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USSR Space Life Sciences Digest

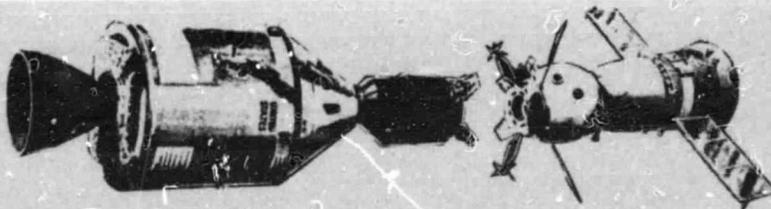
A QUARTERLY REVIEW

Volume 1, Number 4



Prepared for the
Life Sciences Division
National Aeronautics and Space Administration
Washington, D C. 20546

(NASA-CR-164781) USSR SPACE LIFE SCIENCES 882-10700
DIGEST, VOLUME 1, NO. 4 Quarterly Review
(BioTechnology, Inc.) 65 p HC A04/MF A01
CSCL 06D Unclass
G3/51 39384



December 1980

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Prepared for

**Life Sciences Division
National Aeronautics and Space Administration
Washington, D.C. 20546**

Contract NASW-3223

December 1980

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INTRODUCTION

Soviet scientists are making significant contributions to the field of space medicine and biology through their active manned space program, frequent biosatellites, and extensive ground-based research. It is important that U.S. space life scientists be familiar with the literature generated by the Soviet program. The purpose of this document is to provide an overview of the developments and direction of the USSR Space Life Sciences Program.

Information concerning the Soviet space program makes its way into U.S. information banks and publications via a number of routes. While many agencies survey the Soviet literature and produce helpful listings and translations, no agency reviews the full scope of Soviet life science literature pertinent to the space program, and no agency is specifically charged with the task of evaluating and integrating any of this information. This Quarterly Digest is designed to bridge that gap.

The information contained in this Digest is primarily obtained from the following sources:

- Abstracts in Soviet space biology and medicine provided by the Library of Congress, Federal Research Division—NASA Unit II-G.
- *Aerospace Medicine and Biology*—A continuing bibliography (NASA SP-7011).
- *Scientific and Technical Aerospace Reports*—A bibliography produced by the Scientific and Technical Information Office, NASA.
- Foreign Broadcast Information Service, Volume III, Soviet Union—NTIS. Abbreviated FBIS.
- Daily Soviet News Abstracts Publication—Translated abstracts of news items from the Soviet press. Published by Foreign Technology Division, Battelle Columbus Laboratories. Abbreviated Daily SNAP.
- *Space Biology and Aerospace Medicine*—A complete translation of the Russian language monthly journal *Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina*, published in the U.S. by Joint Publications Research Service.
- *Aviation Week & Space Technology*—Weekly periodical published by McGraw-Hill, Inc. Abbreviated AW&ST.
- *Aviation, Space and Environmental Medicine*—Monthly periodical published by the Aerospace Medical Association.
- *Spaceflight*—Monthly periodical published by the British Interplanetary Society.

The goal of this publication is to inform cognizant personnel of the NASA Life Sciences Division of important developments in the Soviet Space Life Sciences Program in a manner that eliminates the need for the arduous task of locating and reviewing the voluminous Soviet literature. Copies of literature cited in the Quarterly Digest may be obtained by contacting:

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HIGHLIGHTS

Launches and Recoveries

The following table presents an overview of recent Soviet launches and recoveries.

<u>Spacecraft</u>	<u>Launch</u>	<u>Crew</u>	<u>Return</u>	<u>Comments</u>
Cosmos 1212	26 September 1980	Unmanned		Investigation of Earth's natural resources.
Progress 11	28 September 1980	Unmanned	Burned up, 11 December 1980	Docked with Salyut 6 30 September 1980; delivered scientific equipment and radio telemetric system for transmitting data of its operation to Earth.
Cosmos 1213	3 October 1980	Unmanned		Space research
Raduga	5 October 1980	Unmanned		Communications satellite
Soyuz 37	23 July 1980	Popov, Ryumin	11 October 1980	Returned after crew spent 185 days in space
Cosmos 1214	10 October 1980	Unmanned		Space research
Cosmos 1215	14 October 1980	Unmanned		Space research
Cosmos 1216	16 October 1980	Unmanned		Space research
Cosmos 1217	24 October 1980	Unmanned		Space research
Cosmos 1218	30 October 1980	Unmanned		Space research
Cosmos 1219	31 October 1980	Unmanned		Space research
Cosmos 1220	5 November 1980	Unmanned		Space research
Cosmos 1221	12 November 1980	Unmanned		Space research
Molniya 1	16 November 1980	Unmanned		Communications satellite
Cosmos 1222	21 November 1980	Unmanned		Space research
Soyuz T-3	27 November 1980	Kizim, Makarov, Strekalov	10 December 1980	Test of the Soyuz T's onboard systems and design in various modes of automatic flight, and joint work with Salyut 6-Progress 11 orbital complex
Cosmos 1223	28 November 1980	Unmanned		Space research
Cosmos 1224	1 December 1980	Unmanned		Space research
Cosmos 1225	5 December 1980	Unmanned		Space research
Cosmos 1226	11 December 1980	Unmanned		Space research
Cosmos 1227	16 December 1980	Unmanned		Space research
Cosmos 1228, 1229, 1230, 1231, 1232, 1233, 1234, 1235	24 December 1980	Unmanned		Space research; all eight put into orbit with one booster rocket
Prognoz 8	25 December 1980	Unmanned		Study of corpuscular and electromagnetic radiation of the sun's radiation and its effect on magnetic fields near Earth
EKRAN	26 December 1980	Unmanned		TV satellite
Cosmos 1236	27 December 1980	Unmanned		Space research

Mission News

- The scientific space station Salyut 6 has been in operation for 3 yrs as of September 29, 1980. Three main crews and eight visiting crews have been onboard. The total time in manned regime has exceeded 18 months. There have been, by anniversary date, 24 link-ups with transport ships and Salyut 6.
- Medical and physiological studies were conducted during the Soyuz 38 Soviet-Cuban flight, especially on the reaction of the cardiovascular system and the effects of blood redistribution in the initial stages of flight. EEGs were recorded by studying parameters of wakefulness, alertness, and tiredness to answer questions of changes in functions and activities of the sensory systems. Preliminary evidence was reported indicating support of the arch of the foot prevented locomotory disorders that accompany weightlessness.
- Landing of artificial Earth satellites or piloted cosmic systems practically anywhere in the world is said to be possible. Ships of the "cosmic flotilla" continuously monitor and control flight and descent of space vehicles. A book entitled *Ships of the Cosmic Service*, issued by the shipbuilding publishers in Leningrad, contains a detailed description of the ships, their equipment, and their tasks.
- Popov and Ryumin returned to Earth on October 11, 1980, after 185 days in space. They underwent physical check-ups and were reported to have suffered no irreversible processes from weightlessness. This was attributed to regular exercise, a varied diet that included fresh vegetables and fruit, and a varying work regime. Heart contractions were somewhat higher than preflight values and there was a loss of muscular mass. Unlike previous flights, no loss of strength in the calf muscle group was observed, although once on the ground changes in gait and other motor actions were noted. Temporary decreases in erythrocyte content and hemoglobin concentration were observed in both cosmonauts' blood.
- Progress 11, which docked with Salyut 6 on September 30, 1980, refueled Salyut 6 automatically for the first time. All previous refuelings had required intervention of a crew. Progress 11 returned to Earth December 11, 1980.
- Analysis of the "isparitel" (evaporator) studies brought the conclusion that high quality coatings of gold, silver, copper, and other metals applied to plates in 0 G were accomplished only with great difficulty in controlling the process. Nevertheless, the products obtained were judged superior to those made under conditions of artificially created vacuums on Earth.
- On November 28, the Salyut 6 space laboratory received its 13th crew: Kizim, Makarov, and Strelakov. The men transferred to the station that had been unmanned for more than 6 wks. Soyuz T-3, which carried the crew to the space lab, was guided through space to docking on "automatic pilot," and returned the crew to Earth with a controlled pattern of descent. The Soyuz T-3 crew wore improved pressure spacesuits that consisted of new materials, which allowed greater flexibility after the wearer became used to the inflated suit. The field of vision in the helmets was reported to be enlarged. To prolong the Salyut 6 space station's functional life, the Soyuz T-3 crew replaced a number of systems that needed major repairs. Salyut 6, initially planned for 1½ yrs of use, has now been in operation for more than 3 yrs. Of special concern is the deterioration of the portholes and a discernible effect of spaceflight on the external shielding. These parts are inaccessible to repair.

Personnel News

- **Leonid Kizim:** The pilot of Soyuz T-3 was born in Krasnyy Liman on August 5, 1941. He graduated from Chernigov Higher Military Aviation School for pilots in 1963, and served in the Air Force. Lieutenant Colonel Kizim joined the cosmonaut program in 1965, and was involved in testing the Soyuz T-3 on the ground.
- **Oleg Makarov:** The flight engineer of Soyuz T-3 was born in Udomlya on January 6, 1933. A 1957 graduate of the Moscow Higher Technical School imeni Bauman, he worked in the design bureau on the development of spaceships and orbiting satellites. Makarov joined the cosmonaut program in 1966 and flew on Soyuz 12 (September 1973). He was flight engineer on the January 1978 Soyuz flight, which was the first visiting expedition to the Salyut 6 station.
- **Gennadiy Strekalov:** Soyuz T-3's cosmonaut-researcher was born in Mytishchi on October 28, 1940. He graduated in 1965 from the Moscow Higher Technical School imeni Bauman and subsequently worked in the design bureau, developing new spacecraft. Strekalov has been in the cosmonaut program since 1973.

Meetings

- The regular meeting of the Soviet/American Working Group on Space Biology and Medicine met on November 2. Soviet and American scientists discussed results of the experiments performed onboard the biosatellite Cosmos 1129. Also discussed were procedures for selection and training of cosmonauts, and vestibular disorders and possible means of pharmacological prevention.
- The Scientific Council of the USSR Academy of Sciences on Comprehensive Problems of Human and Animal Physiology, the Scientific Council of the USSR Academy of Medical Sciences on the Study of Human Adaptations to Various Environs, and the Institute of Physiology imeni Pavlov of the USSR Academy of Sciences held a meeting to consider advances in the field of thermoregulation and human and animal adaptation to hot climates and high temperatures. The conference took place in November at the Turkmen Academy of Sciences' Institute of Physiology and Experimental Pathology of the Arid Zone.
- The Tbilisi Conference on Lasers in Biology and their use in treatment of disease was held in November during the All-Union Conference Seminar of Biophysicists on Problems of the Application of Laser Technology in Biology. The conference was attended by representatives from the USSR, Hungary, East Germany, Bulgaria, the U.S., France, and West Germany.
- A Soviet-French conference was held on October 14 in the Azerbaijan capital, Baku. It was held in accordance with the intergovernmental agreement on the study and use of outer space for peaceful purposes. The scientists and specialists summed up the results of joint research and experiments, and mapped out prospects for further cooperation.

(Material in the "Highlights" is drawn from FBIS, October-December 1980; Daily SNAP, October-December 1980; and AW&ST, October-December 1980.)

GROUND-BASED RESEARCH

Space Medicine and Physiology

Hypokinesia

Key word: Joint Report

General formatting requirements for the preparation of the joint Soviet-American Experiment on the Effect of Hypokinesia (SAEH) report and working guidelines for standardizing the materials of the Joint Working Group were published (Anonymous, 1980).

Key words: vascular system, microcirculation, exercise

The effect of 182 days of antiorthostatic hypokinesia and 30 days of rehabilitation on the blood microcirculation in the sclera of the eye and the nail folds of the fingers and toes was studied in 18 healthy men by Chernukh et al. (1970). The authors reported marked changes in microcirculation of the sclera and feet and less pronounced changes in the hands. A regime of prophylactic physical exercises was held responsible for the favorable circulation in the hands.

