8. ECG energy characteristics

8.1 ECG spectral components

ECG is a complicated multicomponent signal. As any other signal, it consists of harmonics, each of them is a raw sinusoidal signal. The spectral analysis theory is widely used in engineering sciences, especially in the study of information signals received from complex nonuniform objects. ECG is one of these objects.

Fug. 116 represents the ECG and its spectrum.

In the figure, one can see that the number of harmonics equals to 24. The frequency interval between them equals approximately to 1 Hz. The amplitudes of harmonics differ. The vectorial addition of harmonics produces the ECG represented in figure.

Figure 117 provides the more detailed representation of harmonics. Within the range above 15 Hz, among the fundamental harmonics the low amplitude harmonics are also recorded. They take place in each harmonic initial and end point. These pulses correspond to response pulses of sympathetic nervous system and parasympathetic nervous system. They also contribute to the ECG form.

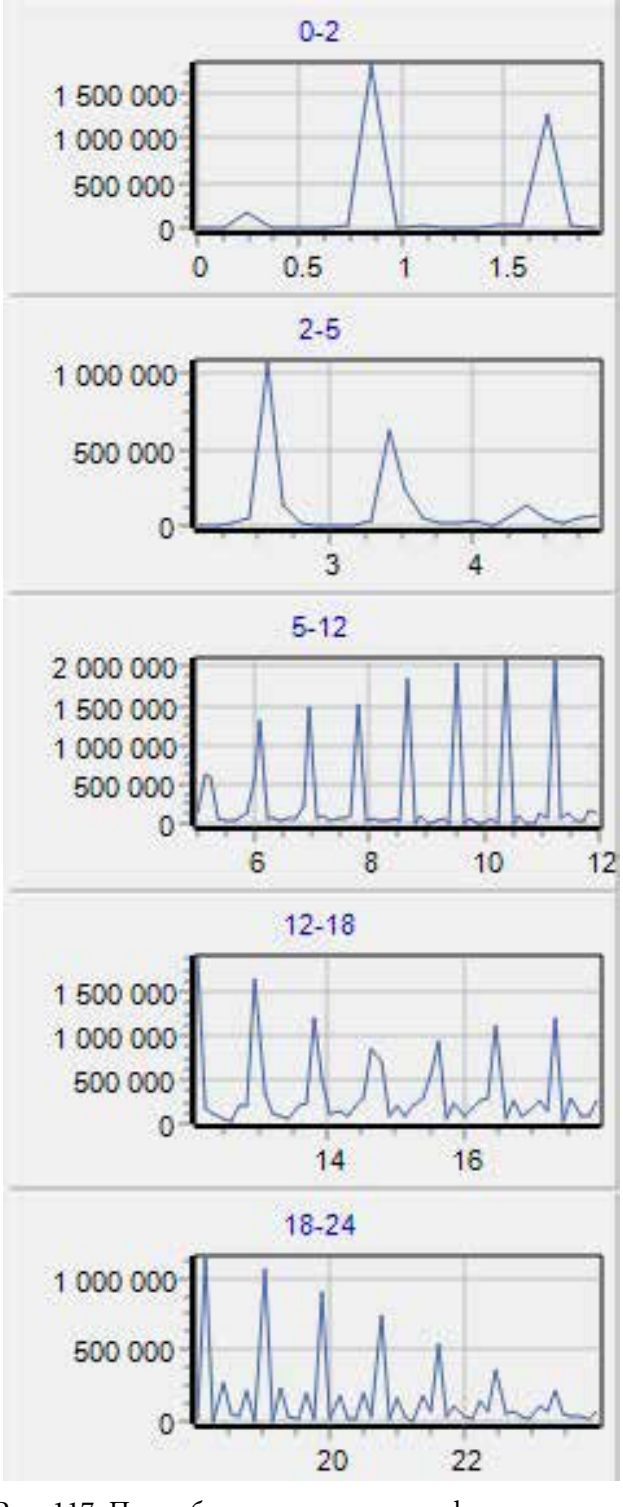


Рис. 117. Подробное представление формы гармоник ЭКГ

So it follows that ECG forms 24 response pulses generated by various body organs. Each response pulse is driven by other response pulses that are part of sympathetic nervous system, and is inhibit-

ed by the response pulses of parasympathetic nervous system. The amplitude of all response pulses can vary over a wide range. It can be observed even in orthostatic test. However, the quantity of main harmonics stays the same and equals to 24.

The parameters of various ECG spectra are shown in Fig. 118.

