THE FUNCTIONAL STATUS OF EXTREME ACTIVITIES OPERATORS ASSESSING METHOD

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Abstract. The article substantiates that for a reliable assessment of the physiological state of people engaged in extreme activities, a holistic, integral assessment is necessary, which is formed on the basis of a systemic approach and taking into account various physiological parameters, namely, visual-motor reaction; tapping test; blood pressure; pulse; Stange test; Genchi test; galvanic skin response (GSR); self-assessment of condition using the well-being, activity and mood assessment test (SAM). For visualization and quantitative assessment of the functional state, a petal diagram was used, which allows for dynamic assessment of homeostasis and provides a more accurate assessment of a person's ability to adapt to extreme conditions. To interpret the obtained values of the integral indicator, its norms were calculated based on official statistics of the Ministry of Health of Ukraine for the selected age group of 25–35 years. Using the example of individuals who have experienced physical stress, the effectiveness of this approach in identifying individuals with potential limitations in their adaptive capabilities is demonstrated. An algorithm for implementing the method is presented, and integral indicators are calculated. The findings of this study provide a valuable tool for selecting and monitoring individuals engaged in extreme activities.

Keywords: Homeostasis, Extreme conditions of activity, Functional state of the organism, System approach, Assessment, Integral indicator.

1. Introduction

The human body as a biological object is an organized complex of functionally related organs and systems, the interaction of which ensures life, in particular, in extreme and constantly changing conditions. Under such conditions, the human body is able to maintain structural and functional stability (homeostasis), which ensures an appropriate level of human health, good health and an adequate level of performance. An indicator of homeostasis, in fact, is the functional state (FS) of the body, which consists of several components, namely, indicators of the state of the cardiovascular, respiratory, nervous systems and self-assessment of the body's condition.

Extreme types of professional activity of a human operator require the highest regulatory and adaptive capabilities of the human body. Indicators of adaptive capabilities are the speed of return of the functional system indicators to the normal state after stress or load. In particular, if during exercise the indicators begin to significantly exceed the norm and then within several hours do not return completely to normal, then we can judge the insufficiency of the body's adaptive capabilities.

2. Drawbacks

To date, there is no unified point of view on the component composition of the body's FS. Some scientists distinguish emotional, volitional and cognitive components, others include socio-psychological, psychological, psychophysiological, physiological, motivational, emotional and activation components, and also assume the existence of non-specific and specific components of FS. When describing and assessing FS, many methodological approaches are used, based on a significant variety of indicators. In particular, physiological, psychological, complex and structural methods are distinguished. The principles of integrity and multilevel state indicate the inadmissibility of the preference of physiological or psychological methods, and in combination with the principles of structurality and integrativeness of the state – the need to use structural methods [1–6].

That is why the task of creating a method for assessing FS, based on the principle of systematicity, which ensures the study of the human body as a holistic structure and the assessment of its condition by an integral indicator, is relevant. Such an approach will provide a qualitative assessment of the FS of the body and will allow to detect with high probability whether the body is in a state of homeostasis, and therefore the quality of the results of professional selection of operators of extreme activities.

3. Goal

The aim of the article is to improve the professional selection of operators of extreme activities by applying the developed integrative method of assessing adaptive capabilities based on a systems approach.

4. Features of assessing a person's functional state

Any forms of living nature are considered as open self-regulating integral systems capable of maintaining structural and functional stability (homeostasis) in variable or extreme conditions of existence. The mechanisms for ensuring such stability are very diverse and have been fixed in the course of long evolution at the genetic level. They are aimed at the formation of various forms of adaptations at all levels of the organization of living systems. The organism as an open system exchanges matter, energy and information with the external environment, reacting to them in one way or another, which ensures the constancy of the internal environment, i.e. homeostasis [5, 6].

