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Heart Rate Variability and Mental Status of Teachers as Parameters of Occupational Health

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***Abstract*—Stressful situations, especially of a psychological nature with reduced motor activity, create conditions for the tension of the regulatory systems of the human body. Teachers belong to a group of professions prone to disruptions in adaptation and the appearance of pathological deviations and the occurrence of diseases. They are the ones who need regular monitoring of the level of stress and measures to maintain and strengthen the level of health. The functional state of the body is an integral characteristic of the state of health and the maintenance of homeostasis by mobilizing functional reserves is its goal. The degree of tension of regulatory systems characterizes the level of the functional reserve of the body, a decrease in which impairs the body's ability to adapt to the measured conditions of the external and internal environment. In this case, overstrain and depletion of regulatory mechanisms become main risk factors for health. Since cardiovascular system with its regulatory apparatus is an indicator of the adaptive reactions of the whole organism, we used heart rate variability to assess the level of the functional reserve. This allowed us to assess the general tension of regulatory mechanisms and functional state of the organism as a whole.**

Keywords—health, professional health, professional and psychological qualities, performance, functional state, adaptation

I. INTRODUCTION

Modern conditions of labor activity of workers in the educational system in the current circumstances, exacerbated by the pandemic, require rethinking. There is a need in a deeper approach for studying the problem of psychophysiological and adaptive characteristics in the teacher's personality.

The most alarming circumstance in the study of characteristics is, on the one hand, serious professional requirements for the teacher's activities from the position of society and, on the other hand, the decline of the prestige and authority of the teacher.

These phenomena have an ambiguous effect on the socio-psychological atmosphere of the teacher's professional activity, thereby reflecting on their mental and physical health.

The combination of all factors, both external and internal, leads to the need for studying professional health, associated with professional burnout and maladjustment characteristics. Researchers define professional health of a teacher as the ability of the basic mechanisms inherent in a human body (compensatory, protective, regulatory) to ensure a person's working capacity, and his/her development in the process of professional activity [1], [2].

The problem of professional health is positioned on the interface of psychological, medical and pedagogical sciences. Many Russian researchers see the main reason for the occurrence of professional burnout in the chronic professional stress of teachers [3], [4], [5], [6], [7], [8], [9], [10], [11], [12].

The closest to our research are the works on the relationship of psychological and psychophysiological such as V. I. Maistrenko [13], G. G. Berntson [14], J. T. Cacioppo, L. G. Tassinary [15].

The ideas about changes in temporal and especially frequency indicators of heart rate variability during the formation of individual symptoms of emotional burnout have been significantly supplemented by N. A. Agadzhanyan, R.M. Baevskiy and A.P. Berseneva [16], [17], F. Shaffer and J. P.

Ginsberg [18], M. Shakouri and L. H. Ikuma [19], F. Aghazadeh, I. Nahmens [20].

The purpose of the work is to study the psychophysiological characteristics that are represented by such parameters as a heart rate variability (HRV) and the mental status of teachers.

II. Materials and Methods

The main research methods of this problem:

- theoretical (study and analysis of philosophical, psychological and pedagogical literature on the research problem);
- diagnostic (questionnaire survey, testing) [21].

At the theoretical level, the study was aimed at identifying the essence of the concepts of "professional burnout", "occupational stress", characterized by maladjustment, a decrease in the level of stress resistance and a change in the frequency indicators of heart rate variability.

At the empirical level, the study was focused on identifying the psychophysiological characteristics of the teacher's personality in the educational system, directed to formation of a professional stress-resistant state with the ability to regulate the frequency indicators of heart rate variability.

The neurovegetative regulation of the heart rate of teachers may be caused by changes in the frequency indicators of heart rate variability and may reflect the degree of formation of phases and symptoms of professional burnout.

The purpose of the work is to study the psychophysiological characteristics that are represented by such parameters as a heart rate variability (HRV) and the mental status of teachers.

The object of the study are teachers with a reduced level of stress resistance working at schools in Naberezhnye Chelny.

The subject of the research is neurovegetative regulation of heart rhythm and features of the functional state, maladaptive disorders of teachers.

III. Results and Discussions

The subject teachers who had previously passed the selection for the level of stress resistance were chosen as our sample. The majority of the group were women with mean age of 43years old.

