

HEART RATE VARIABILITY - AN OBJECTIVE CRITERION FOR PREDICTION OF HEALTH RISK IN WORKERS.

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Summary

The study brings experimental evidence, that the chronically decreased heart rate variability (HRV) leads to increase of absence due to sickness and morbidity rate (respectively speaks for an increase of health risk). Two preliminary selected on the basis of HRV workers populations, each comprising 100 subjects, were compared 3 years after selection. It was found that workers with less variability are exposed to a higher risk for development of pathological processes namely in circulatory, respiratory and digestive systems. Diseases distribution was found to be age-dependent. The role of the chronically accumulated stress upon the probability for health deterioration is discussed.

Key words: work-related stress, health risk, heart rate variability.

Introduction

It is now a generally accepted opinion, that severe forms of work-related chronic strain correlate with absence due to sickness, morbidity and unspecified subjective health complaints (sleep disturbances, premature fatigue). The exact psychophysiological mechanisms, however, by which strain might produce these disorders are scarce or missing (1). Due to the poor state of theory formation it is hardly possible to arrive analytically at any empirically testable conclusion.

As one of the most urgent aims of environmental and occupational medicine should be to clarify what sort of stress mechanisms may eventually lead to long-term suffering and chronic disease, we proposed a multifactorial model including person-related, work-related and society-related stress influences impinging upon a human being. Maladaptation, which becomes apparent at different ages and after varying lengths of work exposure is regarded as a result of destabilization of psychophysiological feed back mechanisms. But this concept has not the potential to explain differences observed between subjects exposed to the same stressors. A possible solution of this problem is to describe quantitatively the term "chronic individual strain" by assessment of long-term lasting level of vegetative equilibrium, as the last is common physiological end reflecting all kinds of person - environment relationships. Some people are obviously able to stabilize their person-environment relationship without increasing the cost of adaptation (first phase). Others may reach a new steady state (heterostasis) overcoming successfully for a certain period health impairment (second phase). There are also subjects, which do not exhibit complaints and symptoms related to work strain but their autonomic balance turned to be more "ergotropic" oriented (third phase). A certain proportion finally reach a stage at which adaptation reserves are markedly shortened and the physiological cost of adaptation is strongly augmented (fourth phase). That proportion is "between the health and the illness" (the probability some diseases to be manifested increase and the autonomic equilibrium is even more ergotropic oriented). In the final fifth phase the stress induced after effects and the health impairment becomes obvious (2,3). It appears that the phenomenon "stress accumulation", is producing a chronic drift of vagal-to-sympathetical equilibrium towards sympathetical prevalence (chronic autonomic ergotropic drift - CAED). As the computer analysis of heart rate variability reflects the autonomic balance, it can be used for early prediction of work-related health risk.

The aim of the present study was to apply the model "stress-stain (chronic autonomic disequilibrium) - health risk" by dividing a large group of textile - workers (cohort field study) into two defined groups of varying autonomic balance, one representing first two phases of stress adaptation, and the other representing the third and fourth phases of stress adaptation. The effects of the above described phases of health risk (subsequent development of health problems) were followed up.

Procedure.

Subjects

The field study was carried out in two textile producing plants. The investigation was designed as a longitudinal prospective study. From a multitude of 324 predominantly shift workers two samples (groups) were selected on the basis of the mean groups values of Index of vegetative equilibrium (IVE), the higher values of the which are pointing CAED. Both groups had comparable environmental and working conditions as well as mean age and length of service.

According to the preliminary hypothesis presupposing existence of correlation between CAED and health risk, the first group had low mean group level of IVE, respectively was presupposed to possess a low level of health risk and the second group vice versa (table. 1.).

Table. 1. Two sample groups of followed up textile workers selected according IVE score.

