For this reason, medical selection had to ensure that cosmonaut candidates possessed the necessary "margin of safety." The approach chosen involved in-depth clinical examinations including a battery of loading tests, which provided a rather complete picture of state of health and functional capacities and an assessment of an individual's reserve capacities.

The end result of the cosmonaut selection process imbued this process with critical importance. If a somatic defect was overlooked or functional physiological capacities were incorrectly assessed, this would inevitably have serious consequence for the health of the cosmonauts, entail loss of the substantial time and resources spent preparing individuals for a specific space program or lead to abortion of a space flight due to worsening of an undiagnosed illness (Babiychuk A.N., 1965; Vyadro M.D., 1967; V.V. Vlasov, V.I. Kopanev, 1990; L.T. Wier et al, 1989).

From the very beginning, selection of cosmonaut candidates was based on experience with medical selection of fighter pilots. Thus, aviation medicine, provided the foundation for the development of a new branch of medical science -- space medicine -- and professional selection of cosmonauts developed on the basis of a system of medical selection of flight crews that had already been developed and validated.

Medical selection involved in two stages: stage 1 (initial) occurred on an out-patient basis in aviation sections [of hospitals?] and the second stage (final) on an in-patient basis in the Central Scientific Research Aviation Hospital (CSRAH).

During the first stage, medical documentation and the personality traits of the candidates were studied. A special medical board (consisting of leading specialists in aviation and clinical medicine) performed preliminary selection of candidates from a group of fighter pilots.

Examinations were performed only on individuals no older than 35, weighing no more than 70 kg, and no taller than 175 cm. Participation in the examination by the candidates was strictly voluntary. Of the pilots recommended for further examination, several hundred men initially expressed the desire to become cosmonauts. After interviews and medical selection, 331 pilots were recommended for further examination in the CSRAH. During the

period of more than 1.5 months before they entered the hospital, a portion of these individuals lost the ambition to become cosmonauts, due to their family, job or other circumstances, the uncertainty of the future, and fear that the comprehensive medical examination would reveal a condition that would limit or terminate their professional careers. A total of 134 candidates entered the hospital for the second stage of selection.

Because of the large battery of clincial and X-ray tests stipulated by the plan for the in-patient examination, it was divided into two substages containing equal number of tests, especially X-rays. The first substage involved clinical and clinical-physiological examinations, using the test battery stipulated for fighter pilots.

After completion of the test battery on the candidates, the results obtained were analyzed exhautively and after discussion by the hospital medical certification board a a decision was made concerning continuation of the examination using a special test battery. So that dynamic observations could be conducted, and in order to confirm the objectivity of the decision made, the candidates were released from the hospital to their units, but relieved of their duties for 45 days.

During the final substage of the hospital examination, functional reserve capacities were evaluated and the presence of latent defects in the health of the candidates identified. In particular, research was performed on endurance of moderate levels of hypoxia (altitude 6000 m, duration 15 minutes) during positive pressure oxygen breathing, and of barometric pressure differentials, etc. Centrifugation was used to determine duration of endurance of +Gz acceleration of 6-, 7-, and 8-G.

During the tests, severity of emotional reactions to various loadings, work under conditions of interference, and rate of attention switching, etc., were also investigated.

After completion of the hospital tests, the cosmonaut candidates were presented to the hospital medical certification board, which after discussion of the results of the out- and in-patient stages, issued a preliminary certification decision concerning fitness or lack of fitness to undergo specialized forms of training.

The final medical certification of fitness of cosmonaut candidates for the special training was made by the Main Medical Board, which was made up of leading specialists in clinical and space medicine, the Ministry of Defense and the Ministry of Health of the USSR and is the highest organ of medical certification of cosmonaut candidates.

In 1959-60, in accordance with the adopted program of medical selection, cosmonaut candidates underwent the second stage of examination in the CSRAH and the first contingent of cosmonaut candidates was selected, including Yu.A.G, G.S.T., N.G.N., P.R.P., V.F.V., V.M.K., P.I.B., F.F.L., Ye.V.Kh, V.V.G.

The first contingent consisted of a total of 20 individuals, but not all of them eventually flew in space. Subsequently health problems or lack of occupational fitness led to exclusion from this group of K.A.Ya.(during the specialized training he was diagnosed as showing signs of **capillary toxicosis, and was excluded during his first year of training), Z.D.A (excluded due to ulcers during his eighth year in the corps), V.V.S. (due to non-professionally related back injury during his first year in the corps) and four others due to lack of occupational fitness.

From 1959 until the present, several cycles of cosmonaut candidate selection have taken place, but the original selection system has remained essentially unchanged.

Further improvement of the designs of rocket engines and space craft will lead to further increase in the difficulty of cosmonauts' flight missions and to expansion of scientific and technological and biomedical research [performed in space], which in turn, will compel modification of the process of cosmonaut selection, as has been continually the case

Thus, the complexity of the technical program has required that specialists who are highly educated in various areas of science and technology (payload specialists) be included in the crew of spacecraft. The functional duties of these individuals on actual flights and their professional qualifications, on the one hand, and their comparatively lower level of physical fitness and presence of certain health conditions, on the other, has led to the use of an individualized approach to determining their fitness for flight (Yegorov P.I., et al, 1966; Gurovskiy N.N., Korotayev M.M., et al., 1973).

The final medical certification of fitness of cosmonaut candidates for the special training was made by the Main Medical Board, which was made up of leading specialists in clinical and space medicine, the Ministry of Defense and the Ministry of Health of the USSR and is the highest organ of medical certification of cosmonaut candidates.

In 1959-60, in accordance with the adopted program of medical selection, cosmonaut candidates underwent the second stage of examination in the CSRAH and the first contingent of cosmonaut candidates was selected, including Yu.A.G, G.S.T., N.G.N., P.R.P., V.F.V., V.M.K., P.I.B., F.F.L., Ye.V.Kh, V.V.G.