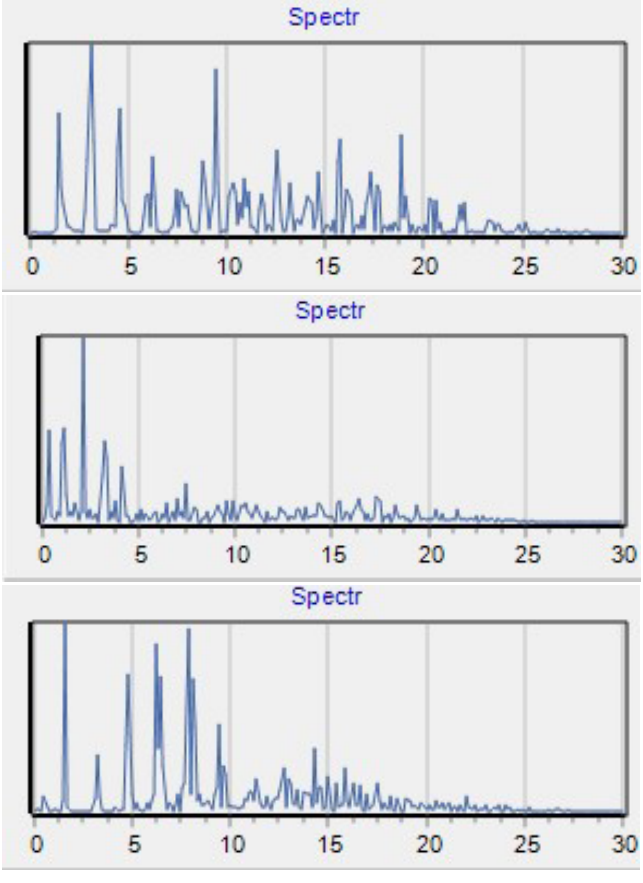


Fig. 118. Examples of various ECG spectra

8.2 ECG spectral components-and-central nervous system relation

The response pulses are the harmonic components of ECG. The amplitude and width are their basic characteristics. In pathological changes, the pulse width can sufficiently increase, while the amplitude decreases.

However, the same may happen at high attention concentration. At that, the sympathetic nervous system and parasympathetic nervous system impulses may be identical to basic impulse. Figure 119 shows the examples of the response pulses stretching at various levels of attention focusing. In figure 119a, the pulse represents the normal ordinary state of a person. The attention is switched adequately, no concentration on a particular action is present. Figure 119b represents the impulse of football player before the world championship and the breaking the record. His attention is focused on himself. It helps to concentrate the energy and not respond to external irritants.

Figure 119 c represents the response pulse of the handicapped person. In a few months this person commited suicide.

These fact demonstrates the ECG form and CNS state relation.

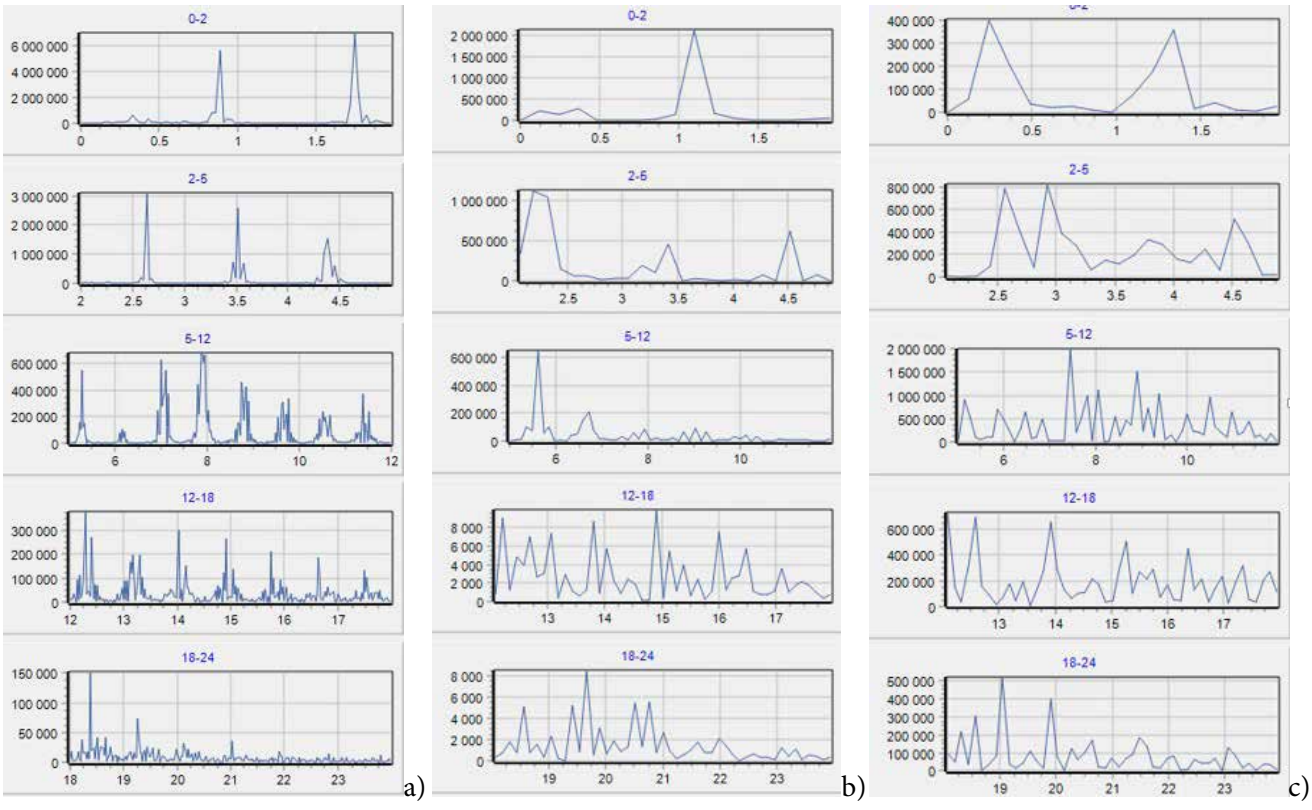
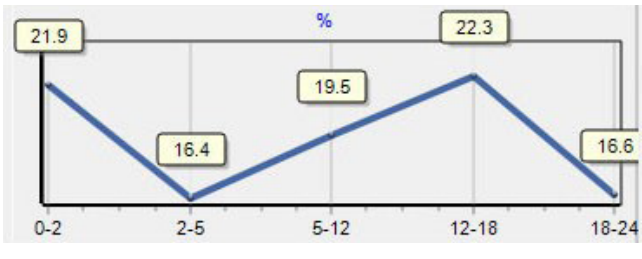


