Military Personnel Selection and Diagnostic Control of Human Functional State in High Altitude Conditions

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Abstract. In the paper the initial attempts and modern approach to the evaluation of individual resistance to high altitude hypoxia in the human organism are reviewed. It is presented a big informative material about using Valsalva maneuver and its modified versions (Burger probe, Flack test, etc.) for a diagnostic estimation of cardiovascular function in the different areas of public medicine and applied human physiology. Specific role is attached use of dosed version of Flack test with 50 sec. duration of strain (DFT) for prognostic evaluation of functional opportunities of the human cardiovascular system, its adaptive potential and regulative functions in high altitude conditions. Clinical observations performed during acute period of adaptation of selected individuals to altitude of 3600 meters demonstrated an 80%-level of verification of the results of this prognosis. Method of military contingent selection and control procedures for healthy service at frontier posts in high mountains of Tien Shan and Pamir are described. It was shown that exemption of people with low resistance to hypoxia (by the results of preliminary selection with the DFT) from military service in mountain regions of Tien-Shan and Pamirs has allowed researches to bring down the morbidity among frontier-guards at high altitude frontier posts by more than 18%; to reduce the number of severe high altitude disadaptations from 70-75 to 35 cases per year; and practically to avoid lethal consequences of severe mountain disease.

Key words: Dosed Flack Test, Straining, Hypoxic Resistance, Adaptation, High Altitude, Cardiovascular System.

I. Background: initial attempts and modern approach to the evaluation of individual resistance to high altitude hypoxia in the human organism.

Development of disadaptive forms of high altitude pathology with military personnel sent to mountains, behavioral and psychological incompatibility among the personnel do great harm to the human health, to his ability to work and cause large social and economic losses. This means that when forming military units including border guards to serve at high altitude, it is extremely important to reveal individuals who have high possibility to get "adaptation" sicknesses.

To diagnose correctly, to predict and, finally to prevent situations which are dangerous to human health is an important problem requiring an immediate solution.

An important component for ensuring the successful resolution of this problem is to select military service personnel by means of a scientific process, in which adaptability to high altitude environments is considered. The qualitative and purposeful selection of the recruits for a service in high mountainous regions largely prevents the development of the disadaptive phenomena, reduces the probability of high mountainous forms of pathology originating. It is necessary to mention that the first attempts to select soldiers resistant to high mountainous hypoxia were undertaken by the Russian doctors at the end of the last century.

When considering the early research on two subjects, the works of Tretyakov, N.N. [1897] should be emphasized. Tretyakov's research noted, that the development of symptoms of mountain illness is exhibited by military service men in different degrees, and that at an altitude of 3000-4000 m, they lose ability to execute any activity. Tretyakov, based on his observations, has raised a question about the necessity of

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individual selection of military service men for service in high altitude regions. He offered method of selection, which envisaged that before dislocation of a military unit in mountains, the special functional test should be conducted as though, permitting to reveal weak and low resistant soldiers unable to serve in high altitude conditions. Tretyakov offered to conduct the tests with considerable physical exercises in conditions of normal barometric pressure, i.e. on the plain. He wrote that a selection conducted by forcing soldiers to run two Russian versts (3500 English feet), chasing each other, and determining who lagged behind, was subject to faint in vomiting etc., or had a pulse so weak, that it could not be counted, were recognized as not being fit. Tretyakov, observing the condition of soldiers after they had been transferred to the mountains, noticed that the soldiers who more likely to be subjected to "attacks of mountain sickness" were those who already were physically weak or elderly. However, such a method of selection still could not prevent the progress of many of the symptoms of mountain sickness and could not ensure the keeping of a rather high level of fighting efficiency of the soldiers, in case of climbing to an altitude of 4000-5000 m.

In military medicine in the Soviet period, great attention was given to ensuring the fighting efficiency of soldiers in high altitude conditions. Complex expeditions to study the progress of mountain sickness were carried out, and measures for preventive maintenance of acute mountain sickness were developed. In particular, research of Solovjev, V.K. [1934] indicated that physically strong soldiers with good cordial activity should be allowed to work and serve. The author highlights, that with all other conditions being equal, humans with small, but so-called, "steel muscle" will have an advantage over humans with large, massive muscles requiring plenty of oxygen. At the same time, research on interrelation between deterioration of oxygen transport in conditions of high altitude hypoxia and physical state of an organism has shown, that even for well trained athletes to endure high altitude can be much greater obstacle than for people who do not go in for sports [J. Dempsey, 1986; R.J. Shephard et al. 1988].

Real scientific development of tests permitting evaluation of human endurance of oxygen deficiency begins in 30s - 40s years of our century in the period of rapid development of aviation and high altitude flights. During these years scientists recognized that a pressure chamber could be used to evaluate individual reactions to hypoxic hypoxia and to increase pilots' resistance to it, especially for those who reacted most poorly to a lack of oxygen [P.I. Egorov, 1937; V.V. Strelcov, 1938, 1945; A.M. Apollonov and V.G. Mirolubov, 1988].

Unlike Soviet researchers who showed the principal possibility to increase quickly the pilots' resistance to high altitude hypoxia during ascent in the low-pressure chamber, Western scientists used pressure chamber tests for the purposes of medical examination to select candidates for flight personnel.

Due to empirical observations and accumulated scientific data, it has become possible to proceed from a simple ascertaining of one or another human functional state to scientifically grounded evaluations of a person's possible state in the future under the influence of unfavorable environmental factors. And, on this prognostic basis, to develop principal concepts and methods of selecting people, who would have a high probability of keeping their working capacity in certain professional or ecological conditions.

Research in the field of personnel selection and forecasting of working capacity are practically impossible without a preliminary evaluation of the functional systems of an organism and its potential ability to adapt to extreme conditions of an environment. In many respects, this research depends on the elaboration of adequate methods of prognosis, permitting, in usual conditions, to determine degree of stability and a probable level of working capacity of the individual when transferred to unusual conditions, for example, under the adaptation in mountains.

The literature on the functioning of the human organism in extreme conditions, and, in particular, the literature on hypobaric hypoxia, shows that the majority of the researchers are inclined to study the physiologic deflections of an organism in dynamics to the influence of the hypoxic loading tests. The specialist's efforts are aimed at clarifying the range of physiologic standards on separate parameters of the organism, defining reactions to different systems, searching for additional signs describing probe endurance. Such an approach allows researchers to judge with a certain degree of reliability, the level of functioning of this or that physiologic system of an organism, to determine the volume of reserve capabilities and, finally, to have a picture about the adaptive capability of the individual to extreme factors. Adaptive capability is the final link leading to prognosis, and its correct and concrete definition will determine whether the prognosis will be long-term or short-term. That is why modern prognostic diagnosis is based on an evaluation of the degree of human adaptive capability which first of all is understood as an adequate level of functioning of physiologic systems in the changed conditions [V.P. Kaznacheev et al., 1980]. Individual human qualities, on the whole, reflected in concepts, such as working capacity, endurance and adaptive capability. According to the opinion of Imangulov, R.G. [1982], these concepts and the human conditions, expressed by them, are closely interconnected and are a reference point for the fighting capacity of military service men. Through determining the state of the physiologic, psychophysiologic and mental functions of a person, it is possible to estimate the informative and motivate maintenance of learn-fighting activity of the experts, the range of adaptive-compensatory opportunities of the person and to predict fighting capacity of the military men during the learn-fighting preparations.

From the physiologic point of view, the success of adaptation, its completeness and resistance are determined by a range of adaptive and compensatory mechanisms, by the level of physiologic reserves of the person [A.S. Solodkov, 1982; A.A. Aidaraliev et al., 1988]. Use of the reserving opportunities is based on the coordinated reactions of separate bodies and systems, which change in unequal ways, but as a whole, provide optimum functioning for the organism as a single unit. The physiologic reserves, as Brestkin, M. P. [1958] remarked, are provided with certain anatomical, physiologic and functional features of structure and activity of the organism, significant intensification of heart activity, increase of the general intensity of blood flow, pulmonary ventilation, high resistance of cells and tissues to various external influences and internal changes in the conditions of their functioning.

Though the physiologic reserves of an organism are individual and are largely determined by hereditary features, they can, in a sufficient degree, be changed under the influence of external environmental conditions. So, during the development of condition of acquired adaptation reserve abilities of an organism can rise both at the expense of increasing contours of the maximal intensification of functional activity of physiologic systems, and at the expense of contours reducing the basal level of activity [G. M. Yakovlev et al., 1990]. The authors note that in the first case the adaptive ability of an organism to achieve a marginal level is caused by both its inborn and gained features.

A specific method of revealing of human individual resistance to hypoxic hypoxia is a pressure chamber test. Along with that, the faster and more expressive mechanisms of protection from hypoxia are in a human, the higher is his ability to adapt [V.I. Medvedev, 1982]. The prognosis is usually based on distinctions in the condition of a number of systems, mainly vegetative, immediately after climbing and after one-hour stay at the higher altitude. According to the opinion of Asyamolova, N. and Malkin, V.B. [1968], a test in a pressure chamber at an altitude of 5000 m. reveals the individual features of adaptive reactions of blood circulation. The USA and Germany, on the other hand, use ascent in a pressure chamber to 7500 m to test individual reactions to hypoxia.

It is necessary to emphasize that there is no direct correlation between resistance to acute hypoxic hypoxia (ascent in the pressure chamber) and chronic high mountainous hypoxia. So, the research of Malkin, V. B. [1968] shows that people who have extremely low sensitivity to acute hypoxia and who have experienced conditions of collapse, sharp bradycardia during the ascent in a barometric camera, and who preserved for a long time (up to 30 days) high mountainous resistance to the chronic influence of alpine environmental factors during transfer to mountains and climbing.