The first contingent consisted of a total of 20 individuals, but not all of them eventually flew in space. Subsequently health problems or lack of occupational fitness led to exclusion from this group of K.A.Ya.(during the specialized training he was diagnosed as showing signs of **capillary toxicosis, and was excluded during his first year of training), Z.D.A (excluded due to ulcers during his eighth year in the corps), V.V.S. (due to non-professionally related back injury during his first year in the corps) and four others due to lack of occupational fitness.

From 1959 until the present, several cycles of cosmonaut candidate selection have taken place, but the original selection system has remained essentially unchanged.

Further improvement of the designs of rocket engines and space craft will lead to further increase in the difficulty of cosmonauts' flight missions and to expansion of scientific and technological and biomedical research [performed in space], which in turn, will compel modification of the process of cosmonaut selection, as has been continually the case

Thus, the complexity of the technical program has required that specialists who are highly educated in various areas of science and technology (payload specialists) be included in the crew of spacecraft. The functional duties of these individuals on actual flights and their professional qualifications, on the one hand, and their comparatively lower level of physical fitness and presence of certain health conditions, on the other, has led to the use of an individualized approach to determining their fitness for flight (Yegorov P.I., et al, 1966; Gurovskiy N.N., Korotayev M.M., et al., 1973).

The high level of resources that must be expended during the stage of preflight preparations requires dmeands that the assessment of state of health and functional reserve potential, and the prediction of the occupational longevity of cosmonaut candidate made by the medical experts be of extremely high quality.

The level of responsibility of each member of a spacecraft crew for perfomance of the mission and for flight safety is the basis for a differential approach to examination of candidates. At present, it is the practice to consider state of health and job duties when formulating medical selection criteria for a particular candidate. Those who will be cosmonauts must meet the most stringent criteria. The state of health and psychophysiological traits required of payload specialists and instructors must support a high level of performance, good fulfillment of the flight mission, and assurance of flight safety. The least stringent certification approach is applied to payload specialists who will not be directly involved with spacecraft control equipment or systems responsible for the lives of the crew. However, they too must go through the full examination and the certification decision is based on the results of the examination. The individualized approach is most extensively applied to selection of payload specialists. Factors considered include analysis and evaluation of their professional performance, reserve potential, the uniqueness of their research, whether they can be replaced as an experimenter, and prediction of their ability to perform their specific missions.

Procedures for Medical Certification and Completion of Documents for Cosmonaut Candidates

Selection of cosmonaut candidates starts with study of the personality traits of applicants who have expressed the desire to undergo the special cosmonaut candidate selection test battery. The entire battery of medical tests is performed during the stage of cosmonaut selection for each candidate regardless of his future flight duties.

For each candidate recommended for participation in selection, a medical certification card in an established format is filled out and clinical/diagnostic studies are performed: X-ray of the sinus cavities of the nose in two views (forward and side), fluoroscopy of the chest

cavity, electrocardiography in 12 leads, general analyses of blood and urine.

Candidates are examined by clinical specialists, in the process of which each medical expert establishes his own diagnosis and provides a recommendation of the desirability of further examination within the cosmonaut candidate selection program.

The decision concerning allowing candidates to go on to the second stage of examination is made at a meeting of the medical certification board.

Before beginning the second stage of examination, it is recommended that the following clinical and laboratory studies be performed: X-raying of the stomach and duodenal intestine with spot-film roentgenography: fibrogastroduodenoscopy; ultrasound study of the liver, gallbladder, pancreas, and kidneys; bicycle ergometric test; echocardiography; analysis of fractions of stomach secretions and duodenal contents.

Candidates starting the in-patient examination (second stage) bring with them reports on the clinical and X-ray tests already performed during the out-patient selection stage. These are examined and tests are repeated only if indicated.

If a health condition is identified during the examination that would preclude candidates from undergoing the special training, the results of the examination are comprehensively evaluated by the hospital medical certification board, which makes the decision to terminate the special test battery and recommends that the patient be discharged from the hospital or to complete a test battery required for in certification of individuals in professions?? The decision of the hospital medical certification board is entered in the case history of the certification protocol and the protocol book of the hospital medical certification board.

The final decision as to whether a candidate will be allowed to undergo special training is made in the Main Medical Boad and formulated as a protocol. The decision of the Main Medical Commission is recorded in the medical section of the department to which the certified individual belongs.?

Medical Requirements (Standards) on the State of Health of Cosmonaut Candidates The list of diseases presented here cannot enumerate all possible nosological forms of diseases that may be encountered during actual medical examination of cosmonaut candidates. Many years of experience with medical selection and biomedical monitoring of cosmonauts during their professional careers has confirmed the correctness? and objectivity of the medical certification process. In cases where rare diseases or functional disorders are identified, fitness for special training is determined after consideration of the following:

- severity of the disease and the functional disorders it has given rise to;

- reversibility of the pathological process;

- amount of compensation for existing disorders;

- status of compensatory mechanisms, as measured during loading tests;

- endurance of loading tests;

- level of training in speciality;

- history of previous performance in the presence of health problems;

- possibility of further worsening of the diseases in response to special training or space flight factors;

- personality factors;

- candidate motivation;

- duration of scheduled flight and nature of work during flight.

Psychological and Neurological Diseases

Justifications for certifying a candidate as unfit are the following:

1. All forms of psychological disorders regardless of their duration. The diagnosis must be established in a specialized therapeutic division.

2. All forms of psychological disorders at the level of neurosis.

3. Epilepsy.4. Consequences of injury to the brain and spinal cord, resulting from infection or intoxication, with persistent clinical manifestations.

5. Organic diseases of the central nervous system.

6. Persistent and severe disorders of autonomic functions of permanent or paroxysmal nature.

7. Diseases and results of injury to peripheral nerves with persistent disorders of function or chronic pain syndrome.

Internal Diseases

1. Chronic infectious diseases.

2. All forms of pulmonary tuberculosis.

3. Diseases of the endocrine system regardless of severity.

4. Diseases of blood or hemopoietic organs

5. Diffuse diseases of connective tissue.

6. Chronic allergic diseases.

7. Chronic diseases of the lungs, pleura, or respiratory tract of tubercular etiology or their consequences entialing disorders of external respiration.

