CORRELATIONS BETWEEN CERTAIN HEARING CHANGES AND VEGETATIVE BALANCE IN MINERS

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SUMMARY

This study responds to the priorities of the National Health Strategy aimed at control and mitigation of the hazardous effects of the workplace factors on cardio-vascular diseases of people in active working age from the branch "Mining industry".

The aim of this work is to study the vegetative balance (by analysis of heart rate variability - AHRV) and the correlations with the state of miners' hearing functions.

Sixty eight miners (diggers and mate-diggers) from mining industry were studied. This paper treats the results of AHRV examination of 25 miners who have no major and additional causes, leading to hearing injury - traumas, other diseases, medicines, etc.

The analysis of heart rate variability was made by computer analysis of heart rate and variability. Standard ECG electrodes at bi-polar breast lead-off were used for recording ECG signals. The echo-cardiographic signal was converted by an ECG converter board into epochs of cardiac events (R-R intervals) for 10 minutes. The principal indices of heart rate variability were analysed.

The obtained results provide the ground for further comprehensive studies on different workers contingents from other industries in order to detect workers with initial changes in the hearing analyser and to establish the corresponding pathogenetically based registration, monitoring, and treatment system.

The studies conducted for monitoring the dynamic of vegetative equilibrium reflect the degree of disturbed heterostasis by chronically manifested sympatic activity in miners, diagnosed by AHRV indices.

The revealed significant relationships between hearing changes and AHRV indices prove the presence of an extra-aural paraprofessional effect and statistically significant relations with the changes in the critical organ.

The revealed highly significant correlations between AHRV indices and hearing show a significant relationship between the physiological vegetative level (assessed by AHRV) and the hearing status at chronic exposure to work-related stress factors in miners.

The chronic sympathicotonia is an additional pathogenic factor (besides acoustic stress) manifested by spastic changes in the microcirculation of the cochlear neuroreceptor elements.

Key words: miners, hearing changes, para-professional effect

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INTRODUCTION

It has been proved that the analysis of heart rate variability (AHRV) can be used as an early biological marker for detecting pre-clinical correlates of the hazardous effect of conditions and character of work (3, 8).

The method is based on monitoring the dynamics of vegetative changes accompanying the disturbed heterostasis at acute or chronic effect of work-related stress factors.

Literature data (1, 2, 6, 7, 12) substantiate the evidence that the effect of noise noxa on the auditory sensor system creates possibilities for formation of para-professional diseases as an expression of its extra-aural impact.

A number of works (9, 10, 11, 13, 14) studied the central and cerebral haemodynamics and established a close relationship between the changes in the hearing analyser and the cardio-vascular system.

The degree of relationship between unfavorable specific changes in auditory specialized sensuousness and the dynamics of vegetative balance (estimated by AHRV) as an early sign of extra-aural para-occupational effect in workers in noisy manufactures is not clarified in details.

This study is in accordance with the priorities of the National Health Strategy for identification, control and mitigation of the hazardous effect of workplace factors on cardio-vascular diseases of people in active working age from the sector "Mining industry".

The aim of this work is to study the vegetative balance (by AHRV) and the correlations with the state of miners' hearing functions.

MATERIAL AND METHODS

Miners work under conditions of high noise levels generated by drilling hammers PR-24L (Russia) - 127 dB/A/, PTch-75 MZ (Hydravlika - Bulgaria) - 126 dB/A/, VVD (Atlas-Kopko - Sweden) - 128 dB/A/ and telescopic perforators PT-26 and TP-36, Angelova (1965). The noise is wide-band with frequency up to 8,000 Hz.

It should be noted that its character and parameters depend on the construction features of the drilling hammer, weight, number of shots per minute, pressure of the condensed air and character of mine conditions (1, 2). Local vibrations, cooling microclimate and work, connected with heavy physical load on the upper limbs are additional hazardous factors of the working environment (besides acoustic stress).

Sixty eight miners (diggers and mate-diggers) from mining industry were studied. This paper will analyse the results of AHRV examination in 25 miners who have no major and additional causes, leading to hearing injury - traumas, other diseases, medicines, etc. The studied persons are distributed in two groups:

• I group (12 workers) - mean age 37.9 ± 1.02 and length of employment up to 15 years;

• II group (13 workers) - mean age 47.7 ± 2.4 and length of employment over 15 years.