The functional state of a person (FS) is a whole complex of properties that indicate the level of his vitality, is the basis for characterizing the activity of the organism in certain conditions, directions, with the available reserve of strength and energy and serves as the main criterion for characterizing the capabilities of a person. The general functional state of the human organism consists of certain changes. They occur in all its physiological systems, acquire shifts under the influence of mental processes, such as sensation and perception, thinking and memory, attention and imagination. It also depends on subjective experiences. Because of this, the FS of the organism in each specific situation is unique. Nevertheless, scientists have identified the main ones: normal vital activity, borderline, pathological.

The assessment of these states is based on the interaction of various functional systems as units of integrative brain activity. It has been established that in the process of work, three functional systems are activated - the main (reflex acts in the form of movements, actions according to the type of specific work activity; secondary (human reactions to stimuli that are extraneous to the main functional system); and restorative (the body's reactions in response to the depletion of energy substances). These three functional systems enter into neurophysiological conflict with each other, since they are incompatible at the same time. However, due to the coordination function of the brain, work activity is carried out effectively. But this state persists until the body's reserves exceed a certain limit [9, 10].

The restorative functional system, through the process of inhibition, blocks the execution of the labor process, which constitutes the main functional system. As a result, labor activity slows down, unnecessary and inaccurate actions and movements occur during work, attention is scattered, thinking deteriorates, reactions to side stimuli intensify, and neuro-emotional tension increases. To force oneself to work, the employee needs great tension and willpower. This leads to significant changes in the indicators of the cardiovascular system, gas exchange and the activity of other internal organs, which determines his general and professional success in work, including extreme ones [11, 12].

Modern FS assessing methods widely use physiological indicators, in particular EEG (electroencephalogram), ECG (electrocardiogram), GSR (galvanic skin response), respiratory rate (RR), skin temperature, blepharomotor response, blood pressure, stroke volume and minute blood volume, etc., as well as biochemical indicators. When using physiological indicators of FS, it is necessary to take into account a number of aspects:

– specificity of human reactions;

– change of a particular indicator depending on its initial value (Wilder's law);

– nature of vegetative reactions, which may depend on the basic properties of the nervous system, gender, age characteristics, as well as on general physical fitness [12, 13].

5. A systematic approach to forming an integral indicator

The systems approach is based on the definition of a system consisting of many elements, since the physiological function of the organism is ensured by a different set of functional indicators. A living organism, which includes such levels of organization as molecular, subcellular, cellular and tissue-organ, is not a simple sum of these systems in terms of self-regulation and self-organization, because each of the lower levels has a constancy of physiological constants with a certain degree of autonomy [6].

The assessment of the functional capacity of a bioobject (human organism) is carried out according to several parameters of different functional systems of the organism. In this regard, we can speak about the legitimacy of using the integration of indicators of different system levels, structures and subsystems in the assessment of the functional capacity, since the integration processes permeate the entire hierarchy of the complexity of the organism. Any integral indicator, on the one hand, generalizes the influence of a certain set of partial indicators, on the other hand, allows us to assess the influence of each partial indicator on the final result, which is especially relevant in the tasks of assessing the functional state.

Since functional states are complex systemic reactions to the influence of internal and external environmental factors, their assessment should be comprehensive and dynamic. The most significant indicators for identifying the specifics of a particular state are the activity indicators of those physiological systems that are leading in the process of performing physical activity [13].

The principle of integrativeness of the system approach is a general system justification of the methodology for assessing human FS using an integral indicator obtained from a set of any characteristics, indicators, signs obtained using various methodological procedures. Therefore, the idea of integral indicators of functional systems best allows assessing the operator's condition and his level of homeostasis.

To determine the FS of the organism, a method is proposed using several parameters of various functional systems of the organism, their relationship to each other and graphical display in the form of a petal-type graph, which perfectly reflects the functional dependence of three or more variables, provides visualization of information for comparing certain trends, is as convenient as possible for its understanding, quick perception and drawing a logical conclusion from a large amount of data obtained [14].

In order to dynamically monitor the change in indicators reflecting the FS of the organism, the method of system functional profiles (SFP) was used, in which, for the quantitative assessment of the FS of the organism (bioobject) and its visual representation, a petal-type graph is constructed from the studied parameters taking into account the parameters (SFP) and the area formed by the values of the studied parameters during the assessment is calculated. At the same time, it is possible to determine the corresponding areas and the difference between the total value of the area of the functional state of the organism at the time of the study and the area of the "norm" displayed on the petal diagram.