8. All stages and forms of essential hypertension.

9. Organic diseases of the cardiac muscle, cardiac artery, aorta, or valves with insufficiency of general or coronary circulation.

10. Chronic diseases of the digestive organs, or consequences of their injury or surgery entailing persistent digestive disorders or tendencies to become more acute.

11. Chronic kidney diseases.

12. Disorders of the joints, of infectious, metabolic or endocrine genesis.

Surgical and Urological Diseases

1. Malignant neoplasms.

2. Specific lesions?? of the lymph nodes, bones, joints, visceral organs.

3. Large benign neoplasms impeding movement or wearing of special clothing.

4. Consequences of burns of frostbite if there are trophic disorders or scars tending to ulceration.

5. Consequences of injuries, diseases and also congenital defects of the bones, cartilage, muscles, tendons and joints with disruption of functions and anatomical changes.

6. Degenerative-dystrophic diseases of the spinal cord or consequences of injuries with functional disorders and pain syndrome.

7. Flat feet of degree III.

8. Diseases and consequences of injuries to the peripheral vessels in the presence of trophic disorders and disruption of circulation.

9. Chronic rectal pain, complicated hemorrhoids.

10. Influenza.

11. Urolithasis.

12. Developmental anomalies of the kidneys, urinary tracts, and sex organs.

Diseases of the Ear, Nose, and Throat

1. Chronic diseases of the middle and outer ear.

2. Persistent hearing loss: unilateral - up to 1.5 m; bilateral - up to 2 m.

3. Disorders of the barofunction of the ears and sinuses.

4. Diminished tolerance of vestibular stimulation.

5. Chronic purulent and purulent-polypous? diseases of the nasal sinuses.

6. Diseases of the larynx with loss of voice.

7. Stuttering and ankyloglosssia.

8. Consequences of trauma and diseases of the ear, nose, and throat accompanied by functional disorders.

Stomatological Diseases

1. Caries in 10 or more teeth.

2. Periodontal disease with atrophy of the alveolar process and tendency to recurrence.

3. Chronic recurring disease of the mucous membrane of the mouth.

4. Abnormal occlusion.

5. Chronic diseases of the parotid and salivary glands.

Opthalmological Diseases

1. Developmental anomalies.

2. Chronic recurring blepharitis and conjunctivitis.

3. Chronic diseases of the coatings? of the eye, amotio reinae, atrophy of the optic nerve.

4. Glaucoma.

5. Paralysis or persistent paresis of the motor nerves of the eye, concomitant squint of more than 10 degrees.

6. Diminished visual acuity to not less than 0.5 D for payload specialists and not less than 0.8 D for payload specialists.

7. Anomalies of refraction.

8. Paralysis or spasm of accommodation.

9. Dichromatism and type A or B anomalous trichromatism.

Skin and Venereal Diseases

1. Widespread diseases, not amenable to treatment.

2. Gonnorhea.

3. Syphilis.

Gynecological Disease.

1. Severe fibrocystic breast diseases.

2. Swelling or prolapse of the female sex organs.

3. Urogenital and enterovaginal fistulae.

4. Defective development of the female sex organs, accompanied by disorders of their functions.

5. Adhesions (endometriosis?) accompanied by functional sexual disorders.

6. Persistent disorders of menstrual functions.

Functional Disorders

1. Diminished tolerance to exposure to :

- moderate degrees of hypoxia;

- extreme decompression of the atmosphere;

- radial acceleration;

- change in body position;

- physical exercise;- combinations of adverse ?conditions.

2. Diminished tolerance of the effects of short-term weightlessness, not amenable to training.

3. Negative personality traits.

Methods of Medical Certification and Criteria For Assessing the Functional Status of Cosmonaut Candidates and Cosmonauts

High quality performance of space missions depends on many factors, among which professional performance of the cosmonaut is far from least important. Such perfomance can essentially be predicted form an inidividaul's state of health, physical endurance capacity, and psychophysiological traits. Professional performance capacity can only be evalutated after a comprehensive clinical and functional examination of the patient involving provocative loading tests simulating cosmonaut flight tasks.

Since at the time the majority of candidates requesting examination for medical cosmonaut selection, they have not been diagnosed as suffering from a diseases and have no health complaints, the major task of the clinical examination was to rule out latent forms of active?current? diseases, to evaluate physiological functional and reserve potential with respect to future flight performance, and to develop an individualized preparation program for space flight. This made it necessary to conduct a comprehensive examination and to perform, even in the absence of complaints, a number of obligatory highly informative clinical tests.

At the same time, experience with medical observation of cosmonauts during their careers and improvement of spacecraft and life support systems has enabled us to make adjustments in the medical requirements for the health status of candidates, and in the

number and methods of clinical tests used in medical certification of cosmonauts.

Major Methods of Tests Used During Cosmonaut Candidate Selection

Studies of visceral organs:

- in-depth study of medical history to rule out development of acute paroxysmal disorders of consciousness and performance;

- physical examination;

- special methods: endoscopy of the esophagus and gastrointestinal tract, ultrasound tomography of the organs of the abdominal cavity, kidneys, prostate, x-rays of the stomach and duodenum, electrocardiography in the 12 standard leads at rest, echocardiography, 24-hour Holter monitoring, dopplerography of the heart and major blood vessels, study of the functions of external respiration and gas exchange, dynamic observation of blood pressure;

- laboratory studies:

a) blood (general clinical analysis, blood group, Rh-factor, hepatic tests, enzymes, Australia antigen, HIV virus, Wasserman response, coagulogram, thyroid hormones, insulin, 2-hour sugar loading tests;

b) analysis of stomach secretion fractions;

C) urine (clinical analysis, bilirubin, salts, electrolytes);

d) feces (coprogram, analyses for occult blood, protozoa and helminth eggs);

e) secretions of the prostate gland.

Neurological Analyses.

