QUANTITATIVE PARAMETERS OF HUMAN'S FUNCTIONAL STATE IN THE ERGATIC LEARNING ENVIRONMENT

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Abstract: Modern learning process designed for the widespread use of computers and immersive educational environment. A number of papers (see [2], [7]) show the changes in the functional state (FS) of the people working at the computer, which then leads to the persistent violations of the FS. We have considered the possibility of using the integral test - measuring the electroskin characteristics in some micro-zones (ESC MZ) on the human body, in ergatic or immersive computer system to assess its FS. The results showed significant differences in the number of ESC MZ after classes conducted in an ergatic learning environment.

Introduction: The number of people who use computer equipment at work, leisure and education, using internet, reached 2 billion and continues to grow rapidly. Therefore it is advisable to focus on human working conditions in the computer ergatic learning environment.

The spread of computer systems is due to their interactivity, making it possible to communicate directly with any person "on the other side of the screen", or an active dialogue with the information system, its structure similar to the real communication between people [1]. As a result, users spend ergatic system "man-computer" for many hours every day. People around the world are included in a variety of ergatic computer systems as an integral part of them. The main feature of a computer system from any other technical system is its Immersiveness. Therefore, there are actual issues of preserving their health in these circumstances, to compensate possible negative effects on human FS.

Objective:

1. To study the effect of human staying and working in the ergatic environment onto changes in his/her FS;

2. By the methods of valuation changes in heart rate variability (HRV), upper limbs rheovasography (RUL) and the ESC MZ set quantitative indicators such influence.

Materials and methods:

The statistical processing of the measurement results was carried out with the help of the standard software package STATISTICA 6.0.

As a model of work situation in the ergatic system the educational process with the use of computers has been selected. To conduct the study were randomly selected group of 157 individuals, university students, aged 18-19 years, 71 males and 86 females. Dosage cognitive load for them is a 4-hour training sessions, held in ergatic computer system. Classes include familiarization with theoretical material and execution of practical work only on the computer. Students had to comply fully with the job offered to them and to pass final computer testing to assess the quality of learning and practical skills. The studies were conducted at the same time of the day - from 12.00 to 16.00, to avoid the influence of circadian rhythms on the overall study.

We hypothesized that quiet work ergatic system can lead to functional stress, having, in all probability, the nature of specific fatigue varying degrees [2]. Many studies have noted that the indicators used for these purposes in the last 30 years have been measuring the performance of cardio - vascular activity. There is exist the concept, that the analysis of the physiological mechanisms of heart rate regulation makes it possible to obtain information about the functional state of the whole organism [4]. Violation of the autonomic regulation of the cardiovascular system is an early sign of the body's failure to adapt to stress and leads to a decrease in efficiency. [5]. Therefore, the research program included such instrumental methods:

- Heart rate variability HRV;
- Upper limbs rheovasography RUL;
- ESC MZ.

HRV indices enable quantifying the impact of the rhythm of the heart of the central, autonomic, humoral, reflex regulation and evaluation mechanisms on the basis of this current human FS and its adaptation reserves. [8], [9].

For the analysis, we have chosen to assess HRV in short segments (5-minute recording time) and used the time (RR, SDNN, rMSSD, pNN50) and frequency (HF, LF, VLF, LF / HF) factors. The analysis of HRV in short segments excludes the impact of the activity of the sinus node of different physical and mental activity, circadian changes.

RUL is among the non-invasive methods, allows us to study the dynamics of the pulse volume of tissue. RUL makes it possible to distinguish between different types of collateral and the main blood, to diagnose disorders of the venous outflow. RUL recording was carried out according to standard procedures.

Correlation between the changes of ESC MZ and person's FS described in the well-known works Y.Nakatani, A. Nechushkin. [10] [6]. Registration of ESC MZ was carried out according to Nakatani test [6]. For establishing the correlation between the values of ESC MZ and HRV and RUL parameters, such measurement was conducted simultaneously with the registration of HRV and EGR.

Registration of all the mentioned FS parameters was fulfilled in two stadies. The first records were conducted before the work in the computer learning system. Second - after the end of the final test.

The discussion of the results

It was found that as a result of the 4-hour lesson in computer ergatic system functional state of study participants changed.

HRV. The total capacity of TP frequency spectrum from 0.015 to 0.15 Hz, which expresses the total activity of the autonomic nervous system influence on heart rate, increased by almost 16%. Growth occurred in all ranges of the spectrum, especially the significantly increased rate of the power spectrum of low waves LF. Growth in the VLF range was 14%, it reflects the increased activity of the slowest system circulatory regulation - humoral - metabolic. The low-frequency part of the spectrum, LF, has increased by 17%. High power HF oscillations increased by

almost 13%. Despite the increase in performance as the sympathetic and parasympathetic regulation of the cardiovascular system, sympatho - vagal index, LF / HF, that characterizes the balance of sympathetic and parasympathetic influences on heart rate, increased by only 6.33%. This indicates a slight shift of the vegetative balance towards the dominance of the sympathetic division of the ANS, which is characteristic of the stress of the body. [9] The national methodological recommendations invited to consider the LF / HF index vagosympathetic interaction that reflects the relative activity of the sympathetic nerve center of the medulla oblongata [Baevsky R.M. et al., 2001].

