk showed them to be the most important factor affecting heart rate. Physiological effects of psychic load at work persisted round the clock, which is reflected by a correlation between heart rate during leisure time and sleep and some measures of load and/or working time.

INTRODUCTION

Many authors believe heart rate to be a useful load indicator, since it integrates reactions to physical effort, heat stress and mental effort and emotional stress resulting from work attitude and psychosocial significance of situations encountered. This conclusion is based on studies conducted both in laboratory conditions (2, 16, 19, 20, 21) and in the workplace (7, 9, 10, 12, 13, 15, 17). Such factors as limitation of motor activity, monotony and sensory deprivation cause a drop in heart rate in heat and emotional stress whereas mental effort causes its increase. This increase is higher than one would expect, considering the intensity of the physical effort involved. It is also known that, even though heart rate recovery after a physical effort is quite fast, psychological effects

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of stressogenic situations persist over a long period of time (11, 18). The search for physiological indicators of the psychic load is justified mostly by the fact that it is not always possible to predict precisely the workload purely by estimating the intensity and types of stimuli. Typically, industrial management is the kind of work where the psychic load is the dominating one.

Psychic load estimation is not an easy task, since there is no generally accepted concept of load and no method of measuring it. Attention has recently been focused on the methods of estimating the subjective psychic load. They are quite easy to apply following the definition of load which says that the psychic load constitutes an individual reaction to work performed (4, 22). In order to answer the question whether it is psychic load that contributes significantly to the functional state of the human organism, it seems necessary to assess the relationship between the extent of load and the level of physiological reactions.

The aim of the present study was to carry out this kind of analysis with respect to the perceived psychic workload reflecting the intensity of effort, and to heart rate reflecting physiological reactions to work. In view of the diversity of factors contributing to psychic load, it has been decided to determine which of them most significantly affects physiological reactions during work and whether the extent of the psychic load modifies these reactions only during work or also during leisure time. The study involved persons employed as managers in a major textile factory in Lodz. This paper presents the results of the study's investigations on women.

MATERIAL AND METHOD

The study focused on 16 women managers from the following departments: technical advancement, programming and organization, planning and economics, personnel and professional training, exploitation, finances, employment and wages, law, designing, a diagnostic laboratory and a cultural centre. Data on age, duration of employment and the number of subordinates are presented in Table 1.

The subjects had their ECG recorded for 24 hours with the use of the Medilog 3000 (Oxford) recording device. During the entire period of registration, those examined completed activity diaries noting the times of changing their type of activity. They were also asked to rate: 1) the strenuousness of each task or situation in terms of the perceived intensity of physical effort; 2) difficulty in terms of mental effort, and 3) neuro-emotional tension. The ratings were made according to a 5-degree scale on which "1" corresponded to the lowest intensity and "5" to the

TABLE 1. Characteristics of the Tested Group

Number of subjects	Age	Employment period		Number of subordinates	Level of education
		total	as an executive		
16	42.0 ± 6.2	20.8 ± 6.2	11.8 ± 5.3	16.6 ± 14.1	14 university graduates 2 high school

highest. A detailed description of the activities was used to estimate their energy expenditure. The values of energy expenditure for each activity were taken from literature (8).

The subjects were also asked to estimate the perceived psychic load according to the method developed at the Department of Work Psychology, Institute of Occupational Medicine in Lodz (5). The method involves a subjective estimation of work requirements and of ability to cope with them. It includes six measures of psychic workload: mental difficulty, monotony, risk, responsibility, interpersonal conflicts and time pressure. The assessment involves a comparison of the subject's work with the description of tasks or names of professions to which particular values in points (1—9) are attributed. The scale for each type of load contain nine descriptions of tasks or professions and the subjects were supposed to match their own work with each of these descriptions. The rating of work requirements corresponds to the mean value of activities associated with workload basically as work performed by the person examined. When rating the abilities, the subject marks all the tasks she can cope with and the result corresponds to the highest-rated task.