In sport activities dosed standard exercises are used for evaluation of physiologic reserve (Letunov tests, step tests modifications, velo-ergometria, treadmill and treadbane), [V.P. Zagryadski and Z.K. Sulimo-Samuillo, 1976; A.S. Mozjuhin, 1982; V.L. Karpman et al., 1988], moreover the level of reserve capabilities may be judged first of all by parameters of the function of cardiovascular and respiratory systems, and the volume of gas exchange [A.S. Solodkov, 1982].

The research of Mirrahimov, M.M. et al. [1983] showed that during the study of organism's response reactions to various exercises (Harvard's step-test, standard veloergometric exercise with the power of 900 kgm/min during 6 minutes, running to various distances) for a large group of the examinees the best kind of exercises for evaluation of a person's functional state is a method of standard veloergometria.

The choice of an optimum exercises was conducted at sea level where the examinees were asked to do exercises listed above: the volunteers were subdivided into groups of "strong" or "weak", depending on their performance on these tests. Then the volunteers were moved to high mountains at 2900 m., from this height they climbed to the altitude of 3870 m. where they made various kinds of activities. During the research it turned out that part of the examinees were not able to complete physical activities. Based on the results of endurance of climbing to an altitude of 3870 m, on endurance of veloergometric exercises, on research of the objective status (along with attention to clinical symptoms and to complaints of the examinees), a group of persons who endured very badly the transfer to mountains was chosen. It is interesting that the considered group, in conditions of foothills, had shown the worst results of the loads endurance. Only three persons referred by the author in foothills to the "weak" group satisfactorily endured exercises at altitude. From 17 persons who were chosen in this group, on the third day of adaptation to high altitude conditions there remained 13, as the four were sent to foothills. From the rest, the three persons were dismissed from exercises right up to the 45th day of stay in mountains, as on an electrocardiogram they revealed symptoms of hypoxia of the myocardium, overload of right ventricle and sinus tachycardia. As the authors determined, under such a submaximum veloergometric load, the most expressed mobilization of physiologic functions happens: it is rather great to mobilize reserve, and, at the same time, not so hard to take out an adaptive mechanisms of organism within physiologic limits.

On the basis of clinical parameters and the change of parameters of the cardiovascular and respiratory systems during the execution of a standard veloergometric load, the authors developed a prognostic method of selecting the examinees in groups with a different level of resistance to hypoxia, conventionally called "strong", "average" and "weak".

The most informative parameters were the heart and breathing rate at exercise climax, the index of trends, the sum of pulse activity and its recovery. The index of trends in the strong group was higher than in the weak group by 0.5 points. The sum of pulse activity in the "strong" group in average made 747 + 27.4 strokes per a minute, where in the "weak" group it was 1001 + 6.9 strokes per a minute, the pulse sum of recovery in the same groups - 679+ 22.9 and 831+ 27.9 strokes per a minute accordingly. For persons attributed to the "weak" group a large surplus of heart and breathing rate was marked in execution time of exercises. To the important indications permitting the subdivision of the examinees into groups, apart from physiologic parameters, the authors also attribute clinical manifestations arising during standard exercises (the 2nd tone accent, it's splitting at the pulmonary arteries etc. The criteria for placing someone in a "weak" group include: a low vital capacity of lungs (less than 3000 ml), the volume of forced inhalation – attributed VFI (less than 1000 ml), tests of Tiffno (less than 70%), heart rate (more than 75 strokes per a minute), breathing rate (more than 28 strokes per a minute), the test of Shtanger (less than 45 sec.), the test of Genchi (less than 25 sec.).

The analysis of electro cardiograms made at sea level and in the mountains, shows that the changes in electrocardiograms were registered the most frequently in the weak group.

Emergence of disadaptive phenomena during the performance of physical exercises in the mountains in individuals with minor changes of electrocardiograms at sea level points out to the necessity of more careful selection of people to work in high altitude conditions. Registration of electrocardiograms is mandatory for all those being inspected and for this, implementation of various probes (hypoxic ones, tests with physical load, etc.) during electrocardiogram is deemed quite useful.

The range of organism's capabilities or its physiologic reserves is revealed also through various functional probes (probes of Shtanger, Genchi, Valsalva, etc.; probe with breathing of hypoxic gas mixture and re-respiration probe), [A.G. Dembo et al., 1975; V.P. Zagryadski and Z.K. Sulimo-Samuillo, 1976; P.V. Buyanov and P.V. Pisarenko, 1977; A.B. Gandelsman et al., 1984; V.V. Goranchuk et. al., 1997, K.S. Drugova, 1997]. Implementation of these probes is much simpler in comparison with testing in pressure chambers, and it does not require expensive and unique equipment, and can provide their application in field trips. Probes of straining under impaled breathing and re-respiration characterize the compensatory processes on the part of the respiratory system and blood circulation, the ability of an organism to maintain the acid-alkali balance and the reserve capabilities of an organism [G.M. Pokalev, 1976].

One of such test which has been widely used in aviation and space medicine, is the so called "Flack's test" and some other modifications of Valsalva's probe [P.I. Egorov, 1925; V.E. Danilov, 1948; G. Armstrong, 1954; M.M. Link et al., 1975; L.G. Maksimov et al., 1975]. They are widely used for diagnosing of cardiovascular diseases in various fields of medicine and human applied physiology.

A breathing test with straining was offered by the Italian scientist Antonio Maria Valsalva (1666-1723) in 1704 for use in diagnosing ear diseases [A.M. Valsalva, 1717]. In the first half of the 20th century Flack, and then also Burger, modified Valsalva's test and developed a new technique for estimating the functional state of the cardiovascular system on the basis of that test.

In 1917 Martin Flack, a lieutenant colonel of British Air Force, while studying the influence of straining using Valsalva's experiment on the human organism, measured the heart rate right before the probe and every five seconds during the straining. Applying this method for selection of candidates to military aviation, the author used the manometric systems for dosed straining force, connected to a mouthpiece, in which the examinee executed an exhalation. The test consists of the examinee making a deep inhalation and then an exhalation in the mouthpiece for pressure maintenance in the pressure gauge equal to 40 mm of the mercury pole. The examinee should continue the dosed straining «till refusal».

The author considered it as a good indication, when at this time a cordial rhythm would speed up just moderately or remain unchanged, and straining would proceed, at least for 50 seconds. He considered slowed down or noticeably speeded up cordial activity and also, increase of blood pressure, as indications of shortage of blood circulation functions [M. Flack and B.S. Oxon, 1921; M. Flack and B.S. Burton, 1922].

More than a half-century ago, Anderson, G. [citation by P.I. Egorov, 1925] wrote that the Flack's test with straining was a valuable method to use to find out the condition of the lungs, heart, and brains of good and poor pilots; thus, "eligibility models" for air flights could be established. Anderson's research showed that, those pilots, who suffered at high altitudes, couldn't hold back breathing unlike those, who were not influenced by altitude.

Afterwards, a program of tests for medical examination of the pilots was confirmed at the Ministry of Aviation of Britain. One of the tests has been used up until present time and is the one with a 4 millimeter U-tube with mercury (Flack's test). According to Dawson, P.M. [1943] the original modification of the test with straining had been very successfully used to determine functional conditions of British Air Force pilots, and proved itself as the most reliable test. However, some authors in their researches have obtained the results which denied the significance of Flack's test as one determining physical eligibility in aviation [A.W. Lapin, 1943; T.J. Powell and F.A. Sunahara, 1958; M. Vlasak, 1963]. Obviously, differences in methodology related to the dosage and the time of straining may have made the above-mentioned researchers have a negative opinion about the use of Flack's test in a pilot examination.

Confirmation of the suitability of Flack's test, as an indicator of the emotional and physical characteristics of candidates for flight, was given in 1944 by Anon [quotation on T.J. Powell and F.A. Sunahara, 1958] after examination of 9573 pilots of Canadian Air Force, when the author obtained a large percent (57,6%) of the coincidence by test's results. Then the efficiency of the respiratory test with straining was proved for selection of the astronauts and aviators in the USA [N.M. Link et al., 1975]. In the opinion of the authors, except for an evaluation of the reflex regulation of vascular systems, the test is of interest for revealing the violations of a cordial rhythm by the data of an electrocardiogram and arterial pressure.

In particular, Asiamolov, B.F. et al. [1979], studying the resistance of the human to strain on "head-pelvis", have determined the exact correlation between the expressed violation of a cordial rhythm during the execution by the examinees of Valsalva's test and the endurance of strains. In their work, the prognostic value of the performed test is accentuated, as the expressed violations of a cordial rhythm revealed by the Valsalva's probe, were observed in individuals with reduced resistance to strains. The dosed probe with straining became highly useful under the evaluation of compensatory reactions of the human cardiovascular system [L.G. Maksimov et al., 1975]. The original prognostic criteria, as the authors consider, may be the biggest deflections of the investigated indicators during the execution of the test (Amax), after test (Amax"), and also sum of these deflections (Amax + Amax"). Thus, for example, under the violations of heart activity regulation the systolic pressure is increasing considerably immediately after the execution of test and in a period of recovery. Under the normal state of heart activity the changes of arterial pressure (AP) are insignificant [V.P. Zagryadski and Z.K. Sulimo-Samuillo, 1976].

From the changes of systolic and diastolic pressures before and after the execution of the test Zagryadski, B.D. and Sulimo-Samuillo, Z.K. [1976] have offered an informative parameter (PQR – parameter of quality of a reaction), permitting us to evaluate the response of the cardiovascular system to an additional stimulating effect.