6. Research results

A group of 15 men aged 25–35 years was selected as the initial data. The set of studied indicators includes: visual-motor reaction (VMR); tapping test; blood pressure; pulse; Stange test; Genchi test; galvanic skin response (GSR); self-assessment of the condition using the SAM test [15].

To assess the compliance of the initial values with the norm indicators and determine the degree of regulatory and adaptive ability of the bioobject (human), the procedure for measuring the indicators is carried out in three stages: at rest; after running at a speed of 8 km/h and lasting 10 minutes; after a rest lasting 1 hour [16]. A fragment of the results obtained at different stages of the study is given in the table 1.

Table 1. Fragment of the results obtained at different stages of the study

No.	Name of the research phase	Pulse, cl	Pulse pressure	Barbell test, s.	Sample of the genchi, s	Tapping test, cl	VMR, ms	SAM test	Galvanic skin response, MOм
Research 5	Resting state	66	40	70	30	250	230	55	25
	After loading	120	55	46	31	230	231	40	100
	After 1 hour of rest	60	55	60	45	260	231	60	75
Research 6	Resting state	55	40	60	40	190	200	55	10
	After loading	88	48	46	31	222	231	30	55
	After 1 hour of rest	55	40	60	40	190	200	55	10
Research 7	Resting state	55	39	53	48	251	240	43	13
	After loading	120	55	30	22	230	231	40	150
	After 1 hour of rest	60	55	30	22	230	240	60	150

To calculate a certain range of the norm, when the values fall into which it is possible to judge their compliance with the norm and the state of homeostasis of the organism, the lower values of the norm of the selected indicators are marked on the petal diagram graph and the resulting areas are calculated, which are taken as the lower limit of the homeostasis range. The lower and upper values of the norm are obtained on the basis of official statistics of the Ministry of Health of Ukraine for the selected age group [17]. The area of the norm is calculated by the method of triangles according to the formula:

$$S_{\text{нм}} = \left(\frac{1}{2}\mathrm{P_n} \times \mathrm{P_{tn}}\frac{\sqrt{2}}{2}\right) + \left(\frac{1}{2}\mathrm{P_{tn}} \times \mathrm{P_{sn}}\frac{\sqrt{2}}{2}\right) + \left(\frac{1}{2}\mathrm{P_{sn}} \times \mathrm{P_{gn}}\frac{\sqrt{2}}{2}\right) + \left(\frac{1}{2}\mathrm{P_{gn}} \times \mathrm{T_{tn}}\frac{\sqrt{2}}{2}\right) + \left(\frac{1}{2}\mathrm{T_{tn}} \times \mathrm{VMR_n}\frac{\sqrt{2}}{2}\right) + \left(\frac{1}{2}\mathrm{VMR_n} \times \mathrm{SAN_n}\frac{\sqrt{2}}{2}\right) + \left(\frac{1}{2}\mathrm{SAN_n} \times \mathrm{GSR_n}\frac{\sqrt{2}}{2}\right) + \left(\frac{1}{2}\mathrm{GSR_n} \times \mathrm{P_n}\frac{\sqrt{2}}{2}\right), \quad (1)$$

where P_n – the value of the lower limit of the pulse; P_{tn}– the value of the lower limit of the pulse pressure; P_{sn} – the value of the lower limit of the Stange test; P_{gn} – the value of the lower limit of the Genchi test; T_{tn} – the value of the lower limit of the tapping test; VMR_n – the value of the lower limit of the simple visual-motor reaction (VMR); SAN_n – the value of the lower limit of the SAN test; GSR_n – the value of the lower limit of the galvanic skin response (GSR).

Using formula (1), the lower limit of the range corresponding to the state of homeostasis is calculated:

Snm = 23677.5.

Similarly, the upper limit of the range is calculated – the range of the area of homeostasis can be defined as: *Snm* = 33600. Then the difference is defined as Δ = *Snm* – *Snm* = 9 922.5. An example of calculation is given for a state of rest; normal values are calculated similarly under load and after rest.