The study took place at the end of the working week and met the requirements for conducting such events. Before the start of the study, the adaptation period was maintained for 5-10 minutes. HRV recording and psychological testing were carried out in a sitting position with calm breathing. All possible interferences leading to emotional excitement such as conversations, phone calls and the appearance of other persons in the office were excluded.

We used statistical and spectral methods for analysis of the HRV results. There is normally a slight (10%) irregularity of sinus rhythm in case of a healthy person at rest. This arrhythmia is known as respiratory arrhythmia of the heart. It increases with inhalation and decreases with exhalation. An excessively stable rhythm, accompanied with significant increase in the central circuit, indicates its rigidity. The stable rhythm consequently results in a depletion of neurohumoral regulatory mechanisms.

For the majority (the 69% of the surveyed teachers), the functional state is assessed as permissible or maximum permissible, for the 26.7% it is critical, with a tendency for this indicator to deteriorate with age (r = 0.8) «Table 1».

TABLE I. Average values of temporal and spectral HRV indicators of the studied teachers

index	value
RRNN, ms	795.5+22.1
SDNN, ms	46.7+11.2
Heart rate, HR (beats per minute)	76.4+2.3
MxDMn (ms)	215.9+50.8
Stress index, Baevsky index (%/ms^2)	319.9+63.9
Total spectral power, TP (ms^2)	4598+2472.4
VLF (ms^2)	534.1+163.9
Low-frequency, LF (ms^2)	1619.6+882.4
High-frequency, HF (ms^2)	2444.2+1448.0
LFnorm (%)	49.1+4.6
HFnorm, (%)	50.9+4.6
LF/HF	1.2+0.2

The duration of RR-intervals (RRNN) is 795.5±22.1 ms, heart rate (HR) 76.4±2.3 beats per minute, Standard Deviation of the Normal-to-Normal (SDNN) 46.7±11.2 ms, MxDMn 215.9±50 ms, stress index 319.9±63.9%/ms^2. Majority of the surveyed teachers (62.5%) has a tension of regulatory mechanisms, whereas 20% of the teachers are in a state of maladjustment or overstrain.

We performed a spectral analysis of HRV, interrelated with the activity and balance of the sympathetic and parasympathetic parts of the nervous system, the general adaptive potential, the activity of ergotropic and humoral-metabolic mechanisms of regulation of the HR.

High-frequency waves, the power of which characterizes vagal activity and the autonomous circuit of heart regulation in teachers, on average, is 2444.2±1448 ms^2, while the physiological norm was detected only in the 6.25% of the teachers with up to 35 years old of age.

Vasomotor waves (slow first order) characterizing the state of the subcortical nerve centers, i.e. sympathetic nervous sysrem (SNS) activity, in particular - the regulation of vascular tone is on average 1619.6±882.4 ms^2, while the physiological norm was also found in a small part (6.25%) of the teachers.

Waves of a very low frequency of the second order, despite the controversial nature of the physiological nature of this component, according to some researchers, reflect the activity of the intersystem level of control - ergotropic and humoral-metabolic mechanisms of HR regulation. On average, this figure was 534.1±163.9 ms^2.

It can be assumed that the process of blood pressure regulation in the examined teachers is carried out due to nonspecific mechanisms and by activating the sympathetic part of the autonomic nervous system, which leads to psychoemotional stress and functional changes in the state of the cerebral cortex.

The vagosympathetic balance coefficient averages 1.2±0.2 the majority (the 62.5% of the teachers) has a predominance of the sympathetic or parasympathetic division of the autonomic nervous system (ANS).

Neurotic conditions such as anxiety, neurotic depression, asthenia, hysterical type of behavior, obsessive-phobic and autonomic disorders were investigated and evaluated using a clinical questionnaire. A value greater than +1.28 indicates a sufficient level of the indicator, less than -1.28 indicates a decrease in the level of the studied state, and a value in the range from -1.28 to +1.28 indicates an intermediate (transient) result «Fig. 1».