The authors consider that if the meaning of PQR exceeds 0.10-0.25, then the cardiovascular system of the examinee is in a condition of stress. At the degree of increase of the pulse for 5 sec., in relation to an initial level during the execution of the Flack's test the following three types of reactions are distinguished:

- No more than 7 strokes – good
- No more than 9 strokes - satisfactory
- 10 strokes and more - unsatisfactory

It is also an estimated criteria of the state of cardiovascular system.

Through the research of Sergeev, V.N. [1959] it is established that a limit of allowable displacement («norm») under the Valsalva's test (15-20 sec.) using the data of oscillometry are:

a) an increase of diastolic and mean arterial pressure AP no more than 10-15 mm of mercury pole (Hg);
b) changing of systolic pressure AP (increase or decrease) for 10-20 mm of Hg;
c) decreasing of pulse pressure no more than 15-20 mm of Hg;
d) decrease of oscillometric index no more than 5-8 mm of Hg.

According to the author's data, patients with "pulmonary heart", even in the latent period of violation of compensation, the increase of diastolic more than 20 mm of Hg is a distinctive sign. During the decrease of contractile function of the myocardium, an expressed decrease of pulse pressure (more than 30 mm of Hg) and oscillometric index is observed.

The functional test of heart by Valsalva/Burger [M. Burger, 1921, 1925] gave the beginning to the diagnostics of many cardiovascular diseases, and it is recommended to apply the test under latent violations of hemadynamics and the clarification of character of the functional violations with "pulmonary heart", myocardiodystrophy, compensated valvular disease of heart, and hypertonic illness of heart of the 1st degree [W.C. Little et al., 1985; R.A. Nishimura and A. Jamil Tajik, 1986].

This method was successfully applied under the aortography and coronarography [H. Ludin, 1962], during a study of the large vein and the "right heart" [P. Amundsen, 1953; A. Celis et al., 1956], and the kidney's arteries [J.M. Riby, 1965; A.W. Templeton, 1965]. It had been shown that the application of the test with a simultaneous record of the vector-, ballisto- and electrocardiograms, to a greater degree reflects the changes in the functional state of heart [I.N. Vasiliev, 1978; A.F. Zarine and E.Y. Gaile, 1982]. Valsalva's test is often used for study of peripheral hemacirculation and arterial pressure [R.H. Johnson et al., 1969; B.D. Zabudski and S.V. Gadiatov, 1970; J.L. Reid et al., 1971], vein pressure and tonus [E. Wick and R. Knebel, 1961], changes in hemadynamics of visceral organs [B. Gforer, 1951], the state of vascular baroreceptors [J. Szachowski et al., 1968; L. Stejskal, 1969; H.A. Palmero et al., 1981; D.S. Goldstein et al., 1982; B.Trimarco et al., 1983; K. Shimada et al., 1986; S.A. Smith et al., 1986], the state of electromyographic activity [P. Tornow and C., Durst 1969] and the dynamics of blood circulation through the brain [H. Lechner et al., 1968; A.I. Martynov et al., 1968; V.G. Spirin and E.I. Savchenko, 1974].

It is recommended to apply the test or determining the degree of blood circulation deficiency in liver with rheography [T. Posteli and G.C. Garbini, 1968], as well as for evaluating the functional state of heart of patients with chronic pulmonary diseases [F.V. Arsentiev et al., 1975; A.A. Penkovich,1966]. The specific characteristics of heart's response to the Valsalva's test provide an opportunity to get a picture of the functional state of the vegetative nervous system [R.U. Looga, 1970], the response is one of the indicators of the effectiveness of sanatorium and climate treatment, especially of the functional therapy results.

Valsalva's test in Burger and Flack's modifications is of significant interest in sports and medical researches [M. Burger et al., 1929; H. Reindell et al., 1954; G.K. Birzin, 1958; A.G. Dembo et al., 1975; V.A. Zinochkin, 1985; V.L. Karpman et al., 1988].

It serves as a tool of medical control in physical culture education practice, in solving the problem of the acceptability of dosing, of static efforts connected with straining, in particular; and has large significance for the whole range of sports, in which straining is the integral part of sport activity. This includes, for instance, heavy athletics, shot-put and hammer-throw. Along with these sports, in which the role of exertion is particularly large, the increase of internal pulmonary and internal abdominal pressure is observed during wrestling contests, gymnastic exercises and a whole range of other kinds of sports, in which breathing can also be detained [M. Burger and D. Michel, 1957; A.B. Kozlov et al., 1985]. As studies conducted by Reidell H. et al., [1954] was shown, Burger's pressure test is especially valuable when combined with X-ray kymography of the heart for selecting individuals inclined to collapse, during examination of persons practicing in diving, rock-climbing and weight-lifting.

According to the opinion of Chaillet-Bert P. [1956], it is better to use Flack's "endurance" test in a combination with Pashone-Martine's test (i.e. an orthostatic test before and after knees-bends performed during 40 seconds). He supposes that if these tests are sequentially applied one after another, they mutually supplement each other, characterizing the functional state of the "right heart" in the first case, and the "left heart" in the second case.

From the studies of functional states of highly qualified sportsmen performing underwater diving, who performed Valsalva's test before and after the standard veloergometric exercise, it was found that along with frequency of heart rate, it is worthwhile to use indicators of a cardiac output: systolic volume and blood volume per minute, for evaluating an endurance test [V.A. Zinochkin, 1985].

Dembo, A.G. and co-authors [1975] recommend conducting such respiratory tests strictly in a combination with oxyhematometry to control changes in oxygenation of the arterial blood, because the maximum detention of breathing sometimes results in a significant fall of HbOO in blood. These data confirm studies of other authors which revealed that oxyhematometric indicators can be an adequate reflection of compensatory capabilities of the respiratory and heart vascular systems [E.M. Kreps, 1959; N.V. Belyaeva, 1967], and the oxyhematometric method itself can be useful for understanding of hypoxic effects [N.A. Saunders et al., 1976; R.J. Smyth et al., 1986].

The results of the conducted research give us a basis to consider that it is worthwhile to conduct Flack's test with simultaneous registration of the oxyhematometric indicators that allow us to more fully determine the functional state of the human both in rest, and after the physical efforts.

At the same time, special attention should be paid to the separate prognostic approaches to the analysis of testing results with the purpose of selecting the persons suitable for the pilots' profession, for determination of training level of sportsmen, etc. This also could be used for an evaluation of the functional state of people in conditions of mountain hypoxia. As Armstrong, G. [1954] has noted, in an analysis of the test's results for selecting people suitable for the pilots' profession, it is necessary to take into account that in a healthy person the heart rate remains practically constant, or increases within the limits of 72-96 strokes per minute, depending on duration of straining (usually 50-60 sec.). If the pulse becomes much more frequent, for example, within the limits of 72-132 or 144 strokes per minute, then the results of the test are considered unsatisfactory. By results of such test it is possible to judge both about steadiness of nervous centers managing the breathing and blood circulation, and about the potential degree of endurance of this person. Applying so-called dosed tests when, for diagnostic purposes, the time of straining is limited from 20 up to 50 sec., some authors have detected that in normal conditions the increasing of pulse frequency, in comparison with the basic data, proceeds for approximately 15-20 sec., and then the frequency of heart rates is stabilized [V.L. Karpman et al., 1988]. With an insufficient quality of regulation of the heart's activity in individuals with an increased reactivity, the frequency of heart palpitations can be increased during the test. If the initial increase of pulse is replaced by its consequent decrease, that is an indication of a negative response to the test. On the other hand, for well-trained sportsmen the response to the increase of internal pulmonary pressure is expressed only insignificantly. So, the increase of pulse frequency for each 5 sec. at 1-2 strokes, in relation to basic data, is evaluated as an excellent response to the straining. Along with that, the duration of straining is 45-55 sec. If the acceleration of pulse achieves 3-4 strokes for each 5 sec. of straining, then the response is evaluated as "good". The higher speed of pulse (5-7 strokes) is satisfactory for sportsmen, and for untrained people is indicative of a good physical state of the organism.

According to the data of Zinochkin, V.A. [1985], for individuals with reduced physical efficiency, the apparent tachycardia is marked during a Valsalva's test, even prior to the initiation of exertion.

When evaluating the state of the heart muscle by the reaction of maximum arterial pressure to a pressure sample, Burger [M. Burger, 1956] has considered three types of reactions. The normal type of reaction is that the systolic pressure almost never changes during the straining. The increase of arterial blood pressure during straining and the restoration to an initial value in 20-30 seconds after the experiment is stopped (the second type) is typical for trained sportsmen. A negative reaction to the sample (the third type of reaction) is expressed by a significant decrease of AP during straining.

According to the opinion of Burger, M., the increase of the arterial pressure during the test is connected with the fact that the trained heart is capable of pushing large volumes of blood through narrowed lung capillaries. For an untrained heart, this ability is less, owing to how the blood pressure falls in comparison with the initial test [M. Burger, 1925, 1926]. With an "astenic" heart a severe fall in the blood pressure takes place, which can result in collapse, as the regulation of the tone of the vessels is broken. As the research of Reindell, H. et al. [1954] have shown that this test is especially valuable for revealing sportsmen most inclined to collapses.

Trimarco, B. et al. [1983] recommend the use of an analysis of changes in cardiorhythm and systolic pressure in the end of straining during Valsalva's test for estimating the individual state of the examinees. In their opinion, the greatest deviation of heart rate and the least increase of systolic pressure in this period, by comparison with norm, are an attribute of hypertension in the surveyed persons.

