



Assessment of the functional state of boxers by complex results of rhythmocardiographic analysis

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Abstract

Objective of the study was to identify the functional state of boxers using complex indicators calculated on the basis of HRV, with an assessment of the feasibility of their use for qualified athletes.

Methods and structure of the study. Qualified boxers aged 21-26 years (n=14) participated in the experiment a week before the competition, with a sports experience of 9 years. We used the «Varicard 2.52» complex for processing cardio-intervalograms and analyzing heart rate variability.

Results and conclusions. According to the value of the tension index, two boxers revealed a predominance of centralization of heart rhythm control, psycho-emotional tension and a high degree of stress, while others showed optimal tension in regulatory systems. Based on the value of the indicator of activity of regulatory systems, one athlete's functional state was determined to be optimal, three boxers – a state of moderate tension of functional regulatory systems, two – a state of pronounced tension, and the rest – overstrain of regulatory systems. Assessment of the condition based on the location of the degree of tension of regulatory systems and functional reserves in the phase plane indicated that one boxer has a high probability of developing a pre-morbid state, while five athletes have a probability of transition to a pre-nosological state. Complex indicators calculated on the basis of HRV analysis data are sensitive in assessing the current state of an athlete, in dynamic control and allow predicting the development of pathological abnormalities even before the appearance of the first symptoms of the disease.

Keywords: *functional state, heart rate variability, complex indicators, boxing.*

Introduction. At the stage of improving sports-manship, there is an urgent need for rapid assessment of the athlete's response to loads within the framework of training and competitive activities. A methodology and technology for studying and assessing the functional state of an athlete's body that has been in demand in recent decades is the analysis of heart rate variability (HRV). The mathematical model of the functional state of the body uses indicators of the degree of tension of regulatory systems and their functional reserve, which are calculated according to HRV analysis data [2]. The main methods of HRV analysis: statistical, variation pulsometry, autocorrelation and spectral analysis, provide up to 40 different parameters

recommended by Russian and European-American standards. Each of the indicators allows one to study and evaluate the state of autonomic regulation of the physiological mechanisms of body functions [2]. Assessing each indicator and comparing it with the statistical average and functional optimum for a specific age, gender, occupational and regional group requires significant time.

Objective of the study was to identify the functional state of boxers using complex indicators calculated on the basis of HRV, with an assessment of the feasibility of their use for qualified athletes.

Methods and structure of the study. The experiment involved boxers in the welterweight and middle

weight categories of Master of Sports (n=4) and candidates for Master of Sports (n=10) 1-2 weeks before the competition, the age of those examined was 21-26 years, sports experience 9-13 years. We used the «Varicard 2.52» complex for processing cardiointervalograms and analyzing heart rate variability. Heart rhythm registration was carried out in compliance with the conditions necessary to obtain reliable primary materials. Processing, analysis and substantive study of research materials were carried out using statistical software packages «Statistics 6.0».

Results of the study and discussion. The tension index of regulatory systems characterizes the activity of sympathetic regulation mechanisms and the state of the central regulatory circuit [5]. During physical activity, activation of the central circuit of heart rhythm regulation and increased sympathetic activity is manifested by stabilization of the rhythm, a decrease in the spread of cardiointerval durations, and an increase in the number of intervals of the same type in duration (an increase in the amplitude of the mode) [2]. Fluctuations in the values of IN in the range of 80-150 c.u. are taken as the norm. in a state of relative muscle rest. Physical activity typical for sports activities can cause growth by 5-10 times.

There is evidence that against the background of stress, increased attention, in a state of readiness for strenuous activity, but still without load, the tension index can reach 200-300 units. The values of this indicator in the group of boxers are $122,14 \pm 58,02$ c.u., in the group of welterweight boxers – $117,4 \pm 41,5$ c.u., in the middle weight category boxers $124,8 \pm 67,9$. The personal values of boxers have a wide range - figure 1.

It should be noted that differences in the values of the stress index are not related to weight category, age, or qualifications (correlation coefficient up to 0,121). We assume, based on anamnesis data, that the tension index increases as the battle approaches. In Figure 1 two boxers (gray bars) have a voltage index over 250 c.u., fights should take place in 4-6 days. For non-athletes the values are 50-150 c.u. are interpreted as optimal tension of regulatory systems, and values of 150-500 can signal physical stress, systematic lack of sleep, decreased reserve capacity, and the presence of chronic fatigue syndrome [4].

At the same time, there is information that values in the range from 150 to 299 indicate moderate tension in regulatory systems, and this accompanies a state of readiness to realize one's potential in competitions [1], values 300-599 c.u. indicate a pronounced ten-

sion in regulatory systems (a state of pronounced distress, excessive activity of stress-implementing systems) [5].

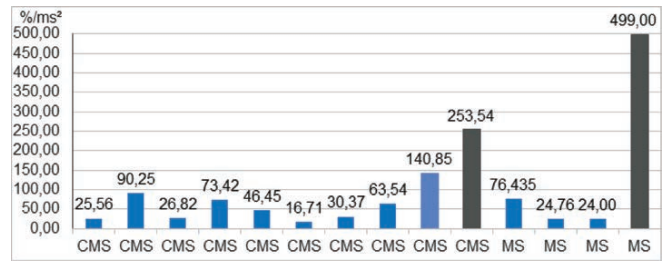


Figure 1. Tension index values in boxers (n=14)

One of the methods for diagnosing functional states (non-nosological diagnostics) is to calculate the indicator of activity of regulatory systems (PARS) [2]. This indicator is calculated in points using an algorithm that takes into account statistical indicators, histogram indicators and data from spectral analysis of cardiointervals. PARS allows you to differentiate different degrees of tension in regulatory systems and assess the adaptive capabilities of the body [3].