Heart rate was calculated from ten minute periods of 24 h ECG recording. Mean heart rates were then calculated for working time (HR work), leisure time (HR home) and sleep (HR sleep). For working and leisure time also the weighted mean value of energy expenditure per minute and the weighted mean of estimations of strenuousness, difficulty and neuro-emotional tension were calculated. In view of the fact that such additional factors as age and resting heart rate influence heart rate during work, two indices were calculated taking the sleeping heart rate as the resting heart rate. Thus, the calculated ratios were HR work /HR sleep and HR home/ HR sleep. The relative heart rate i.e. the percentage of heart rate reserve which constitutes the work pulse was calculated according to the formula (1)

$$\text{HR } \% = \frac{\text{HR work} - \text{HR sleep}}{\text{HR max} - \text{HR sleep}} \times 100\%$$

HR max was calculated according to the formula (1):

$$\text{HR max} = 220 - \text{age}.$$

RESULTS

During the 24h ECG recording the subjects worked for about 7 hours and slept about 6 hours 45 min. The remaining time was occupied by their travel to work, household chores and rest (nearly 2 hours). Energy expenditure amounted on the average to 0.69 kcal/min during work and to 1.13 kcal/min during leisure time. The differences between these values were statistically significant ($p = 0.02$). Heart rate, just like energy expenditure, was higher at home, but in this case the difference was not very big (3.5 beats/min) and so statistically insignificant. The differences between the values of the percentage heart rate reserves "at work" and "at home" and between the ratios of the heart rate "at work" and "at home" and the sleeping heart rate were also statistically insignificant.

The small differences in heart rates coupled with the significant differences in energy expenditure indicate that other factors characteri-

TABLE 2. Physiological Indices of Load during Work and Leisure Time

Variables	at work	at home	during sleep
Duration (min)	427 ± 98	597 ± 102	406 ± 46
Energy expenditure (kcal/min)	0.69 ± 0.20	1.13 ± 0.32	—
Heart rate (beats/min)	86.0 ± 13.1	98.5 ± 9.4	66.6 ± 8.0
Relative heart rate (%)	17.2 ± 9.6	21.1 ± 5.3	—
Ratio of heart rate at work and at home and sleeping heart rate	1.30 ± 0.16	1.35 ± 0.08	—

zed not just by energy expenditure influence the subjects during work. This seems quite obvious in view of the nature of the profession. Generally speaking, the work of managers involves such tasks as setting working schedules for subordinate divisions, supervision, preparation, correction and signing of documents, preparation of reports for superiors, dealing with current administrative and financial matters, participation in meetings and conferences, holding talks with subordinates and contracting parties, staying informed with professional literature, implementation of new working methods (computerization). In rating the

work requirements the highest grade was given to the possibility of interpersonal conflicts and mental effort. The lowest grade was given to monotony. The mean values of subjective estimation of coping with work requirements indicate that the possibilities failed to meet the requirements only in the case of mental difficulties, yet individual values varied greatly (Tab. 3). In view of the fact that subjective estimation

TABLE 3. Profile of Perceived Psychic Workload

Load indices \ Estimated load measure	Mental difficulty	Monoton	Risk	Responsibility	Conflicts	Time pressure
Work demands	6.27	3.48	5.19	6.18	7.09	5.92
	1.80	1.07	1.81	1.80	4.35	1.48
Ability to cope with	5.98	4.37	6.55	7.17	7.43	7.27
the demands	1.69	1.91	1.87	1.66	1.34	1.33

of psychic load described as work requirements and the ability to cope with these requirements another kind of estimation was applied. It was designed to compare subjective load in the workplace and at home. It has been found that work on the job was rated higher in terms of difficulty and neuro-emotional tension, while work at home was considered harder (Tab. 4).