The functional meaning of the test is explained by the fact that strong contraction of the exhalating respiratory muscles with closed upper respiratory ducts (i.e. a glottis or a mouth and a nose) results in increase of pressure inside the lungs, to the stagnation of the veins, and to an increasing resistance to the blood flow in the vessels in the small circle of blood circulation. Due to this, there is a decrease of the systolic volume of blood circulation [R.U. Looga, 1970; V.G. Spirin and E.I. Savchenko, 1974; I.N. Vasiliev, 1978; V.L. Karpman et al., 1988]. The decrease of blood circulation volume per minute is accompanied by a change in the tone of the vessels, infringement of blood circulation to the brain, and a change in the quality of the regulation of heart activity.

Straining with a closed mouth and nose leads not only to an increase of internal pulmonary pressure and reorganizations connected with it in the system of cardiopulmonary blood circulation, but also to alveolar hypoxia [A.A. Penkovich, 1966] and to cerebral hypoxia [R.W. Alman and J.F. Fazekas, 1962; J.S. Meyer et al., 1966] as a result of the infringement of blood flow. The last effect, according to the data of the authors, in its turn, caused, on one hand, by the fall of volume of blood per minute, and on the other hand -

by the constriction of blood vessels in the brain, and lung capillaries. As with Valsalva's test, the pressure of COO in the arterial bloods falls. The data of Duke, H.N. [1954], Bergofsky, E.H. et al. [1968], Viles, P.H. and Shepherd, J.T. [1968], Hauge, A. [1969], and Bergofsky, E.H. [1969] specify that fact, the development of alveolar hypoxia is exactly one of necessary components of a pressure reaction of an organism.

From the above stated evidence it follows that respiratory tests with straining, such as Valsalva's test and its modifications, along with the above-described effects to the cardiopulmonary blood circulation, have expressed hypoxic influence on the human organism. The development of alveolar hypoxia and cerebral hypoxia, as the consequence of infringements of blood supply, causes an immediate compensatory-pressure reaction of the cardiovascular system which is displayed in increased frequency of heart reductions and arterial pressure [R.U. Looga, 1970, 1973]. According to the data of Strohl, K.P. et al. [1984], from the degree of compensation of hypoxic stress by the cardiovascular system, when a person is undergoing a respiratory test, one can get an idea about the resistance level of any individual to oxygen deficiency.

The effectiveness of Valsalva's test, used as a hypoxic functional test, is explained by the following: the straining, when parts of the upper respiratory ducts of a human are closed during testing, results in static tension of the lung vessels, vein stagnation and changes in heart regulation [P.E. Paulev et al., 1988). This is well known as "the reflectory preservation of oxygen" phenomenon, which greatly depends upon the continuous supply of oxygenated blood in the organism [R. Elsner and P.F. Scholander, 1965]. Consequently, the extended utilization of oxygen reserves by organs specifically initiates such extreme situations as cerebral and alveolar hypoxia.

II. The Dosed Flack test as a method of diagnostic control of the human functional state in the extreme environmental conditions of high altitudes.

The Valsalva maneuver, and its modified versions (Burger probe, Flack test, etc.) as was mentioned above have widely been used for a diagnostic estimation of cardiovascular function in different areas of public medicine and applied human physiology. In mountain conditions we used a dosed version of Flack test with 50 sec.' duration of strain. According to the results of our studies [V.P. Mahnovsky et al., 1984, 1985, 1986, 1988, 1989], applied to 820 young and healthy military servicemen during adaptation to different altitudes of Tien-Shan and Pamir (800, 1800, 2800, 3600 and 3800 meters), there are some solid preconditions for applying this modification of Flack test to high altitude medico-biological studies in order to estimate the functional state of a human during adaptation to hypoxia. We have found that application of a dosed Flack test is an effective method of estimating the functional state of the human cardiovascular system, particularly of its adaptive potential and regulative functions in conditions of short-term as well as long-term effects of high altitude hypoxia. Table# 1 includes short descriptions of the main areas and directions of using the versions of the Valsalva maneuver.

Basing on the dosed Flack test, we have developed and implemented an express-method of prognostic estimation of the human organism's resistance capacity to the effect of the hypoxic factor into military medicine practice (implementation actions: register No171944 dated 12.01.86 and register No. 85 dated 16.01.98). This method has demonstrated a high effectiveness both for operative medical control of functional state of vital human systems under the influence of stress factors of environment and activities, and for evaluation of general adaptability of organism and the prognosis of acquired adaptability. The great significance of using the dosed Flack test as a prognosis probe was determined by mass selection of military servicemen for high altitude service. Clinical observations performed during acute period of adaptation of selected individuals to altitude of 3600 meters demonstrated an 80%-level of verification of the results of this prognosis [V.P. Makhnovski and R.V. Bolshedvorov, 1986]. Exemption of people with low resistance to hypoxia (by the results of preliminary selection) from military service in mountain regions of Tien-Shan and Pamirs has allowed researches to bring down the morbidity among frontier-guards at high altitude frontier posts by more than 18%; to reduce the number of severe high altitude disadaptations from 70-75 to 35 cases per year; and practically to avoid lethal consequences of severe mountain disease (document No181350 dated 20.01.87).

Therefore, the studied and approved procedures of prognostic estimation and selection mentioned above can be assumed as a basis of a suggested method to control or correct the human functional state in high altitude conditions.

Below we describe our method with necessary procedures on control of the human functional state in the extreme environmental conditions of high altitudes.

Table #1

Main Areas and Directions of Using the Versions of the Valsalva Manoeuver

Area	Version	Directions	References
Aviation and Space Medicine	Flack test, 20-30 sec.- dosed Valsalva maneuver	selection of pilots and cosmonauts	Danilov, 1948; Armstrong,1954; Link et al.,1975
Naval Medicine	50 sec.-dosed Flack test	estimation and control of cardiovascular function of navy contingent during long-term autonomous navigation	Aidaraliev et al., 1988; Makhnovski, 1991
Sports Medicine	Burger Pressdruckprobe	estimation of physiologic possibilities and control of coaching levels	Birzin, 1958; Karpman et al., 1988
Mountain and Military Medicine	50 sec.-dosed Flack test with registration of electrocardiogram, arterial blood pressure, and arterial blood oxygenations	estimation and prediction of human functional states during short- and long-term adaptation at high altitude; estimation of level of human hypoxic resistence; selection of military contingents for serving in high altitude conditions	Makhnovski et al., 1985, 1985a; Makhnovski and Bolshedvorov, 1986; Makhnovski et al., 1988; Makhnovski, 1991; Makhnovski et al., 1998
Public Health	Valsalva manoeuver	medical diagnostics and control of cardiovascular diseases	Posteli and Garbini, 1968; Little et al., 1985; Nishimura and Jamil Tajik, 1986
Human Physiology	Valsalva manoeuver, Burger Pressdruckprobe	estimation of the functional state of different organs of the blood circulation system and its vegetative nervous regulation	Gforer, 1951;Celis et al., 1956; Wick and Knebel, 1961; Ludin, 1962; Takagi and Magasaka, 1964; Sharpey-Shafer, 1965; Riby, 1965; Lechner et al., 1968; Tornow and Durst, 1969; Reid at al., 1971; Looga, 1973; Zarine and Gaile, 1982; Trimarco et al., 1983; Smith et al., 1986

Description of the Method

The method includes pre- and high-mountain phases of measures using the dosed Flack test (DFT) described below:

Pre-mountain phase

Selection: using the DFT with the criteria of Table #2 to identify an individual level of hypoxic resistance, i.e. high hypoxic resistance (HHR), average hypoxic resistance (AHR) and low hypoxic resistance (LHR).

High-mountain phase

Control: using the DFT with the criteria of Table #2 to identify, in proper time, the cases of illnesses due to disadaptive disorders in the AHR and HHR persons.

The Dosed Flack Test:

For the test, a person is asked to take a deep breath and then slowly breath out the air into a tube connected with a manometer, in order to lift up and maintain a level of airway pressure of 40 mm of Hg for 50 seconds against a closed mouth and a nose. The electrocardiogram and arterial oxygen saturation are monitored before, during, and after (for 3 min.) the straining. Arterial pressure is measured before, at the end (i.e. at 45-50 sec.), and after (i.e. at 1, 2 and 3 min.) the straining. The integral rheocardiogram is monitored before and after the straining.

The Selection Procedure:

To determine a level of individual hypoxic resistance of a person, it is necessary to conduct a comparative analysis of the DFT results with the use of the value's range of critical physiologic indicators and coefficients and with due regard to the "weight" (significance) of the integral coefficients devised on the basis of our investigations [V.P. Makhnovski, 1991] as mentioned in Table #2. The highest number of coincidences for the measured values of the person's physiologic indicators with the table's data (in the 1st step of the analysis) and the final confirmation of it by the integral coefficients (in the 2nd step of the analysis) allow the division of the subjects into 3 groups, according to their hypoxic resistance type (HHR, AHR and LHR) and so to select the necessary contingent for work at high altitude conditions.

Data Treatment:

Heart rate (HR): HR is calculated on the basis of the electrocardiogram.

Systolic and diastolic pressures is measured by sphygmomanometry.

Mean arterial blood pressure: from the systolic and diastolic arterial pressures, the MAP is calculated as the sum of 1/3 of the pulse pressure and the diastolic pressure.