- study of medical history to rule out fainting, collapse and other losses of consciousness;

- neurological status - evaluation of state of the motor, coordination, sensory and reflex functions of the nervous systems, state of the autonomic nervous system;

- supplementary methods of research: x-ray of the bones of the skull in two views, electroencephalography using standard provocative tests, study of the vessels of the brain.

Psychological Studies

Psychological study is directed at: identification of latent psychopathy or deviations in the neuropsychological sphere; determination of the structure of personality, leading motivations, and values; study of stress tolerance, endurance of difficult living conditions, behavior patterns and reactions in interpersonal interactions; and also evaluation of learning ability with respect to operator tasks and skill stability.

Methods used in the psychological examination include interviews, observation, study of medical history and work and professional records, personality testing (simulated operator performance, behavior patterns and reactions in intergroup interactions).

The studies using personality testing methods enable objective evaluation not only of level of psychological development, but also character traits and temperament. This informaion is used not only during the selection stage, but also in development of individualized plans for special cosmonaut training.

Individual assessment of readiness to perform operator tasks and evaluation of psychological performance capacity include study of stability, concentration and allocation of attention, visual and auditory memory, thinking, spatial and temporal orientation (ability), sensorimotor coordination, ability to work under time pressure, and also study of psychological performance under conditions of prolonged (uninterrupted) work (I think they mean what is called in English performance in sleep deprivation).

Increase in the complexity of flights programs increases the level of demands made on the psychophysiological status of a cosmonaut and makes it necessary to constantly adjust the methods and criteria used in psychological studies.

Techniques for presenting data: - qualitative analysis and use of a composite numerical indicator for comparison with the norm as a conclusion.

- evaluation of behavior patterns and reactions in intragroup interactions in the form of a conclusion, including description of methods used.

Surgical? Studies.

- study of history of past diseases, traumas, surgical operations;

- external examination;

- digital examination of the rectum, and prostate gland;

- X-ray of the cervical region of the spine in frontal, lateral and diagonal projections, of the thoracic, and lumbar-sacral regions of the spine in the frontal and lateral projections;

- excretory urography while patient is in supine and standing position (10 or 15 minutes after beginning of administration of contrast preparation) with descending cystography;

- ultrasound study of the prostate gland;

- for women - gynecological examination, ultrasound study of the uterus and ovaries, mammography.

Opthalmological Studies.

Status of visual function: study of color perception using color tables, measurement of visual acuity, the closest point seen clearly, study of eye movement system, binocular vision, visual fields, measurement of refractionusing objective methods (including cycloplegia (with drops?).

Clinical examination of the eyes - external examination of the eyes and their adnexa?, color lacrymal-nasal? test, biomicroscopy using a slit lamp on narrow and dilated pupils, direct and reverse ophtalmoscopy on dilated pupils, measurement of intraocular pressure.

Otolaryngological Studies.

- study of history;

- exo- and endoscopy;

- study of functioning of the otolarynogological organs: nasal breathing and smell; barofunction of the ear and nasal sinuses, auditory function (whisper, pure tone and speech audiometry, timpanometry);

- vestibular history;

- study of vestibular functions;

- electronystagmographic test (to exclude presence of spontaneous and positional nystagmus);

- caloric irrigation (to rule out areflexia, predominance of labyrinth response and direction);

- rotation tests (to rule out areflexia and predominance of directional response);

- study of the vestibulospinal reflexes (to rule out ataxia and pathological reactions);

- optokinetic test (to exclude areflexia and response asymmetry);

- study of tracking movements of the eyes (to rule out disruptions of smooth tracking and "ataxia" of tracking movements);

- determination of individual susceptibility to motion sickness: endurance of cumulative effects of Coriolis acceleration for both intermittent and continual exposure for 10 minutes.

During the vestibulometric tests, vestibuloautonomic, vestibulosomatic, and vestibulosensory reactions are evaluated.

Stomatological Analyses.

Complete stomatological examination.

Provocative Tests.

-tilt test;

- tests with lower body negative pressure;

- test with graded and submaximal physical exercises;

- examination in the barochamber for endurance of moderate hypoxia (H = 5000 m).

- examination in the barochamber for endurance of high levels of atmospheric decompression (H = 7000 m)

- centrifuge test with +Gz acceleration equal to 3-5-G;

- centrifuge test with +Gx acceleration of 4-6-G;

The tilt test involved sequential exposure of the subject to tilt in the following positions;

- horizontal - 20 minutes.

- head-down - 15 degrees - 6 min., 30 degrees - 6 min.

- head-up - 90 degrees - 20 minutes.

In alternate minutes the following parameters were recorded: EKG in standard and chest leads, blood pressure measured using Korotkov's method, echocardiogram to compute systolic and minute volume (output) of the heart, dopplerography of the major vessels of the head.

Table 1: Evaluation of endurance of tilt test;

General state (subjective evaluation): Good: Rather good. Satisfactory: General state is good, may be some complaints of slight fatigue or weakness. Poor:Complaints of marked general weakness, dizziness, feeling of heat moving in waves throughout the body. May be loss of consciousness and convulsions.

General appearance; Good: Normal, sometimes there is slight cyanosis of the hands. Satisfactory: Hyperhydrosis of the axillary cavities of the palms, there facial pallor, in some cases general appearance remains normal. Poor: Facial pallor, hyperhydrosis of the skin of the head, chest, palms, marked decrease in muscle tonus.

Respiration: Good: Unchanged or slight changes in respiration rate in either direction. Satisfactory: Unchanged or slight changes in respiration rate in either direction. Poor: Dyspnea. Isolated deep respiratory movements.

End systolic pressure: Good: Usually somewhat depressed, remains within normal limits; less often is elevated. Satisfactory: Moderately depressed, remains within baseline limits. Poor: Markedly depressed.

Pulse pressure: Good: Somewhat depressed, remains rather high (over 30 mm Hg) Satisfactory: decreases to 25-20 mm Hg; in some cases while diastolic pressure decreases, pulse pressure may be very high. Poor: Markedly decreases (below 20 mm Hg); sometimes, while diastolic pressure decreases, pulse pressure may be rather high.