Table 2. Norm values of indicators

Indicators norm	Pulse, cl	Pulse pressure	Barbell test, s	Sample of the genchi, s	Tapping test, cl	VMR, ms	SAM test	Galvanic skin response, MOм
Upper limit	80	50	60	40	250	230	70	20
Lower limit	65	40	40	20	220	220	40	10

Table 3. Values of the areas of the lobe diagrams for each patient

Status Research No (investigated)	Resting state	After loading	After 1 hour of rest
5 investigated	30875.25	33619.60	36372.00
6 investigated	22645.00	27804.70	22645.00
7 investigated	31723.30	35119.00	34394.50
9 investigated	30780.40	34217.75	33503.75
11 investigated	29277.50	35647.50	30007.25
15 investigated	31723.30	34252.40	32308.15
% deviations	*6.7*	*33.3*	*26.7*

Table 2 shows the values of the upper and lower limits of the norm of the selected indicators.

Based on the results, a petal diagram of the norm indicators was constructed (Fig. 1).

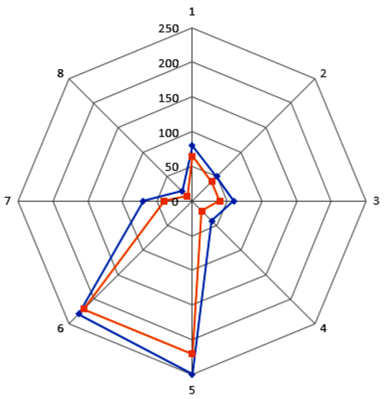

Fig. 1. Normality chart diagram

Fig. 1 shows the normal values: upper and lower limits.

Similarly, the values of the areas of the petal diagrams are calculated for each subject. The calculated values of the areas are given in Table 3. The areas that differ from the norm and by which it is possible to judge the discrepancy of the homeostasis state are marked in color.

The algorithm for assessing the professional ability of the subject and the correspondence of his homeostasis state is shown in Fig. 2.

From Table 3. it follows that the number of subjects who had deviations in the homeostasis index at rest is 6.7 %, in the state after load – 33.3 % and after an hour of rest – 26.7 %. According to the results obtained, it is possible to judge the ability of the subject to extreme professions, based on their adaptive capacity. Subject 6 had deviations in the index already at rest, so it may be recommended for him to undergo an examination by specialists to determine the cause of the deviation.

Most likely, these are the consequences of an illness or a certain pathology. After eliminating the causes, it will be possible to take this test again. Subjects 5, 7, 9, 11, 15 have deviations in the indicators immediately after the load. This may indicate both satisfactory physical training and low adaptive capabilities. To determine what exactly is affecting, it is necessary to pay attention to the fact that in subjects 11 and 15 the values of the indicators after rest are again within the normal range, which indicates a rapid regulatory ability. Most likely, the deviations during the load of subjects 11 and 15 indicate satisfactory physical training, and the deviation of the condition indicator is not so difficult to eliminate with regular rehabilitation exercises. And in the situation with subjects 5, 7 and 9, there is a consequence of low adaptive and regulatory capabilities, because their indicators have not returned to normal values after rest. This can also be eliminated, but with the use of measures aimed at developing adaptive capabilities.