Fig. 119. Response impulse width of: a) sane man b) world record breaker c) suicidally inclined person

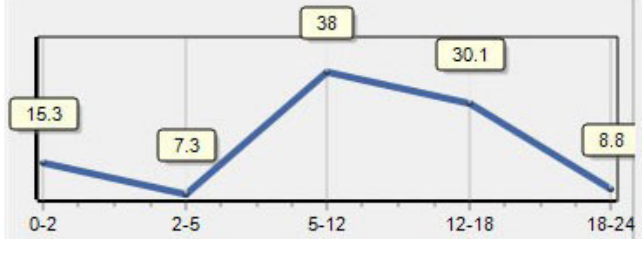
8.3 Связь энергетики сердца и физиологических адаптационных реакций

The adaptive response theory has been developed by Lyubov Khaimovna Garkavi, the soviet scientist. This theory determines that the millions of internal and external factors are counteracted by human organism by using only five reactions. They are: stress, training, normal activation, excited activation and overactivation [46]. The response is actuated by the immune system input.

Each reaction determines the metabolic cost required for its support. The normal activation is the most energetically favourable reaction. The investigation proved that the ECG harmonics energy depends on the adaptive response type. This is very important, because the reaction type can be plainly determined from the harmonic energy. We know that all harmonics can be arranged in five groups. The harmonics energy comparison shows the relationships corresponding to a definite type of reaction. Fig.120 represents the graphs of energy correlation for each of five groups.



a)



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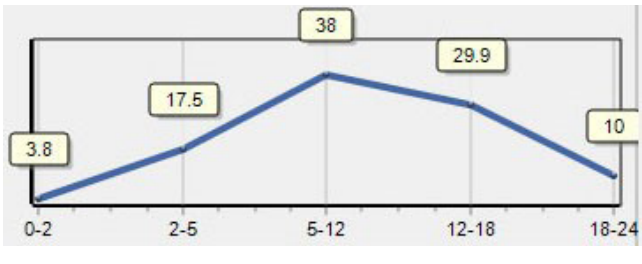
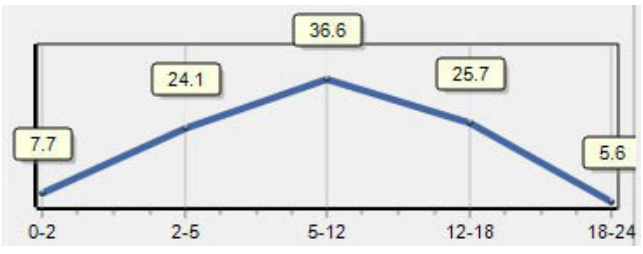
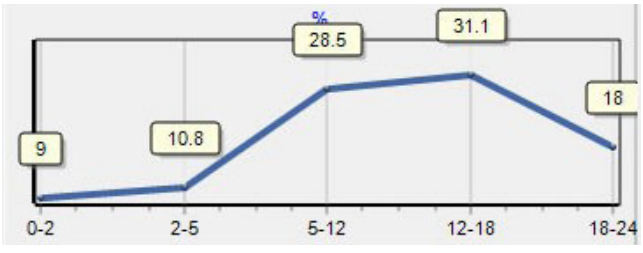


c)



d)



e)

