Methods of the passenger`s functional state research

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Abstract – The research of the functional state (FS) of the passenger is important for assessing the quality of service of transportation by public transport. Analyzed techniques can be used during research of human's FS. The advantages and disadvantages of different methods of evaluation of FS are established.

Keywords – functional state, psychological and physiological parameters, electrocardiogram, heart rate variability, RSA index.

I. Introduction

Functional state is a set of indicators that characterize the ability of a person to perform the necessary functions under certain conditions. In addition, it is an opportunity to maintain the necessary level of efficiency in the adverse environmental impact [1-5].

For a passenger, it is important how its functional state changes after the trip by public transport and the subsequent ability to perform the necessary work correctly.

N. Gulev notes that the formation of FS is influenced by psychological indicators (they demonstrate changes in psychological processes), and physiological (changes in human body systems) [2].

II. Analysis of literature

Today, there is a large number of methods for identifying, analyzing and characterizing the passenger's FS. The most complete description of them is in the source [1]. Many methods used in psychophysiology were borrowed from sport's medicine and professional selection and training of astronauts [3].

Among the psychological methods of determining the FS is distinguished an analysis of changes in the structure of the visual process and the solution of problems in accordance to Derevyanko, as well as various questionnaires and tests [1-3]. The most widespread of these are: the "clock" test, aimed at the study of spatial imagination; questionnaire of Eysenck, to determine the type of temperament; red-black tables of Schulte-Platonov and "proof-reading test" used for research of attention [3].

However, physiological methods have become more widely used. Possibly, there is an estimation of the FS on the frequency and depth of breath (electropneumography), that is, with extraneous influences, the number of breaths-exhalations per minute increases and depth decreases. One of the methods also considers an indicator such as blood pressure. Its elevation indicates that the body is experiencing some stressful influence. The critical flashing frequency estimates the state of the visual analyzer when a person ceases to notice the individual light streams that flash with a certain increasing frequency and begins to see a continuous flow. An electromyogram demonstrates the potentials of the muscles when stimulation is spreading by muscle fibers [1].

The most used methods for determining the FS are [1,3]:

- electroencephalography;
- skin-galvanic reaction;
- Electrocardiography.

Electroencephalography (EEG) evaluates the processes occurring in the pasamger's brain. The removal of indicators occurs in stationary conditions using special electrodes, which are fixed on the human's head. The assessment consists in determining the potential difference between the two points of the brain. The most effective use of this method is in the study of a single factor, because in another case, different areas of the cerebral cortex will be affected, which can lead to distortion of the results. EEG displays the biopotentials of the brain, expressed by some rhythms. Exactly the change in these rhythms shows the transition of man from one state to another. The disadvantage of the method is the inability to use it in the process of passenger's movement due to the need for no movement during the experiment [1, 3].

The skin-galvanic reaction consist in assessing of the electrical conductivity of the skin of the passenger. The essence of this method is also to determine the difference in potentials with an increase of sweating, electrical conductivity of the skin, which is observed when a person develops nervous activity. The advantage is the simplicity of registration, as well as the independence of the subjective factor. And disadvantage is insufficient informativeness [1, 3].

The most common and studied is method of research of the FS by an electrocardiogram (ECG) analysis. The basis of the analysis is the investigation of the record of potentials that occur during the excitement of the heart muscle. These potentials while recording are displayed in the form of teeth. Their amplitude, frequency, duration, distance between them are the main characteristics of the work of the heart [4].

One of the methods for assessing the relationship between the work of the heart and the nervous system in general and the reflection of the process of adaptation of the organism to the environment is the variability of the heart rate (HRV) [4].

III. Heart rate variability and its indexes

There are many methods for determining and analyzing HRV, but the most comprehensive assessment is given by the regulatory systems activity index (RSA index) implemented by R. Baevsky. This is the sum of conditional points, which are determined on the basis of different indicators of HRV [2, 3, 6]:

- mathematical expectation (M, rNN) is the average of all R-R intervals in the sample. Its elevation reflects the high functionality of the cardiovascular system, and the decrease – activation of high levels of regulation of the heart rate;

• mean square deviation (δ, SDNN) – characterizes the state of regulation mechanisms, inversely degree of activity of the sympathetic part of the autonomic nervous system (ANS);

• mode (Mo) – shows the number of R-R intervals that are most commonly encountered, the most likely level of operation of regulatory systems;

• variational sweep (VS, dX) is the difference between the largest and the smallest value of the cardiointerval, the index of the maximum amplitude of the regulatory influences of the ANS;

• Mode amplitude (AMo) is the percentage of cardiointervals that correspond to the mode range. The increase points to the growth of the activity of the sympathetic nervous system (SNS) and the high mobilization of the circulatory system, while the decrease is due to the predominance of the parasympathetic nervous system (PSNS) and the weak centralization of cardiac rhythm control;

• coefficient of variation (CV) is a normalized estimate of the mean square deviation. The increase demonstrates the shift of the vegetative equilibrium towards the growth of the activity of the PSNS;

• spectral power in the range of very low frequencies (VLF);

• spectral power in the range of low frequencies (LF);

• spectral power in the range of high frequencies (HF).

In addition, to determine the RSA index it is necessary to calculate the tension index (TI), which can serve as an independent index of passenger FS. It characterizes the state of the central contour of regulation, the activity of sympathetic regulation mechanisms and is calculated [3-5]:

$$TI = \frac{AMo}{(2dX \cdot Mo)}; \quad (1)$$

This indicator is extremely sensitive to the effects of the SNS. For significant stresses can grow in 5-10 times. Normally, it is 80-150 conventional units.

From the indicators above you can calculate RSA index [3, 5]:

$$\text{RSA index} = |A| + |B| + |C| + |D| + |E| \quad (2)$$

A – the total effect of regulation (rNN);

B – function of automatism (SDNN, dX, CV);

C – vegetative homeostasis (dX, AMo, IH);

D – stability of regulation (CV);

E – activity of nerve centers (VLF/TF, LF/TF,HF/TF).

The value is expressed in conditional balls from 1 to 10 and describes a certain functional condition of the passenger [2, 3]:

• 1-3 points – the state of optimal stress or physiological norm;

• 4-5 points – moderate tension, to adapt to irritants additional functional reserves are required;

• 6-7 points – the state of intense stress, active mobilization of protective mechanisms;

• 8-10 points – state of exhaustion (asthenization), failure of adaptation. The body does not cope with stress, the activity of control mechanisms decreases, signs of pathology appear.

Conclution

Each of the analyzed methods provides important information about the passenger's FS.

The most accurate and easy to use is the calculation of RSA index of Baevsky with the help of indicators determined on the basis of the analysis of the recording of the electrocardiogram.

However, for the sake of completeness of the information it is expedient to use the considered methods in the complex.

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