Key words: skeletal system, X-rays, osteoporosis

Podrushnyak and Suslov (1973) used X-ray micrography to study the optical density of 5 bones in 9 people (24-29 yrs) before and after strict bedrest lasting 16-37 days. Photometric studies of the X-ray film determined the concentration of bone structure before and after hypokinesia; bone tissues of 25 cadavers of healthy individuals (18-70 yrs) who died of injuries were also examined. The results of the X-rays showed that there is a wide range of responses to hypokinesia. Some healthy young people exhibited pronounced osteoporosis after a relatively short period of hypokinesia. Additional results showed that hydroxyapatite crystalline structure and concentration culminates by the age of 20-25. From 25-60 yrs, the crystal lattice remains stable, but the X-ray analysis indicated a reduction in density.

Key words: hydroxycorticosteroid, adreno-hypophysal system, space flight factors, exercise

Kalandarov et al. (1980) considered the effect of factors inherent in space flight on plasma hydroxycorticosteroid (11-HCS) levels. Free plasma 11-HCS is biologically active but requires binding with transcortin, a plasma protein, for transport to target tissues. While bound, the steroid is reversibly inactive, until delivered to the site of action. The scientists measured free, bound and total plasma 11-HCS in 43 men, 22-36 yrs, who were divided into 8 groups. Group 1 consisted of 5 men who underwent simulated ascent to 8000 m, expectation of G forces on a centrifuge, and a limited time psychological test. 5 men in group 2 experienced the same procedure but were also given food supplements (FS) of vitamins, minerals, glucose and phosphatide concentra. 7 men in group 3 underwent physical exercise and timed mental work, and FS. Groups 4, 5 and 6, with 6 men in each, underwent hypokinesia at +6°, -2° and -6° respectively. Group 7's men experienced

high CO₂ (3%) and low temperatures (16°), while group 8's 4 men experienced high CO₂ (3%), high temperatures (35°) and high humidity (90%). After the simulated ascent, group 1 showed some decrease in free 11-HCS and an increase in the bound steroid. The anticipation of G forces was accompanied by an elevation of both forms, while the testing resulted in a decline in both. Group 2 retained baseline levels throughout the experiment. Group 3 exhibited a decrease in both forms until FS were given; a recovery of free 11-HCS level was noted. After the 26th day of hypokinesia, group 4 showed a decline in bound 11-HCS, but no changes were seen in the free form. Groups 5 and 6 showed no changes in the bound 11-HCS but low levels of free 11-HCS were noted. The addition of ACTH to each of the hypokinetic groups resulted in increased levels of all HCS forms for groups 4 and 5 but a decrease in group 6's responses. On the 2nd day of exposure, group 7 showed an increase in free 11-HCS and a decrease in the bound 11-HCS. By the 7th day of exposure, these had reversed. During the recovery period, total 11-HCS attained baseline values. Group 8 experienced a decline in HCS on the 2nd day of exposure although by the 7th day, free 11-HCS rose. A steady decline in the protein-bound steroid was seen. During recovery the fractions diminished. No conclusions were presented.

Key words: water immersion, cardiovascular system, fluid-electrolyte system, endocrine system, renal system, homeostasis

Shulzhenko et al. (1979) investigated cardiovascular, fluid-electrolyte, and biochemical parameters in simulated weightless conditions. Healthy volunteers were exposed to a 7-day water immersion; they were kept dry by a waterproof, highly elastic cloth. The experimental results suggest the hypophyseal-adrenal and renal systems function together to regulate responses of the cardiovascular system and fluid-electrolyte metabolism during acute adaptation of the human body to reduced gravity.

Key words: book, long-term flight

Gazenko (1980) is the editor of a book that examines the biological and physiological effects of long-term spaceflight. Hyperbaric conditions, hypokinesia, weightlessness, hypoxia, and hypercapnia are among the support systems studied.

Key words: cardiovascular system, short radius centrifuge, immersion, gravitational acceleration, weightlessness

Vil'-Vil'yams and Shul'zhenko (1980) evaluated the reactions of the circulatory system after simulation of detraining from weightlessness, and the prophylactic value of gravitational acceleration. Healthy male volunteers were immersed for 72 hrs in a "dry" immersion tank. The ability of subjects to withstand 3 Gz from a centrifuge with a 7.25 m radius, acceleration 0.2 G sec⁻¹, for 5 min after immersion was first recorded. The next 2 parts of the experiment following immersion consisted of 2 60 min short radius centrifugations (SRC) within a 24-hr period, or 3 40-min rotations in 24 hrs. During all experiments, EKG, earlobe pulse, and blood pressure (BP) level in earlobes were measured. Before and after rotation, a sphygmogram of the carotid, a rheogram of the femoral artery, the BP in the shoulder, heart rate, and per minute heart volume were also

recorded. After immersion, resistance to 3 Gz dropped in 56% of the cases. After immersion and periodic rotation on the SRC with the different regimes, only 29% of the cases exhibited less resistance to the overload. Resistance in the control lasted for 5 min; after immersion alone it was about 4 min. Following SRC rotation, the resistance time increased, with no differences between one rotation regime or the other. The results led the scientists to suggest using periodic gravitational overload on a SRC to diminish the effects of detraining in the cardiovascular system from immersion.

Key words: hemocoagulation, head-down tilt, weightlessness

Drupina et al. (1979) examined the little-studied response of blood clotting ability to ground simulated weightlessness. Healthy volunteers, 23-36 yrs, were confined to bed with a negative torso incline of -4° for 49 days. One group of 9 was strictly confined to bed, while a second set underwent a physical exercise program. A third hypokinetic group consisted of 6 volunteers with different forms of autonomic-vascular dysfunctions. Increased coagulation activity was observed compared to background levels of clotting factors on the 12th, 15th, 27th-30th, and 42nd-45th days of hypokinesia. Follow-up studies occurred on the 3rd-5th, 10th-12th, and 25th days of rehabilitation. From the 12th day of hypokinesia on, an increasing plasma tolerance to heparin was noted. Factors VIII and IX were found to be in greater concentration by day 25; prothrombin complex activity increased during the same period. Thrombin time decreased throughout the study; fibrin-stabilizing factor increased around the 45th day. No changes in fibrinogen content were observed. The content of free heparin declined during the immobilization study; this was interpreted to mean a decline in the anticoagulant activity. During rehabilitation, the hypercoagulation symptoms persisted for 2 wks. No significant differences were observed in responses from the "pure" hypokinetics and those with some physical exercise, except for a trend toward fibrinogen content reduction in the latter. The group with autonomic-vascular dysfunctions exhibited the same shifts as the other two groups with some differences, notably a decrease in fibrinolytic activity. The authors postulated that some of the observations are due to the decrease in plasma volume and stress from deficiency of muscle deexcitation that accompanies hypokinesia. They emphasized that the hypercoagulation that occurs with bedrest might present a risk of developing cardiovascular disease and/or thrombotic complications.

Key words: water metabolism, bedrest, tritium

Krotov (1980) investigated the regulation of water metabolism under hypokinetic conditions. He defined a "water metabolism regulation factor" for evaluating the range of daily fluctuations of the proportion of consumed water and its content in the body. This index was designed to measure fluctuations of tritiated water eliminated from the body in 24-hr periods. 6 healthy men and 4 dogs were studied during free motor activity and during 49 days of bedrest or immobilization. Krotov established that under conditions of long-term hypokinesia, regulation of water metabolism is disturbed in both organisms. Still more marked changes were observed 2-3 wks after restoration of motor activity. Krotov cited the shifts as evidence of general biological regularity of disturbance in the regulation systems after long-term restriction of motor activity and in the early restoration period. The metabolism of tritium in either the human or animal body was not addressed.

Key words: water immersion, fluid retention, urine, hydroxycorticosteroid

Balakhovskiy and Noskov (1980) tested their hypothesis that increased 17-hydroxycorticosteroid (17-HCS) is responsible for fluid retention and sodium excretion after a water load in cosmonauts just returning from space. 6 healthy men, 19-21 yrs, underwent 60 hrs of water immersion. Urine was collected, measured for volume and assayed for sodium (Na), potassium (K), 17-HCS and creatinine. After 56 hr a standard 2% water load test was performed to assess the functional state of the kidneys and glucocorticoid activity of the adrenal cortex. An increased excretion of all substances was seen throughout the study, except for K, which did not change. On the 2nd day, creatinine excretion increased 24% over the 1st day's 34% increase. Daily excretion of total 17-HCS was somewhat higher than background data, but not statistically reliable. After immersion, there was a decrease in diuresis, Na and K excretion. 17-HCS and creatinine decreased to background levels. Water load tests resulted in an increase in K excretion rate with total 17-HCS excretion decreasing somewhat. Na excretion remained at background levels, as did creatinine which characterized glomerular filtration. From this study, functional changes were not obtained that had led the authors to hypothesize hypocorticoidism in weightlessness as a cause of endocrine metabolic disturbances. No reliable decrease in 17-HCS urine excretion during the 60-hr immersion was observed, nor were the fluid retention and Na excretion duplicated in this simulation.

Key words: Soviet-American Working Group, LBNP, Salyut 6, veloergometer, water salt exchange, exercise, weightlessness

Kakurin et al. (1980) addressed the physiological changes and problems that occur in the weightless environment of spaceflight and assessed the value of present prophylactic methods. To examine these treatments, bedrest for varying periods of time (up to 49 days) was used as a model of reduced gravity. Of particular concern were the responses of the cardiovascular system (CVS), water-salt exchange, and renal function. Healthy male volunteers up to 35 yrs were examined for baseline physiological values, especially orthostatic tolerance and the corresponding CVS indices. Each form of prophylaxis (physical training, electrostimulation of muscles, LBNP training, ephedrine and strychnine administration, water-salt supplements) was studied individually and the effects on muscle strength and volume, orthostatic resistance, and CVS responses were evaluated and compared with control groups that only underwent bedrest. Subsequently, combinations of the various methods were tested for their effectiveness. It was concluded that exercise was the most effective means of preventing muscle atrophy and CVS deconditioning but that a combination of methods resulted in enhancement of the overall prophylactic effect.

Key words: circulatory system, erythropoiesis, antiorthostasis

Burkovskaya et al. (1980) investigated the effect of prolonged antiorthostatic hypokinesia (AOH) on circulating blood volume and some parameters of kinetics of erythroid elements. 18 men were subjected to AOH of -4° for 6 mos. They were divided into 3 groups starting the 7th day. Group 1 underwent intensive physical training; group 2 had physical exercise of shorter duration; while group 3 had no exercise. Further, lower body negative pressure was used on the 1st and 2nd groups through the experiment; they were also given fluid and salt supplements. Before and during AOH, plasma volume (PV), blood volume (BV) and erythrocyte mass (EM) were calculated.

The intensity of erythropoiesis as well as erythrocyte life span were determined from the rate of maturation of reticulocytes in vitro. By 2 mo, BV had declined 2 to 35% from base levels. Group 3 showed the most significant blood loss of 19.4% (groups 1 and 2 declined 11 and 8% respectively). The decrease was equally from PV and EM. After 4 mo, most subjects did not demonstrate further BV decreases; some showed minor increases. Averages were 6.4, 14.5 and 17.7% lower in the 1st, 2nd and 3rd groups from baseline. EM had declined an average of 8, 10, and 19.4% in the 1st, 2nd and 3rd groups by the 60th day. For the next 2 mo of AOH, there were no further decreases in EM; those who exercised intensively exhibited some increases. Shortened E life spans were shown 1.5 mo into AOH, most obviously in the 1st group. This value did not change through the rest of the experiment, and anemia did not develop. Bone marrow production of E showed an increase by the 46th day of AOH. After this, intensity of erythropoiesis increased only in group 3. Rate of maturation peaked on the 86th day of AOH. The researchers concluded that the decrease in BV was caused in part by a reduction in erythrocyte survival. After the 1st 2 mo, no further declines were noted. The increase in bone marrow production and rate of differentiation of erythroid elements are believed responsible for this adaptation. Exercises only slightly counteracted the adverse effects of the AOH on the circulatory system.