Types of cardiovascular self-regulation are determined by the express-method of integral evaluation of blood circulation [Arinchin N.I., 1978] on the basis of calculation and percent comparison of the following cardiovascular indexes: (1) fact and proper means of cardiac index (CI = cardiac output/body weight) and (2) fact and proper means of index of total peripheral resistance (TPR = (1333 x 60 x MAP)/CI):

$$C = 100\% \times \text{ fact } CI \,/\, \text{proper } CI;$$

$$P = 100\% \times \text{ fact } TPR \,/\, \text{proper } TPR$$

If in the post-test period there is C > P - a prevalence of cardiac type reactivity of self-regulation; and if there is C < P - a prevalence of vascular type reactivity of self-regulation.

Type of vegetal reactivity: determination of type of vegetal reactivity during the DFT is made on the basis of comparison of indicators of heart rate (HRc - control, HRt - in the end of testing) and arterial pressure (*Am*AP0 - control amplitude, *Am*APt- amplitude in the end of testing) by Grotte's formula [A.V.Vein et al., 1981].

$$A = 100\% \times (A_mAP_t - A_mAP_0) \,/\, A_mAP_0;$$

$$B = 100\% \times (HR_t - HR_0) \,/\, HR_0$$

Table #2

The Criteria of Human Selection for Work at High Altitude

Indicator	Method	Type of Human Hypoxic Resistance		
		HHR	AHR	LHR
Heart rate (HR)	Electrocardiography	increase of HR frequency by 1-4 beats per minute for every 5 sec. during 15 sec. at onset of the straining, then relatively stable heart rate	increase or decrease of HR during the straining by no more than 20 beats per minute	initial increase of HR, then its sharp decrease during the straining (i.e. more than by 20 beats per minute)
Systolic arterial pressure (SAP)	Sphygmomanometry	insignificant increase of SAP (i.e. no more than 20 mm of Hg), then its fast restitution (i.e. in 30-50 sec.) after the end of the straining	increase or decrease of SAP, but level of decrease of SAP during the straining must be no more than 20 mm of Hg with its fast restitution after the end of the straining	significant increase or decrease of SAP (i.e. more than by 20 beats per minute) with its relative long-term restitution after the end of the straining
Mean arterial pressure (MAP)	Calculation according Zagryadski and Sulimo-Samuillo [1976]	insignificant change of MAP during the straining (i.e. no more than 4-5 mm of Hg)	change of MAP during the straining is 5-6 mm of Hg	change of MAP during the straining is more than 6 mm of Hg
Index of type of vegetative nervous reactivity	Calculation with use of cardiovascular indicators according Vein et al. [1981]	a parasymphatetic against increasing or relatively stable value of systolic pressure during the straining	a normotonic during the straining	an expressed symphatetic against increasing systolic pressure during the straining

Table #2 (continue)

The Criteria of Human Selection for Work at High Altitude

Indicator	Method	Type of Human Hypoxic Resistance		
		HHR	AHR	LHR
Index of type of cardiovascular self-regulation reactivity	Calculation with use of cardiovascular indicators according Arinchin [1978]	cardiovascular regulation during the straining	cardiovascular regulation during the straining	expressed cardiac or vascular regulation during the straining
Rate of reducing oxygen saturation	Oxyhemametry	insignificant rate of HbO_2% reduction during the straining	insignificant rate of HbO_2% reduction during the straining	high rate of HbO_2% reduction during the straining
Index of compensatory reactivity rate (CRR)	Calculation with use of oxyhemametric indicators according Makhnovski et al. [1989]	CRR = more than 1,20	CRR = 1,00 - 1,20	CRR = less than 1,00
Index of economizing efficiency of oxygen utilization (E)	Calculation with use of oxyhemametric indicators according Makhnovski et al. [1989]	E = 0,32 and more	E = 0,25 - 0,31	E = less than 0,25
Test's tolerance coefficient (TTC)	Calculation with use of cardiovascular indicators according Makhnovski [1984]	TTC = 0,20 - 0,99	TTC = 0,99 - 3,12	TTC = more than 3,12
Functional reserve coefficient (FRC)	Calculation with use of cardiovascular indicators according Makhnovski [1984]	FRC = positive value: 2,00 and more	FRC = positive value: 0,20 - 2,00	FRC = negative value: less than - 0,50

In norm there is A > B, and the regulation is basically conducted by means of arterial pressure, but not by heart rate's changes. If means of A and B increase significantly during DFT there is a prevalence of symphatetic type of vegetal reactivity.

Oxyhemametric indexes: On the basis of a degree of oxygen saturation (HbO2%) changes in arterial blood accordingly the phases of oxyhemagraphic curve [Tichvinsky S.B., 1960] which characterizes the separate time periods of HbO2% during the DTF a rate of reducing oxygen saturation (VHbO2%), an economizing efficiency of oxygen utilization (E) and a compensatory reactivity rate (CRR) are calculated according the following formulas [V.P.Mahnovsky, E.I.Kuzuta, 1989]:

$$V_{HbO_2\%} = \Delta\, HbO_2\% / \Delta t\ ;$$

$$E = 0{,}02 \times t_{AB}$$

$$CRR = \int_D^E V_{HbO_2\%}\, \Delta t \ \Big/ \int_E^F V_{HbO_2\%}\, \Delta t$$

These indexes characterize indirectly rate of oxidative processes in blood and its compensatory functions.

Integral evaluation of physiological reserve and quality of the DFT individual tolerance are made on the basis of our designed and verified [V.P.Mahnovsky, 1991] the following coefficients: test's tolerance coefficient (TTC) and functional reserve coefficient (FRC). These coefficients are our modification of an indicator of biosystem adaptability of prof. Melnikov N.P. [1977]. Calculation of the coefficients is based on integrative comparison of fact means of heart rate, systolic and mean arterial pressures (for TTC) or diapasons of its variability (for FRC) which are monitored (1) in rest conditions, (2) in the end of the DFT and (3) in post-testing period. The coefficients are calculated by the following formulas:

$$TTC = \sum_{i=1}^{n} Ki\left(\frac{|P_{p_i} - P_{c_i}|}{|P_{p_i} - P_{t_i}|} - \frac{|P_{t_i} - P_{c_i}|}{P_{c_i}} \right),$$

P – absolute mean of monitoring or calculated parameter, P_c – control mean of the parameter, P_t – a mean of the parameter in the end of strain, P_p – mean of the parameter at 3rd min. of post-testing period, K – coefficient of Djukov V.G. [1970] which characterizes informative and vital importance of every parameter in evaluation of organism's adaptable level.

$$K_i = 1 - (\sigma_i / M_i)$$

σ – standard deviation and M – average mathematical mean of variation of mentioned parameters for most majority of healthy people in normal conditions.

If a subject has good level of the DFT tolerance a value of TTC must have a tendency to minimum mean.

$$FRC = \sum_{i=1}^{n} Ki\left(\frac{|D_{\delta_i} - D_{c_i}|}{|D_{p_i} - D_{t_i}|} - \frac{|D_{t_i} - D_{c_i}|}{D_{c_i}} \right)$$

D – a dispersion of monitoring or calculated parameter, D_c – a control mean of dispersion of the parameter, P_t – a dispersion of the parameter in the end of strain, P_p – a dispersion of the parameter at 3rd min. of post-testing period, K – a coefficient of Djukov V.G. [1970] which characterizes informative and vital importance of every parameter in evaluation of organism's adaptable level.

A value of FRC is in direct dependence from diapason of the monitoring indicators variability, especially during the DFT and post-testing period. When a human organism is reaching an adaptable state the value of FRC must have a tendency to maximum mean, so as the physiological indicators in period of functional exercise get new diapason of its variability which increases mainly and also continues as "a marking reaction" to save in post-testing period on the same level (i.e. $Dp \approx Dt$).

Note: a difference of indicators means in these formulas is absolute.

The Control Procedure:

The DFT should be conducted periodically, especially on the third, seventh, fifteenth and twenty fifth days of high altitude adaptation, to find out the disadaptive disorders in the AHR and HHR persons.

Thus, by using the method mentioned above, two important goals could be achieved: the control of human cardiovascular functional activity in high altitude conditions and reducing the cases of mountain illness.

Referenses

Aidaraliev, A.A., Baevsky, R.M., Berseneva, A.P., et al., 1988, *Komplexnaya ozenka funkcionalnih reservov organizma (A Combined Evaluation of Organism Functional Reserves).* Frunze: Ilim Press, 195 pp. (in Russian).

Aidaraliev, A.A., Balykin, M.V., Karkobatov, H.D., Makhnovski, V.P. et al., 1988, Research of Physical Work Capacity of Naval Contingent. *In: Materiali voenno-morskoi nauchnoi konferencii (Materials of the Naval Scientific Conference)*, Vladivostok, pp. 68-70 (in Russian).

Alman, R.W., and Fazekas, J.F., 1962, Cerebral Physiology of the Augmented Valsalva Maneuver. *Am. J. Med. Sci.*, Vol. 244, No. 4, pp. 202-210.

Amundsen, P., 1953, Planigraphy in Muller and Valsalva Experiments. *Acta Radiol.*, vol. 40, pp. 387-394.

Apollonov, A.M. and Mirolubov, V.G., 1983, Effect of High Altitude on Pilot's Organism during the Flight. *In: Voenno-sanitarnoe delo (J. Military-Sanitary Works),* No.7, pp. 16-24 (in Russian).

Arinchin, N.I., 1978, Issues of Tension and Tonicity in Normal Conditions and Pathology of Blood Circulation. *In: Fiziologia cheloveka (J. Human Physiology),* Moscow, No.3-4, pp. 462-465 (in Russian).

Armstrong, G., 1954, *Aviation Medicine*. Moscow: Inostrannaya Literatura, pp.55-58 (in Russian).