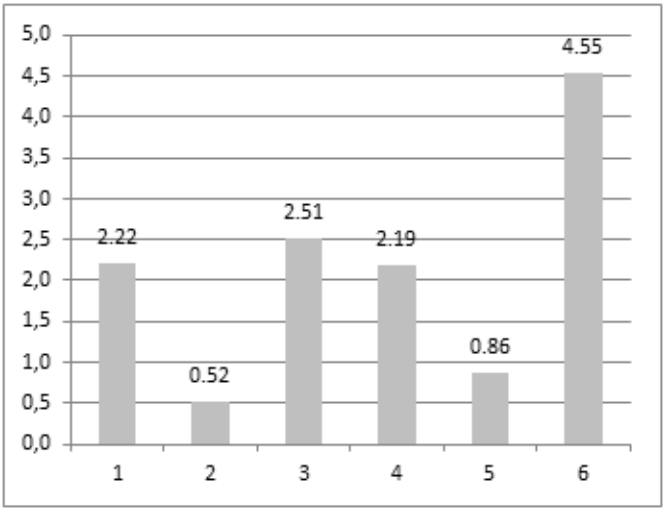

Fig. 1. Indicators of diagnostic coefficients (conventional units) of neurotic states of the examined teachers. Note: 1 - anxiety, 2- neurotic depression, 3 - asthenia, 4 - hysterical type of behavior, 5 - obsessive-phobic disorders, 6 - vegetative disorders

Analysis of the examination results, employing the clinical questionnaire by K.K. Yakhina and D.M. Mendelevich, demonstrate a high level of neurotic disorders. Depressive and obsessive-phobic disorders were most often determined, less often anxiety and asthenia. Some teachers showed simultaneous changes in mental disorders on several scales.

As the coefficient of neurotic depression is on average 0.52+0.8, the 16.7% of the surveyed teachers also have pronounced disorders, while the 50% of the surveyed teachers have an intermediate state.

Expressed obsessive-phobic disorders are also noted in the 16.7% of the teachers with an average value of the coefficient 0.86+0.8.

The coefficient "anxiety" averages 2.22+0.9, whereas the 16.7% of the teachers also have a pronounced anxiety. With an average value of asthenia in the study group of 2.51+1.1, the 16.7% of the teachers are in a state of severe asthenia. The studied group of the teachers is not characterized by a hysterical type of behavior, the diagnostic coefficient averages 2.19+0.8, but the 33.3% of the teachers are in an unstable state.

According to the results of the clinical questionnaire, the 83.7% of the teachers do not notice autonomic disorders in themselves. The average value of the coefficient is 4.55+2.3.

It should be noted that only the 16.7% of the teachers surveyed are in a state of stable mental adaptation without manifestations of one or another neurotic disorder. However, the 66.7% of the teachers were found to have unstable states due to increasing neurotic depression and obsessive-phobic disorders.

The questionnaire of maladaptive disorders reveals asthenic and psychotic reactions and states of the subjects. All the surveyed teachers showed signs of maladaptive disorders (MAD) «Fig. 2».

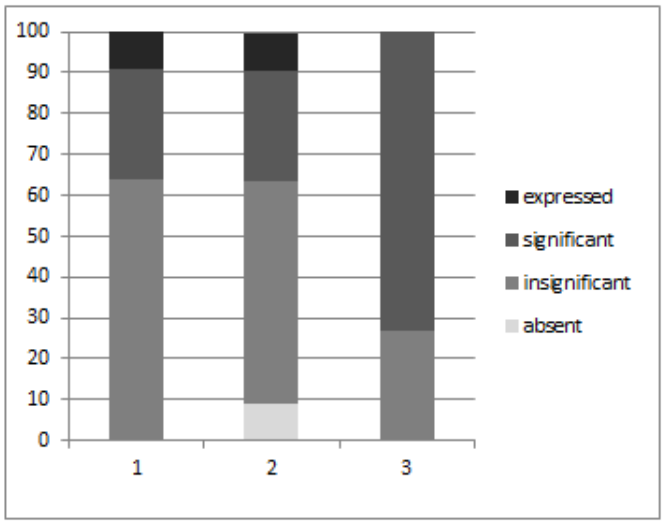

Fig. 2. Indicators of maladaptive disorders (%) of the studied teachers (1- integral assessment, 2 - asthenic reactions, 3 – psychotic reactions)

The average MAD in the study group was 6+0,5. Minor maladaptive disorders are observed in the 63.6%, while significant signs of violations are noted in the 27.3% and pronounced – in the 9% of the teachers.