Key words: EKG, exercise, antiorthostasis, cardiovascular system

The effect of prolonged antiorthostatic hypokinesia (AOH) on cardiac bioelectrical activity was studied by Turbasov (1980). 18 men underwent AOH of -4° for 6 mo. They were divided into 3 groups. Group 1 underwent intensive physical training; group 2 had physical exercise of shorter duration; group 3 had no exercise. Electrocardiograms were recorded in the morning before breakfast before, during and after the AOH period. Mean heart rate (HR) did not differ significantly from background in any group; the least marked values were from group 2. An appreciable increase in HR was seen in all groups during the recovery period, especially in group 3, which suggested a more pronounced decline of functional capability. Atrioventricular conductance increased as did the QRS complex amplitude; T wave amplitude decreased, primarily in groups 1 and 3. The ST segment indicated no pathological developments. The changes in the EKG recordings at the repolarization stage are complex; the author speculated on various physiological components that might have contributed to his observations.

Lower Body Negative Pressure

Key words: rheogram, radioisotope, circulatory system, hemodynamics

Yarullin et al. (1980) made a comparative study of rheographic and radioisotopic methods of the changes in central and regional hemodynamics occurring with lower body negative pressure (LBNP). 12 male test subjects, 26-38 yrs, were exposed to LBNP which was increased in a stepwise manner (2 min of 25 mm, 3 min of 35 mm, 5 min of 40 and 50 mm Hg). Radioisotope (intravenous injections of ^{131}I and ^{113m}In) and rheographic methods were used simultaneously. Both methods showed that all subjects presented a decrease in blood volume to thoracic organs and, to a lesser extent, the head. The most marked changes were noted at the start of the test. Reliable recordings that agreed with each other were obtained from both methods in studying the regional redistribution of blood with LBNP. The researchers advised use of the impedance method to follow hemodynamic changes from LBNP because of its simplicity and noninvasive nature.

Key words: positive pressure, circulatory system, radioisotope, rheography, mechanical compression

Letskova and Murakhovskiy (1980) studied changes in blood distribution with lower body compression. 8 males, 18-40 yrs, sat in a mock-up of an aircraft chair wearing an anti-G suit which allows application of mechanical pressure over the lower part of the body. Radioactive label dilution, radiocardiography, and tetrapolar rheography were used to record blood redistribution. Occlusion of vessels in the lower limbs and elevation of the intra-abdominal pressure were the cause of noted effects: increase in peripheral resistance and redistribution of blood to the upper part of the body. In the course of the compression, some recovery was observed toward the base volumetric values of circulation; these were attributed to compensatory reactions in response to the lower body compression. The greatest shifts were observed immediately after the creation and removal of the mechanical compression.

Key words: antiorthostatic position, weightlessness, spatial perception, mechanoreceptors

Spatial orientation in man suffers a deterioration in accuracy during the head tilt down position. Bokhov et al. (1980) investigated possible compensation of sensory changes caused by antiorthostatic positions by means of lower body negative pressure (LBNP). The researchers used the accuracy of setting an indicator pointer in relation to a turning reference pointer and the subject's evaluation of his position with respect to the horizontal as tests on 8 people. The tracking test resulted in fewer errors when the reference pointer was initially parallel to the subject's longitudinal axis than when it started at 120° to the body axis. Reaction time as a function of reference pointer orientation was reliably shorter when LBNP was applied than in its absence. This result was interpreted as the consequence of increased afferentation from the receptors of the lower extremities, especially from pressure of internal surfaces of the vacuum suit on the feet. Close contact of the body with support surfaces has been shown to be beneficial on pilot and cosmonaut performance reliability. The subject's evaluation of his position was performed during and after LBNP, while horizontal, eyes closed. A typical illusion of seeming to have the head above the horizontal line with or without LBNP was observed, although the illusion was more pronounced without the LBNP. The illusion was hypothesized to be related to efflux of blood from the top half of the body. LBNP was explained to lessen the illusion by causing less blood to pool in the top part of the body. More blood in the lower half of the body during LBNP could also stimulate the mechanoreceptors, again explaining a decrease in tracking errors. They concluded that LBNP warrants consideration as a means of preventing hemodynamic disorders and of optimizing performance in weightlessness.

Exercise

Key words: isometric exercises, muscle exertion, hypodynamia

Concern about the prevention of hypodynamia in industrial situations led Kovalik (1979) to conduct experiments to determine the effects of isometric muscular exertion on the human body. Subjects performed exercises that included movements encountered in normal, active life, such as flexion and extension of extremities, in a conventional manner, with 50% maximum force of muscle tension, and with maximum force. Pulse, arterial pressure, skin temperature, respiratory

rate, minute respiratory volume, and electrical activity of the muscles involved were measured. Kovalik found the greatest shifts in these parameters occurred when the exercises were performed for 20 secs at maximum force without movement. Increased indices were obtained when the exercises were done at 50% maximum muscle tension for 20 secs, with or without movement. Using the latter procedure, 10 exercises were suggested for use in sedentary working conditions.

Key words: hypokinesia, orthostasis, rehabilitation

Soldatov and Finogeyev (1970) investigated different regimens of treatment for rehabilitation following prolonged hypokinesia. Under study were passive and active programs: the former utilized physical therapy and massage, while the latter consisted of athletic training. In the first stage of research, 10 athletes underwent 10 days of hypokinesia and 14 days of rehabilitation. Pronounced declines in muscle tone and strength, vestibular function and orthostatic stability were noted, as were decreases in cardiovascular conditioning and circulating fluid volume. 1.5 months after the bedrest period, all 10 athletes were still below the baseline values for certain motor functions. The authors used these results as a basis for the following model for rehabilitation: increase the person's strength and muscle tone; restore orthostatic stability; and increase general endurance. To test the model, subsequent experiments utilized groups of both athletes and non-athletes, undergoing 10 or 30 days of ortho- or antiorthostatic hypokinesia (+6, -2, -6°), and rehabilitated with physical training, physical therapy, or no program. The groups undergoing physical training exhibited the fastest clinical recovery. The authors suggest, however, that the most effective treatment is a comprehensive program using both passive and active means.

Key words: oxygen consumption, orthostatic position

Glezer et al. (1979) considered the effects of age, body build, and sex on oxygen (O₂) consumption under conditions of rest, standing, moderate exercise, and physical load. The recorded parameters were O₂ consumption, O₂ pulse, O₂ requirement, recovery coefficient, O₂ consumed for 1 kg exerted load, work efficiency, and blood lactate/pyruvate ratio. To evaluate the effects of age, 37 healthy males, 17-72 yrs, were divided into 3 groups on the basis of age. The oldest group (50-72 yrs) exhibited less O₂ consumption at rest or moderate exercise, more O₂ consumed when assuming a standing position, lower O₂ pulse, recovery coefficient and work efficiency under moderate physical load, and increased lactic acid in the blood compared to the other 2 groups. The effects of body build were studied using 40 males, 20 of normal build and 20 with developed musculature. The latter group showed greater O₂ consumption under all circumstances. Although data from female subjects were not presented, the authors maintain there is no difference between men and women of the same age and degree of physical development on O₂ consumption during rest or physical load.

Acceleration

Key words: cardiovascular system, hypokinesia, weightlessness, centrifugation, dry immersion

To develop countermeasures against cardiovascular deconditioning in weightlessness, Vil'-Vil'yams and Shulzhenko (1980) examined the cardiovascular function of four subjects

exposed to 28-day dry immersion before and after 6-day cycles of rotation in a short-arm centrifuge to provide 1-2 Gz, bicycle ergometer exercise, and a combination of the two. An exposure to acceleration of 3 Gz in a 7.25-m arm centrifuge was used as a provocative test. The above countermeasures reduced but did not eliminate entirely immersion-induced cardiovascular deconditioning. Nevertheless, a combined use of acceleration of 1-2 Gz in a short-arm centrifuge and bicycle ergometer exercise was recommended as a countermeasure.

Vibration

Key words: ultrasound, labyrinth, stimulation

Gershuni et al. (1980) investigated the auditory sensations obtained from ultrasound of frequencies higher than 225 kHz that are modulated for amplitude by sonic range oscillations. The experiments entailed focusing the modified ultrasonic beam directly into the otic labyrinth, into the bones of the forehead, or through water outside of the cranium (to eliminate ultrasonic effect on the head itself). Dependence of threshold intensity on the duration of the stimulus was determined by the appearance of auditory sensation by the subject. The results indicate the ultrasound induced stimulation of the dendrites of spinal ganglion cells, not the hair cells of the labyrinth.

Space Motion Sickness

Key words: vestibular system, nystagmus, labyrinth, nitroesters, EEG, occupational disease

Kapranov (1979) used EEG recordings to investigate the effect of caloric stimulation of the labyrinth on thresholds and duration of vestibulosensory reaction in chemical industry workers. The meatus acusticus externus of workers exposed to nitroesters and a control group was irrigated with 100 ml of water at 19^o for 10 sec. When the sensation of vertigo appeared, the subject pressed a button; the resulting signal was recorded over the EEG tape. At the end of the rotation sensation, the subject again pressed the button, which was also recorded as a signal. Comparison of duration of illusory sensations of healthy people with the chemical workers showed increased duration among the latter group, directly correlated with production length of service. Further in 11.3% of the workers, there was a suppression or complete absence of nystagmus. Kapranov postulated the general toxic effect of the nitroesters, and a specific effect on the sensory controlling centers are responsible for the responses. He recommended the test as an evaluation of the vestibular analyzer in the clinical practice of occupational disease.

Key words: nystagmus, vestibular system, trapezoidal rotation

Grigorova et al. (1980) considered the value of stop-stimulus and trapezoidal rotation programs for discerning which limits are most effective and informative for measuring deviation of the cupulondolymphatic system. 24 healthy men underwent 2 rotation programs: stop-stimulus from right and left rotation (angular velocity 90^o/sec) and trapezoidal rotation with different sets of angular accelerations and velocities. Postrotational nystagmus was recorded for the stop response. In the trapezoidal rotation, both rotational and postrotational nystagmus were recorded at each

acceleration. 2 nystagmus indices, duration of the response and maximum angular velocity of slow nystagmus component, were noted. The results showed that duration of response was not changed by stimulus strength, and postrotational nystagmus (with negative acceleration) was longer than rotational nystagmus (with positive acceleration). They concluded that duration of response provided little diagnostic information, while a ratio of rotational and postrotational nystagmus duration from the trapezoidal program is an informative index. An optimum acceleration and rotation rate should be selected to attain maximum angular velocity of the slow nystagmus component. They advised use of the trapezoidal program since it provides more accurate measurement of function and tone balance of the vestibular system and does not cause unpleasant sensations. They also suggested use of the maximum angular velocity of the slow nystagmus component as a basic index in otoneurological diagnosis.

Key words: musculoskeletal system, posture, asymmetry, stabilograph

Boloban and Otsupok (1979) examined the functional asymmetry of posture during the maintenance of athletes' poses and its effects on the execution of individual and group exercises. Competitive acrobats were studied for three years. While they performed alone or in groups, regulatory movement direction, range, frequency, and period were recorded on a four-channel stabilograph, which measured body oscillation. Twisting and bending oscillations were also analyzed by photographic data, noting preferred sides for execution of various movements. Each acrobat, on the basis of the analysis, was found to have left- or right-sided functional asymmetry; this was deemed important in execution of group acrobatics in that maintenance of stability of the system the acrobats jointly developed differs from individual maintenance. It was concluded that most of the acrobats exhibited left-sided functional asymmetry, but successful execution of certain stunts requires combinations of functional asymmetry. The authors advise consideration of the role of functional asymmetry of posture regulation in making pairs and groups of acrobats and in choosing them to perfect the teaching and training of athletic procedures.