Systolic volume: Good: Decreases by 30% of baseline, does not fall below 30 ml. Satisfactory: Decreases by 50% of baseline, does not fall below 20 ml. Poor: Decreases by more than 50% baseline, falls below 20 ml.

Cardiac output: Good: Decreases by 30% baseline. Satisfactory: Decreases by 50% baseline. Poor: Decreases by more than 50% baseline.

EKG: Good: Regular heart rhythm, moderate respiratory cardiac arrhythmia. Satisfactory: Regular, marked respiratory arrhythmia, migration of pacemaker along the auricle??, isolated extrasystoles. Poor: Frequent auricular and less often ventricular extrasystoles, polytopic, group extrasystoles, allorhythmia, etc.

T wave: Good: Depression of amplitude by 30% of baseline. Satisfactory: Depression of amplitude by 50% of baseline, slight deformation of T wave in leads 1-3. Poor: Significant decreases in amplitude up to the isoelectric level, appearance of biwaves, biphases and inversions??.

ST segment: Good: Unaltered. Satisfactory: Depression by up to 1.0 mm. Poor: Depression by more than 1.0 mm. Table 2: Evaluation of endurance of head-down tilt.

General state: Good: Slight sensation of rush of blood to head. Pulsation in temples. Satisfactory: Some feeling of discomfort. Marked sensation of rush of blood to head, pulsation in temples. Poor: Marked discomfort, sensation of heaviness in head and that it is about to burst, headache.

General Appearance: Good: Flush of face and sclera. Satisfactory: Slight cyanosis of face and lips. Poor: Marked cyanosis of face and neck. Table 3: Evaluation of tolerance of LBNP tests.

General state: Good: Good. Satisfactory: Good. Poor: Complaints of general weakness, dimming of vision, dizziness, nausea, perspiration, sensation of heat. Development of state of collapse, convulsions, loss of consciousness.

General appearance: Good: Normal, possibly moderate pallor of the facial triangle. Satisfactory: Moderate facial pallor. Poor: Marked facial pallor, cyanosis of the lips, local or general hyperhydrosis.

Pulse blood pressure: Good: Somewhat decreases, remains 25 mm Hg or higher. Satisfactory: Decreases to 15 mm Hg. Poor: Below 15 mm Hg, marked wavelike fluctuations.

EKG rhythm: Good: Regular, heart rate increases by up to 15 beats.minute. Satisfactory: Satisfactory, heart rate increases by more than 15 beats/minute. Poor: Tachycardia, alternating with bradycardia, extrasystoles, disruption of intracardiac conductivity.EKG T wave: Good: Decreases by up to 30% of baseline. Satisfactory: Decreases by up to 50% of baseline, slight deformation of the T wave in leads 1-3. Poor: Significant decreases, diffuse deformation of T wave, slight decrease in 1T segment.

Systematic [sic.] volume: Good: Decreases by up to 30% of baseline. Satisfactory: Decreases by up to 50% baseline. Poor: Decreases by more than 50% baseline. LBNP involved a stepwise increase in decompression in a vacuum chamber? depressurized volume? with subject in horizontal position:

25 mm Hg - 2 minutes;35 mm Hg - 3 minutes;40 mm Hg - 5 minutes;50 mm Hg. - 5 minutes.

While negative pressure was applied EKG, blood pressure, echocardiographs, and dopplerographs of the major vessels of the

head were recorded. The graded submaximal exercise test involved determination of physiological tolerance of physical exercise and used a continuous stepwise increase in loading on the bicycle ergometer. During the test, EKG was recorded in 12 leads and blood pressure was measured using Korotkov' method, gas exchange parameters were studied.

Instead of the bicycle ergometer appropriate exercise on the treadmill could be used.

Table 4: Evaluation of endurance of graded physical exercise on the bicycle ergometer

General state (self report): Good: Good. Satisfactory: General state is rather good, there may be complaints of slight fatigue. Poor: Complaints of general weakness, fatigue, loss of consciousness may occur.

External appearance: Good: Normal, sometimes slight hyperhydrosis; Satisfactory: Moderate hyperhydrosis. Poor: Significant hyperhydrosis of the skin, head, chest, palms, marked facial pallor. tendency to faint.

Respiration: Good: Appropriate Satisfactory: Strained, with inclusion of auxiliary musculature Poor: Frequent (rapid?) labored respiration, dyspnea.

Gas exchange: Good: Parallelism between increase in loading and magnitude of pulmonary ventilation, oxygen consumption and heart rate. Oxygen consumption at the peak of loading is no less than 30 ml/kg min. Satisfactory: Oxygen consumption no less than 25 ml/kg min. Poor: Oxygen consumption 25 ml/kg and less.

Oxygen pulse?: Good: Greater than 13 ml/beat. Satisfactory: 10-13 ml/beat. Poor: Less than 10 ml/beat.

Systolic pressure: Good: Increases to 200 mm Hg. Satisfactory: Increases to 220 mm Hg. Poor: Exceeds 230 mm Hg or decreases sharply as loading increases.

Diastolic pressure: Good: Unchanged or changes within limits of + or - 100 mm Hg from baseline. Satisfactory: Increase to 110 mm Hg. Poor: Increases above 120 mm Hg.

EKG rhythm: Good: Sinus. Satisfactory: Sinus, monotopic extrasystoles (greater than 5 % REST OF SENTENCE MISSING Poor: Sinus, frequent monotopic systoles (no greater than 5% of heart rate per minute, grouped, polytopic allorhythmia (3 or more), paroxysmal tachycardia, fibrillation or palpitation of the aurical, auricular-ventricular blockade, blockade of the branches of the His' bundles, shortening of the P interval.

T wave: Good: Slight (by up to 50% of baseline) [sic.] increase?change? Satisfactory: Significant increases or decreases, sometimes the decreases is accompanied by flattening?. Moderate (by up to 75% of baseline) changes in the position of the amplitude axis. Poor: Becomes biphase or is inverted (inversion) in some cases, gigantic? decreases or significant increases in amplitude (by more than 75% baseline).