As the average value of asthenic reactions is about 6+0.6, the only the 9% of the teachers have no signs of violations. For the rest, they are either insignificant (54.5%), or tangible (27.3%), or pronounced (9%).

Psychotic reactions average 5+0.2. At the same time, all the teachers show either minor (27.3%) or significant signs (72.7%) of violations.

The results of the "Tapping test" of the studied teachers showed increasing fatigue and weak switching of the nerve centers of the motor analyzer «Fig. 3». The analysis of the value of motor asymmetry did not reveal any significant severity of the leading hand (the coefficient of asymmetry falls within the range [-0.1; +0.1]). However, indicators of the state

of dynamics of fatigue, lability, and strength of the nervous system of the right and left hands differ.

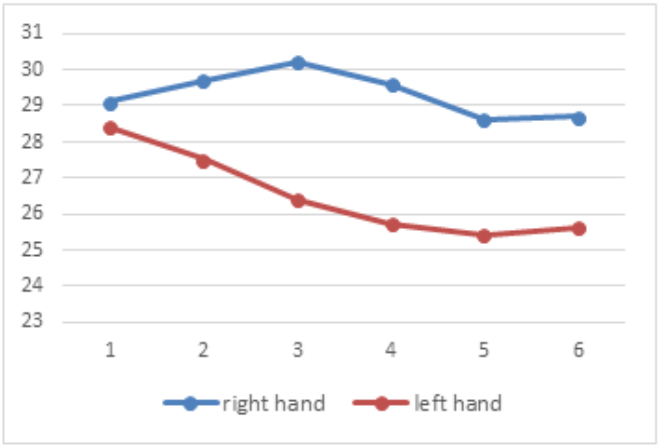

Fig. 3. Dynamics of fatigue of the nerve centers of the motor analyzer (number of beats per every 5 seconds)

A strong nervous system (increasing and convex types of dynamics of nervous processes) is found only in the right hand (30% each) of the studied teachers «Fig. 4». Average strength (even type of dynamics) in half of the observed samples (50%) in the right and 10% in the left hand. Weak (30%) and medium-weak (50%) strength of the teachers' nervous system is revealed to a greater extent in the results of the tapping test on the left hand.

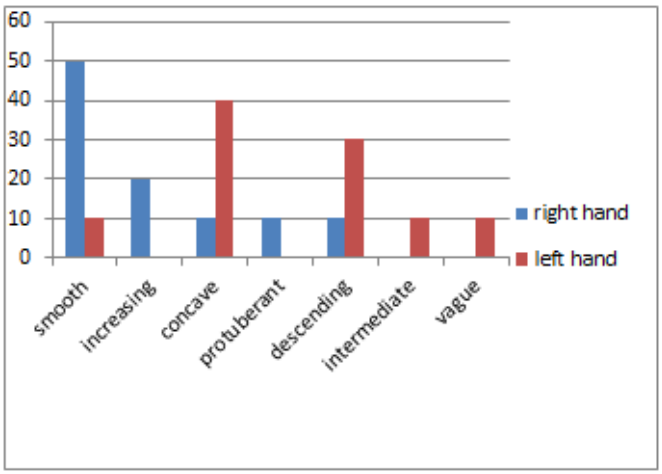

Fig. 4. Type of dynamics of the maximum rate of the studied teachers (%)

Majority of the teachers has a weakly labile nervous system. On the left hand: low for the 10%, below average for the 80%, average for the 10% of the teachers. On the right hand: the 30%, the 40% and the 30% of the teachers, respectively. We evaluated the strength (endurance) of the nervous system by the amount of beats. On the right hand: the 20% of the teachers have the endurance of the nervous system below average, the 60% have average, the 20% of the teachers have above average. On the left hand: the 60% and the 40% of the teachers, respectively (below average and average).

IV. Conclusion

Most of the surveyed teachers are in a state of unstable or severe mental maladjustment with manifestations of anxiety, signs of asthenic and psychopathic reactions. The analysis of cardiointervalography revealed functional disorders of vagosympathetic balance, activity of ergotropic and humoral-metabolic mechanisms of heart rate regulation.

Some teachers need a complex psychophysiological correction of their health.

The practical significance of the study is determined by the possibility of using the peculiarities of the state of the functional systems of the body. Effective preventive measures and training programs can be developed for restoration of the psychoemotional status and health of teachers, as well as for the prevention of personality crises.

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