The calculation of PARS is based on a number of criteria. These are: the total effect of regulation in terms of heart rate; the total activity of regulatory mechanisms by standard deviation or by the total power of the spectrum; vegetative balance according to a set of indicators; the activity of the vasomotor center, which regulates vascular tone, according to the power of the spectrum of slow waves of the 1st order, and the activity of the cardiovascular subcortical nerve center or suprasegmental levels of regulation according to the power of the spectrum of slow waves of the 2nd order [2].

Correlation analysis of the relationship between the tension index and the indicator of activity of regulatory systems established a weak connection (correlation coefficient 0,417 at $p < 0,05$, $n = 14$). The result is expected, since the values of the stress index provide urgent information about the current state of the athlete based on statistical indicators of HRV, characterizing the degree of centralization in the control of heart rate, the calculation of PARS is carried out according to an algorithm that takes into account, in addition to the method of variational pulsometry, both the stress index, statistical, spectral methods of mathematical analysis and HRV histogram indicators. The optimal PARS value is from 1-2 points, which was stated in only one athlete; in three boxers, a state of moderate tension of functional regulatory systems was observed

(blue bars in Figure 2). The remaining athletes have a state of varying degrees of tension in the regulatory systems from pronounced (5 points) to overstrain (6 points and above).

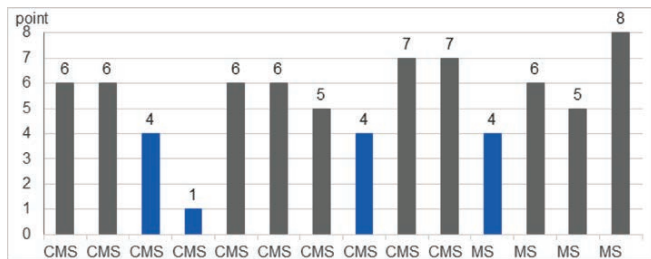


Figure 2. Values of the activity indicator of regulatory systems in boxers (n=14)

In recent years, in space medicine, a probabilistic approach has been proposed for assessing the functional state of a person and the level of adaptive risk based on HRV analysis data [7] with the calculation of integrative indicators of functional reserves and the degree of tension of regulatory systems. We used this approach to determine the likelihood of developing pathological abnormalities in boxers during the training period when the greatest total impact of various stress factors is noted.

The chosen approach makes it possible to establish the likelihood of the development of pre- and pathological conditions even before the appearance of the first symptoms of the disease [4]. On the phase plane (Figure 3), the classes of functional states are located so that the physiological optimum is characterized by positive values of functional reserves and negative values of the degree of tension of functional systems - this is the lower right rectangle.

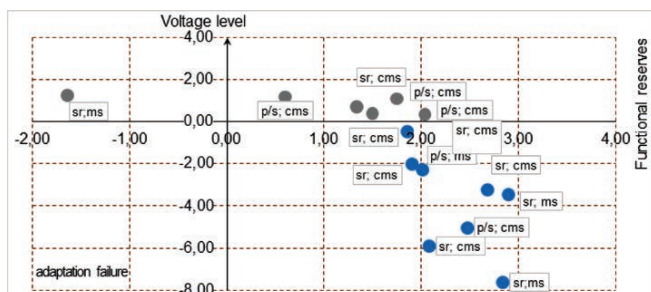


Figure 3. Distribution across the space of functional states formed based on HRV results for boxers (n=14). sr – average weight category; semi-middle-weight; Candidate for Master of Sports; MS – master of sports

In Figure 3, in the upper right square there is a pre-nosological state of overfatigue, in the upper left - a state of overstrain, in the lower left - a pathological state (failure of adaptation). In the context of the paradigm of the likelihood of developing pathological abnormalities based on the results of HRV analysis using a mathematical model, we can assume that in one of the boxers the current functional state indicates a high probability of developing a pre-morbid state, and the condition of five more athletes is assessed as pre-nosological (in Figure 3 their data is highlighted gray). The data of other boxers are in the functional optimum segment with a fairly wide spread.

Выводы. Assessing the functional state of boxers using complex indicators calculated on the basis of heart rate variability analysis data allows us to ascertain the athlete's current state, use them in dynamic control and predict the development of pathological abnormalities even before the first symptoms of the disease appear.

According to the integral indicator, which reflects the degree of centralization of heart rate control, psycho-emotional stress and the degree of involvement of the body in stress, it is possible to track the dynamics of the athletes body's reaction to specific physical loads and other impacts that accompany them.

The indicator of activity of regulatory systems (PARS) allows you to differentiate the degree of tension of these systems and assess the adaptive capabilities of the body, but provides only a discrete assessment of the functional state, which reduces its value in daily monitoring of the athletes condition.

Assessing the athletes condition by the location of the degree of tension of regulatory systems and functional reserves in the phase plane, forming the space of functional states, makes it possible not only to «award» the class of the functional state, but also the trends in the transition of functional states from optimum to pathology.

We believe that the use of the described complex indicators in sports practice will ensure individualization of the management of the training process.

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