*Report*

# Application of principles of space medicine to health monitoring of the aging population

Roman M. Baevsky[1*], Azalia P. Berseneva[1], Peter A. Baevsky[2], Maia Master[3]

[1] Institute of Biomedical Problems of the Russian Academy of Sciences
Russia 123007 Moscow, Khoroshevskoye sh. 76A

[2] Company «Autosun Health Technology Inc»
Canada, Toronto

[3] Resort "Mishpacha"
Canada, Ontario

[*] Corresponding author
phone: +7 (499) 193-62-44, e-mail: rmb1928@mail.ru

Submitted: 17 March 2015
Accepted: 10 April 2015
Published online: 16 May 2015

Abstract

Monitoring the health of astronauts based on the assessment of the functional state of the body within the realms of norm and pathology. The area of functional states qualifies as the yellow score of health on a notional scale "traffic light of health". Modern medicine is particularly interested in studying the health of the yellow score, because of the preventative measures that could still be taken before making contact with the healthcare system. This method has been used in a study of a group of people (mean age >70) during their stay at a resort in northern Ontario. Data were obtained by a spectral analysis of HRV. High-frequency oscillations (HF,%), indicating the increased activity of the parasympathetic system, which protects the body from stress was significantly increased. Centralization of control of autonomic functions (IC) was decreased as well as heart rate. All these changes indicate growth of functional reserves, aimed at increasing protection against stress' effect due to environmental factors. This research shows that the method based on space medicine assessment in health can be successfully utilized within various fields of physiology and medicine, particularly in gerontological practice to dynamically monitor and research ways to improve the health of the elderly.

Keywords

Health • Functional states • Stress • Space medicine • Heart rate variability • Aging • Spectral analysis • Risk of disease • Functional reserves • Gerontology

Imprint

Roman M. Baevsky, Azalia P. Berseneva, Peter A. Baevsky, Maia Master. Application of principles of space medicine to health monitoring of the aging population; Cardiometry; No.6; May 2015; p.22-29; doi: 10.12710/cardiometry.2015.6.2229 Available from: www.cardiometry.net/no6-may-2015/principles-of-space-medicine

## Introduction

Recently a company «Autosun Health Technologies» has developed a new approach to objectively measuring the psychological level of stress through analysis of heart rate rhythm [1]. This project was done in collaboration with Institute of Biomedical Problems; the leading organization in Russia that is conducting and monitoring research on the Russian segment on the international space station. The new approach is called “Traffic Light of Health”, this approach is grounded in theory based on space medicine which was established in the 1970’s [2,6]. The concept of the theory is that the health index is signified through a three-color scale: green - normal, yellow - requires attention to present health, red - initial signs of pathology are evident. In the forefront of this scale is the yellow score, as it borders between health and disease. It is this border state that is studied in space medicine, as the astronauts are practically healthy people who have been specially selected, through a vigorous process, and trained to work in difficult conditions and in constant stress. Even in those cases fatigue, sleep disturbances, decreased appetite and irritability is evident. These are signs of adaptation caused by stress and the demands placed to adapt to the vastly different conditions of space. Such changes are not dangerous, as they are a sign of the adaptive capacity and are thus in the yellow score of the scale. Experiment “Pneumocard” had the objective to acquire new data that would expand our knowledge of the mechanisms by which the cardiovascular system adapts to the conditions of long-duration space mission.

Regular modern medicine is particularly interested in studying the health of the yellow score on the scale, because it is a bordering state of health and disease. Once pathology becomes symptomatic, it is then brought to the attention to physicians and specialists. There are no clear-cut diagnosis of the disease, and physicians are known to engage patients only when a definitive diagnosis of a disease is to be made. Thus, as long as the person does not see a physician, doesn’t undergo certain laboratory tests (chemistry, microbiology, complete blood count to name a few), they generally practice "home medicine". “Home medicine” has in recent years became quite widespread. It is to practice medicine, apply therapies and usage of diagnostic equipment in the home environment. For example, measuring blood pressure by a store-bought device or by accessing the internet for health related information to be used to treat a health issue at home without guidance by regulated medical personnel.