Key words: Meniere's disease, vertebrobasilar system, cervical osteochondrosis, hypertension, rheoencephalogram

Meniere's disease is believed to originate from dysfunction of autonomic innervation of the inner ear vessels, with symptoms of labyrinthine arteriole spasms or dilation. Nikolayev and Mertsalova (1979) investigated cerebral vascular regulation in patients with the disease using rheoencephalography (REG). The REGs were analyzed for changes in elasticity and tonus of the cerebral vessels, i.e., internal carotid arteries and the vertebrobasilar system. Patients were also examined by X-rays for signs of cervical osteochondrosis: 12 of the 35 patients with Meniere's disease examined exhibited this ossification. Angiospasm were noted in all 21 subjects with cervical osteochondrosis; signs of hypertonus were found in 88.5% of all patients studied, usually in the entire vertebrobasilar system, whether or not cervical osteochondrosis was present. Patients over 45 yrs who had suffered for more than 5 yrs with the disease also exhibited hypertonus in the internal carotid arteries. The researchers suggested the more intensive changes in cerebral blood circulation results from dysfunction in the autonomic nervous system, with vasomotor impairment in the vertebrobasilar system and internal carotid arteries and sometimes sclerotic vascular changes or other manifestations of hypertension.

Key words: cervicolabyrinthinus, spinal reflex, acceleration, proprioceptors, vestibular system

The manner in which the vestibular system receives information from the central nervous system can be disrupted by acceleration of the body. Such impulsation can result in either stimulation or inhibition of the action of motorneurons. Yarotskiy (1979) attempted to define the physiological effect on the spinal reflex apparatus by cervicolabyrinthine impulsation. More than 100 people were involved in a protocol involving 30 rapid counterclockwise head revolutions at 2/sec with synchronous recording of 20 patella reflex acts. The recording was accomplished with a sensor attached to the calf. Yarotskiy detected a braking and release pattern in patella reflexes from cervicolabyrinthine impulsation in 85% of the subjects. It was suggested that such a test can be used diagnostically or prognostically to assess the functional condition of the spinal reflex apparatus.

Key words: vestibular system, proprioceptors, musculoskeletal system, posture, EMG

Gurfinkel' (1980) examined how the upright body position is stabilized by comparing movements in the ankle joint with electromyograms (EMGs) of the gastrocnemius group of muscles. The experiment consisted of a rocking platform with the subject standing so the axes of the ankle joints coincided with the rotation axis of the platform. The shifts in the leg and upper body were observed and compared with the EMGs obtained at the different frequencies of oscillations/sec. As the body tilted forward to maintain balance, a flash on the EMG was observed, corresponding to stretching of the muscle group. Subsequently, the subject's body was fixed in belts and braces, so stabilization on the part of the subject was not necessary; the subject's head alone was also fixed, and stabilization reactions in response to the tilting of the body were observed. The results led the author to believe that the main object of regulation of orthograde position is body position, not head position alone. He proposed that proprioceptive cues, especially from the surface of the feet, provide the vertical information for maintaining the upright position of the most massive portion of the body: the torso, arms and head. The roles of the vestibular and visual systems work in conjunction, in normal movement and posture regulation, with the kinesthetic sensory receptors as a unified sensory complex for attaining and maintaining orthograde position.

Key words: musculoskeletal system, orthograde position, synergy, EMG, autonomic control

Alekseyev et al. (1979) investigated compensatory muscular reactions from the attainment and stabilization of a vertical stance in 14 healthy subjects. Each stood in a relaxed position with body weight uniformly distributed. Stimulation of the nervus tibialis with a single electrical pulse caused involuntary movement by inducing bending of the sole of one foot. This results in contraction of the musculus triceps surae. The corresponding reactions of other leg muscles were recorded on EMGs. The tests indicated the involuntary bending of the sole is accompanied by simultaneous activation of the anterior groups of muscles. The posterior groups were inactive. The researchers found these groups of anterior or posterior crural and femoral muscles respond as a unit, with the same threshold activation values and latent periods. Comparison of this study with data on voluntary movement demonstrates that the muscular responses observed are no different from voluntary movement except in timing: involuntary movement invokes response, while voluntary movement involves anticipatory reactions.

Key words: vestibular system, fistula, nystagmus, labyrinthitis, electronystagmogram

Vasil'yeva (1980) reviewed the problems encountered in evaluating vestibular disorders with weakly pronounced symptoms caused by inflammation, especially in the absence of labyrinthine fistulas. The absence of a fistula symptom, particularly in the presence of other vestibular symptoms, does not exclude the diagnosis of either labyrinthitis or labyrinthine fistula. After years of observing patients with a variety of vestibular disorders, the author found limited and latent forms of labyrinthine affections with weak, often doubtful vestibular symptoms, are often characterized by: complaints of vertigo; vestibular symptoms with directionality, e.g., spontaneous nystagmus toward the healthy ear while resting and toward the painful ear upon examination, or disorders seen in arm deviation reactions, including finger-finger or finger-nose tests, always to the side opposite to nystagmus; and vestibular disorders that frequently disappear in 3-4 wks, due to compensation from the central nervous system. It was advised to examine thoroughly patients with only slightly pronounced vestibular symptoms that indicate asymmetry in labyrinthine functioning to select the correct diagnosis and treatment.

Key words: transportation conditions, functional state

Laksin and Novoselov (1979) studied the effect of transportation conditions on performance capacity of passengers in order to establish the time for most rapid inclusion in productive activity following a trip. 18 healthy students, 18-25 yrs, were studied before, during, and after a 32-hr trip in an open car. The researchers measured the time it took for simple visual-motor reactions, rate of processing information by visual analyzer using the correction test, physical performance capacity, strength of flexor muscles in the right wrist, and pulse rate. In the first 12 hrs of the trip, the rate of processing information by visual analyzer was reduced. On the second day of the trip, there was a decrease in physical performance capacity and an increase in pulse. On arrival, an increase in time for simple visual-motor reactions and the greatest increase in pulse in the experiment were noted. On the morning after arrival, the time for simple visual-motor reactions were again within the initial limits; processing information with the visual analyzer was still below initial rates; physical performance approached rates at the beginning of the trip; and pulse rates were lower, but still above the initial rates. Within 24 hours of arrival, all parameters but pulse were at the initial levels. Pulses remained 4 beats higher, perhaps because the climate was hotter and more humid than Moscow, site of origin. Throughout the observation period, the strength of flexor muscles remained the same. The authors postulated that the changes noted were due to the microclimate within the car, especially since restoration of functional state to the initial levels occurred within 1 day.

Key words: boat, air sickness, seasickness, hypodynamia

Komendantov and Razsolov (1978) expounded on the historical development of theories, experiments, and clinical studies concerning various forms of motion sickness. They emphasized causes and mechanisms, especially those of space perception and equilibrium. Several graphics on the pathogenesis of motion sickness were presented, and prophylactic procedures and therapies were briefly evaluated.

Key words: vestibular system, nystagmus, electronystagmography, ventriculography

Blagoveshchenskaya and Puchkov (1980) used electronystagmography to measure tolerance to ventriculography (VG) with various radiocontrast media and to determine characteristics of vestibular reaction alterations based on the medium used. 17 males and 16 females, 17-64 yrs, with a variety of pathologic processes of the brain (tumors, aneurysms) were studied. 18 underwent VG with water soluble contrast media, while 15 underwent VG with water soluble contrast media introduced into the ventricular system with the emulsive radiocontrast medium Myodil. Nystagmus was recorded just before the VG examination and 45-50 minutes after the introduction of the medium into the ventricular system. Spontaneous, caloric, and optokinetic nystagmus were measured. The investigators found that VG with water soluble contrast media gave clinically good tolerance. Vestibular reflexes in 9 of the 18 subjects improved after introduction; that is, hyporeflexia of caloric nystagmus disappeared, and more correct rhythms appeared. Most changes were very weak. The group undergoing VG with water soluble media and Myodil had more frequent and clear disturbances of vestibular reflexes, especially after the caloric test. All observations were irrespective of type of pathology. The conclusion was reached that the reduction of vestibular disturbances after VG with only water soluble media was probably because of the dehydrating effect it exerted on the cells.

Key words: vestibulovegetative stability level, electronystagmography, nystagmus, motion sickness

Polyakov (1980) proposed a method of classification of individuals' susceptibility to motion sickness. 60 healthy men, 20-40 yrs, were rotated in a chair with closed eyes and a forward head angle of 90°. After attenuation of rotary nystagmus, the subject was straightened for 2 sec, and rotation continued for 1.5 min more. Nystagmus was recorded throughout with electronystagmography (ENG). The duration of nystagmus, number of beats, amplitude, frequency, and rate of rapid and slow components of nystagmus were studied. 30-40 min after the test, the vestibulovegetative stability level (VSL) of each subject was calculated from the results using previously published formulae. From the VSLs, subjects were classified as having high or low tolerance, and their ENGs were labelled stable or unstable, respectively. The rate of nystagmus attenuation of the stable group was higher than the corresponding group; they also exhibited lower intensity of nystagmus. The dynamics of extinction of horizontal nystagmus were felt to be an excellent means for identification of people with high or low tolerance to motion sickness.

Key words: stapedal muscles, impedance reflexometry, acoustic reflex, speech discrimination

Moroz et al. (1979) undertook a study to clarify the existence of an interrelationship between speech sound discrimination capability and the condition of the muscular apparatus of the tympanic cavity in people with neurosensory hearing impairment. 101 students, 17-21 years, with approximately the same degree of hearing impairment were the subjects. 90% of the conditions resulted from childhood diseases or the administration of ototoxic antibiotics, but all had normal undamaged tympanic diaphragms. Using impedance reflexometry, the scientists determined absolute and relative acoustic reflex threshold (ART) values. The absolute value is the decibel intensity of a stimulus that causes contraction of the stapes muscle; the relative value (ART₀) is the

level of acoustic pressure above the acoustic threshold required to trigger AR, usually about the same decibel level as the auditory range (45-50 dB). Speech audiometry was also performed and compared with the acoustic reflex data. It was found that most subjects with high ART_0 values (40 dB) possessed good speech discrimination, while those with low ART_0 values usually did not. Normal physiological values for AR amplitude increment in response to increasingly intense stimuli were also associated with good speech signal discernment; subjects with high AR amplitude increment values or extremely low values or no AR usually had poor speech discrimination. It seems that muscular contraction in the middle ear provides for better reception and discrimination of sound signals: poor discrimination was seen in subjects without AR or in those where reflex appeared but did not change in amplitude in response to stimuli of varying intensity. Other mechanisms are obviously involved since not all subjects fit into the above patterns; some subjects with narrow dynamic audiorange and negative AR had good speech discrimination while others with positive AR and relatively good dynamic audio characteristics had poor discrimination. Impedance reflexometry is advised for objective typing of hearing conditions and to determine appropriate types of hearing aids.

Key words: Meniers's disease, otosurgery

Soldatov (1979) discussed the surgical management of Meniere's disease, which has the primary morphological symptom of edema of the otic labyrinth and the main pathogenetic factor of dysfunction of inner ear innervation. Untreated, the edema causes steady deformation of the labyrinth. Operations such as drainage of the endolymphatic sac and vestibular neurectomy are viewed as means of preventing progressive hearing loss. In the reversible stage of endolymphatic edema, he suggested and described operations on nerves in the tympanic cavity, leading to a reorganization of vegetative innervation of the inner ear vessels which may hinder endolymph accumulation. Observations of 250 such operations suggest these interventions are sufficiently effective for both vestibular dysfunction and hearing disorders. Positive results with vestibular dysfunction were obtained in 84% of those operated upon, with hearing improvement in 12%; preoperative hearing levels in 55% were maintained without subsequent deterioration in later years. If no effect is obtained from resectioning the tympanic cord and plexus, draining and shunting the endolymphatic sac was advised as well as 2 types of cochlea decompressive operations: fenestration with drainage and shunting of the tympanic scala and cochlear duct through the cochlear window. In the case of unilateral affliction and severe symptoms the author advised tympanotomy and removal of the bony covering; then perforation at the base of the stirrup, scraping of the labyrinth and introduction of streptomycin solution into the cavity. This obviates the symptoms and the need for vestibular neurectomy and scarpectomy. Soldatov suggested the simplest and least traumatic interventions, surgery on tympanic cavity nerves, be tried first. If ineffective, the more complex methods of drainage or shunting are called for during the reversible stage of edema. The surgery proposed on the tympanic cavity and endoperilymphatic shunting of the cochlea can be done at any stage deemed necessary.