TABLE 4. Estimation of Strenuousness, Difficulty and Neuro-Emotional Tension during Work and Leisure Time

Estimated situations	Difficulty	Strenuousness	Tension
Work	2.02	2.39	2.26
	0.68	0.43	0.80
Leisure time	1.81	2.69	1.67
	0.76	0.37	0.65

In order to assess the relationship between the perceived psychic load and its physiological effects, multiple regression analysis was applied, where both kinds of ratings, age, number of subordinates, time and energy expenditure at work and at home were treated as independent variables (Table 5 and 6). Among the independent variables in regression equations used to predict the scope of circulatory reaction during work, the most common ones were age, the rating of requirements, the assessment of risk, estimation of coping with conflicts and time pressure, estimation of strenuousness and difficulty of work and the number of subordinates. Energy expenditure during work, the estimation of re-

TABLE 5. Regression Equations Describing Dependence of Circulatory Load Indices during Work and Leisure Time on Age, Working Time and Expenditure during Work and Leisure Time and on Estimations of Work Demands and Ability to Cope with Them

Dependent variables / Independent variables	Heart rate		Relative heart rate	Ratio	
				HR work	HR home
	at work	at home	at work	HR sleep	HR sleep
Age	—3.060	—0.890	—1.858	—0.0300	—0.0034
Working time	0.079				—0.0014
Leisure time		—0.041			—0.0012
Energy expenditure at work					
at home		18.988			0.2052
Number of subordinates			0.485		
Estimation of demands concerning: mental					
difficulty			3.328		0.0278
risk	3.392			0.0631	
responsibility			2.570		0.036
conflicts	—9.913		—1.066		0.0041
time pressure			—1.840		—0.0088
Estimation of the ability to cope with:					
mental difficulty				0.0454	0.0068
monotony			—1.316		—0.0235
risk				—0.0349	
responsibility		—3.871	—4.837		—0.0510
conflicts		6.043	2.743	—0.0637	—0.0032
time pressure	—4.940			—0.0706	
Constant	269.246	112.716	91.148	3.170	2.866
Multiple correlation coefficient	0.833	0.810	0.998	0.937	1.000
p value	0.005	0.034	0.0001	0.0011	0.0000

quirements concering monotony, and the estimation of neuroemotional tension, did not appear in any of the regression equations. The scope of circulatory reaction during leisure time was affected by age, energy expenditure at home, ability to cope with responsibility and conflicts, neuro-emotional tension at home and in the workplace. This reaction during leisure time was not affected by estimations of requirements involving monotony of work, risk, the estimation of ability to cope with hazardous situations and time pressure and also estimation of difficulty and neuro-emotional tension at work.

Heart rate during sleep depended on heart rate during work and

TABLE 6. Regression Equations Describing the Dependence of Circulatory Load Indices during Work and Leisure Time on Age, Working Time, Energy Expenditure and on Estimations of Strenuousness, Difficulty and Neuro-Emotional Tension

Dependent variables / Independent variables	Heat rate	Relative heart rate		Ratio HR work
	at home	at work	at home	HR sleep
Age	—1.445	—1.761	—1.547	—0.022
Working time	—0.052	0.041	0.029	
Energy expenditure				
at work			—15.025	
at home	29.876		7.450	
Numebr of subordinates		0.416	0.324	0.007
Estimation of working time				
as regards strenuousness		—14.348	—5.884	—0.227
diffculty		10.233		0.146
Estimation of leisure time				
as regards strenuousness	—10.608			
diffculty	—10.383			
tension	15.944		7.315	
Constant	173.581	—80.333	72.404	2.351
Multiple correlation coefficient	0.845	0.894	0.929	0.880
p value	0.0375	0.0029	0.0061	0.0014

leisure time and on the time at work. This relationship could be described by the following equation:
HR sleep $= -9.84 - 0.32$ HR work $+ 1.07$ HR home $+ 0.02$ working time.
Multiple correlation index amounted to $R = 0.042$ $p = 0.0001$.