Parameter	Low level of IVE (Group1)	High level of IVE (Group2)	p1-2*
Total number of probant	100	100	
work experience(+ SD)	12.6 + 4.3	14.3 + 5.6	
Men	37	31	
Women	63	69	
Mean age (+ SD)	43.7 + 10.1	41.4 + 8.4	
IVE (measured value) (s-2)	112.4 + 28.1	209.7 + 43.5	<0.05
Difference between measured and age-related values of IVE	-26 + 4.7	+43 + 6.4	<0.05
Unspecified psychosomatic symptoms (mean score)	36 + 4.1	59 + 9.7	<0.01

* (Mean group scores of IVE were compared by student's "t" test for independent variables).

The selection of the two groups was done by arrangements of all 324 investigated persons in three dipoles according to their IVE scores, age and length of service. From IVE dipoles two groups each containing 100 workers were selected - the first with the lowest and the second with the highest IVE values. After computing their mean age and length of service values a filtering statistical procedure employed to the "age" and "length of service" dipoles helped to construct the final two samples described in table. 1.

Method

IVE individual scores were obtained as mean from three 10 min. lasted registrations of heart rate variability (HRV), provided in three consecutive days. IVE was computed by means of a mathematical algorithm, which includes: LTV (long-term

cardiac variability); AMo. (amplitude of the Moda expressed in percent); IC (index of centralization, which is the ratio between the spectral power connected with long and respectively with short spectral waves (0.02 - 0.05 Hz divided to 0.2 - 0.4 Hz) and TP (total spectral power). By means of statistical procedure including selection of the main HRV components (singular values decomposition in the space of Karunen-Loew) these HRV measures proved to contain the main part of HRV informativeness towards the level of vegetative equilibrium. After varimax rotation they were normalized and received adequate to their informativeness coefficients of weights (4, 5). The low values of IVE score speaks about parasympathetic prevalence, whereas the higher values are obtained when autonomic equilibrium is sympathetically (ergotropic) oriented. This fact is well described in specialisated literature (6).

The relation between IVE and the phase of adaptation was checked out before this investigation. This procedure included: first - establishment of IVE age-related "normal" values (based on 4836 investigated persons, aged from 20 to 70 years, divided to 10 age-pentads); second - assessment of the correlation between IVE and some other tests describing stress reaction quantitatively. As such tests were used a large group of clinical, paraclinical, questioner - based and other measurements.

The unspecified psychosomatic symptoms (UPS) (headache, restlessness, nervousness, depression, dizziness, anxiety, abnormal sweating, chronic fatigue, chest pain, sleep disturbances, angina pectoris, tachycardia, arrhythmia, nausea, epigastric pain, constipation, diarrhea, urticaria, loss of appetite, undue finger etc.) were collected by a special questionnaire. It comprised 22 parameters and every parameter had 4 levels of occurrence (from 1 = never to 6 = very often). The maximum of the scale was 88, the minimum (not any symptoms) was 22. Scores on this scale were transformed in percents and was thought to be an overall measure of the present health state of a practically health person. All persons being ill were excluded from the investigation.

The assessment of the relationship between the IVE mean group score and the practical realization of the predicted level of health risk was done three years later. Both groups were compared on the basis of the information for their rate of absence due to sickness and morbidity rate obtained from the individual histories of diseases and injuries and classified according to ICD (International Classification of Diseases) - (7).

Results

The total amount of work-related stress accumulation (assessed by IVE) differs significantly in both groups as well as the level of not specific psychosomatic symptoms (UPS). (table. 1.).

The multiple step-wise regression analysis of IVE dependence on UPS is described in table 2.

Table 2. The dependence of Index of vegetative equilibrium (IVE) on unspecified psychosomatic symptoms (N = 200)

Dependent Variable Y	Independent Variable	Coefficient	t - Value	F - Ratio
IVE	Intercept	- 136.25	-2.69 **	3.29
IVE	UPS	17.12	2.58 **	3.29

** p < 0.01

The statistically highly significant dependence of IVE from UPS is pointing that stress accumulation is altering the overall health well being of the investigated persons and that IVE can be used operationally for defining the quality “health” of practically not ill persons.