On board a spacecraft, all crew members are also able to use their own rather complex medical equipment, designed for regular medical monitoring and medical research. There are clearly traced analogies between space medicine and home medicine. But there is one more important analogy to be discussed. It refers to the “yellow” score of health on the scale. People utilizing this scale are healthy individuals interested in sustaining their health. While in space, the crew investigated are regarded as "very healthy" people with a large margin of functional reserves in the body, home medicine deals with a decrease of the functional reserves in people who are on the verge of transition from health to disease, in both cases we have to talk about the “yellow score” of health. Below are figures from the book by AI Grigoriev and RM Baevsky «Problem of Health Evaluation and Conception of Norm (M., 2006) [6], which shows the relationship of the "Traffic Light of Health" with the different kinds of standards (Figure 1) and the dependence of the functional reserves and the degree of tension of the regulatory systems (Fig. 2).

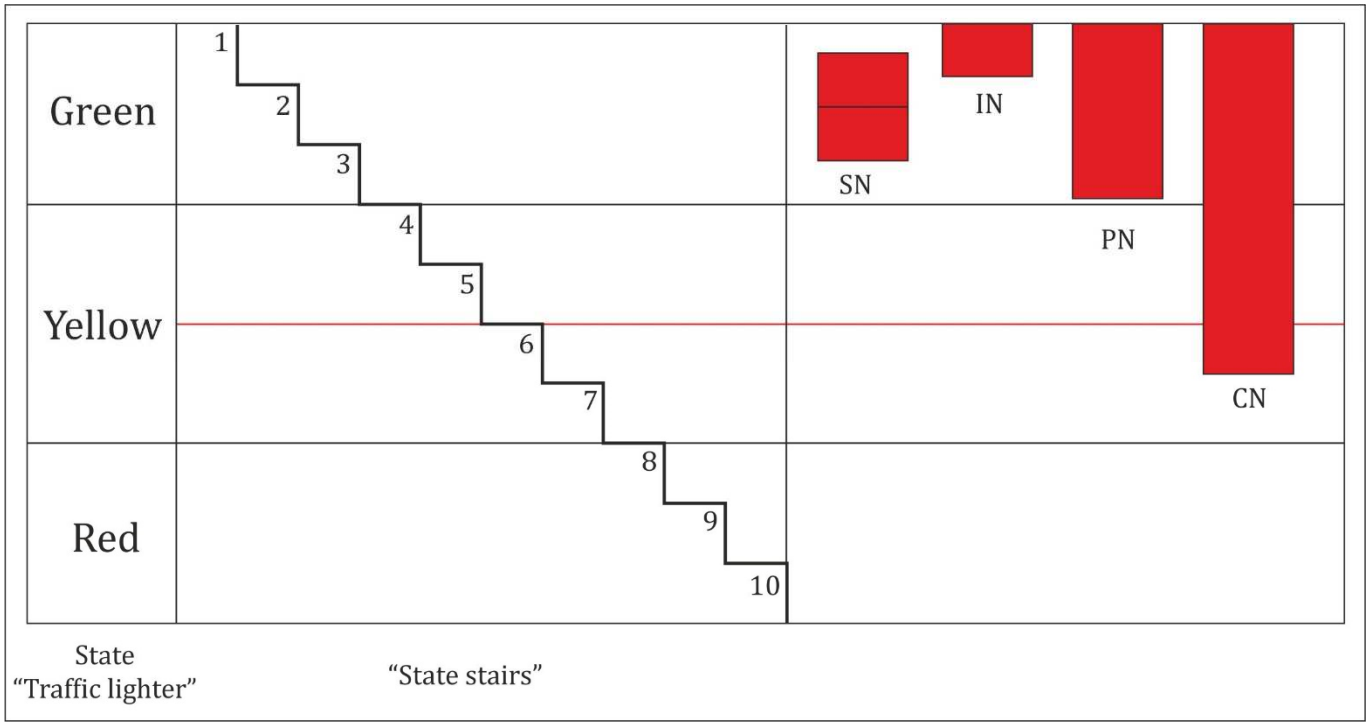


**Figure 1.** Various kinds of norms and classifications of functional states
SN – statistical norm; IN – ideal norm; PN – physiological norm; CN – clinical norm

