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Application Of Space Technologies For Valuation Of A Stress Level

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Abstract: The adaptation of large long-term experience of application Heart Rate Variability in space biology and medicine and medical researches is represented. The description of the new approaches is given which are fixed in a basis of diagnostic computer systems "NeuroResercher™ 5.0" (or System of Computer Vegetology "CardioTensionTest™ 5.0" as module in the frame of "NeuroResercher™ 5.0") and "Variocard". These systems for thorough clinical and experimental scientific investigations and experimental investigations (for specialists of R&D institutes, doctors of functional diagnosis rooms of hospitals possessing clinical bases of R&D institute and medical university chairs, during clinical and preclinical testing of drugs, medical and biological R&D institutes carrying out Neurophysiological investigations in the field of labour medicine and sport medicine, development of infantile nervous system, medical education establishments.

1. Introduction

At the boundary of XX and XXI Centuries the significance of emotional stress on health of the people is promptly increased. In this connection the necessity in simple for realisation, scientific based methods of a quantitative evaluation of power of systems regulation of an organism increases. There is a necessity because of objective quantitative measurements of a level of emotional stress and reserves of regulation cardio-vessels systems regulation in time to apply the reasonable methods of treatment and preventive maintenance of stress-genesis diseases, to predict outcomes myocardial infarction or origin "of sudden death" on a hum noise of complete well-being.

The problem of valuation of a stress level of the space crewmembers has arisen from the most first steps of cosmonautics development. It solution was connected to development of the concept about cardiovascular system as an indicator of adaptive reactions whole body.

Since the 60-th years during the first human flights in space was developed the technology of researches, based on the heart rate variability analysis and valuation on these data of an autonomic system state and activity of subcortical centres, connected with psycho-emotional excitation and increasing the enero-metabolic processes at physical loads. In the subsequent years the Heart Rate Variability analysis begins widely to be used in USSR (Russia and Ukraine) in clinical and preventive medicine, and from 80-th years has applied in Western Europe and USA. Hundreds articles and reports about using of the heart rate variability analysis in clinical practice and applied physiology are at present annually published.
However, so far in earthly medicine the space technology of stress level valuation is not enough used. The important of this technology is determined by that the majority of diseases is results of overstrain and exhaustion of the mechanisms of physiological functions regulation and diagnostics of a regulatory systems state is the most effective on Heart Rate Variability parameters.

Therefore in a space medicine 10-balls scale of valuations of a stress level is developed, that permits to determine risk of diseases and to supervise results of fulfilment of the preventive recommendations.

The adaptation of large long-term experience of application Heat Rate Variability has allowed to create computer diagnostic systems “CardioTensionTest™ 5.0” and “Varicard”.

2. Functionality’s of systems

These systems allow:

- To quantitatively evaluate the emotional stress rate;
- To quantitatively evaluate the “regulation stability” under extreme conditions;
- To evaluate the regulatory systems tension level reflecting the activation rate of neuro-endocrine of “stress axes”;
- To carry out medical control and prediction of an organism’s functional possibilities, to diagnose the following states: a) satisfactory adaptation; b) functional tension; c) unsatisfactory adaptation; d) adaptation failure.
- To determine the functional state of a heart rhythm regulation system according to R.M. Bayevsky’s classifier [1] pointing out five cardiac rhythm features: 1. Indication of summary effect of all regulatory influences; 2. Cardiac muscle automatism; 3. Regulatory influences on stability rate; 4. State and interaction of VNS parts (vegetative homeostasis); 5. Indication of subcortical nervous centres state.
- To evaluate arterial pressure regulation system activity (Ssw1);
- To evaluate thermal regulation system activity (Ssw2).
- “CardioTensionTest™ 5.0” and “Varicard” have substantial advantages over other available systems.

It is necessary to mark some important features of these systems, which increase reliability and reliability of results.

3. “CardioTensionTest™ 5.0”

3.1. Detection of R-peaks and R-R intervals

Reliable automatic discrimination of R-peaks is of primary importance. In the available systems R-peaks are discriminated by means of an electronic amplitude filter, i.e. An R-peak is discriminated from other ECG peaks (P, T) by its higher amplitude. Such approach has low reliability because under emotional stress, in the periods of negative emotional state, in cases of hypoxia and myocardial ischemia of different etiology, a T-peak amplitude significantly increases.
Besides, hardware-based discrimination of R-peaks does not permit to account for the presence of artifacts (spikes, displacements and other ECG distortions) [2]. At the same time, discrimination of only one "false" R-peak (or omission of a real R-peak) causes a nonlinear distortion of the analysis results by 60-80 times [1].