DISCUSSION

The results obtained in the present study offer an assessment of the extent of psychic load from both psychological and physiological points of view. According to the authors of the method of subjective estimation of psychic workload (5), the ratings of work requirements took on high values for mental difficulty, responsibility, interpersonal conflicts and time pressure. As regards risk-related requirements, the rating level was medium high, while monotony was rated low. Mean values in rating the ability to cope with these requirements were a little higher than the rating of the requirements, which indicates that in most of the cases there was no overload resulting from requirements higher than the possibilities. The profile of the requirements indicates that, according to the subjects ratings, the nature of manager's work is different from that of a power plant operator, telephone exchange

operator or a physician (4). The rating of the possibility of interpersonal conflicts, which dominated in the tested subjects, was never so high for the above-mentioned professions.

On the basis of circulatory reactions (according to the classification of Navakatikian (17) one can conclude that the subjects performed work associated with significant psychic load, because the average heart rate was in the range of 89—95/min. There are no available data on the scope of circulatory reaction during similar work performed by women. Industrial managers examined by Henningen and Wortham (10) during work had an average heart rate of 80/min. The heart of male industrial managers examined by Krauze and Sowa (13) was in the range of 60——100/min. Percentage reserve heart rate during work amounting to 17% in our subjects, was higher than in women operating spinning frames and looms (5) and a little lower than in women employed in the metallurgic industry in Finland (7). Mean value of the HR work/HR sleep ratio, amounting to approx. 1.30 in our subjects was lower by comparison to the ratio obtained by Fordham in nurses (6), by Diament in female students (3) and by Goldsmith in vehicle assembly line workers (7). One can assume that lower values of this index found in our subjects results from smaller physical load during work and a heart rate a little higher during sleep. The value of HR home/HR sleep ratio amounting to approx. 1.35 was very similar to the values obtained in the study performed in nurses and female students (3, 6).

The circulatory load during work does not depend on energy expenditure but on other work-related loads, specifically on risk-involving requirements. It is thus a measure of load and it causes the most varied physiological reactions, but this problem requires further investigation.

As predicted, the physiological consequences of workload persisted round the clock, which is indicated by the dependence of heart rate during sleep on working time. The circulatory load during leisure time was higher when the ratings of work requirements were higher, the ability to handle them lowered circulatory reactions. The higher heart rate during work, the lower during sleep. This is in accordance with the results of Kulikovskij who found that sleeping heart rate after intense mental work is lower than in control conditions. He explained this phenomenon by an increase in parasympathetic tension which is higher when after-work fatigue is greater (4). The sleeping heart rate was higher when it was also higher "at home". The latter is most dependent upon energy expenditure during leisure time. For most subjects the time spent at home was not only leisure time. It was devoted not only to everyday housework, but also to gardening, making pickles and jams etc. (the investigation was carried out in summer) — in on extreme

case, energy expenditure at home amounted to 900 kcal, corresponding to moderate physical work.

The relationship between sleeping heart rate and time at work indicates that the activities during leisure time do not make for sufficient relaxation and, as a result, physiological effects of one's professional involvement persist over a long period of time. Therefore, it seems necessary to develop relaxation methods appropriate for this group of workers.

The analysis of the relationship between the scope of circulatory reaction and the estimation of workload yields conclusions not only on the contribution of psychic load to physiological cost, but on methods of testing those factors. Physiological cost could be explained better by indices comprising sleeping heart rate regarded as the resting level. The level of those indices, reflecting changes dependent upon individual factors not associated with work, depends on a greater number of parameters characterizing workload than the level of absolute values of heart rate. It seems that the assessment of psychic workload consisting of the analysis of work requirements and the ability to cope with them, is more useful for predicting physiological cost of work involving this kind of load than a mere assessment of work difficulty and neuro-emotiolnal tension associated with work performed. The ratings of particular load measures were the predictors of circulatory reactions both at work and at home. The rating of risk-related requirements, one of the measures of psychic load, appeared in all three equations, describing the physiological cost of work. This measure was rated at the medium level. The rating of requirements involving a possibility of interpersonal conflicts, which was the highest-rated load measure, appeared only in one equation as a predictor of heart rate during work and, interestingly, as a factor lowering heart rate. This shows the purposefulness of using the results of physiological tests in assessing the weight of particular load measures in a general assessment of psychic load.

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