Key words: sailors, physical exercise, motion sickness

Motion sickness is experienced by 50-70% of sailors during storms. A program of physical exercises was described by Salanin (1979) who tested for effectiveness in preventing this problem.

In comparing the results of tests of susceptibility to motion sickness given to groups before and after a program of exercises and to a control group, he found that physical education can habituate the vestibular apparatus and help prevent motion sickness.

Key words: hypoacusis, ototoxicity, antibiotics

Bakay and Neschetnaya (1979) reviewed ototoxic side effects of a number of drugs and the problem of preventing such actions. The specific mode of damage or destruction, when known, of many antibiotics, diuretics, tranquilizers, local anesthetics, cardioactive drugs, chloroquine, salicylates, and their combined use was described. The greatest damage occurs from antibiotics, which affect the cochlea. The authors described cellular studies of the induced damage; the action of the drugs upon respiratory enzymes and mucopolysaccharides within the cochlea seems to be the cause of hearing reduction or loss. Experiments on the accumulation of ototoxic antibiotics in the inner ear and the resultant biochemical changes were also detailed. Measures designed to reduce or prevent auditory damage were discussed. These methods include the introduction of ozotone with streptomycin; anabolic preparations (e.g., methacil and meradine) administered in conjunction with various antibiotic preparations, and low molecular weight polyvinylpyrrolidone solution or calcium chloride use to detoxify streptomycin and monomycin. The development of pharmacological prevention of ototoxic side effects was encouraged.

Key words: vestibular system, musculoskeletal system

Matsnev (1980) discussed the motion sickness disorders associated with space flight. The article is divided into phenomenology, cosmonaut experiences, and hypotheses and research. The roles that visual, tactile, vestibular, and proprioceptor senses play in inducing or contributing to space motion sickness were probed, with the author maintaining that experience and research argue against a major contribution from the redistribution of body fluids.

Key words: vestibular system, Meniere's disease, EEG, carbogen

Boronoyev (1978) used EEGs to analyze the therapeutic effect of oxygen and carbogen therapy in Meniere's disease. Previous studies, using visual inspection of EEG records, were imprecise due to large individual differences in background EEGs and difficulty in detection of pattern shifts as a response to functional loads. Boronoyev used a system of constructing fields of bioelectrical activity of the cerebral cortex. 20 normal persons and 75 patients with Meniere's disease were examined. 380 fields of electrical activity were constructed and studied. In the 1st group of patients with a vasospastic form of disease, vestibular disturbances disappeared or decreased after inhalation of 5-7% carbogen. This was confirmed by normalization of the electrical fields. In the 2nd group (vasoparethical form) field normalization occurred after use of oxygen therapy. The 3rd group consisted of patients upon whom neither oxygen nor carbogen produced any effect as confirmed by an absence of field changes. The observed correlation between clinical data and changes in spatial characteristics of brain electrical potential fields permits an assessment of the character of vascular disorders in Meniere's disease and the determination of the effectiveness of different therapeutic tactics.

Circadian Rhythms

Key words: crewmember selection, master rhythm, labile rhythm, weightlessness

Stepanova (1980) discussed the elements of circadian rhythms in man. Individuals who adapt well to sleep-waking cycle changes are classified as having flexible rhythms, or constancy. Those who do not adapt well are said to possess labile rhythms. The former group was considered by the author to be the better choice for cosmonauts because of the stresses in schedules and environment that are encountered in flight. Stepanova urged that each man's individual biorhythmological status, especially in relation to the time of day his maximum efficiency occurs, be taken into account when planning activities for the cosmonauts, in order to have the most responsible operations coincide with the period of peak efficiency.

Psychology Research

Key words: aviation, equipment, pilot error

Ponomarenko and Zavalova (1980) examined cockpit equipment properties and capabilities to determine the best use. Pilot errors resulting from poor quality of various components of the equipment are described and methods for eliminating causes of some erroneous actions of pilots are discussed.

Key words: subjective assessment, angular orientation, perception

Bozhkov et al. (1979) studied the manner that people perceive physical similarity between figures presented in different angular orientations. 80 subjects were challenged with 3 random nonagons, presented in pairs. The nonagon pairs were of identical or nonidentical figures in the same or differing orientations. Each subject was asked to state whether the pairs flashed on a screen were of the same or different figures. The time the subject took to answer, the angle of mutual orientation of the pairs, and the correctness of response were tabulated, leading the authors to the following conclusions: (1) identification errors increased linearly as the angle went from 0 to 90° between identical figures; errors slowed from 90-120° and stayed constant or increased slightly from 120-180°; (2) the subjective assessment of 2 polygons close in form but differing in physical parameters remained constant, regardless of angle of mutual orientation; (3) the specific form of the random polygon used influenced the general level of correctness for figure differentiation; (4) following a preliminary interpretation of figures before the actual experiment, the latent period of response increased without a change in the correctness of differentiation.

Key words: EEG, alpha rhythms, theta rhythms, neurophysiology, Volterra theorem

A correlation between types of emotional stress and alpha and theta rhythms in humans was shown by Simonov and Rusalova (1980). Alpha rhythm is depressed when the subject is attentive to the surrounding environment; it is elevated when the subject imagines emotionally involving events. Theta rhythms exhibit increased amplitude during memory retrieval. The authors cited

these observations as support for functional definitions of the 2 rhythms: alpha, or sensory rhythms, are related to signals from the environment; theta rhythms represent emotional responses to activity of thought mechanisms. The interaction of excited and inhibited neurons was briefly examined in terms of Volterra's theorem on the natural changes in the amplitude and oscillation frequency in systems composed of any 2 types of antagonistic events.

Key words: functional asymmetry, dominance, cerebral hemisphere, occupational screening

Fedoruk and Dobrokhotova (1980) examined the relationship between the level of operator activity and the functional asymmetry of hands, feet, eyes, and ears to optimize working conditions and efficiency through an occupational screening program. 200 men, 20-35 yrs, engaged in "operator" occupations, were grouped into 3 classes. The 1st class of 89 men were rated as "good" performers; the 2nd class of 67 were rated "satisfactory"; while the 3rd class of 44 men had been involved in an accident of some sort, not necessarily their fault. The dominance of right or left hand in executing procedures was rated, as was the dominance of the right or left foot. To determine the dominant eye, aiming skill was evaluated by having them gaze at a small object 2-3 m away, then alternately closing the right and left eye. The eye was considered dominant if no shifting of the object occurred when it was closed. Hearing dominance was determined by dichotic listening to words with concurrent presentation on the right and left, and tabulation of the number of correctly repeated words. Their results, with the exception of the data on foot asymmetry, indicated that class 1 men were dominantly right-handed. There were no left-handers and few ambidextrous or symmetrical people. Left-handed asymmetry and symmetry increased in class 2 and was highest in class 3. Mentioning that operator layouts are constructed for the right-handed majority, the authors maintained that right-sided asymmetries (left-hemisphere dominance) are instrumental in efficient and accident-free operator performance. The data were believed to justify using such tests in professional screening and vocational counseling.

Pharmacology

Key words: weightlessness, research

Shashkov and Sabayev (1980) cursorily outline the use of drugs in manned spaceflights. The physiological changes that occur in the weightless environment and the possible use of pharmacological preparations to counteract them are listed. Further research on preparations that might be of use by man in space was urged.

Nutrition

Key words: dehydrated foods

Bychkov and Markaryan (1980) examined a long-term diet of dehydrated food, simulating that expected to be used on a prolonged spaceflight. 35 test subjects in 5 studies were used. The results of the studies suggest that a diet of only dehydrated foods is feasible for up to 1 yr. The investigators report that dehydrated foods after a 2-yr storage and proton irradiation (24,000 rads) retained their biological value and provide adequate nutrition.

Crewmember Selection and Training

Key words: compatibility, personnel

Kulikov (1979) examined sociopsychological compatibility effects on personnel interrelationships aboard a submarine, and explored complementary temperaments. Stress was laid upon the need for creating conditions permitting personnel to deal with compatibility problems especially during the confining conditions of a long voyage.

Key words: osteochondrosis, vascular system

Alekseyev (1980) reported that experience in screening cosmonaut candidates shows that many of them present osteochondrosis of the cervical spine. In some selected individuals there are signs of progressive intervertebral osteochondrosis. Bony outgrowths in this region sometimes cause ischemic circulatory disturbances in the vertebrobasilar system, caused by reflex angiospasm of vertebral arteries. Alekseyev advised assessment of blood flow of basilar and internal carotid arteries and determination of functional capabilities of collaterals and latent circulatory disturbances in the corresponding vascular reservoirs. A functional test, involving rotation of the head and throwing it back to an angle of 45° was described.

Key words: engineering application, physical training, simulation studies

Pilot-cosmonaut Demin (1977) described the training and work cosmonauts undertake in preparation for their flights. The article is addressed to the layman and covers the activities cosmonauts are expected to engage in and the background such endeavors require. Knowledge of engineering and its practical application, physical training to withstand the rigors of spaceflight, and simulator training to learn control of the spacecraft are among the topics mentioned.

Key words: medical selection

Rudnyy et al. (1980) outlined the medical selection process used to screen cosmonaut candidates. Volunteers come from flight personnel and specialists in professions such as engineering and medicine. Ages range from 25-45 yrs. The physical examination consists of 3 stages: the first screening occurs on an outpatient basis where background information is collected and a cursory examination is performed; candidates selected from stage I are consulted and examined extensively in a hospital (tests are described); those chosen from stage II are screened while training. Decisions at all stages are made by a commission of examining physicians and confirmed by the Chief Medical Commission. The conditions under which volunteers are considered medically unsuitable are listed.

Key words: technical maintenance, psychophysiology

Stepanov et al. (1980) examined the aspects of technical maintenance (TM) on a manned spacecraft. They defined planned TM as the evaluation and maintenance of the craft's apparatus. This is contrasted with unplanned TM or repair which involves failures of equipment, diagnosis of

the problem, dismantling and reassembling the piece in question, and subsequent regulation and checking. The primary parameters in all TM endeavors are the complexity of the equipment, the amount of time necessary for completion of the task, and the technical capabilities of the crew. The authors strongly recommended back-up systems to ensure the safety of the crew. Further, they advised thorough TM training for the crew, simplification of equipment and repair operations, and strict adherence by the cosmonauts to regimes that optimize their psychophysiological capabilities.

Simulation Studies

Key words: locomotion, weightlessness

Beletskii and Konikova (1979) analyzed the phenomenon of walking under conditions of simulated weightlessness. Using a biped walking machine, they studied the plane motions of the extremities. They reported that simulation of walking under 0 g conditions requires much smaller control moments than that needed in a gravitational field.

Key words: mathematical models, biochemical systems

Pravetskiy et al. (1979) suggested parameters for devising and testing mathematical models of the human body's response to spaceflight conditions. They advocate studies and measurements on animals, volunteers, and corpses, and utilization of such measurements and responses in formulating a quantitative model for predicting human metabolic and physiologic responses in space.