The stage of detection consists of two steps - on a first step of the analysis the system uses methods of automatic detection.

3.2. Automatic detection

Automatic detection of R - peaks (waves) and R-R- intervals - not hardware, but computer detection of R-waves according to three specially designed independent criteria.

An original algorithm is used for this purpose that makes it possible to reliably detect R-waves not only for clinical purposes at rest, but also for investigations of under the conditions of operator's activity - operators, pilots, sports persons etc., as well as animals under the condition of free behaviour in chronic experiment.

On second step of recognition R- peaks in the system the quality control of detection, and then semiautomatic and hand-operated correction is carried out.

3.3. Visual checking of R peak detection

Makes it possible to check up visually on the monitor screen the detected R-waves with further manual correction (detection or elimination) of 'false' or omitted R-waves in a defect section.

3.4. Automatic editing

Detection or elimination of 'false' or omitted R-waves in a defect section basing on the original correction algorithm.

3.5. Manual correction

Manual correction (insertion or elimination) of 'false' or omitted R-waves in a defect section (especially important when investigating the subjects (operators) during their activity or functional tests.

4. Mathematical and statistical analysis

The reliability of R-peaks selection ensures at a stage of a mathematical and statistical analysis high reliability of results. The universal analysis is carried out which allows evaluating practically all levels of regulation.

Calculation of a set of well known from the literature mathematical and statistical values (31 value) reflecting the result of statistical, correlation and spectral analysis of the cardiac rhythm. Integral interference-proof from the point of view of computer processing index AI (anxiety index) and ART (anxiety reaction type index) are used;
4.1 Correlation analysis

Sequences of R-R (N-N) intervals, that makes it possible to estimate the degree of control centralisation, domination of one of the vegetative nervous system sections, quantitatively estimate the degree of emotional stress;

4.2. Spectral analysis

Sequence of R-R’ (N-N) intervals that makes it possible to estimate the degree of activation of subcortical nervous centres controlling the blood flow regulation apparatus, measure the degree of stress of the neuro-endocrine function regulation apparatus;

![Figure 1: Visualization of results in the form of charts of R-R (N-N) interval distribution histograms, correlograms and spectra; results of factor analysis, possibility to present in one chart and compare several states simultaneously.](image)

4.3. Multidimensional factor analysis

Makes it possible to compress information and reduce a large number of values to 2-3 factors [3]. This approach makes it possible to range (quantitatively estimate and compare) the subjects as to the level of stress of the regulation systems, 'regulation stability'; quantitative estimate the state of integrative function of hypothalamus. The ranging results are output to a 3D chart. There is a possibility to create factor models for various age groups and contingents of the subjects [3].

Large advantage “CardioTensionTest™ 5.0” is the possibility of inclusion it in the structure of the developed advanced system of the computer EEG “NeuroResearcher™ 5.0”. It allows simultaneously to conduct a research of an EEG, and to compare results to data of a calculus of Heart Rate Variability.

5. “Varicard”

“Varicard” is specialised hardware-software complex for the Heart Rate Variability analysis is at present developed, in which are used as western standards of this technique, as created in a space medicine criterion of stress level estimation. Is allocated three zones (Fig. 2) (green, yellow and red) determining danger of development of diseases. In a complex structure there is base of knowledge, forming individual preventive and healthcare
recommendation by results of valuation at stress level. The complex is tested in a number of clinical establishments, is used at mass preventive examinations of thousands people, as well as at investigation of the health in schools.

![Diagram](image)  
**Fig. 2.** A Ladder of states and system of an evaluation of functional states of a type "Traffic Light".

6. Summary

The Heart Rate Variability analysis is modern technology of valuation of the health states in applied physiology, clinical practice, rehabilitation and preventive medicine. This technology was developed in space medicine as the method for stress level estimation. Widely application of this approach in different parts of human sciences is very important for understanding the unity and differences of the health and disease.

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