ST Segment: Good: Unchanged. Satisfactory: Decreases in horizontal or rising diagonal not greater than 0.75 mm. Poor: Decrease in horizontal or decreasing diagonal of greater than 1.5 mm; ib rising diagonal by more than 2.5 mm, if the absolute duration is not less than 0.8 seconds.

The barochamber test for tolerance of moderate hypoxia (H=500 m) was conducted with exposure to that altitude equivalent for a period of 30 minutes. At the same time EKG and blood pressure were recorded. Physiological tolerance of hypoxia was considered diminished if the EKG recorded in hypoxia showed grouped or polytopic extrasystoles, inversion of the T wave, displacement of the SST interval; or sharp slowing of atrioventricular and intraventricular conductivity, regardless of nature of changes in other parameters (BP, HR, external appearance, self reported state).The barochamber examination for tolerance of high levels of atmospheric depressurization involved prebreathing for 60 minutes followed by ascent to 10,000 m with exposure duration of 15 minutes. Physiological tolerance to extreme atmospheric depressurization was considered diminished if during the study the following were observed: - decompression disroder in the form of intense pain in the joints and muscles, "high altitude cough," pain below the breastbone and in the area of the heart, itching;- symptoms of high altitude meteorism, marked distension of the abdomen accompanied by sharp pain; - collapse of fainting.

The centrifuge examinations involved +Gz acceleration of 3-5-G for 30 seconds and +GX acceleration of 4-6-G for 40 seconds. Tolerance of +Gz acceleration (5-G 30 seconds) and +Gx acceleration (6-G 40 seconds) was considered diminished if any of the following occurred: - poor subjective endurance of the acceleration;- collapse or loss of consciousness during the acceleration or subsequently;- presence of frequent monotopic grouped or polytopic extrasystoles, paroxysmal tachycardia, heterotopic pace makers, disruption of intracardiac conductivity;- decreased binocular acuity of vision of greater than 0.4 diopters compared to baseline;- increases greater or equal to 1 second in latency of conditioned motor reflexes to light signals; - decreased blood pressure in the vessels of head to below 30-50 mm Hg;- appearance of multiple, sometimes merged petechia {Something missing?} bleeding;- later than 48 hours after the test, appearance of protein and other pathological changes in urine;-if marked tachycardia (pulse greater than 190 beats/minutes, tachypnoe (respiration rate greater than 40 cycles per minute), facial pallor, or hyperhdyrosis occurred during exposure, fitness certification required a second test on the centrifuge.

Measurement of Susceptibility to Motion Sickness

Test with continuous cumulative exposure to Coriolis accelration.

Subjects, sitting in a Barany chair or on an electrically rotated chair, assume a pose making the angle of rotation pass through the torso.

Against a background of uniform rotation (at a rate of one rotation every 2 seconds) with closed eyes at the end of the fifth rotation the subject at the experimenter' command begins to move his head from the right shoulder to the left (or vice versa) and back at an angle of no less than 30 degree to each side with respect ot the vertical.

The head movements are continusous, without excess strain on the neck muscles and the head is turned smoothly without stopping at the extreme or central postiions (for 2 seconds per movement from shoulder to shoulder).

Rate of head movement is controlled using a metronome or other device. It can also be regulated by the time required to say the numbers 21 and 22 (2 seconds).

Counting of the time elapsed during the test must begin with the moment of the first head movement. Before beginning of the study, the subject is instructed concerning the nature and clinixal symptoms of possible subjective sensations he may experience during the test and is told he must inform the experimenter about them as soon as they occur.

Autonomic symptoms during rotation are recorded along with the time that they occr. At the same time the subject is observed for the appearance of external symptoms of vestibulo-autonomic disorders.

Test of Exposure Cumulative Intermittent Coriolis Acceleration

The subject, sitting on a Barany chair of electrically rotated chair, takes a position so that the angle of the trunk with respect to the axis of rotation is 90 degrees, the eyes are closed. Against a background of constant uniformrotation of the chair with a rate of 180 degrees per second (one complete rotation, every 2 seconds), at the experimenter's command at the end of the fifth rotation, the subject begins to straighten up and then return to the starting position with smooth movements, taking three seconds per cycle.

For self-regulation of the time interval the subject is asked to pronounce the numbers 21, 22, 23, aloud. Straightening and bending the torso occurs at the experimenter's command every 5 seconds. During the pause, the subject maintains previous posture.

The test is conducted for a period of 1 minute, after which the experimenter notes the severity of autonomic responses and asks about subjective sensations. During a cycle (minute) the subject must perform five sets of straightening motions and four bends of the torso. After completion of a minute of rest, the test continues in the same order for another minute, but the chair rotates in the opposite direction.

The 1 minute period of the test is counted starting from the moment the subject is given the command to straighten up, i.e. only time spent straightening and bending the torso is counted. Preliminary rotation (5 turns) is needed to create a backgorund of continuous rotation and is not counted.

The appearance of pronounced autonomic-vestibular symptoms (pallor, hyperhydrosis, nausea, the need to vomit) during the test or

immediately afterwards are criteria of threshold tolerance of Coriolis acceleration.

The occupational prediction made for subjects showing these symptoms is as a rule negatvie. Tests for endurance of Coriolis acceleration must be conducted during the first half of the day, no sooner than 2 hours after eating.

On the day of the test involving intermittent exposure to Coriolis acceleration the subject must not be scheduled for any other loading tests (centrifugation, hypoxic tests, etc.) If there has been a disruption of his eating, sleeping or rest schedule or if he is ill, the test is rescheduled.

If indicated, other methods using equipment and provocative tests not stipulaed in the compulsory test battery may be used.

Analysis of the Causes of Medical Disqualification of Cosmonaut Candidates and Cosmonauts

Between 1959 and 1985, a total of 774 individuals, mainly pilots, were examined as part of the cosmonaut selection program in the Central Aviation Hospital.

The leading cause of professional disqualification of subjects in this group was diseases of the visceral organs (34% of the total number of disqualified candidates); of these the majority (62.0%) suffered from cardiovascular diseases .