Space Biology

Hypokinesia

Key words: artificial gravity, angular acceleration, semicircular canal, nystagmus, latency period

Hypokinetic experiments on rats were performed by Ovechkin and Shipov (1980) as preparation for an experiment on weightlessness and artificial gravity effects on semicircular function. 30 rats were divided into equal groups. Group 1 was subjected to 21 days of hypokinesia in box cages; group 2 rats were in similar cages and were rotated on a centrifuge (2 G) all but 1 hr each day. Group 3 were controls. Vestibular nystagmus from increasing angular acceleration (10, 20, 30, and 40°/s²) was examined 2 wks before, on the termination day (0 day) and 3 times after the experiment. Group 1, especially on 0 day, showed a longer latency period during accelerations of 10 and 20°/s² than controls and fewer beats at 10°/s². 30 and 40°/s² accelerations never produced differences. Rats exposed to hypokinesia in a rotating device exhibited a longer latency period of the nystagmic reaction to accelerations of 10 and 20°/s² on all days after the experiment. There were fewer nystagmic beats, compared to groups 1 and 3, on 0 day and after exposure to all levels of acceleration; repeated exposure resulted in lessened adaptation from the group 2 rats. These results were similar to those observed in rats studied in artificial gravity aboard Cosmos 936. The

group 1 results, however, were unlike the nystagmic reactions seen in animals exposed to weightlessness. The authors concluded that hypokinesia, or restricted movement, produces certain effects on semicircular canal function that is unlike weightlessness and therefore, this simulation is inappropriate for studying weightlessness effects on the semicircular canals.

Key words: catecholamines, neurotropic agents, rat

Melnik and Paladiy (1972) studied catecholamine content in the adrenal glands and brain of white rats under hypokinetic conditions or injected with neurotropic agents. Prolonged hypokinesia was accompanied by adrenalin retention increase and noradrenalin retention decrease in the adrenals, hypothalamus, cerebral hemispheres, cerebellum, and medulla oblongata. Changes in catecholamine retention following administration of neurotropic chemicals depended upon the substance: mellepramine increased retention while spasmolytin was observed to cause adrenalin retention in the adrenal glands but not the brain.

Key words: exercise, food supplements, reproduction

The effect of exercise and food supplements during hypokinesia on rat reproduction was examined by Stroganova et al. (1980). 45 7-mo old rats were divided into 5 groups, each group consisting of 3 males and 6 females. The 1st group of rats submitted to hypokinesia; a box cage restricted movement. The 2nd group of rats under hypokinetic conditions received vitamin and mineral enriched feed. The 3rd group underwent hypokinesia and exercise. Rats in the 4th group were also restricted in movement but received both food supplements and exercise, while the 5th group was the control. Exercise consisted of swimming in a tub of water for 30 min a day, except for days off. After 30 days of hypokinesia, males and females were allowed to mate. The offspring produced were weighed on the 1st and 10th day, then sacrificed at 30 and 60 days, when internal organs were weighed. The lowest reproduction rate was obtained from the 1st group (33%); the 2nd and 3rd groups' rate was 50%. All females in the 4th groups had offspring, while the reproduction rate of the controls was 67%. Birth weights of rats born to the 2nd and 3rd groups were somewhat higher than the controls; rats from the 1st and 4th groups were no different, although rats born of the 4th group weighed 13.8% higher than controls after 10 days. Viscera of baby rats in the 1st group at 1 and 20 mo was lower than controls, whereas that from the 3rd and 4th groups exceeded controls. The use of exercise and food enrichment was determined to have improved the reproductive function of the rats in spite of hypokinetic influences.

Key words: gastrointestinal system, enzymology, invertase, rat

Abdusattarov (1980) investigated the effects of prolonged hypokinesia on enzyme activity in the middle portion of the small intestine. 84 rats were divided into 2 groups. The experimental group was kept in single cages for 30 days under hypokinetic conditions; the control group was maintained under ordinary laboratory conditions. From the enzyme measurements, it was concluded that invertase formation and inclusion into the cell membranes undergo phase changes throughout the course of hypokinesia.

Key words: metabolism, phosphorylation, tissue respiration, rat

Kovalenko et al. (1970) studied the metabolic alterations resulting from prolonged hypokinesia (100-170 days) in 2000 rats. The animals were kept in cages which limited their mobility. An increase in muscular oxygen requirements and a reduction in tissue respiration in the liver and myocardium were noted. Phosphorylation decreased in the myocardium, liver, and skeletal muscle. Prolonged hypokinesia was further associated with an increase in weight and alterations in the mineral and protein metabolism.

Key words: overalls, Macaca rhesus

Urmancheyeva and Dzhokua (1980) reported a method of producing clinostatic hypokinesia in monkeys using specially designed overalls. These restraints which buttoned in the back had pairs of tapes stitched into the side seams which passed through openings in a canvas-covered cot. With such immobilization, the monkey's legs extended in the hip and knee joints but arm and ankle movement were unrestricted. Every 2-3 days, the monkey was turned from back to abdomen. A 3-yr-old monkey was kept in this manner for 45 days. Arterial pressure, EKGs, weight, behavior, and orthostatic tolerance were studied. After habituation to the restriction, arterial pulse was found to remain in the physiological range. EKGs showed no changes from base data, although in the supine position, a sinus arrhythmia developed on the 2nd-6th days. Weight dropped 17% and leg circumference decreased. After the 45 days of hypokinesia, orthostatic tolerance revealed a shortening of the period of primary vascular reaction to 10 min; in the 15th min, progressive orthostatic hypotension developed. Weight loss and decreased volume and tonus of muscles of the lower extremities was reversed within 1.5 mo after the restriction.

Key words: glycolysis, pentose-phosphate shunt, bile acids, cholesterol, rabbit

The assimilation rate of carbohydrates via glycolysis and the pentose-phosphate shunt, as well as changes in bile in hypokinetic rabbits, were studied by Ryl'nikov (1980). Results indicated that rigid immobilization of rabbits is accompanied by a reduction of glycolysis rate in the liver and heart, and a simultaneous increase in the pentose-phosphate pathway activity. It is also followed by cholesterol accumulation in the blood and tissues in spite of accelerated excretion of cholesterol and bile acids.

Key words: thyroid, immobilization, body weight, rat

The response of the thyroid gland to hypokinesia was studied by Bekishev (1978). 200 white rats were kept in 16x6x6 cm cages for 90 days. Functional activity of the thyroids increased after 24 hours of partial immobilization and peaked after 15 days. After 30 days of immobilization the functional activity was normal in 1/3 of the animals and after 60 days in all animals. Following 15 days of immobilization, the test animals began to lose weight and remained underweight for the rest of the test period. When returned to normal conditions, they caught up with and even overtook in weight the control animals after 1 mo. All changes observed during hypokinesia were reversible after 1 mo.

Key words: lymph organs, hypoplasia, stress, rat

Kaplanskiy and Durnova (1980) investigated the accidental involution of lymph organs in rats, using a ground based study simulating 20-day spaceflight. They inferred from the experiment that lymph organ involution seen in rats exposed to prolonged space travel is caused by chronic and acute stress. Chronic stress is associated with weightlessness and leads to hypoplasia of lymph organs; acute stress is connected with the transition from weightlessness to normal gravity which exacerbates chronic stress-induced lymph tissue atrophy. Spleens of both weightless and hypokinetic rats exhibit inhibition of erythropoiesis and accumulation of hemosiderin resulting from accelerated erythrocyte degradation attributed to decreased motor activity.

Key words: RNA content, nucleotide composition, protein content, motoneuron, rat

Gorbunova (1971) investigated the effect of hypokinesia on the ribosomal ribonucleic acid (rRNA) content, nucleotide composition, and dynamics of protein content in the motoneurons of rat spinal cord anterior horns. The results demonstrated that nucleotide composition of total cellular RNA throughout the hypokinetic period remained unchanged. Even with a change in the functional state of the neuron, the newly transcribed rRNA remains a faithful copy of the DNA that codes for it.

Key words: hypoxia, corticosterone, succinate dehydrogenase, sinusoidal modulated currents, rat

Melik-Aslanova and Frankel (1978) reproduced hypokinesia in rats by keeping them for 30 days in special box cages that restricted their mobility in all directions. They found that resistance to acute hypoxia following hypokinesia increased. Also observed and correlated with the hypoxia resistance was a considerable rise in succinate dehydrogenase activity in the liver and brain, and reduced levels of corticosterone. Primary oxidation of succinate was indicated from the data, which has importance in the adaptation of oxidative metabolism to acute oxygen insufficiency. The experiment further involved use of sinusoidal modulated currents throughout the hypokinetic period, which were found to promote normalization of the above parameters.

Vibration

Key words: vestibular system, primary afferents, lateral semicircular canal, frog

Orlov (1980) investigated responses of primary afferents of the lateral semicircular canal in *Rana temporaria* to direct vibration of the labyrinthine wall in the range of subsonic and low sonic frequencies. Male frogs were immobilized with curare. The left labyrinth was opened from the bottom of the capsule to expose ampular and middle portions of the lateral semicircular canal and the 8th nerve. For stimulation of the canal, he used an end-fused glass rod embedded in a quartz resonator, the planes of which were connected to the output of the G6-14 subsonic frequency generator that produces sinusoidal oscillations, frequency range 0.05-200 Hz. The vibrator made contact with the membranous wall of the middle part of the lateral semicircular canal and the glass

rod was moved in a 60° angle with the long axis of the canal. This enabled observation of shifts of the endolymph and the consequent changes of the impulsation frequency of the afferents to be made, which were not seen in the absence of sinusoidal oscillations. The vibrator's frequency-amplitude, or gain, characteristics were obtained and poststimulus histograms were constructed for the evaluation of the responses of the primary afferents. It was possible to study the gain in velocity and phase shifts between the peak of the response and the peak of the stimulus, which result in utriculopetal displacement of the endolymph and a similar deflection of the cupula. The displacements occurred during the half period of the sinusoid when the glass rod put pressure on the canal wall. Primary afferents of the frog were found to fall into 3 groups based on frequency characteristics. The 1st group contained the most numerous examples (81.4%) and consisted of wide-range units. The lower boundary of the frequency range lies around 0.05 Hz and the upper is in the range of 60-180 Hz. To the 2nd group (11.1%) belonged high-frequency units in which vibration responses started only with 20-40 Hz; there were no low-frequency stimulation responses. The upper boundary is in the 100-150 Hz range. The 3rd group (7.4%) consisted of low-frequency units that react to stimulation of 0.05 to 20 Hz frequencies; increase in frequency yielded no response. The direct vibration of semicircular canals permits the study of vestibular responses in a wide range of frequencies and allows registration of the activity of the primary afferents of the vestibular nerve, including those within the labyrinthine capsule, when it is not necessary to identify the afferents. In the frog, most of the afferents that innervate the canal clearly react to vibration with frequencies up to 100-150 and some up to 180 Hz.

Radiation

Key words: beta radiation, hyperthermy, liver, cerebrum, rat

Matyushivchev et al. (1979) used 204 mongrel white male rats to assess the effects of beta radiation and combined radiation and thermal overload. 60 rats were used as a control group; the remaining 144 were divided into 9 groups of 16. 4 groups were exposed only to beta radiation from ⁸⁵Kr at 2.5, 3.05, 4.45, or 7.4 k-rad doses; 4 groups were exposed to both radiation and heat (36°, 80-90% humidity); and 1 group was exposed only to thermal overload. After days 5, 12, 19, and 26, 3 rats from each experimental group and 15 controls were decapitated and ATPase activity (ATPA) was determined from aqueous extracts of the liver and cerebral hemispheres. Enzymatic activity was expressed in microM/min of increased inorganic P per mg extracted protein. Liver ATPA was affected most strongly by 4.45 k-rad doses, where there was a change of 112% in comparison to controls. Other dosages, including 7.4 k-rads, exhibited weaker effects. Cerebral ATPA showed maximal deviations from 2.5 k-rads (75%); increased dosage was accompanied by weakening effects. Thermal overload alone had no effect on ATPA. In combination with beta radiation, thermal stress reinforced the radiation effects in the liver and attenuated them in the brain. ATPA in the liver exhibited a 3-fold increase when the 7.4 k-rad dose was accompanied by hyperthermy. There was not an equally noticeable increase, however, with the other dosages. In cerebral tissue, radiation at 2.5 and 3.05 k-rads and heat showed a weakening in the postradiation effects; 4.45 k-rads with heat resulted in a slight intensification, while 7.4 k-rads and heat had the same effect as without heat. Exposure to beta radiation therefore exhibited tissue specificity in its action.