Their individual data were compared with those of a control group consisting of persons, employees at the National Center of Hygiene, Medical Ecology and Nutrition and other Scientific Institutes who do not work under conditions of acoustic stress. The control group comprised 29 persons, 17 men and 12 women, aged 43.5 ± 1.09, clinically healthy with normal audiological status (8).

The corrections of the age factor were made according to Efrussi's table (2). The hearing analyser was studied with an audiometer MA-31 (DDR) by the classic method for tonal threshold audiometry. Air conductivity was monitored for the frequencies 125, 250, 500, 1,000, 2,000, 4,000, 6,000 and 8,000 Hz.

The vegetative balance is evaluated through Analysis of Heart Rate Variability (AHRV) Danev's test, (3). The analysis of heart rate variability was made by a computer analysis of heart rate and variability. AHRV is successfully applied for precise diagnosis of fatigue, disadaptation, exhaust of functional reserves and pre-nosological states. It is appropriate for use as those states affect in a characteristic pattern the wave structure of the cardiotachogram; it enables the more precise assessment of the state of vegetative balance. The diagnostic potential of AHRV is based on the following physiological phenomena: suppression of respiratory sinus arrhythmia, appearance of "discrepancy" in AHRV values, expressed centralization in the process of management and regulation of heart rhythm, elevated organization in the distribution of dynamic row of cardiointervals. All these phenomena are observed at fatigue, overstress, worsened adaptation and distress. Standard ECG electrodes at bi-polar breast lead-off were used for recording ECG signals. The echo-cardiographic signal was converted by an ECG converter board into epochs of cardiac events (R-R intervals) for a 10-minute period. The approbation of the method has proven that the interindividual dispersion is within the physiological limits during the test time of 10 minutes. Thus a representative sample is formed. The degree of statistical significance calculated according to the Danev's method (4) is above 0.99% for all individuals.

The following indices of heart rate variability were analysed:

1. Indices related to statistical characteristics of R-R intervals:

- mean value of cardiointervals (X ms),
- standard deviation (SD ms),
- variation coefficient (Cv%),
- mean square of subsequent differences (Δ ms),
- mean difference between adjacent cardiointervals (V ms),
- sum of positive differences between adjacent cardiointervals (Ss),
- number of waves in the cardiotachogram (N) greater than 10 ms,
- mean amplitude of the waves in the cardiotachagram (S/Ns),
- total power of the wave structure of the cardiotachogram (S.Ns).

2. Indices related to the distribution of cardiointervals

- mode (Mo),
- amplitude of the mode (Amo%),
- variation scope (Δ R-R ms),
- index of stress (IS^{S-2}),
- vegetative rhythm index (VRI^{S-2}),
- index of adequacy of regulation processes ($IARPS^{S-1}$),
- index of vegetative equilibrium (IVE^{S-1}),
- indicator of vegetative balance (IVB^{S-3}),
- homeostatic index (HI^{S-2}).

The results were processed by multiple correlation analysis with HRV indices as the dependent variable, and the hearing sensitivity as the independent variable with determination of the correlation ratios "R".

RESULTS AND ANALYSIS

Table 1 shows the average numerical values of audiograms for the air conductivity in both groups of miners. The cumulative audiograms show the typical basoapical curve with the characteristic Karhardt's peak for the critical frequency of 4,000 Hz. The high frequencies - 4,000-8,000 Hz are at most affected, followed by those in the range 125-250 Hz with following inclusion of the speech band frequencies 2,000-1,000-500 Hz which explains the late speech hearing deterioration.

It can be seen that the longer employment record corresponds with increased values of the tonal hearing threshold for air conductivity which is a manifestation of aggravation of hearing disturbances.

The results from the analysis of heart rate variability for the I, II and control group are presented in Table 2. The following relationships are determined from the analysis of heart rate variability:

1. The indices values of cardiointervals variability are significantly lower;

- the standard deviation (SD) for the I and II group, 29.7 and 27.4 respectively is higher than that of the control group;
- the sum of the positive differences between adjacent cardiointervals (Sv) is lower for the I and particularly for the II group (8.1 and 6.7 respectively);
- the average difference between adjacent cardiointervals (V_1) is 47 for I and 23.8 for the II group of miners;
- the total value of wave energy in the cardiotachogram (SN) decreased from 1,754 for the I group to 1,134 in the second group respectively.