Fig. 120. Energy dependency for each of five groups:
a) stress b) training c) normal activation d) excited activation, e) overactivation

8.4 Stability of cardiovascular system state

"State stability" is a systematic parameter. It is determined based on the heart contraction rhythm analysis. The "tensity indices" formula is a system parameter according to R.M. Baevsky theory. It includes R – R intervals based on which we calculate the departure from a mean value. This value characterizes the organism tension state. Also, the graph is constructed and used for determination of cloud of values (Fig. 121 for R – R). By replacing RR with SV we obtain the graphs characterizing the stroke volume. The square containing the points 2x2 shows the steady state condition, while the 3x3 square shows the middle-steady condition. The cloud like in RR interval shows the unstable condition.

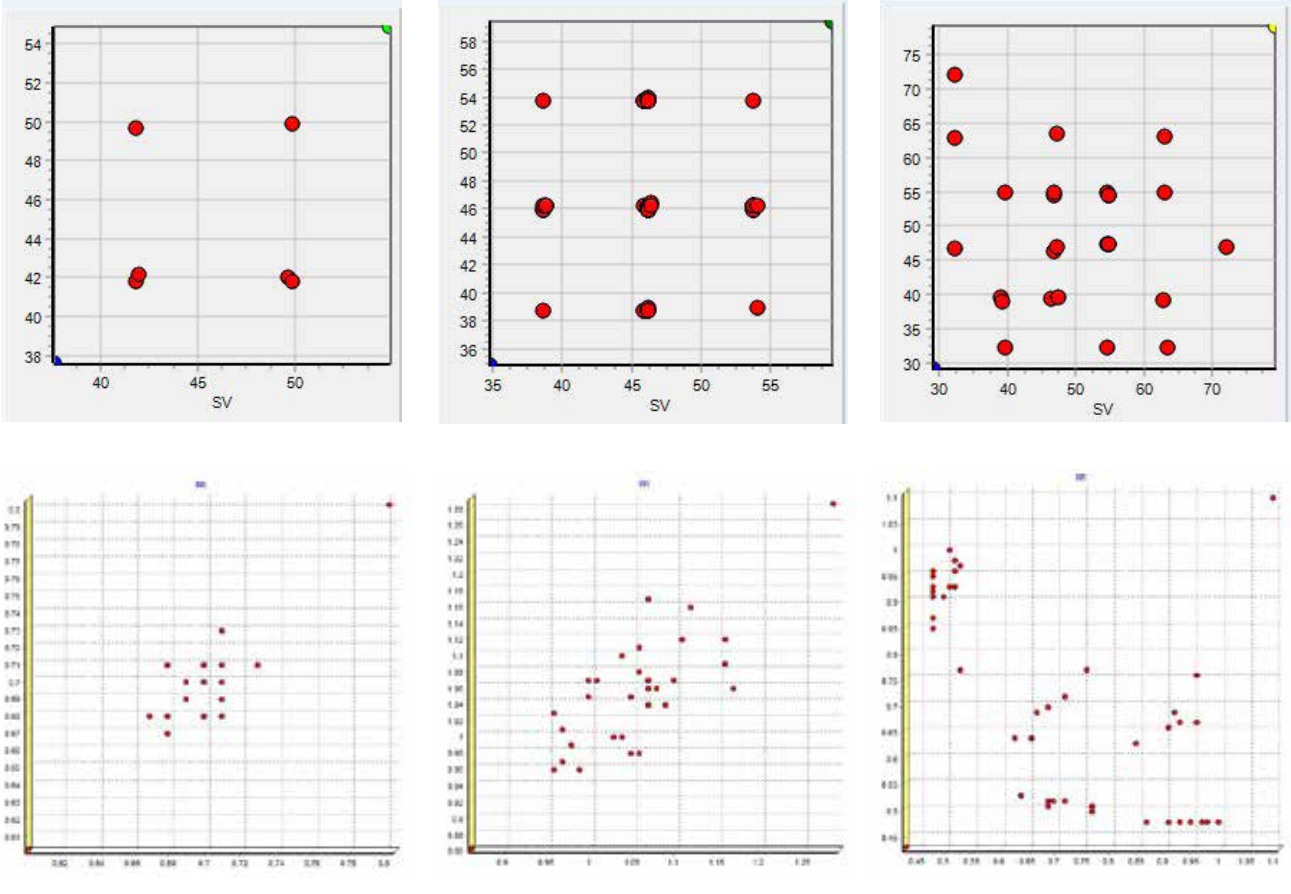


Fig. 121. Stroke volume (SV) and R – R intervals