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EVALUATION OF THE FUNCTIONAL STATE OF CARDIOVASCULAR SYSTEM UNDER CHRONIC STRESS

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Summary. Characteristic trend in Central and Eastern European countries, including Bulgaria, is the increased level of cardiovascular morbidity and mortality. Reliable method for investigating of disturbed autonomic cardiovascular control, considered as a mechanism for development of cardiovascular diseases under chronic stress is the analysis of Heart Rate Variability. The aim of our study is investigation of the influence of stress factors on the employees' functional state of cardiovascular system studied by Heart Rate Variability (HRV) and arterial pressure. 61 employers from the Gas Assembly and Construction industry were examined. The time- and frequency-domain HRV measures are sensitive indicators for investigation of autonomic cardiovascular control and for determination of disturbances in the autonomic nervous system function. The chronic stress induced significant decrease of mean values of RR intervals, and ratio of spectral powers of RR intervals in the low to high-frequency area. Our study revealed that the diagnosis of early pre-morbid disturbances and autonomic dysfunction contribute to registration, and respectively to decreasing the risk of cardiovascular morbidity and mortality.

Key words: cardiovascular system/physiopathology; heart rate (source: MeSH)

INTRODUCTION

Characteristic trend in the Central and Eastern European countries, including Bulgaria, is the stable level of cardiovascular morbidity and mortality. This trend is induced by the effect of cardiovascular risk factors: psycho-social stress, arterial hypertension, decreased physical activity, smoking, diabetes, increased levels of serum lipids. The rate of cardiovascular mortality and general morbidity has increased in the Eastern European countries particularly after 1960 in comparison with the significant reduction in Western European countries, USA, Japan, Canada. Bulgaria takes one of the leading places
in the world in respect to myocardial infarction mortality. Due to these reasons, the early detection and prevention of cardiovascular diseases is current topic in our country as it ensures not only the favourable health state of the employees but also the adequate performance of the working activity, job safety, and organization of the working process.

Our long lasting research experience and practice up to now in this direction as well as the paraclinical and clinical studies done are aimed to detection of the morbid disturbances at their early stage of development, treatment of disease symptoms, and prevention of health complications.

The autonomic cardiovascular control studied non-invasively by Heart Rate Variability and especially its spectral components are applied by the occupational and clinical specialists as powerful predictors for determination of cardiovascular morbidity and mortality [3, 4, 6, 7, 9, 11, 13, 14]. The work place studies are considered as indicating the effect of stress factors of work environment on the functional state of cardiovascular system, detecting early asymptomatic forms of cardiovascular diseases and as for the evaluation whether workers with ischemic heart disease could continue their working activity [5].

The aim of our study was investigation of stress factors influence on the functional state of cardiovascular system of the employees from the Gas Assembly and Construction industry by autonomic cardiovascular control and arterial pressure examinations.

**DESIGN AND METHODS**

1. Design

The variability of heart rate and systolic and diastolic blood pressure were measured in 61 employees from the Gas Assembly and Construction industry (first group) (engineers, economists, computer specialists), mean age 39.54 ± 1.29 yr and in a control group (second group): 39 employees working at institutes, mean age 38.14 ± 1.76 yr.

The examination of the successive values of cardiac intervals was performed by 10 minute - registration of the ECG signal (I bipolar standard lead) in a sitting position after one hour period of relaxation.

Following stages of the investigation were determination of ventricular and supraventricular extrasystoles with the computer program for detection of heart beat disturbances, and the arterial systolic and diastolic blood pressure measurement.

2. Methods


The analysis of Heart Rate Variability was performed by the application of IBM technics, specialized hardware and software programs [1, 10].

The hardware of the method is module converting ECG-signal into cardiointervals (RR intervals). Hardware's device allows direct connection with the interface: PC "COM 2".
The successive values of R-R intervals were analyzed. The time- and frequency-domain Heart Rate Variability (HRV) measures were calculated from the analysis of successive inter-beat values. Following functional tests were analyzed: cardiogram, histogram, scattergram, spectral analysis of HRV.

- The following time- and frequency-domain HRV measures and HRV-derived indices were calculated:
  - Time-domain HRV measures: mean value of successive cardiointervals (X) (msec), respectively mean heart rate (beats/min)
  - Frequency-domain HRV measures: the ratio of spectral powers of cardiointervals in the low- to high-frequency area - Frequency-domain Index (FDI) (arb. un.)
  - HRV-derived indices: Physical Stress (PS) (arb. un.); Health Risk (HR) (%)

2.2. Computer method for detection of supraventricular and ventricular extrasystoles

The determination of the extrasystolic type: supraventricular or ventricular was performed with the computer method for detection of supraventricular and/or ventricular extrasystoles in HRV recordings.

2.3. Arterial blood pressure measurement

The systolic and diastolic blood pressure (BP) was measured with the sphygmomanometer „Riester“.

2.4. Data analysis

The HRV measures, HRV-derived indices, heart rate, systolic and diastolic blood pressure were calculated and were represented as means ± standard errors. The differences between mean values of the HRV measures, HRV-derived indices, heart rate, systolic and diastolic blood pressure in the groups studied were calculated with the t-test for independent variables.