The distribution of diseases of visceral organs serving as a reason for disqualification of cosmonaut candidates is as follows: (in percentage of number deemed unfit due to diseases of the visceral organs)

- myocardiopathology of varying etiology - 36.0- myocardiosis (coronary sclerosis) - 14.0- neurocirculatory asthenia - 12.0- chronic gastritis, gastroduodentitis - 16.0- ulcerative disease of the stomach and duodenum - 5.0- diseases of the liver, biliary tracts; functional hyperbilirubinemia - 9.0; - other visceral organs - 8.0.

Of the diseases of the cardiovaascular system, diseases inducing disruption of conductivity, excitability (?), or automatism of the heart predominated (Aleksandrova, M.P., Pavlova T.Ya., 1972).

While during the first round of selection, these changes were a frequent cause of elimination from the examination program, in the second half of the 1960s, taking account of experience with space flights and the improvement of diagnostic methods, the individualized method began to be used more extensively. In a number of cases after therapeutic/prophylactic measures were taken, candidates [suffering from such diseases?] successfully continued the examination within the special selection program. Functional evaluation of the performance of the cardiovascular system, its reserve capacities and compensatory capacities under ordinary and extreme conditions provided a rationale for allowing these individuals to undergo furhter testing in this program. The drastic increase in information provided by modern diagnostic instrument-based and special methods of study constantly comples modifications in the treatment of normative parameters and a more responsible approach to making the medical certification decisions.

The second most frequent casue of disqualification among the diseases of visceral organs were diseases of the digestive organs. (30%).

Characteristics of nutrition on board spacecraft combined with other flight factors, moderate changes in the mucous gastroduodenal tract combined with secretory, and motor disorders and indications in the medical history of one or more episodes of dispeptic disorder served as a reason for eliminating these individuals from further consideration.

Other diseases of the visceral organs (blood, respiratory organs, etc.) were relatively rare.

The number of candidates disqualified because of diseases of the ear, nose and throat was somewhat lower (26% of all candidates deemed unfit).

Distribution of diseases of the ear, nose and throat:

- chronic tonsilitis - 32%

- chronic sinusitis and vasomotor rhinosinusopathy? - 30%;

- vestibular intolerance - 23%;

- cochlear neuritis - 7%;

- other diseases - 8%

Candidates diagnosed as having chronic tonsilitis are subject to surgical treatment.

Nonsevere vasomotor changes in the mucous membrane without involvement of the functions of the nose or barofunctions are not considered a reason for disqualification.

The results of dynamic observation of the cosmonauts during professional training and in flight has shown that during the initial stages of selection the methods used to study vestibular tolerance were inappropriate to the factors to which cosmonauts were exposed inflight. (The ORTO? method and studies on Khilov swings were used).

The combination of centrifugation followed by use of Khilov swings also failed to produce enough information.

A more promising direction for determining individual sensitivity to motion sickness is research on endurance of cumulative Coriolis acceleration using intermittent and continuous exposure.

The third cause of disqualification was surgical? and urological diseases (15% of total disqualified candidates). In the group disqualifed due to surgical pathology, individuals with degenerative-dystrophic changes in the spine (29%), developmental anomalies of the kidneys and urinary track (8)% and inflammatory changes of the kidney and urinary tract (10%) predominated.

Among neurological diseases, occupying the fourth place as a cause of disqualification (12% of total disqualified cosmonaut candidates) most common was emotional-autonomic instability, manifest under specific conditions during specific loading tests. One indication for terminating an examination within the special selection program was combination of emotional-autonomic instability and disruption of cardiac function.

When a diagnosis was made, the result of the comprehensive psychological examination was given great importance.

Rate of disqualification of cosmonaut candidates for stomatological diseases (up to 8% of total disqualifications) was relatively high. The major reason for disqualification was excess number of dental caries and periodontosis with atrophy of alveolar processes. Diseases and anomalies of visual refraction led to 5 % of the disqualifications, primarily due to diminished visual acuity and anomalies of refractions

Many years of dynamic observation of cosmonauts during their performance of their jobs supported lowering of the requirements for vision of cosmonaut candidates and cosmonauts, as a function of their actual mission during space flight.

Thus, individuals not involved in controlling the spacecraft or systems not requiring a high level of visual performance can be deemed fit for special space flight training if they have myopia of 0.5 in each eye. They may be advised to wear corrective glasses or contact lenses, if the power of the corrective lens does not exceed + or - 2.0 diopters.

Professional Disqualification of Cosmonauts

Between 1959 and 1989, 39 cosmonauts were excluded due to medical disqualification. Here we are only discussing individuals who initially received a good professional prognosis and then developed diseases which were the basis for "acute" disqualifications.

Distribution of Disqualifications on the Basis of Primary Disease

1. Ulcerative disease of the duodenum: 8 individuals, in years: 2,3,8,8,9,19,20.

2. Chronic gastritis: 1 individual in year 7.

3. Hepatitis: 2 individuals in years: 9,12.

4. Heart muscle diseases: 5 individuals in years: 1,2,3,6,8.

5. High blood pressure: 2 individuals in years: 2, 16.

**6. Capillary toxicosis?: 1 individual in year 1

7. Hemophilia: 1 individual in year 1

8. Periodontosis (2nd and 3rd degrees) 1 individual in year 4

9. Osteochondrosis and deforming spondylosis of the spine: 2 individuals in years: 2,8.

10. Trauma and their consequences: 2 individuals in years:1,5

11. Kidney stones: 5 individuals in years 1,3,8,8,9.

12. Autonomic/vascular dystonia: 4 individuals in years: 1,3,3,4.

13. Asthenoneurotic state: 2 individuals in years 3, 15

14. Cervicobrachial radiculitis: 1 individual in year 21

15. Bilateral cochlear neuritis: 1 individual in year 8

16. Diminished tolerance to change in body position: 1 individual in year 3

The most common cause of disqualification was chronic diseases of the stomach and duodenum. Retrospective case histories of these diseases attest to the fact that in 5 of the 9 individuals, moderate changes (*hypersperatory? level of fluid on an empty stomach, labilization of the mucous membrane of the *exit tract? of the stomach into the bulb of the duodenum) had been established during the selection stage. Of 8 individuals with ulcers of the duodenum in 7 the ulcer "niche" was located on the posterior lower wall of the duodenum and in one on the anterior upper wall. In two individuals the course of the disease was complicated by bleeding. Worsening of the diseases in all cases was due to stress situations.