Arsentiev, F.V., Barkov, V.A. and Petruhin, I.S., 1975, Combination of Valsalva Probe with Cardiorheography for Estimation of Contractile Ability of Right Partes of Heart of Persons with Pulmonary Diseases. *In: Kardiologia (J. Cardiology),* No.12, p.109 (in Russian).

Asiamolov, B.F., Khomenko, M.N. and Migachev, S.O., 1979, Valsalva Probe and Prognosis of Human Resistance to "Head-Pelvis" Overloading. *In: Voprosi prognoza ortostaticheskoi ustoichivosti (Issues of Prognosis of Orthostatic Tolerance),* Moscow, pp. 125-130 (in Russian).

Asyamolova, N.M. and Malkin, V.B., 1968, Effect of Second Stay in Mountains on Acute Hypoxic Resistance of Mountain-Climbers. *In: Problemi kosmicheskoi biologii (Problems of Space Biology)*, Moscow: Nauka Press, pp.65-72 (in Russian).

Belyaeva, N.V., 1967, Method of Estimation of Organism Functional State in Process of Carrying out Labour Exercise with Oxyhemametric Indicators. *In: Fiziologia truda (Labour Physiology),* Moscow, pp.40-42 (in Russian).

Bergofsky, E.H., 1969, Ions and membrane permeability in the regulation of the pulmonary circulation. *The Pulmonary Circulation and Interstital Space*, Fishman A.P., Hecht H.H. eds. (Chicago: The University of Chicago Press,), pp. 269-292.

Bergofsky, E.H., Haas, F. and Porcelli, R., 1968, Determination of the sensitive vascular sites from which hypoxia and hypercapnia elicit rises in pulmonary arterial pressure. *Fed. Proc.*, Vol. 27, pp. 1420-1425.

Birzin, G.K., 1958, Some Methods of Cardiovascular Research. The Functional Probes. *In: Klinicheskie i fiziologicheskie metodi issledovania sportsmenov (Clinical and Physiologic Methods of Research of Sportsmen)*, Moscow, pp.42-67 (in Russian).

Brestkin, M.P., 1958, Issue of Effect of Decreased Partial Oxygen Pressure on Organism and Balance Mechanisms of Its Effect. *In: Funkcii organizma v usloviah izmenennoi gazovoi sredi (Organism Functions in the Conditions of Changed Gas Environment*), vol.2, Leningrad, pp.3-11 (in Russian).

Burger, M., 1921, Uber der klinische Bedentung des Valsalva'shen Versuches. *Munch. Med. Wochenschr.,* Bd. 33., S. 1066.

Burger, M., 1925, Der Wert des Valsalva'schen Versuches als Kreislaufbelastungs-probe. Uber die Funktion des Herzens bei akuten Anstreugungen. *Verhandl. d. Deutsch. Ges. F. in Med.*, S. 282.

Burger, M., 1926, Die Herzstromkurve unter der Binwirkung intrapulmonaler Drucksteigerung. Das Elektrokardiogram beim Valsalva'schen Versuch. *Z. Ges. Exptl. Med.*, Bd.52, S. 321.

Burger, M., Burger, H. und Peterson, P.F., 1929, Die Pressdruckprobe als Herzsleistungsprufung. Nach Untersuchungen an Olympischen Wettkampfern, Amsterdam, 1928. *Arbeitsphysiologie J.*, S. 614 (Cit.: Berichte B.D., *Ges. Physiol. u. Exper. Pharm.*, Bd. 52 (1930), S. 418.

Burger, M., 1956, Binfuhrang in die pathologische Physiologie. Leipzig, S.12-58.

Burger, M. und Michel, D., 1957, Funktionelle Engpasse des Kreislaufes. Munchen, S. 16-70.

Buyanov, P.V. and Pisarenko, P.V., 1977, Hypoxic Probe in Estimation of Human Fitness for Activity in Extreme Conditions. *In: Trudi 10-h chtenii posviaschennih razrabotke nauchnih issledovanii i razvitiu idei (Works of 10th Meeting on Development of Scientific Research and Promoting Ideas),* Moscow, pp.48-53 (in Russian).

Celis, A., Cicero, R., Castillo, H. and Arce, E.G., 1956, Temporary Arrest of the Contrast Medium in Angiocardiography. *Acta radiol.*, vol. 45, No.5, pp.341-351.

Chaillet-Bert, P., 1956, Unification des tests cardio-functionelles dans le sport. *XI-e Congress Intern. de Medicine Sportive. Rapports et Communications*. Luxembourg, pp.67-95.

Danilov, V.E., 1948, Acute Vascular Deficiency of Pilots and Some Methods for Its Determination. *In: Klinicheskaja medizina (J. of Clinical Medicine*), Moscow, vol.26, No.9, p.43 (in Russian).

Dawson, P.M., 1943, An Historical Sketch of the Valsalva Experiment. *Bull. Hist. Med.*, vol. 14, No.3, pp. 295-320.

Dembo, A.G., Popov, S.N., Teslenko, J.A. et al., 1975*, Sportivnaya medizina (Sports Medicine).* Moscow: Fizkultura i Sport Press, pp.169-175 (in Russian).

Dempsey, J., 1986, Is the Lung Built for Exercise? *Med. Sci. Sports. Exerc.*, vol. 18, pp.143-155.

Djukov V.G., 1970, Classification and Quantitative Evaluation of Functional Resistance of Organism Systems. *In: Adaptacia organizma cheloveka i djivotnih k ekstremalnim prirodnim factoram sredi (Adaptation of human and animals to extreme natural environmental factors),* Novosibirsk, p.71 (in Russian).

Drugova, K.S., 1997, Reaction of Cardiac Rhythm and Diastolic Function of Myocardium of Left Ventricle under Hypoksemic Shift during Hypoxic Probe of Healthy Persons and Persons with Cardiovascular Diseases. *In: Gipoksia: mehanizmi, adaptacia, korrekcia (Hypoxia: Mechanisms, Adaptation, Correction),* Moscow, pp.35-36 (in Russian).

Duke, H.N., 1954, The Side of Action of Anoxia on the Pulmonary Blood Vessels of the Cat. *J. Physiol. (London),* vol. 125, pp.373-382.

Egorov, P.I., 1925, Issue of Research of Pilot's Cardiovascular System. *In: Gigiena truda (J. Labour Hygiene),* No.12, p.41 (in Russian).

Egorov, P.I., 1937, *Vliyanie vysotnih poletov na organizm letchika (Effect of High Altitude Flights on Pilot's Organism).* Moscow, pp.10-40 (in Russian).

Elsner, R. and Scholander, P.F., 1965, Circulatory Adaptations to Diving in Animals and Men. *Physiology of Breath-Hold Diving and the Ama of Japan* (Ed. By Rahn H. and Yokoyama T.), Publ. No.1341 (Washington), pp.281-294.

Flack, M. and Oxon, B.C., 1921, Respiratory Efficiency in Relation to Health and Disease. *Lancet*, pp.693-696.

Flack, M. and Burton, H.L., 1922, An Investigation into the Physiological Significance of the «40 mm Mercury Test». *J. Physiol. (London)*, No.6, pp.50-52.

Gandelsman, A.B., Evdokimova, T.A., Ponomareva, V.P. et al., 1984, Return Respiration as a Method of Studying Human Respiratory-Hemadynamic Reserves. *In: Puti mobilizacii funkcionalnih rezervov sportsmena (Ways of Mobilization of Sportsman Functional Reserves)*, Leningrad, pp.30-34 (in Russian).

Gforer, B., 1951, Der viscerallen Haemodinamic beim Valsalva'schen Versuch. *Med. Wschr.,* H.5, S.262.

Goldstein, D.S., Horowits, D. and Keiser, H.R., 1982, Comparison of Techniques for Measuring Baroreflex Sensitivity in Man. *Circulation*, Vol. 66, pp.432-439.

Goranchuk, V.V., Sapova, N.I., Ivanov, A.O. et al., 1997, Perspectives of Improvement of Functional Hypoxic Probes. *In: Gipoksia: mehanizmi, adaptacia, korrekcia (Hypoxia: Mechanisms, Adaptation, Correction),* Moscow, p.28 (in Russian).

Hauge, A., 1969, Hypoxia and Pulmonary Vascular Resistance; the Relative Effects of Pulmonary Arterial and Alveolar pO_2. *Acta Physiol. Scan.*, vol. 76, pp.121-130.

Imangulov, R.G., 1982, Estimation Criteria for Troops' Fighting Efficiency. *In: Voenno-medicinskii jurnal (Military Medical Journal),* No.10, pp.35-37 (in Russian).

Johnson, R.H., Crampton-Smith, A. and Spalding, J.M.K., 1969, Blood Pressure Response to Standing and to Valsalva's Maneuvre: Independence of the Two Mechanisms in Neurological Diseases Including Cervical Cord Lesions. *Clin. Science,* vol. 36, pp. 77-86.

Karpman, V.L., Beloozerskii, Z.B. and Gudkov, I.A., 1988, *Testirovanie v sportivnoi medizine* (*Testing in Sports Medicine).* Moscow: Fizkultura i Sport, 207 pp. (in Russian).

Kaznacheev, V.P., Baevskii, R.M., Berseneva A.P., 1980, *Donozologicheskaya diagnostika v practike massovyh obsledovanii naseleniya (Donozological Diagnostics in Practice of Mass Population Examination)*. Leningrad: Medicina Press, 207pp. (in Russian).