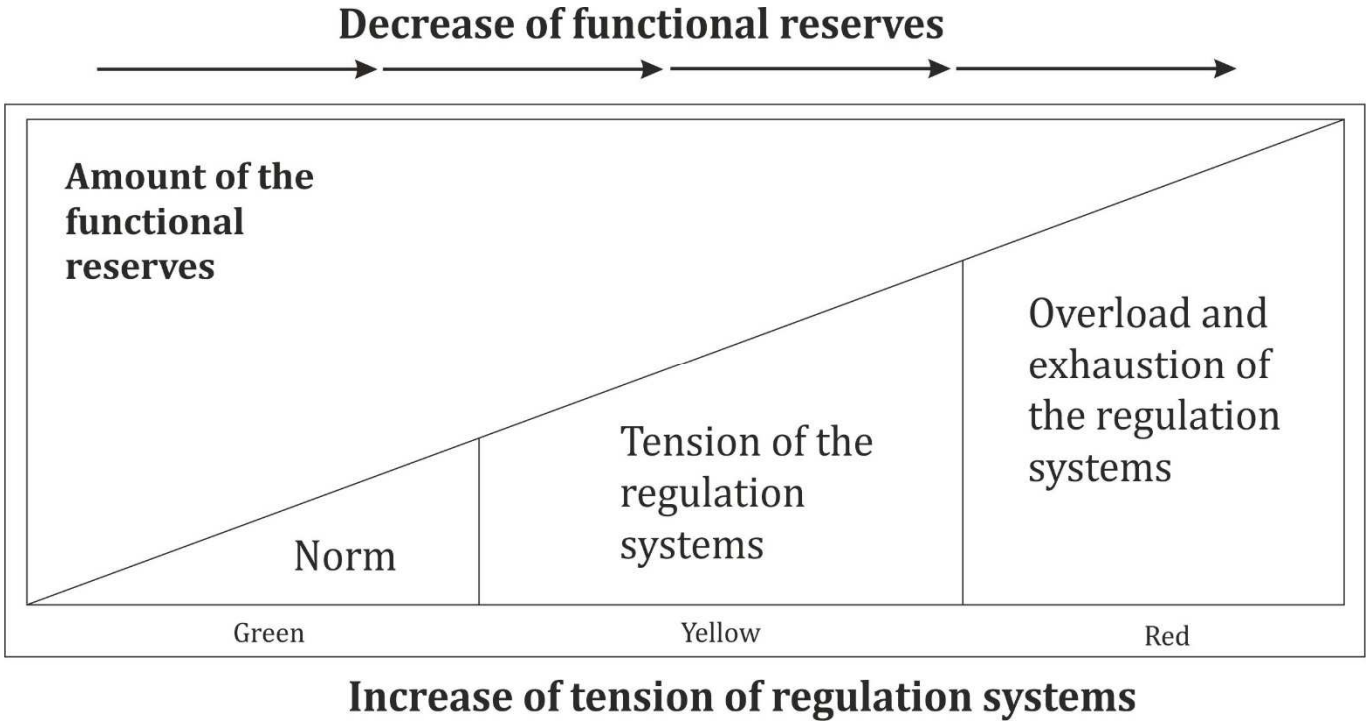


**Figure 2.** Decrease of the functional reserves as a function of risk

These figures show that astronauts who belong to the “green score of health” are very healthy, with large capacity to withstand stress and show no symptoms of pathology. People with reduced functional reserves are considered to be relatively healthy, and are so so-called within the "clinical norm." As can be seen from Figure 1. The range of "clinical norm" occupies almost all the yellow score, almost reaching its border with the red score. What this means is well illustrated by Figure 2, which shows a reduction of functional reserves of the body due to the increase of tension of regulatory systems and the development of stress. It is now generally accepted that excessive stress is one of the leading causes of the decrease of functional reserves and depletion mechanism of vegetative regulation. Prolonged or intense stress is the main cause of the transition from yellow to the red score of health.