Table 1. Correlations between certain audiological indices and indices of heart rate variability

	Audiological indices								Group
	125	250	500	1,000	2,000	4,000	6,000	8,000	
Tonal hearing threshold (THT)	30	29	25	25	30	48	38	38	I
Indices of heart rate variability									
SD (ms)	0.132	0.143	0.147	0.208	0.260	0.573**	0.285	0.130	
AMo (%)	0.107	0.118	0.129	0.213	0.278	0.367**	0.178	0.129	
HI(S^{-2})	0.127	0.145	0.171	0.217	0.413	0.639**	0.193	0.172	
Tonal hearing threshold (THT)	49	42	40	38	45	52	52	45	II
Indices of heart rate variability									
SD (ms)	0.197	0.209	0.301	0.413	0.531*	0.592**	0.223	0.220	
AMo (%)	0.169	0.181	0.199	0.248	0.372*	0.484**	0.152	0.144	
HI(S^{-2})	0.153	0.170	0.288	0.294	0.420*	0.537**	0.220	0.178	

** $p < 0.01$
* $p < 0.05$

Table 2. Indices of the analysis of heart rate variability

Indices		Miners I group	Miners II group	Control group (5)
X (ms)	↓	807.0	762.6	856.0
SD (ms)	↓	29.7	27.4	9.4
AMo (%)	↑	37.0	43.1	27.0
IS (S^{-2})	↓	86.0	94.I	72.4
IVE (S^{-3})	↑	4.8	5.7	3.9
HI (S^{-2})	↑	0.9	1.34	0.6
IVB (%)	↑	0.8	0.9	0.7
Sv	↓	8.1	6.7	
V_1	↓	47.0	23.8	
Ss	↓	8.7	5.1	
SN	↓	1,754	1,134	
IARP	↑	47.0	69	

2. AHRV indices related to the distribution of cardiointervals (AMo) show statistically significant increase of the average value (X) from 37.0 to 43.1 respectively for the I and II group as compared with the controls (20.7). The statistically significant differences in AHRV indices: IARP, IVE, IVB, HI when comparing the two groups of miners prove the prevalence of sympathical chronic syntonization in the vegetative equilibrium as an extra-aural para-professional effect.

3. The other AHRV indices are affected to a lower degree with more weakly expressed and statistically insignificant tendency to deteriorate.

In order to complete the task, multiple correlation analysis was used, to determinate the correlation ratios (R) between the dependent variable (indices of the heart rate variability) and the independent variable (hearing changes).

Table 1 shows the existing significant correlations with positive correlation ratios, $p < 0.01$ and $p < 0.05$ as follows: for SD, AMo and HI for the I and II group of miners at the critical frequency 4,000 Hz. It is interesting that this positive correlation is revealed also for the frequency of 2,000 Hz for the speech band for the II group of workers. On the other hand, the chronically manifested sympathicotonia in miners could be considered as an additional pathogenetic factor (besides acoustic stress) determining the development of changes in the hearing analyser as it leads to spastic changes in the microcirculation of the cochlea with following dystrophic, destructive processes in the neuroreceptor elements.

The obtained results provide the ground for further comprehensive studies on different workers contingents from other industries in order to detect workers with initial changes in the hearing analyser and to establish the corresponding pathogenetically based registration, monitoring and treatment system.

CONCLUSION

1. The studies conducted for monitoring the dynamic of vegetative equilibrium reflect the degree of disturbed heterostasis by chronically manifested sympathic activity in miners, diagnosed by AHRV indices.

2. The revealed significant relationships between hearing changes and AHRV indices prove the presence of an extra-aural paraprofessional effect and statistically significant relations with the changes in the critical organ.

3. The revealed highly significant correlations between AHRV indices and hearing show a significant relationship between the physiological vegetative level (assessed by AHRV) and the hearing status at chronic exposure to work-related stress factors in miners.

4. The chronic sympathicotonia is an additional pathogenic factor (besides acoustic stress) manifested by spastic changes in the microcirculation of the cochlear neuroreceptor elements.

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