Kozlov, A.B., Levenko, N.A., Kostin, A.A., 1985, Change of Blood Urea Content as a Criterion of Sportsman's Recovering Level. *In: Fiziologicheskie probi utomlenia i vosstanovlenia (Physiological Probes of Fatigue and Recovery),* part 1, Kiev, Cheboksari,p.198. (in Russian).

Kreps, E.M., 1959, *Oksigemometria. Tehnika i primenenie v fiziologii i medicine (Oxyhemametry. Techniques and Using in Physiology and Medicine).* Leningrad: Medgiz Press, pp.35-85. (in Russian).

Lapin, A.W., 1943, The Flack Test in Relation to Success in Flying Training. *Reports of National Research Council, Canada* (Associate Committee on Aviation Medical Research, January 16), Report No. 2540.

Lechner, H., Rodler, H. und Geyer, N., 1968, Die Theoretischen Grundlagen der Rheographie und ihre praktischen SchluBfolgerungen. *Elektromedizin.,* Bd.13, H.1, S. 30-33.

Link, M.M., Gurovskii, N.M. and Brianov, N.I., 1975, Cosmonauts Selection. *In: "Osnovi kosmicheskoi biologii i medizini" (Bases of Space Biology and Medicine)*, Moscow: Nauka, vol.3, pp.419-438 (in Russian).

Little, W.C., Barr, W.K. and Crawford, M.H., 1985, Altered Effect of the Valsalva Maneuver on Left Ventricular Volume in Patients with Cardiomyopathy. *Circulation,* vol. 71, pp. 227-233.

Looga, R.U., 1970, Vliyanie objema legkih i krovotoka v malom krugu na regulyaciu sistemnogo krovoobraschenia i dyhania *(Effect of Pulmonary Volume and Blood Stream in Pulmonary Circulus on Regulation of Systemic Blood Circulation and Respiration).* Doctor Thesis, Tartu, pp.20-100 (in Russian).

Looga, R.U., 1973, The Change of Blood Circulation during Valsalva Experience. *Uspekhi fiziologicheskih nauk* (*J. Successes of Physiologic Sciences),* Moscow, vol.4, No.3, pp.134-151 (in Russian).

Losev, A.S., Mahnovsky, V.P., Morozov, S.B., and Shanazarov, A.S., 1988, Effects of Actoprotector Bemithylum on Human Metabolism and Muscular Activity in High Altitude Conditions. *In: "Fiziologia ekstremalnih funkcionalnih sostojanii i metodi profilaktiki" (Physiology of Extreme Functional States and Prophylactic Measures)*, Moscow, pp. 86-87 (in Russian).

Ludin, H., 1962, Aortographie unter Valsava Bedingungen. *Fortschr. Roent.,* Bd.21, S. 611-617.

Mahnovsky, V.P., 1984, Estimation and Prognosis of Functional State of Organism with Using a Method of Quantitative Characteristics of Physiologic Indicators and Its Dispersion Coefficients. *In: "Ozenka i prognoz funkcionalnih sostojanii v prikladnoi fiziologii" (Estimation and Prognosis of Functional States in the Applied Physiology),* Frunze: Ilim Press, vol.1, pp.38-40 (in Russian).

Mahnovsky, V.P., Kuzuta, E.I. and Volkov, E.E., 1985, Prognostic Estimation of Human Physiologic Possibilities in High Altitude Conditions. Voenno-medizinskii jurnal (*Military Medical Journal),* Moscow, No 8, pp.57-59 (in Russian).

Mahnovsky, V.P., Kuzuta, E.I., Shanazarov, A.S. and Larkov, V., 1985a, *Dozirovannii test Fleka kak metod ozenki funkzionalnih sposobnostei cheloveka i otbora pogranichnikov dlja slujbi v usloviah vysokogorja (The Dosed Flack Test as a Method of Estimating Human Functional Possibilities and the Selection of Frontier Guards for Military Service in High Altitude Conditions).* Methodological Recommendations, EMFD Military Medical Service of the USSR, Almaty, 20 pp. (in Russian).

Mahnovsky, V.P. and Bolshedvorov, R.V., 1986, Prognostic Estimation of Frontier-guard's Functional State with Quantitative Characteristic of Physiological Indicators and Its Dispersion Coefficients.

In: Sbornik nauchno-prakticheskih rabot medizinskih uchrejdenii KVPO KGB SSSR (Book of Scientific and Practical Papers of KVPO KGB of USSR), Almaty, pp.120-124 (in Russian).

Mahnovsky, V.P., Shanazarov, A.S. and Volkov, E.E., 1988, Estimation of Organism Functional Possibilities during Adaptation to Different Heights. *In: Voenno-medizinskii jurnal (Military Medical Journal)*, No.11, pp.40-42 (in Russian).

Mahnovsky, V.P. and Kuzuta, E.I., 1989, Indicators of Blood Oxygenation in Determination of Human Hypoxic Resistance. *In: Izvestia Kyrgyzskoi Nazionalnoi Akademii Nauk (News of Kyrgyz National Academy of Sciences),* No.2, pp.76-80 (in Russian).

Mahnovsky V.P., 1991, *Ozenka i prognoz funkcionalnogo sostojania cheloveka v ekstremalnih usloviah okrujauschei sredi (Evaluation and Prognosis of the Human Functional State in the Extreme Environmental Conditions".* Doctor Thesis, Bishkek, 167 pp. (in Russian).

Mahnovsky V.P., Idirisov A.N., Kundashev U.K., and Labkovskaya E.B., 1998, *Metodicheskie rekommendacii po ekspress-otboru i farmakologicheskoi korrekcii voennoslujaschih dlja slujbi v vysokogornih usloviah (Methodological Recommendations on Express-Selection and Pharmacological Correction of Military Contingent for Service in High Altitude Conditions).* – Bishkek: Ministry of Defense Press of the Kyrgyz Republic, 10 pp. (in Russian).

Maksimov, L.G., Pushkar, U.T., Zelenin, A.G. et al., 1975, Estimation of Cardiovascular Compensatory Reactions with the Dosed Valsalva Probe. In: Avaiakosmicheskaya medizina (Aviaspace Medicine), vol.2, Moscow, Kaluga, pp.65-66 (in Russian).

Malkin, V.B., 1968, Significance of Some Regulative Systems in Development of Adaptation to Hypoxia. *In: "Problemi kosmicheskoi biologii" (Problems of Space Biology),* Moscow: Nauka Press, vol.8, pp. 48-52 (in Russian).

Martynov, A.I., Turina, I.I., Alekseev, V.I., 1968, Studying Some Indicators of Cerebral Hemadynamics of Young Healthy People with Rheoencephalography. *In: Kardiologia (J. Cardiology),* vol.8, No.7, pp.104-107 (in Russian).

Medvedev, V.I., 1982, *Ustoichivost fiziologicheskih i psihologicheskih funkcii cheloveka pri deistvii ekstremalnih faktorov (Resistance of Human Physiological and Psychological Function during Extreme Factors Influence).* Leningrad: Nauka Press, 102 pp. (in Russian).

Melnikov, V.N., 1977, Method of Quantitative Evaluation of Biosystem Adaptability. *In: Adaptacia i adaptogeni (Adaptation and adaptogenic substances).* Vladivostok, p.65 (in Russian).

Meyer, J.S., Gotoh, F., Takagi, J. and Kakimi, R., 1966, Cerebral Hemodinamics, Blood Gases and Electrolytes during Breath-Holding and the Valsalva Maneuver. *Circulation*, vol. 33, No.5, pp. 35-48.

Mirrachimov, M..M., Aidaraliev, A.A. and Maksimov, A.L., 1983, *Prognosticheskie aspekti trudovoi dejatelnosti v usloviah vysokogoria (Prognostic Aspects of Work Activity in High Altitude Conditions)*. Frunze: Ilim Press, 160pp. (in Russian).

Mozjuhin, A.S., 1982, What Can a Man? *In: Chymia i jizn (J. Chemistry and Life),* No.9, pp.41-48 (in Russian).

Nishimura, R.A. and Jamil Tajik, A., 1986, The Valsalva Maneuver and Response Revisited. *Mayo Clin. Proc.,* vol. 61, No.3, pp. .211-217.

Palmero, H.A., Caeiro, T.F., Iosa, D.J. and Bas, J., 1981, Baroreceptor Reflex Sensitivity Index Derived from Phase 4 of the Valsalva Manoeuvre. *Hypertension*, vol. 3, pp. 134-137.

Pastushenkov L.V., 1988, Proofs for Universality of Antihypoxants Effects which Optimize Cell Exchange Processes. *In: "Farmakologicheskoi korrekcii gipoksicheskih sostojanii" (Pharmacological Correction of Hypoxic States),* Reports of 1st All the Soviet Union Conference, Moscow 1988, p.97 (in Russian).

Paulev, P-E., Honda, Y., Sakakibara, Y. et al., 1988, Brady- and Tachycardia in Light of the Valsalva and the Muller Maneuver (Apnea*). Japan. J. Physiol.*, vol. 38, No.4, pp.507-517.

Penkovich A.A., 1966, Significance of Valsalva Probe for Estimation of Heart Functional State of Persons with Chronic Pulmonary Diseases. *In: Terapevticheskii Arhiv (J. Therapeutic Archives),* vol.3, pp.34-39 (in Russian).

Pokalev, G.M., 1976, Local and Overall Hypoxic Probes, Its Variances and Clinical Significance. *In: Transport veschestva i tkanevaya nedostatochnost (Substance Transport and Tissue Insufficiency),* Works of Gorkii Medical Institute, Ibid. 64, pp.120-124 (in Russian).