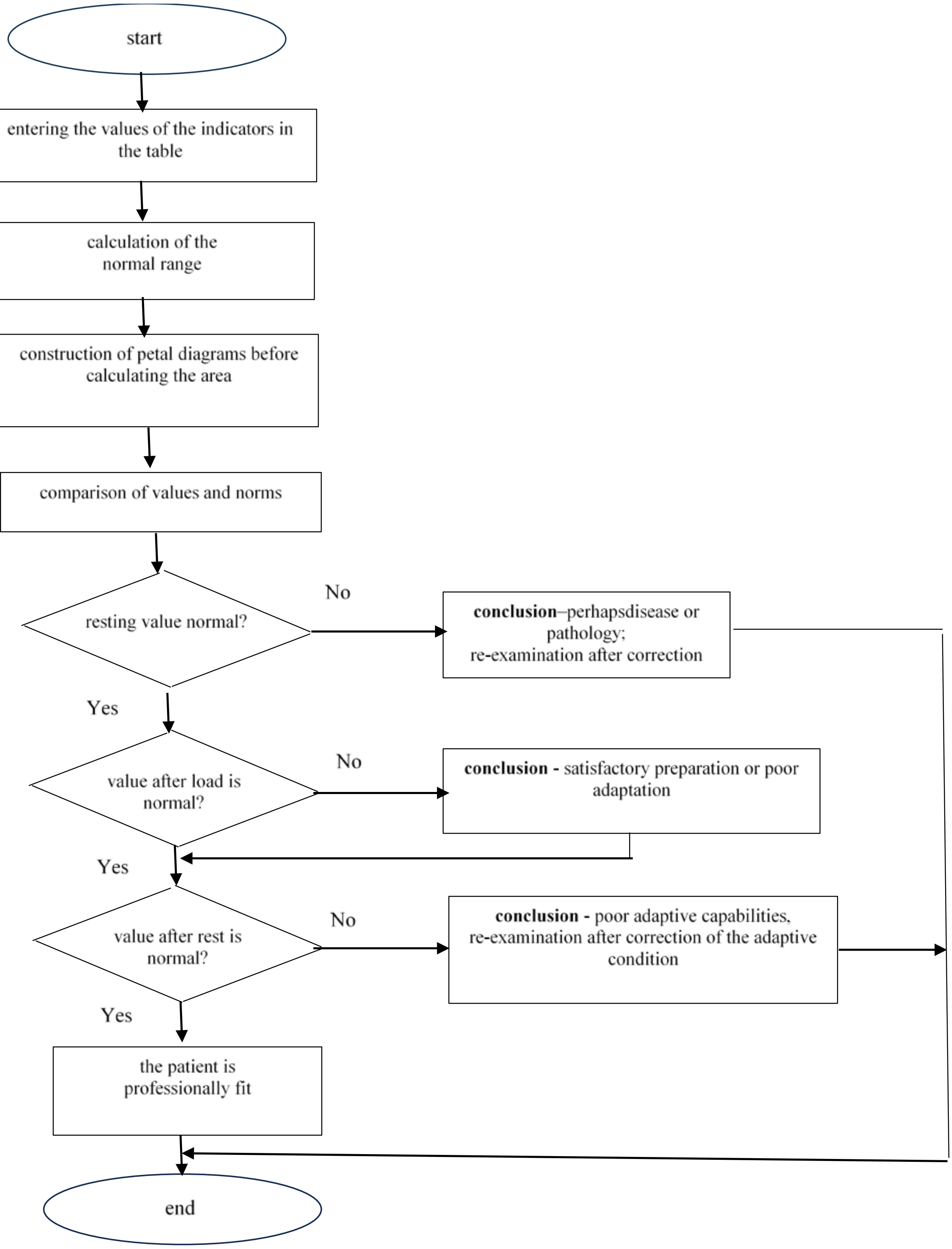

Fig. 2. Algorithm for implementing the method

7. Conclusions

The proposed method of homeostasis assessment is advisable to be used in the professional selection of operators of extreme activities. The results of measurements of the relevant characteristics in different states will allow assessing the adaptive capabilities of the organism. Indicators of adaptive capabilities are the speed of return of indicators of functional systems to the normal state after stress or load. In particular, if during the load the indicators begin to significantly exceed the norm and then within several hours do not return completely to normal – then we can judge the insufficiency of the adaptive capabilities of the organism (in the case under consideration, we can judge by the excess of the obtained area from the “normal area”).

The adaptive capabilities of the body are very important for operators of extreme professions, and sometimes even decisive. It is precisely such types of professions that require the human body to have the highest regulatory and adaptive capabilities so that the body's condition is always at an excellent level, and this level corresponds to the state of homeostasis.

Conflict of Interest

The authors state that there are no financial orother potential conflicts regarding this work

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