Comparison of rate of absence due to sickness .

The average number of days of absence due to sickness per man per year amounts to approximately 9 in group1 and 16 in group2. This increased rate of absence in persons with augmented values of IVE correlate statistically significantly with the increased work exposure (almost coinciding with the increased age).

Comparison of morbidity rates.

Morbidity rates were calculated for both groups after grouping of the diseases and accidents according to ICD.

The highest proportion of diseases is in the respiratory system. This proportion was significantly higher in group2 ($p < 0,01$). The same is truth for circulatory system ($p < 0,01$). Group2 significantly exceed group1 in diseases of the digestive system ($p < 0,05$). Statistically significant is the difference in psychoses, psychoneuroses, skin and subcutaneous diseases ($p < 0,05$). The difference in diseases of musculoskeletal system, genito-urinary system, endocrine and metabolic system,nervous system, sense organs and accidents are not significant. As the percentage of diseases in the circulatory and digestive systems in group 2 was more than twice higher it can be concluded that work-related stress (assessed by HRV analysis) provokes predominantly these types of diseases, which were thought to be triggered by long-term lasting distress (CAED). Statistically significant relationship between the length of service and the percentage of cardiovascular, digestive, endocrine-metabolic, genito-urinary and musculoskeletal diseases (correlation coefficients ranged from 0,69 to 0,86: $p < 0,05$) was found. There exists statistically significant difference in the general prevalence of diseases when compare “younger” with “older” workers (below and over 35 years). The “older” workers show an increased prevalence of circulatory and respiratory diseases ($p < 0.05$). These findings can be explained with higher IVE values found in “older” workers population, which is a well established and proved by many authors phenomenon (6). The more frequent diseases developed in group2 (for three years lasted period) were: for cardiovascular system - hypertension (401 - 405) and ischemic heart disease (414); for digestive system - gastroduodenites (535) and peptic ulcer (533); for respiratory system - influenza (487) and acute upper respiratory infections (460 - 465); for endocrine system - diabetes mellitus.

Table 3. Morbidity rate of group1 and group2 according to disease class (ICD)

Disease	Group1 (%)	Group2 (%)	p value
Endocrine and metabolic (ICD 240 - 279)	1.8	3.9	ns
Psychoses, psychoneuroses (ICD 290 - 319)	2.3	5.3	<0.05
Nervous system, sense organs (ICD 320 - 389)	5.0	0.8	ns
Circulatory system (ICD 390 - 459)	9.9	25.6	<0.01
Respiratory system	31.1	40.7	<0.01

(ICD 460 - 519)			
Digestive system (ICD -520 - 579)	13.7	27.3	<0.05
Genito-urinary system (ICD -580 - 608)	3.2	4.8	ns
Skin and subcutaneous tissue (ICD -680 709)	5.1	11.3	<0.05
Musculoskeletal system (ICD -710 - 739)	16.3	20.6	ns
Accidents (ICD -800 - 959)	18.8	15.4	ns

Discussion

The prognostic value of heart rate variability towards health risk was drawn from the relationship between the absence due to sickness and morbidity rate and the level of CAED. It is possible to conclude, that the preliminary posed hypothesis, predicting strong relationship between CAED and health impairment was confirmed. The prognostic value of CAED was better expressed for cardiovascular, respiratory and digestive diseases than for musculoskeletal, endocrine system diseases and accidents. It should be assumed, that the health risk attributable to the triggered by chronic over-stress diseases is much more pronounced. The cases concerning carcinomatous pathology were not included in this study because their rate of occurrence (in dependence of CAED) was assessed separately (8).

The analysis of diseases distribution related to the age suggests that the differences in diseases rate between group1 and group 2 becomes more pronounced in older workers population, but that tendency is not statistically significant. The significant decline in the state of health with time in group2 is mainly due to cardiovascular disorders. This main sources of health risk for workers with CAED (except carcinomatosis!) is frequently cited by many authors dealing with HRV analysis (9, 10, 11).

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