Posteli, T., Garbini, G.C., 1968, Effecti della proba di Valsalva calibrata sul circulo distrettuale epatico dei soggetti normali e degli ipertesi portali da blocco intraepatico. *Atti. Soc. Ital. Cardiol., II Congr., Firenze, 1967* (Roma), L. 37-39.

Powell, T.J. and Sunahara, F.A., 1958, A Physiological Evaluation of the Flack Test. *Aviat. Med.*, vol. 29, No.6, pp. 444-453.

Reid, J.L., Calne, D.B., George, C.F. et al., 1971, Cardiovascular Reflexes in Parkinsonism. *Clin. Sci.*, vol. 41, pp.63-67.

Reindell, H., Weyland, R., Klepzig, H. and Musshoff, K., 1954, Schlagvolumen und Restblutmenge des Herzens. Sportarzte-Tagung' 1953 in Leipzig. Berlin (Verl. Volk. u. Gesundheit), S.47-66.

Riby, J.M., 1965, The Valsalva Maneuver in Renal Angiography. *J. Urology*, vol. 93, No.5, pp.631-634.

Saunders, N.A., Powles, A.C.P. and Rebuck, A.S., 1976, Ear Oximetry: Accuracy and Practicability in the Assessment of Arterial Oxygenation. *Am. Rev. Respir. Dis.*, vol. 113, No.6, pp.745-749.

Sergeev, V.N., 1959, Method of Pulmonary and Cardiac Probe according Valsalva. *In: Thesisi dokladov 2-i obschekurortnoi konferencii (Proceedings of 2nd All-Resort Conference),* Yalta, pp.19-22 (in Russian).

Shanazarov, A.S., and Makhnovski, V.P., 1991, Effects of Bemithylum on Metabolic Processes and Fitness to Work at High Altitudes. *In: Fiziologia cheloveka (J. Human Physiology),* Moscow, vol.17 (4), pp.117-119 (in Russian).

Sharpey-Schafer, E.P., 1965, Effect of Respiratory Acts on the Circulation. *Handbook of the Physiology*, Sec. 2, No.3 (Washington), pp. 1875-1886.

Shephard, R.J., Bouhlel, E., Vandewalle, H. and Monod, H., 1988, Peak Oxygen Intake and Hypoxia: Influence of Physical Fitness. *Int. J. Sports Med.*, vol. 9, No.4, pp.279-283.

Shimada, K., Kitazumi, T., Ogura, H. et al., 1986, Differences in Age-Independent Effects of Blood Pressure on Baroreflex Sensitivity Between Normal Subjects and Hypertensive Subjects. *Clin. Sci.*, vol. 70, pp.489-494.

Smith, S.A., Stallard ,T.J. and Littler, W.A., 1986, Estimation of Sino-Aortic Baroreceptor Heart Rate Reflex Sensitivity and Latency in Man by a New Microcomputer Assisted Method of Analysis. *Cardiovascular Res.*, vol. 20, pp.877-882

Smyth, R.J., D'Urzo, A.D., Slutsky, A.S. et al., 1986, Ear Oximetry during Combined Hypoxia and Exercise. *J. Appl. Physiol.*, vol. 60, No.2, pp.716-719.

Solodkov, A.S., 1982, Adaptive Possibilities of Man. *In: Fiziologia cheloveka (J. Human Physiology),* Moscow, vol.8, No.3, pp.445-449 (in Russian).

Solovjev, V.K., 1934, *Ocherki po physiologii voennogo truda v usloviyah reliefa i climata Srednei Azii (Essays on Physiology of Military Job in Relief and Climate Conditions in Middle Asia)*. Tashkent, pp.12-31 (in Russian).

Spirin, V.G. and Savchenko, E.I., 1974, Reaction of Cardiovascular System of Healthy People during Respiratory Probes according Valsalva and Muller. *In: Kardiologia (J. Cardiology),* No.3, pp.86-93 (in Russian).

Stejskal, L., 1969, The Jendrassik Maneuver and Valsalva Maneuver. *Electroenceph. Clin. Neurophysiol.*, vol. 26, p.234.

Strelcov, V.V., 1938, Effect of Decreased Barometric Pressure on Organism. *In: Trudi Centralnoi laboratorii aviacionnoi medicini (Works of Central Laboratory of Aviation Medicine)*, No.5-6, Moscow, pp.60-80 (in Russian).

Strelcov, V.V., 1945, *Vliyanie vysoti i uskoreniya na organizm letchikov (Effect of High Altitude and Speeding -up on Pilot's Organism).* Moscow, pp.10-25 (in Russian).

Strohl, K.P. and Altose, M.D., 1984, Oxygen Saturation during Breath-Holding and during Apneas in Sleep. *Chest*, vol. 85, No.2, pp.181-186.

Szachowski, J., Ilmurzynska, K., Hryniewiecki, T., 1968, Wartosc' proby Valsalvy w rozpoznawaniu ubytkow w przegrodzie przedsionkowej. *Pol. Arch. Med. Wewn.,* T. 41, No.4/10, S.515-521 (in Polish).

Takagi, K. and Magasaka, T., 1964, Blood Volume Changes of Various Kinds of Vessels in the Human Skin. *Japan J. Physiol.*, vol. 14, pp.256-264.

Templeton, A.W., 1965, Renal Aortography. Advances and Technique Using the Valsalva Maneuver. *Am. J. Roeutgenol.*, vol. 95, No.2, pp. 383-388.

Tihvinsky, S.B., 1960, *Oksigemometria pri funkcionalnoi probe s zaderjkoi dyhania (Oxyhemametry during a functional probe with breath-holding).* Doctor Thesis, Leningrad, pp.20-80 (in Russian).

Tretyakov, N.N., 1897*, K voprosu ob aclimatizacii (To the Question about Acclimatization).* Doctor Thesis, Sankt-Peterburg, 120pp. (in Russian).

Trimarco, B., Volpe, M., Ricciardelli, B. et al., 1983, Valsalva Maneuver in the Assessment of Baroreflex Responsiveness in Borderline Hypertensives. *Cardiology*, vol. 70, pp. 6-14.

Tornow, P. und Durst, C., 1969, Die Veranderungen normaler und pathologischer Finalschwankungen in den unipolaren Brustwandableitungen bei dem Valsalva PreBdruckversuch. *Z. Kreislaufforsch.,* Bd .58, H.4, S. 377-385.

Valsalva, A.M., 1717, *De aure humana (Traject: ad Rhenum),* Cap. 5 (8), L.84.

Vasiliev, I.N., 1978, Changes of Vector-cardiogram and Electrocardiogram during Valsalva Probe and Burger Probe. *In: Kardiologia (J. Cardiology),* No.7, pp.113-134.

Vein, A.M., Solovieva, A.D. and Kolosova, O.A., 1981, *Vegetososuditaya distonia (Vegetal-Vascular Distonia)*. Moscow: Medizina, pp.1-68 (in Russian).

Viles, P.H. and Shepherd, J.T., 1968, Relationship Between pH, pO_2 and pCO_2 on the Pulmonary Vascular Bed of the Cat. *Am. J. Physiol.*, vol. 215, pp.1170-1176.

Vlasak, M., 1963, Relation of Cardiac Frequency Changes Induced by Flack Test and Pressure Breathing. *Proc. 5th National Congr. Czechosl. Physiol. Soc.* (Prague), pp.178-179.

Voronin, L.I., Shustov, E.B., Kravchenko, V.V., et al., 1988, Effects of Pirocetam and Bemithylum on Work Capacity in Hypoxic Hypoxia Conditions. *In: "Farmacologicheskaya korrekcia gypoksicheskih sostojanii" (Pharmacological Correction of Hypoxic States)*, Idjevsk, pp. 26-27 (in Russian).

Wick, E. und Knebel, R., 1961, Der zentrale Venedruck beim Valsalva'schen Versuch. *Z. Kreislaufforsch.*, Bd. 50, H.11-12, S.539-553.

Zabudski, B.D. and Gadiatov, S.V., 1970, Dynamics of Blood Pressure in Humeral Artery during Valsalva Probe. *In: Materiali 19-i nauchnoi konferencii Tadjikskogo medicinskogo instituta (Materials of 19th Scientific Conference of Tadjic Medical Institute),* vol.1, Dushanbe, pp.97-98 (in Russian).

Zagryadski, V.P. and Sulimo-Samuillo, Z.K., 1976, *Metodi issledovania v fiziologii truda (Research Methods in Labour Physiology).* Leningrad: Nauka Press, 93pp. (in Russian).

Zarine, A.F. and Gaile, E.J., 1982, Some Hemadynamic Changes during Valsalva's Probe and Muller's Probe. *In: "Funkcionalnye probi v issledovanii serdechno-sosudistoi sistemi"* (*The Functional Probes in Research of Cardiovascular System)*, Riga, pp.69-75 (in Russian).

Zinochkin, V.A., 1985, Valsalva Probe as a Method of Estimation of Organism Functional State. In: Problemi ocenki funkcionalnih vozmojnostei cheloveka i prognozirovanie zdorovja (Problems of Estimation of Human Functional Possibilities and Prognosis of Health), Moscow, p.174 (in Russian).

Zurdinov A.Z., 1988, Change of Metabolic Processes during Hypoxic Exposition of Animals and Pharmacological Correction Effects. *In: "Farmacologicheskaya korrekcia gypoksicheskih sostojanii"* (*Pharmacological Correction of Hypoxic States*), Idjevsk, p.51 (in Russian).

Yakovlev, G.M., Novikov, V.S., Khavinson, V.K., 1990, *Rezistentnost, stress, regulacia (Resistance, Stress, Regulation)*. Leningrad: Nauka Press, 238pp. (in Russian).

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