Assessment of the level of stress in space medicine, starting with the first manned flight, began with a method of analysis named heart rate variability. This concept that is used in space medicine, can also be applied to today’s modern medicine. In 1970-1990’s, first in Russia and then in the United States and Europe, analysis of heart rate variability (HRV) has become widely used in various fields of physiology and medicine [6,7]. In recent years this method has been greatly improved to meet the challenges in space medicine. Developed as a probabilistic approach to the assessment of the level of stress and adaptation of the organism [3]. This introduced the concept of adaptive risk. The concept of adaptive risk holds 10 categories of risk, of which only the 4th category presents the concept of development of hazardous situations to health [4]. It is this improved version of the method of analysis of HRV that is used in the above-mentioned "traffic light of health” concept. Thus, space medicine, again, as in the 1970s, becomes the source of a new methodology for assessing health, which is now based on the experience and findings made within space research which includes longitudinal research of healthy individuals living and working in conditions of chronic stress. This research, of course, may be useful in everyday modern medicine, where large numbers of people, particularly the elderly are in need of simple and affordable methods of evaluation and monitoring of their health.

## Research methodology

The "Traffic Lights of Health" concept has been implemented on smartphone platforms such as "Android", which ensures the accessibility to this new method. In order to evaluate its validity and reliability, a study of this methodology has been conducted on the elderly at a resort in northern Ontario, Canada. In this study, there were no attempts made to diagnose or treat any of the participants. The participants were merely observed using the “Traffic Light of Health” concept. The study was conducted on a strictly voluntary basis.

The research methodology has been greatly simplified, and included the following three steps: 1) A questionnaire about the health and general lifestyle 2) measurement of body weight and blood pressure, 3) ECG. Special analysis of heart rate variability according to the ECG and the "Traffic Light of Health" allows objective measurement of the level of stress. Immediately upon arrival to the resort, surveys were conducted in 20 people aged 60 to 85 years (5 males and 15 females, mean age 79.1 years). After 7 days, another follow up examination was completed, which was attended by 14 people. According to the survey results, each participant was assigned to one of the groups of health. It was found that among those surveyed, not one participant could be attributed to the “Green” group. 75%

of those surveyed were "Yellow" (50% of them in a state of functional stress and 25% in the premorbid state). The premorbid state is indicated by the orange score of health. Only 25% were in the "red" group (in the initial stages of various diseases).

## Results

Analysis of the repeated surveys showed quite unexpected results. Most notably, it showed an improvement of health in 10 of 14 participants. The distribution of participants by health groups has shown significant improvement. Some of the participants moved into the green group, the number of persons in the yellow group decreased as did the number of people in red group (see. Figure 3)

The majority of participants had less complaints in regards to the various manifestations of sickness or discomfort. A significant decrease in blood pressure was also noted. HRV parameters and dynamics are shown below.