Key words: stress, hypokinesia, gamma radiation, rat

Chernov (1978) investigated the relationship between radiation sickness and stress. The survival rate, body weight, and weight of some internal organs of the experimental rats were used as the parameters. The animals were exposed to gamma irradiation (800 rads) on the 3rd day of hypokinesia and exhibited increased radiosensitivity. The same dose given on the 20th day of hypokinesia and on the 3rd day of recovery after 20-day hypokinesia decreased radiosensitivity of the rats. Chernov concluded that variations in the radiosensitivity observed may be due to a stress effect from hypokinesia.

Key words: bacteriophage T4, high altitude, space hadrons, mutation frequency, r groups

The genetic effects of space hadrons on bacteriophage T4Br(+) under alpine conditions were studied by Iurov et al. (1979). A dried film culture of the phage was kept in a lead bioblock for 366 days at an altitude of 6100 m above sea level. Some of the film plots had markedly reduced phage survival. Within these, the mutation frequency exceeds the spontaneous background mutation rate 60-100 times. The r mutations from the rI, rII, and rIII groups differed from those found for gamma ray radiation in buffer or nutrient broth or from hadron and HZE particle radiation under spaceflight conditions.

Extreme Temperature

Key words: concha auricula, thermoregulation, rabbit

Slepchuk and Rumyantsev (1978) attempted to determine the threshold amount of heat content decrease necessary to cause vessel constriction of rabbit concha auriculae. Rabbits were tested in enclosures where ambient temperature remained 28-30^o. Thermocouples were implanted in the hypothalamus, cerebral cortex, aortic arch, arterial vena cava, musculus latissimus dorsi, rectum, and subcutaneously. Surgery was performed to make a gastric fistula through which a rubber balloon of 100 ml capacity could be inserted for the introduction of water to cool the animal. The threshold heat quantity given off by the animal body was computed from the water temperature introduced into the stomach by a given formula. A drop in temperature of the concha auriculae was interpreted as a sign for the beginning of a thermoregulatory reaction directed toward preserving body heat. It was observed that body temperature in the aortic arch reflected the average body temperature best. By the time concha auriculae vessels started to constrict, the temperature in the same body section in different experiments did not drop to an equal degree: all but the aortic arch values varied. The experiments also showed that temperature change of any one section is not responsible for vessel constriction, nor is constriction of the concha auriculae linked to any definite water temperature in the balloon. (In separate experiments with an equal threshold quantity of heat given off by the animal's body at the start of vascular constriction, the water temperature varied significantly.) The authors concluded that an average drop in heat content of 266.3 cal at an ambient temperature of 28-30^o induced the thermoregulatory reaction of concha auriculae vascular constriction, and that a certain time, 17±.8 min was required for body heat content to drop and the vascular thermoregulatory reaction to begin.

Key words: thermoreceptors, rabbit

Konstantinov et al. (1980) studied the responses of skin thermoreceptors to variations in skin surface versus interior layer temperatures. Rabbit upper lip and nose skin surfaces were repeatedly subjected to temperatures between 22° and 40° while skin temperatures at depths of 0.1-0.2 and 2.55 mm and the activities of 16 individual cold thermoreceptors were monitored. The 18° variations in surface temperatures were found to cause variations of only 4.5° in the lower layer temperatures, with a time delay of 5-7 min. The firings of 9 of the thermoreceptors varied as skin surface temperature changed; the remaining 7 exhibited a pattern related to deep skin layer temperatures, demonstrating the existence of thermoreceptors at various depths within the skin. It was suggested that this distribution allows the animal to assess the direction and intensity of heat flow through the skin.

Key words: hypoxia, vascular system, partial pressures, hyperthermia, rabbit

Ngi and Keerig (1980) examined hypoxia at elevated temperatures and conditions of decreased and increased humidity. The blood pH and blood levels of CO₂, buffer bases, bicarbonate, lactic acid, and pyruvic acid of hypoxic rabbits after exposure to simulated altitude of 5000 m at 20-22° were identical to those of rabbits exposed to 44-45° temperatures with low relative humidity. Rabbits kept at 44-45° and a humidity of 90-95% showed even greater differences from initial values. To account for the observed hypoxia accompanying hyperthermia, it was suggested that reduced partial oxygen pressure of alveolar air and the shift of the hemoglobin dissociation curve only have small importance: hypoxia of mixed type can be induced by a redistribution of blood and changes in the activity of certain respiratory enzymes.

Space Motion Sickness

Key words: vestibular apparatus, caloric stimulation, bioelectrical activity, flexor muscles, electromyograph, cold shivering, cat

Kuz'mina investigated the effects of unilateral stimulation of the vestibular apparatus on the bioelectrical activity of cat flexor and extensor limb muscles during cold shivering. 48 cats were anesthetized and artificially warmed, preserving an internal temperature of 38-39°. At the start of the experiment, the animal was cooled in a thermal chamber with an ambient temperature of 18-20°, sufficient to cause cold shivering. Bioelectrical activity (BA) of flexors (sartorius and shoulder biceps) and extensors (gastrocnemius, soleus, and triceps) was monitored by electromyographs. To stimulate the vestibular apparatus, caloric tests which test only receptors of the semicircular canals were performed unilaterally on 20 cats; electrical stimulation which tests all labyrinthine structures was used on 28. No bioelectrical activity in any of the studied muscles was recorded in warmed animals. BA appeared in the flexors in proportion to the cooling of the anesthetized cat; activity in the extensors was not seen. During caloric stimulation, bilateral suppression of flexor muscle BA during shivering was observed. In the various experiments, the biceps were always suppressed, but occasionally the sartorius was not. There was no activity in the extensors. Cessation of BA of the muscles of the ipsi- and contralateral sides was not simultaneous: usually the ipsilateral side quenched first, within 2-5 secs following the start of the caloric stimulus.

However, "escape" from the stimulation was seen in the sartorius muscle in 14 of 36 tests. BA resumed in the biceps during stimulation in only 2 tests. Electrical stimulation also resulted in bilateral suppression of limb flexor BA during cold shivering, again with predominance of effect on the ipsilateral side. No extensor BA was observed. The threshold intensity for bicep stimulation was 8.8 v; threshold for the sartorius was 11.6 v. No escape was seen. The effects of the vestibular apparatus on spinal activity were manifested in this experiment as tonic stimulation of the motoneurons connected to the antigravity musculature. The maximum effect during vestibular stimulation was observed on front limb flexors of the ipsilateral side.

Key words: vestibular system, electrostimulation, cat

To study the cat's vestibular nerve response to electrical stimulation, Radkevich and Ayzikov (1977) developed a posteroventral surgical approach. The method, described in detail, allows access to both the ampullary and otolithic nerves of the middle ear.

Key words: histology, otic labyrinth

Anichin (1978) reviewed methods for histological treatment of the otic labyrinth that were elaborated by Wittmaack; the author's own modifications are also described. Techniques for fixation, vital fixation including decalcification, dehydration, and saturation of the tissues under investigation are detailed. Anichin also recommended methods for temporal bone orientation that allow access to sections of internal otic structures in the most advantageous plane.

Psychology Research

Key words: conditioned reflex, experimental neurosis, dog, spatial factor

Selivanova (1979) studied the features of conditioned reflexes and short-term memory in the development of experimental neuroses involving spatial factors. To produce activity with traces from stimuli of different duration, 6 dogs were taught 2 activities. The 1st was a stochastic system of unconditioned reinforcement. The dog was tied while a technician randomly put a piece of meat in 1 of 5 dishes. The dog was either released immediately or after a 30, 60, or 90 sec lag, retrieved the meat, and voluntarily returned to the initial place. Accuracy of choice (short-term memory) was 100%. Trace behavior of picking the correct dish then moving to the last dish eaten from was observed. Moving of feeders within 1 m of original position had no effect. The 2nd activity involved rhythmic stereotypes of conditioned reflexes to light and sound stimuli. The dog was allowed to move freely. In a rhythmic sequence it was given a series of (+) light and sound stimuli and reinforced from the 4th dish. (-) stimuli were to be ignored (differentiation). In this test, moving of the 4th dish did result in a slowing of response. These 2 activities were performed 150 times, then changed. The light stimulus was moved to the 3rd dish and reinforced there; the sound stimulus was moved to the 5th dish and reinforced there. Differentiation was still expected. Spatial transposition of conditioned stimuli was found to disrupt both activities. Mistakes increased greatly in the short-term memory test and trace behavior disappeared. The conditioned stimuli test resulted

in a reduction of number of correct motor reactions accompanied by inadequate motor reactions toward the learned 4th dish. An interruption in the experiment of 1 mo did not improve responses. Selivanova concluded the spatial factors have not only great significance in the formation and occurrence of normal conditioned reflex activity but can be a cause of experimental neurosis as well.

Plant Research

Key words: UV radiation, melaninogenesis, Basidiomycetes

Zhdanova et al. (1978) investigated the resistance several species of melanin-containing mushrooms possess to artificial solar radiation. The fungi have shown resistance to UV radiation, prevalent in the space environment. UV-resistant *Stemphylium ilicis*, *S. sarciniforme*, and *Cladosporium transchelii* and some melaninogenesis-defective mutants were irradiated by simulated solar radiation with 10-12% of the energy in the UV at levels of up to 700 J/m²s in air and 1400 J/m²s in a vacuum. Results for the air environment were similar to those of the vacuum, indicating resistance to damage from UV radiation depends on the melanin content of the cells studied.

Key words: weightlessness, gamma radiation, Spirodela

Kutiakhmedov et al. (1978) studied the effects of simulated weightlessness on the generative capacity of irradiated *Spirodela* meristem cells. Samples were irradiated with Co⁶⁰ gamma radiation and grown normally or under simulated weightless conditions in a clinostat. An increased number of daughter cells were observed in the weightless conditions relative to meristems grown under normal gravity, indicating an increase in radiation resistance. Increased viability, calculated from numbers of generations and numbers of progeny per generation were also observed for nonirradiated specimens in the clinostat relative to those grown under normal condition.

Key words: weightlessness, electromagnetism, onion (Allium sp.)

Gordeyev (1979) discussed the failure of plant growth on spacecraft and experiments that have been conducted using electrical currents in lieu of gravity. Rooted onions were placed in a clinostat. A constant current was fed to one plant, while the other was the control. Within 6 days the control plant exhibited the erratic, directionless growth and wilted tips that has been observed aboard spacecraft. The plant receiving current appeared normal. On the 6th day the current was switched to the control, which revived, while the other plant branched out and ceased growing by the 18th day. Speculation of possible agricultural applications and space applications was made.

Key words: wheat, radish, Chlorella, bioregeneration

Shaydorov et al. (1980) studied the mutual effects of *Chlorella* and higher plants grown together in a closed atmosphere. They found no growth inhibition in any of the plants and inferred the gaseous products of the higher plants and *Chlorella* do not adversely influence one another. It was concluded the plants can be considered biologically compatible constituents of the photoautotrophic component of future bioregenerative life support systems.

Microbiology

Key words: gnotobiota, immunology, pathogen

Podoprigora (1978) reviewed the history and application of gnotobiota: animals with controlled microflora. The techniques for producing germ-free gnotobiota are presented. Using gnotobiota allows biological standardization of some experimental designs. Gnotobiota have been used in space research and are considered necessary for the creation of inhabited space systems. Such animals can be used to study the effects of spaceflight in the absence of microflora, or for finding other forms of life on celestial bodies. Their use in medicine provides a system of investigating the controlled interaction of microflora and organisms, especially with respect to the immune response. The phenomenon of aging is also being studied with gnotobiota. These animals live longer than their normal counterparts in spite of reduced muscle tone, cardiovascular function, etc. The final section expounds on the clinical use of germ-free settings, especially for burn treatment and immune disease.

Bioinstrumentation

Key words: telescope, polaroid, manned spacecraft

Khrunov et al. (1979) presented a theoretical investigation of a model for the detection of manned spacecraft on a background of stars. The stars and spacecraft are considered point sources discretely and arbitrarily situated in the field of view. The search for the spacecraft model is carried out in the field of view of a telescope that is immobile with respect to the background. A formula was presented for the determination of the time of detection as a function of the relative contrast of stars with the background, the number of point sources in the telescope field of view, and the angular velocity of the observer.