Indexes of variation pulsometry decreased. The amplitude of mode, reflecting the stabilizing effect of centralization the heart rhythm management, showed a decrease in the number of cardio intervals, corresponding to the value of mode, as a percentage of the sample volume by nearly 7%. The tension index of regulatory systems decreased on almost 13%. This is a very sensitive indicator of VNS, it characterizes the activity of the sympathetic part of ANS. Significantly decreased the index of autonomic balance and vegetative index rate, 11% and 7% respectively.

The essential difference between the initial and the resulting measurements are in several MZs: IG, TR, GI, R, VB (here is used the French classification of MZs). ESC on right and left sides of the body has changed in the same way, while maintaining the direction of change (increase or decrease values on the right and on the left side of the body).

According HRV, significantly correlated with ESC MZ such indicators:

1. Provisional indexes: SDNN; RMSSD, pNN50.

2. Spectral Analysis Indicators: TP (total power in the frequency range of ≤ 0.4 Hz); HF (power in the high frequency range (0.15 - 0.4 Hz)); LF (low power in the range (0.04 - 0.15 Hz) band); VLF (power in the range of very low (≤ 0,04 Hz) frequencies).

3. Indicator sympathetic-parasympathetic balance (index of regulatory systems tension).

The coefficient of concordance between the HRV parameters and values of the ESC MZ and right and left sides of the body is at 0.75 ÷ 0.87 Ranked correlation coefficient $r = 0.74 \div 0.87$; $p < 0.01$.

We found some of the most highly correlated with each other (Spearman correlation rank up to 0.72, $p < 0.01$) of HRV and ESC MZ. The most severe was correlation with indicators of HRV changes in the following micro zones: MC, C, P, V, VB. However, the most strongly correlated with indicators of HRV microzones were not the most pronounced changes in their values measured at the end of classes. The average values of the left and right side measurements decreased in total by 7% at the end of classes compared with the beginning. Some MZ decline was more than 10%: R, IG, VB, P, TR, GI.

As a result of changes in the definition of indicators of RUL was the most pronounced changes in correlation parameters RUL and changes in the following MZs: F, IG, RP, P, VB, R (coefficient of correlation from 0.54 to 0.65.).

Revealed variations in functional state of the peripheral circulation, and these deviations were different at the left and right forearm. The right forearm showed greater resistance to the applied load. Diastolic wave characterizing venous outflow, remained stable on his right hand and dropped on the left for more than 30%. Notch factor, giving an idea about the state of peripheral vascular resistance, increased on the right forearm at 15% and remained stable on the left. Time of fast blood supply due to the size of the stroke volume of the heart and the elasticity of the large vessels walls, fell on the left forearm to 21.4% and remained the same on the right. At the same time the heart rate changed slightly - less than 3%. On the left forearm at 14% decreased the peripheral resistance coefficient, which reflects the tone of the arterioles, but improved blood circulation in the vessels of small caliber - by 13% and increased by 15% tone of medium and small arterioles, left and right. Especially significant, at 40%, the same right and left asymmetry increased blood supply to the small blood vessels.

ESC MZ showed a significant change. Although the mean values of measurements decreased generally by 7% at the end of classes in comparison with

the beginning, we believe that the assessment of changes in indicators ESC in each MZ Group should be held separately, as each group of the MZ is a separate FS parameter, which can not be summarized with the others. For some MZs decreasing was significant: GI - 18 and 26%, TR - 28% of the right and left, R - 14% of the right and left, IG - 7% and 15%, respectively, VB - 15% of the right and left. The VB and C decrease on the left side was more pronounced than on the right: 7% and 3%; 10% and 4%, respectively.

Conclusions:

1. The results of the investigation showed that training in ergatic computer environment is an essential functional load at the human FS.

2. The quantitative values of such FS changes in learning ergatic system are described.

3. As the study revealed a significant correlation between HRV parameters, RUL and ESC MZ, the ESC MZ parameters can be taken as a way to provide reliable criteria of the human condition under the influence of ergatic system "man - computer" that has high immersivity in comparison with non-computerized classes.

In our other studies we have shown that learning in laboratories without the immersive computing environment does not have such an effect on the student's FS. In that case HRV and ESC MZ parameters changed within a range that not exceeds the statistical error.

These changes are transient in nature. They arise as a result of studying in ergatic computing system. Controllable parameters of FS in our observation are fully restored to the following lesson. However, that such changes do not become FS stable, to compensate these changes proposed to carry out small sports breaks, with the implementation of a special complex for body and eye exercises. It is advisable to complement planned physical training exercises espesially for the eye muscles, which is not applicable now.

Literature

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