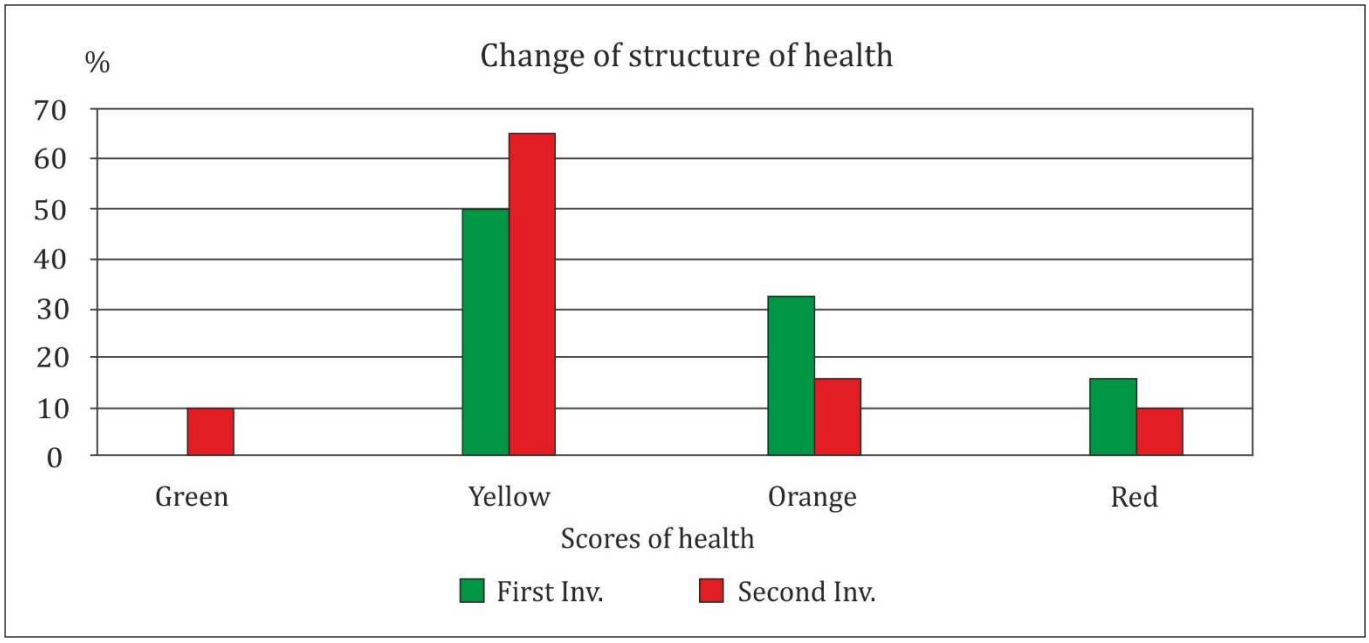


**Figure 3.** Changes in the structure of health after a 10-days vacation

With repeated measurements there was an increase in the stress index (SI, decreased rates of total variability (SDNN) and the total power of HRV spectrum (TP). All these changes point to increased activity of the sympathetic level of regulation, which is typical of mobilization of functional reserves in various treatments.

Data obtained by spectral analysis of HRV strength significantly increased high-frequency oscillations (HF,%), indicating that the increased activity of the parasympathetic system (which protects the body from stress). Increased activity of vascular regulation (LF,%) and energy-regulation of metabolic processes (VLF,%). Decreased centralization of control of autonomic functions (IC), slightly decreased heart rate. All these changes indicate an increase of functional reserves, aimed at increasing protection against stress caused by environmental factors. The diagram in Figure 4 illustrates the dynamics described.

Results of the analysis of heart rate variability in participants at resort "Mishpaha".

| Indicator | Result 1 | Result 2 |
|---|---|---|
| HR | 67,53 | 65 |
| SDNN, ms | 25,67 | 22,1 |
| SI | 215,22 | 279,2* |
| TP, ms2 | 677,56 | 482,38* |
| HF, % | 29,78 | 47,2* |
| LF, % | 19,72 | 27,1* |
| VLF, % | 22,06 | 26,1* |
| IC | 1,83 | 1,56 |

Note: *- significant difference (p>0,05)

