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Short Communication

Interrelation of the Level of Fatigue and the Parameters of the Energy Supply of Activity for Medical Workers

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Relevance

The specificity of the work of medical workers of a surgical department of Ukrainian Children Specialized Hospital OHMADYT, is the shift schedule, with working time at night. It is known that night shifts are associated with impaired melatonin synthesis in the epiphysis, which leads to the development of desynchronosis, arterial hypertension, and metabolic syndrome [1-4,5,6]. The disruption of the normal recovery process, which in natural conditions should occur at night, leads to a decrease in the functional reserves of both the whole body and its individual organs and systems. The cardiovascular system, being an intermediary between the body's systems, performing the function of energy supply, delivery of oxygen and nutrients to tissues, can therefore be considered as a kind of "mirror" reflecting the functional state of the whole body through its functional parameters. Due to the fact that developed fatigue reduces the quality of work, and chronic fatigue leads to the development of asthenic syndrome, systematic monitoring of workers to identify and evaluate the severity of these conditions is important in occupational health and rational management of work.

For this study was used Cardiolyse software and hardware DiaCard 06000 portable cardiograph manufactured by JSC SOLVAIG, a smartphone with Android operating system with a Cardiolyse client program, an analytical cloud server that performs automatic processing of the ECG signal and gives a detailed report on ECG parameters and Heart Rate Variability (HRV). The research was performed at the Ukrainian Children Specialized Hospital "OHMADYT" Ministry of Health of Ukraine, as part of a budgetary research project research theme "The age-related patterns of the systemic adaptation to night work" (state registration number 0116U000500).

The purpose of this study was to clarify the patterns of the relationship of the ECG and HRV parameters [7-9] with the severity of fatigue (both acute and chronic).

Object of Study

70 medical workers, 23 doctors and 44 nurses, of the the Ukrainian Children Specialized Hospital "OHMADYT" of the Ministry of Health of Ukraine participated in this study. The average age of the subjects was 39.23 ± 1.48 years. The average work experience in this field was 18.16 ± 1.47 years. The average number of 24-hours shifts per month was 6.16 ± 0.37.

Research Methods

The subjects were measured for blood pressure by the Korotkov method, with the calculation of Heart Rate (HR). The following derivatives were calculated:

- Average dynamic (systemic) pressure: ADSP = BP diast. + 1/3 * BP pulse.
- Pulse pressure: BP pulse. = BP syst. - BP diast.
- The coefficient of circulatory efficiency: CCE = heart rate * BP pulse.
- Robinson index: RI = (HR * BP syst.) / 100.

Electrocardiographic study with the calculation of heart rate variability was performed in a sitting position, using six branches from the limbs of three standard - I, II, III and three amplified - AvR, AvL, AvF.

To assess the severity of chronic fatigue was used questionnaire by Leonova A.B. [A.B. Leonova and I.V. Shishkin; modification - 2003 https://psy.wikireading.ru/19729] The semantic differential method, with the definition of such characteristics as "Well-being", "Activity", "Mood", "Efficiency", "Fatigue" was used for a subjective assessment of the functional state.

The body mass index and the ratio of waist and hips circumferences were calculated from anthropometric indicators height, weight, waist and hips.

A breath-holding test on a deep breath (the Shtange test) was used to assess the functional reserve of the cardio-respiratory system and to assess the sensitivity of the respiratory center of the medulla oblongata to hypoxia and hypercapnia.

Mathematical processing of the research results was carried out using the SPSS 21.0 program. The relationship between the indicators was described with non-parametric correlation, using the Spearman's rank correlation coefficient.

The Results of the Study and the Discussion

The subjects were divided into groups according to the severity of chronic fatigue [10-13]. 21 people (age 38.3 ± 2.7 years) with the absence of signs of chronic fatigue (0-17 points according to A. B. Leonova test) were in the first group. The second group included 19 people (age 38.0 ± 2.9 years), with an initial degree of chronic fatigue (18-26 points). The third group included 23 people (age 41.6 ± 2.8

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years), with a pronounced degree of chronic fatigue (27-37 points). The fourth group, with a strong degree of chronic fatigue (38-48 points), included 6 people (age 35.8 ± 5.7 years). The fifth group, with asthenic syndrome (more than 48 points), included 5 people (age 39.2 ± 4.9 years). A correlation analysis was carried out to identify the relationship between the severity of acute and chronic fatigue on the one hand, and the parameters of the functional state of the cardiovascular system on the other within each of the above groups.

In group 1 (no signs of chronic fatigue), no reliable correlations were found between the indicator of the subjective assessment of the current level of fatigue and the indicators of the functional status of the cardiovascular system. At the same time, the level of chronic fatigue (according to Leonova A.B.) negatively correlated with the normalized spectral power of slow waves (LF norm) (r_{sp}.=-0.435; p=0.049), the indicator of vegetative balance (LF / HF) (r_{sp}.=- 0.435; p=0.049), and positively correlated with the normalized spectral power of fast waves (HF norm) (r_{sp}.= 0.435; p=0.049) and the complex indicator "State of myocardial reserves" (r_{sp}.=0.496; p=0.022).

In group 2 (the initial degree of chronic fatigue), the subjective assessment of the current level of fatigue positively correlated with the triangular HRV index (HRVTi) (r_{sp}.=0.493; p=0.032). And the level of chronic fatigue had negative correlations with heart rate (r_{sp}.=-0.532; p=0.023) and the complex indicator "K-1" (r_{sp}.=-0.553; p=0.014), reflecting functional state of myocardium .