RESULTS

The effect of work load induced by the work process and work environment factors on the autonomic cardiovascular control investigated with the HRV measures was determined with t-test of Student-Fisher for independent variables. The time- and the frequency-domain HRV measures are sensitive indicators for investigation of the autonomic cardiovascular control and for the determination of disturbances in the autonomic nervous system (ANS) function (autonomic dysfunction) induced by the effect of work load factors. The mean values of the time- and frequency-domain HRV measures, heart rate, systolic and diastolic blood pressure in the two groups studied are presented in table 1. The work load caused significant decrease of mean values of the time-domain HRV measure: mean value of the R-R intervals (fig. 1), and of the frequency-domain HRV measure: ratio of the spectral powers of the R-R intervals in the low- to high-frequency area (FDI) (fig. 2); and significant increase of the HRV-derived indices: Physical Stress (PS) (fig. 3), and Health Risk (HR) (fig. 4) at comparing of employees from the Gas Assembly and Construction industry with the control group. The work load had not changed significantly the mean value of the heart rate, and of the systolic and diastolic blood pressure (table 1).
Table 1. Means (X ± Sx), and level of significance (p) of time- and frequency-domain HRV measures, HRV-derived indices, systolic and diastolic blood pressure, and heart rate in the studied groups

<table>
<thead>
<tr>
<th>Variables</th>
<th>I group</th>
<th>II group</th>
<th>Level of significance (p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>39.54 ± 1.29</td>
<td>37.14 ± 1.76</td>
<td>n.s.</td>
</tr>
<tr>
<td>Heart rate (b/min)</td>
<td>72.31 ± 1.66</td>
<td>75.89 ± 2.35</td>
<td>n.s.</td>
</tr>
<tr>
<td>Systolic BP (mmHg)</td>
<td>131.39 ± 4.07</td>
<td>125.34 ± 3.98</td>
<td>n.s.</td>
</tr>
<tr>
<td>Diastolic BP (mmHg)</td>
<td>83.03 ± 2.84</td>
<td>78.51 ± 1.69</td>
<td>n.s.</td>
</tr>
<tr>
<td>X (msec)</td>
<td>846.18 ± 19.51</td>
<td>755.21 ± 22.97</td>
<td>0.006</td>
</tr>
<tr>
<td>FDI (arb.un.)</td>
<td>38.9 ± 2.15</td>
<td>25.22 ± 1.98</td>
<td>&lt;0.0000</td>
</tr>
<tr>
<td>PS (arb.un.)</td>
<td>-0.77 ± 0.12</td>
<td>0.72 ± 0.28</td>
<td>0.0001</td>
</tr>
<tr>
<td>HR (%)</td>
<td>25.82 ± 1.69</td>
<td>43.81 ± 3.17</td>
<td>&lt;0.0000</td>
</tr>
</tbody>
</table>

Fig. 1. Mean values of X (msec) in the studied groups

Fig. 2. Mean values of FDI (arb. un.) in the studied groups
DISCUSSION

The work load associated with long lasting influence of work process and work environment factors induced significant effect on the autonomic cardiovascular control investigated by the time- and frequency-domain HRV measures, and HRV-derived indices. The persisting influence of the work load under certain conditions as the economic situation in our country is a strong stress factor. The chronic exposure to this stress factor might induce functional disturbances in the autonomic cardiovascular control [2, 5]. Our results indicated that work load associated with the effect of work process and work environment factors had not changed significantly the mean values of the: systolic and diastolic blood pressure, and heart rate. Contrary, our results revealed significant effect of work load on the autonomic cardiovascular control investigated by the HRV measures and HRV-derived indices: X, FDI, PS, and HR. Our results confirmed results of previous researches that HRV measures are sensitive indicators of work load influence [1, 9, 10, 13, 14].
Our results indicated also that the work load of the employees of the Gas Assembly and Construction industry caused significant effect on the autonomic cardiovascular control as it reduced the activity of the sympathetic and the parasympathetic branch of the ANS: decreasing of the ratio of the low- to high-frequency component of HRV (FDI). This pattern of autonomic dysfunction was considered as a pre-cursor of cardiovascular diseases (CVD) [8, 12]. Therefore, the investigation of variability of heart rate, respectively autonomic cardiovascular control, might detect early latent forms of CVD. In the individuals from the Gas Assembly and Construction industry with disturbances observed in autonomic cardiac function, periodical observation of the variability of heart rate is recommended. This observation would ensure CVD prevention, particularly in individuals from Gas Assembly and Construction industry with pre-abnormal and abnormal values of HRV and with increased values of Health Risk.

This study was implemented as the cardiovascular morbidity continues to be a focus for paraclinical and clinical studies in our country. Our study revealed that the diagnosis of the early pre-morbid disturbances and the detected early dysfunctional deviations in the autonomic cardiovascular control contribute to the registration, and respectively to decreasing of the risk of cardiovascular morbidity and mortality in the employees from the Gas Assembly and Construction industry.

REFERENCES


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