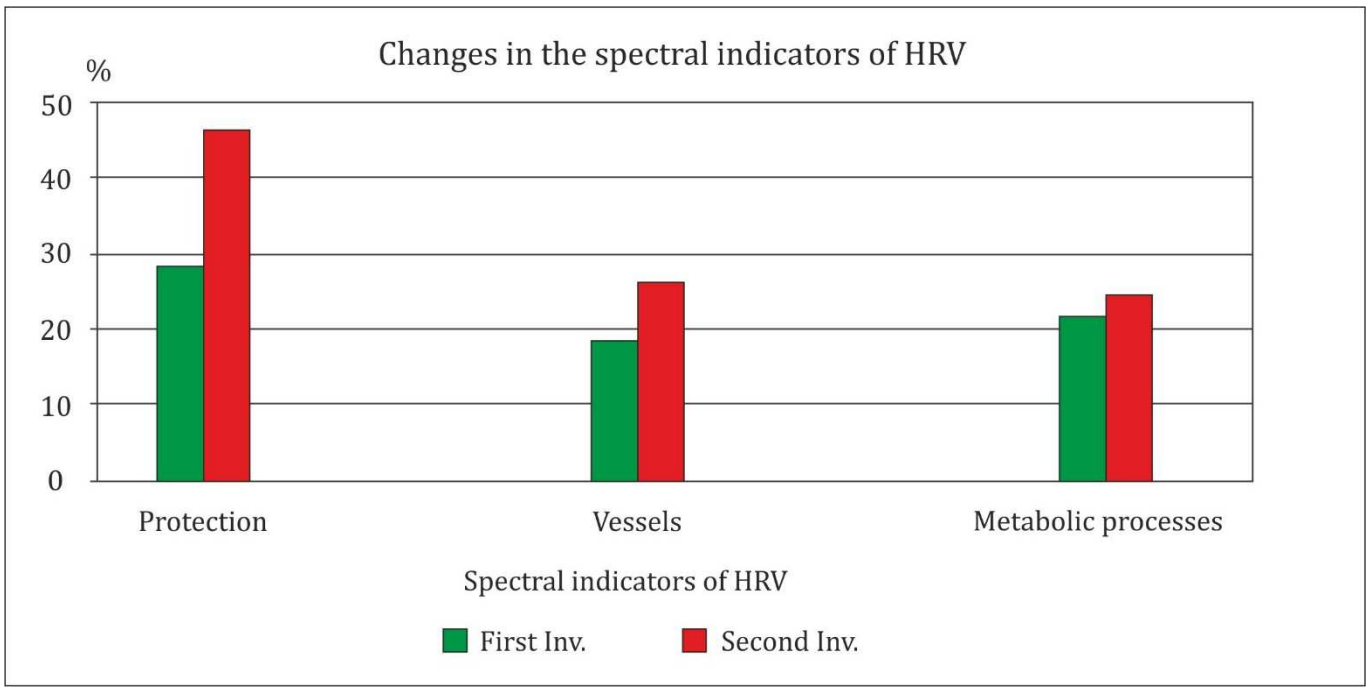


**Figure 4.** Changes in the spectral indicators of HRV after subsequent measurement

## Discussion and conclusions

The research comes to two important conclusions: 1) “Vacation” for elderly people at a resort increases their level of health, as evidenced by positive changes in the structure of health parameters; 2) Increases the level of health according to the analysis of HRV is accompanied by mobilization and increase of functional reserves. Should be to say that these results could be significant for both scientific and practical conclusions.

The scientific research of this study is of some value as it is possible to obtain distinct objective data on the simultaneous increase in activity of both sympathetic and parasympathetic autonomic regulation. Such an outcome is possible if the main regulator of activation (the hypothalamus) that "controls" both divisions of the autonomic nervous system. This is consistent with current knowledge of the mechanisms of aging and is a good scientific rationale for the use of HRV as criteria for evaluating the effectiveness of restorative processes [5].

The practical usefulness of the results is also obvious. We have confirmed that the "Traffic Light Health" and methods of HRV analysis in monitoring the health of older people and are now openly available and accessible.

Modern space technology assessment in health can be successfully used in various fields of physiology and medicine, particularly in gerontological practice to monitor the health of the elderly.

## Statement on ethical issues

Research involving people and/or animals is in full compliance with current national and international ethical standards.


## Acknowledgements

We are grateful to S.I. Anisimov, G.S. Golitsin, V.P. Goncharov, E.A. Novikov, and N.A. Inogamov for useful comments and interest to the work.


## Conflict of interest

None declared.

## Author contributions

RMB, APB, PAB prepared the manuscript and analyzed the data. APB and MM coordinated and helped to draft the manuscript. All authors have equally contributed to the manuscript, read and approved the final manuscript.

## References

1. Baevsky RM, Baevsky AR, Bersenev EY, et al. Use of space technologies of HRV analysis for creation of the operative health control system on the basis of the smartphone. 13th Annual International Gravitational Physiology Meeting; Waterloo, Canada; 16-20 June 2014.

2. Baevsky RM. Non-invasive methods in space cardiology. J. Cardiovasc. Diagn. a. Proced. 1997;14(3):1-11.

3. Baevsky R, Chernikova A, Funtova I, Tank J. Assessment of Individual Adaptation to Microgravity during long term space flight based on stepwise Discriminant Analysis of Heart Rate Variability Parameters. Acta Astronautica. 2010;69:1148-1153.

4. Chernikova A, Baevsky R, Funtova I, Tank J. Adaptation risk in space medicine. 63-th IAC; Italy; 2012.

5. Dilman VM. The law of deviation of homeostasis and diseases of aging. Boston: John Wrigth; 1981. 380 p.