In group 3 (marked degree of chronic fatigue), the indicator of the subjective assessment of the current level of fatigue negatively correlated with the duration of the QRS interval (r_{sp}.=-0.555; p=0.023) and the complex indicator "Integral indicators" (r_{sp}.=-0.505; p=0.023). The level of chronic fatigue had positive correlations with the length of the PQ interval (r_{sp}.=0.610; p=0.002) and negative - with the absolute length of the QT interval (r_{sp}.=-0.576; p=0.004), standardized for the QT interval (QTc) (r_{sp}.=-0.572; p=0.004), the complex indicator "K-2" (r_{sp}.=-0.709; p=0.0002), also reflecting functional state of myocardium.

In group 4 (a strong degree of chronic fatigue), the subjective assessment of the current level of fatigue negatively correlated with heart rate (r_{sp}.=-0.841; p=0.036) standardized for the QT interval (QTc) (r_{sp}.=-0.943; p=0.005), the complex indicator "K-2" (r_{sp}.=-0.886; p=0.019), the alpha angle of the T wave in the frontal plane (r_{sp}.=-0.829; p=0.042) and positively correlated with pulse blood pressure (r_{sp}.=0.870; p=0.024), the indicator "Golden Ratio" (r_{sp}.=0.886; p=0.019), reflecting ratio of electrical systole and diastole. The level of chronic fatigue had negative correlations with the partial spectral power of slow waves (LFn) (r_{sp}.=-0.886; p=0.019), the indicator "Index of the emotional state of HRV" (r_{sp}.=-0.899; p=0.015) and a positive one with an indicator of the ratio of the sum of the amplitudes of the T waves to the sum of the amplitudes of the R teeth in leads I, II, III (r_{sp}.=0.829; p=0.042).

In group 5 (asthenic syndrome), the indicator of the subjective assessment of the current level of fatigue positively correlated with the duration of the QT interval (r_{sp}.=0.900; p=0.037), the indicator "SD of the T-wave symmetry by derivatives" (r_{sp}.=0.900; p=0.037) negatively - with the complex indicator "State of myocardial reserves" (rsp.=-0.975; p=0.005).

The level of chronic fatigue had negative correlations with the following indicators (for all r_{sp}.=-0.894; p=0.041): SDNN, RMSSD, pNN20, SDSD, TP, VLF, (LF + HF), LF, LFn, HF, HFn, HF norm, the ratio of the sum of the amplitudes of the T waves to the sum of the amplitudes of the R teeth in leads I, II, III, the complex indicator "State of regulation reserves", "Entropy", "Fractal index", the alpha angle of the T wave in the frontal plane, "Psycho-emotional index". The level of chronic fatigue also negatively correlated with complex indicators "Operational control of regulation" (r_{sp}.=-0.918; p=0.028), "Integral indicators" (r_{sp}.=-0.968; p=0.007), "Complex indicator of regulation" (r_{sp}.=-0.918; p=0.028), "The index of the emotional state by HRV" (r_{sp}.=-0.918; p=0.028).

The following indicators correlated positively with the level of chronic fatigue (for all r_{sp}.=0.894; p=0.041): the breath-holding time on a deep breath (the Shtange test), the stress index R.M. Baevsky (stress index), specific power of the spectrum in Very Low Frequencies (VLFn), normalized spectral power of slow waves (low frequency waves) (LF norm), ratios VLF / HF, VLF / (LF + HF), LF / HF, autonomic vegetative index (R. M. Baevsky) (PSI), "DFA" indicator.

An early analysis of the relationship between the severity of acute (current) and chronic fatigue and the parameters of the functional state of the cardiovascular system in the group of doctors, without breaking them into groups according to the results of the test by Leonova A., did not reveal a large number of significant correlations. However, breaking down the samples into groups by the level of chronic fatigue, showed the presence of a fairly large number of significant correlations in these subgroups.

The minimum number of correlations was found in individuals with no signs of chronic fatigue, and then the number of these connections increased, as they moved closer to the group with asthenic syndrome, where it was maximum. At the same time, as can be seen from the above results of the work, not only the number of links, but also their strength increased. The severity of acute and chronic fatigue was associated with both the parameters of the functional activity of the autonomic nervous system (assessed by HRV) and the parameters of the functional state of the myocardium (assessed by both generally accepted ECG indicators and the integrated integral indicators proposed by the authors).

It is interesting to note that in individuals with a strong degree of chronic fatigue, the indicator of the subjective assessment of acute fatigue was positively associated with pulse arterial pressure, thus, it was indirectly associated with the mechanical power of the heart.

Also noteworthy is the fact that in individuals with asthenic syndrome, the severity of chronic fatigue (as determined by A. B. Leonova) positively correlated with the breath-holding time during inhalation. This phenomenon can be explained by an increase in the body's resistance to hypoxia, which can be achieved either by reducing MOC (maximum oxygen consumption) or by reducing the overall intensity of metabolic processes in the body. However, this can be explained by an increase in the irritation threshold of the respiratory center with carbon dioxide, that is, it can be considered as a result of dysfunction of the central nervous system. In any case, further research will be needed to clarify this issue, with an assessment of thyroid function, gas exchange, BMD, and thermoregulation.

Conclusion

The results can be used to quickly assess and predict the development of severe fatigue that develops during a work shift using ECG and HRV monitoring. The higher the level of fatigue, the more significant are the correlations with ECG and HRV parameters.

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