Hemophilia, *capillary toxicosis and periondontosis of level 2-3, a reason for disqualification of cosmonauts during their first year in the corps, led to adjustment in the selection tests used and served as a basis for requirements for cosmonaut candidate selection (analysis of blood on a coagulogram and an orthopantogram of the teeth were introduced.)

Five cosmonauts were eliminated due to kidney stones. In all of these the disease had been identified during the stage of preflight

training. In two, excluded for this reasons, during years 1 and in the corps, during selection, analysis of urine after a loading test revealed isolated erythrocytes. The compulsary analyses and an additional urological examination performed during that period failed to reveal any pathological changes in the urogenital system. At present a number of highly informative urological analyses have been added to the compulsory studies of cosmonaut candidates to rule out similar errors during selections.

Four individuals were disqualified due to autonomic/vascular dystonia, all during their first 4 years in the corps.

The adverse course of this disease during the special training program requires extremely stringent individualized approach to cosmonaut candidates with this characteristic.

One case of diminished tolerance of changes in position argues in favor of further improvement in the methods for determining vestibular sensitivity that are currently used.

REFERENCES

1. Argashchenko N.I. Certain physiological aspects of the system for selecting and monitoring of training of cosmonauts. In book: Aviation and Space Medicine, Moscow, 1963, pp. 333-335.

2. Aleksandrova M.P. Research on the early forms of autonomic-vascular dystonia in cosmonaut selection. In the book: Space Biology and Aviation Medicine. Moscow, Kaluga, 1972, pp. 5-7, vol. 2.

3. Borodin A.P. Some issues in flight certification. In book: Aviation and Space Medicine, Moscow, 1963, pp. 81-89.

4. Babiychuk A.P. Voyenno-meditsinskiy zhurnal,{Military Medical Journal}, No. 9, 1967, pp. 18-22.

5. Branov I.I. Methods of studying the tolerance of the human vestibular apparatus and cumulative Coriolis acceleration. Voyenno-meditsinskiy zhurnal, No. 11., 1963, p. 54.

6. Bobrov Yu.M. On the principles for selecting small groups of specialists taking account of their psychological compatibility. XIVth

Gagarin Lectures on Aviation and Cosmonautics, Moscow, 1985, pp. 162-165.

7. Buyanov P.V., Galkin A.V., Terent'yev B.G. Some issues of the selection of candidates for a special contingent. In book: Problems of Space Medicine, Moscow, 1966, pp. 81-83.

8. Bogadashevskiy R.B. Principles, methods and means for psychological study and education of the personality of cosmonauts. XIVth Gagarin Lectures on Aviation and Cosmonautics, Moscow, 1985, pp. 168-170.

9. Vasil'yev P.V., Kotovskaya A.R. Physiological reactions of humans to accelerations in space flights. In book: Problems of Space Biology, Moscow, Nauka, No. 6, 1967, pp. 93-108.

10. Vlasov V.V., Kopanev V.I. The effect of aviation work on health status in light of epidemiological data. Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina, 1990, No. 6, pp. 4-9.

11. Vyadro M.D. Some issues in the theory and practice of medical selection of cosmonaut candidates. Voyenno-meditsinskiy zhurnal, 1967, No. 10.

12. Gazenko O.G., Gyurdzhian A.A. Physiological effects of gravitation. In book: Problems of Space Biology, Moscow, Nauka, 1967, pp. 22-41.

13. Gazenko O.G., Kas'yan I.I., Kotovskaya A.R. Physiological reactions of animals on flights 3,4, and 5 space satellites. Yuganov Y.M. Proceedings of the USSR Academy of Medicine, Biology, 1964.

14. Grigor'yev A.I., Yegorov A.D. Phenomenology and mechanisms of changes in the major physiological functions in humans in weightlessness.Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina, 1988, No. 6, pp. 4-17.

15. Gurovskiy N.N., Krupina T.N. Some issues in selections and training of payload specialists. In book: Aviation Medicine, Moscow, 1971, pp. 150-165.

16. Gurovskiy N.N., Bayevskiy R.M., Krupina T.N. Problems of selection of cosmonauts in light of theory and prediction. In book:

Problems of controlling the physiological functions of humans and animals. Moscow, 1973, pp. 16-171.

17. Gurovskiy N.N. Korabayev M.M. Problems of selecting and training payload specialists and others In book: Gagarin Lectures, Moscow, 1973, pp, 107-111.

18. Yegorov P.I. Problems of selecting payload specialists and others. In book: Proceedings of the Fifteenth International Congress on Aerospace medicine, Medicine, 1966.19. Ivanov V.I. Human Beings in High Altitude and Space Flight, Moscow, Insostrannaya Literatura {Foreign Literature}, 1960.

20. Romanov A.P., Lyk'yanov B.V., Lebedev L.A. Experience With the Blue Planet, Moscow, 1981, p. 399.

21. Sisakyan N.M., Yazdovskiy V.I. The First Manned Space Flights. Moscow. USSR Academy of Sciences, 1962.

22. Yazdovskiy V.I., Yemel'yanov M.D. Weightlessness and the vestibular apparatus. Aviatsiya i Kosmonavtika, 1962, 12, p. 19.

23. Link M.M., Gurovskiy N.N., Bryanov M.D.. Foundations of Space Biology and Medicine, Moscow, Nauka, 1975, vol. 3, pp. 419-452.

24. Wier L.T., Jackson A.S., Pinkerton M.B. Evaluation of the NASA/JSC health related fitness program. Aviation, Space, and Environmental Medicine, May, 1989, p. 438-444.