Key words: electronystagmography, nystagmus, vestibular system

Mironenko and Vilenskiy (1980) reported their development of a portable set of instruments for recording nystagmus with eyes open or closed. Centered on a one-channel electrocardiograph, it is also capable of measuring rotational, caloric, positional, and pressure nystagmus. A calibration half mask is used for convenience of applying electrodes and conducting the calibration.

Key words: electronystagmography, nystagmus, corneoretinal potential

Tanchev (1980) reviewed the historical development of electronystagmography (ENG), the recording of changes in the corneoretinal potential. Starting with the first physiological study of nystagmus in 1881, he described the observations, experiments, theories, and applications of ENG through the present. Current methods employed and some of the problems encountered (e.g., expense, lack of accessibility and standardization) were also detailed.

Key words: optokinetic stimulation, nystagmus

Kandaurov et al. (1980) described an instrument for 2-speed optokinetic stimulation. The machine is small and permits automatic stimulation to the right, left, up, or down, depending on whether the drum is vertical or horizontal. Drum rotation rate is 90 and 198^o/s, while rate of stimulation is 75 and 165 bands per min. The apparatus is placed at the subject's eye level, 600-700 mm away. Nystagmus is induced and has a direction opposite to drum rotation. A fragment of a polygraphic recording from a healthy person is presented, indicating rhythmic, regularly spaced, triangular oscillations.

Key words: rheology, musculoskeletal system, vascular system

Sapuntsov et al. (1979) described a procedure for quantitative measurement of the rheologic indices of human soft tissue. Investigation centered on the muscle of the crus. The response of healthy and edematous tissue to mechanical deformation was recorded and the characteristic curves (elastograms) obtained were presented and differences in the elastograms of normal and pathological muscles of the lower extremities are discussed.

Key words: photoelectric nystagmography, vestibular analyzer

Khechinashvili et al. (1978) explained the design of a photoelectric nystagmograph (PENG) that contains a flexible doubled glass fiber light guide. PENG permits recording of eye movement during stimulation of the vestibular analyzer by an electrical current which is not possible with conventional ENG. The design of the PENG allows use of a powerful light source and high-voltage photomultipliers while preventing errors from unintentional head movement. Since PENG does not allow nystagmic measurement of both open and closed eyes and is a relatively complex technique, it was emphasized that clinical use be in addition to ENG.

Key words: gas chromatography, radiation, hypoxia

Sopikov and Gorshunova (1980) used gas chromatography to trace organic compounds in a study of the effects of spaceflight conditions (e.g., hypokinesia, radiation, hypoxia) on physiological processes of accumulation, distribution, and elimination of these volatile chemicals. They report a simple and rapid method for isolating volatile organic substances from biological material to be submitted to gas chromatographic analysis. The developed method was based on the principle of direct thermal evaporation of volatile compounds from thin layer biological samples, which is accomplished by using a heating element attached with the chromatograph.

Key words: life support systems, nutrient solutions, storage

Methods for storing nutrient solutions for vegetable growth during long-term spaceflight were tested by Gribovskaya et al. (1980). A balanced, concentrated nutrient solution, with the following salts, was studied: KNO₃, CA(NO₃)₂, HNO₃, KH₂PO₄, MgSO₄, iron citrate, trace elements,

Trilon B. Materials tested as containers for nutrient solutions included aluminum (Al) alloy, electrochemically oxidized Al alloy, and rubber hot water bottles. It was found that complete sets of salts of the nutrient solution cannot be stored at all in amounts of 1 liter (l) or less because of precipitation within the 1st wk of storage. It was not feasible to increase the volume over 3 l, however, because of spaceflight condition constraints. The investigators therefore attempted storing each component separately in small batches. The Al alloys were found to be the most unstable of the tested materials because of interaction with nutrient solutions. Changes in pH were extreme and sediments appeared. Corrosion also occurred in both forms of the alloy. The rubber hot water bottles did not cause precipitation but pH increases were as drastic as 10^3 to 10^4 higher. Fungal contaminants were also a problem. The authors concluded that metals were inadequate as storage containers. It was advised that some sort of preliminary treatment of the containers to lower desorption levels be performed.

Closed Life Support

Key words: model, module, psychology, engineering

Pravetskiy (1975-6) expounded on the lack of unity of purpose among researchers and spacecraft construction engineers. He analyzed the components of a life and activity support system and provided a diagram of his conceptual model. In defining an appropriate and realizable life support system, especially for long-term flights, the author proposed a goal-directed and adaptive system that links man with those parts of the spacecraft that create and maintain for the crew conditions guaranteeing physical and psychosocial stability at a required level. A brief mention is made concerning the training of engineers and new specialists in the technology that emerges from this conceptual framework.

Key words: UV fluorimetry, water reclamation

Chizhov et al. (1980) evaluated the technique of using ultraviolet (UV) fluorescence to detect impurities in reclaimed water. The condensate of atmospheric moisture (CAM) and water from hydrogen peroxide (H₂O₂) dissociation were monitored. The ability of simple organic compounds such as alcohols and acids to quench uranyl sulfate luminescence constituted the test. Solutions of these compounds in concentrations of 10^{-1} to 10^{-5} % were examined. The UV fluorimeter was able to detect alcohol contamination to 10^{-3} % and acid contamination to 10^{-4} %. No differences in purity between water reclaimed by CAM or H₂O₂ dissociation were found.

Key words: gas exchange, wheat, rat

An automatic control of gas exchange in a life support system (LSS) was described by Korbut (1980). An autotrophic organism is depended upon to provide oxygen (O₂) and use carbon dioxide (CO₂) of heterotrophic organisms, such as man, in functional LSSs. This experiment on continuous control of gas exchange between the two life forms used a sealed phytotron for the autotroph (in this case, wheat) and an airtight chamber for the heterotroph (4 rats). Gas exchange was allowed between the 2 chambers but constantly regulated. When CO₂ concentration reached a specified

lower range as determined by a gas analyzer, a blower turned on, moving air through the LSS until there was an equilization of CO₂ and O₂ concentrations. With an increase in O₂ concentration above a set level, there was an automatic decrease in level of light exposure of the plants; if O₂ concentration decreased, there was an increase in exposure level. At the end of the 20-day test, both the wheat and the rats had grown normally and grain yield after the vegetation period was satisfactory.

Exobiology

Key words: Mars, Viking landers, hydrated iron oxides, hydrogen peroxide, microorganisms

Murzakov et al. (1979) maintained that it is possible to assume there are hydrated iron oxides of the limonite type and frozen hydrogen peroxide (H₂O₂) on Mars based on studies carried out by the Viking landers. Despite the strong biocidal effect of H₂O₂ on microorganisms, it also promotes the extraction of organic nutrients in black earth, which are consumed by surviving microorganisms. The increase in carbon dioxide, along with a decrease in oxygen, was said to be evidence for active metabolic processes of soil aerobic microorganisms. Organisms stable to H₂O₂ action and capable of induced synthesis of catalase which breaks down H₂O₂ may explain the increase of oxygen in desert soil when an increase in CO₂ is also observed. The addition of limonite seems to decrease the toxic effect of H₂O₂ on microorganisms.

SPACEFLIGHT RESULTS

Mission Reviews

Key words: psychology, crewmember training, book

Denisov (1979) discussed in layman's terms Soviet and worldwide achievements in cosmonautics. He considered the problem of man's interaction with equipment on spacecraft and in stations, and the optimum combination of operators with the multiplicity of onboard equipment. The uniqueness of spacecraft is presented from the point of view of providing functioning "cosmonaut-spacecraft" systems.

Key words: Salyut 6, Soyuz, physiology, metabolism

Gazenko and Yegorov (1980) reviewed some medical data from the 1979 Salyut 6-Soyuz flight involving Lyakhov and Ryumin. The daily flight regimes were presented along with some medical observations of the crew's condition. The postflight condition of the 2 men is described; no permanent physiological changes were observed.

Key words: Salyut 6, adaptation, geophysical studies, radio astronomy

Zaitsev (1980) enumerated the developments and achievements that have resulted from the USSR's space research program through Popov and Ryumin's Salyut 6 habitation. He briefly covers the topics of spaceflight adaptation and rehabilitation, which they believe are fully understood, scientific fact-finding results, geophysical observations and applications, radio astronomy endeavors, and technological experiments in space.

Cardiovascular System

Key words: LBNP, veloergometer, rheogram, cerebral vascular system, Salyut 4

Kas'yan et al. (1980) studied the functional state of cerebral circulation during adaptation to weightlessness in the Salyut 4 crew using the rheographic (REG) technique. Blood redistribution and compensatory reactions of the cerebral vessels were followed. The REGs in flight were recorded with an on-board portable "Levkoy-3," which relayed the information to ground stations. Functional loads used were negative pressure on the lower half of the body (LBNP) of -25 and -35 mmHg for 5-10 min and physical load on a veloergometer (VEL) of 450-600 ug for 4-5 min. Recordings were made 3-7 days preflight, during the spaceflight, and up to 10 days postflight. Preflight LBNP effect consisted of increased efflux of venous blood from the cranium and clearly affected all the main REG indices of the wave. A reduction in tone of the average and small cerebral vessels and, to a lesser extent, the large arteries, was observed. Total pulse cerebral blood filling during LBNP diminished noticeably as did the index of systolic blood filling. Stopping LBNP led to opposite results and pulse cerebral blood filling exceeded original levels by 10-20% for a time. Normalization of REG indices occurred within 2-5 min. VEL effect was the opposite of LBNP:

there was an increase in pulse blood filling of the brain by 20-30% and a rise in systolic index of blood filling. A reduction in tone of the resistive cerebral vessels and an improvement in venous efflux from the cranial cavity were noted. The tone of the large cerebral vessels dropped with the VEL load. Normalization of REG indices occurred in 4-8 min. During spaceflight, the same reactions were noted but with individual quantitative differences. A distinct drop was noted in blood flow through cerebral vessels, apparently from prolonged weightlessness. VEL load during flight preserved the general trend: a very positive effect of the physical load on the cerebral blood circulation. In all examined cosmonauts, there was a significant rise in pulse cerebral blood filling index in response to muscle load as compared to preflight studies; this trend intensified with an increase in flight duration. Following VEL, all subjects showed an improvement in blood advance over the large cerebral vessels during flight, but the pronounced nature of these changes dropped with increased flight duration. REG index normalization usually occurred 3-7 min after cessation. During the 53-60 day period of flight, however, normalization often was not noted even 10 min after the end of the load. Physical load on the VEL under conditions of prolonged weightlessness induced more pronounced responses on the part of the REG than in preflight period. Postflight studies showed differences from preflight. After LBNP load in the 1st days after landing, large differences from preflight indices were observed. LBNP produced a rise in tone of the large cerebral arteries. After VEL, changes in the main REG indices were maintained as in preflight studies except for a rise in the large and small cerebral vessels' tone and a trend, after a load, of the cerebral pulse blood filling to rise to a greater degree than preflight. It was concluded that functional load induced a distinct reaction in the brain's vascular system at all stages of the study. This was most noticeable in the 3-4th wk of stay in 0 G, but was reduced by the 53-60th day of flight. Early postflight was characterized by the appearance of paradoxical responses to REG load and increased time of restoration after load.

Key words: Salyut 6, LBNP

Degtyarev et al. (1980) reported the results of a study of circulatory reactions to LBNP conducted in the 1st Salyut 6 orbital station's crew during their 96-day flight. The commander (CDR) and flight engineer (FLE) underwent LBNP and cardiovascular parameters were measured before, during, and after spaceflight. The 1st test in space was made in the 2nd wk of the mission and revealed a more marked reaction of the circulatory system to induced redistribution of blood than before flight in both cosmonauts. The results were believed to show the beginning of adaptation to 0 G when compensatory and adaptive mechanisms were not fully formed. The visiting crew, without time to adapt, showed severe decreases in venous return of blood to the heart in the LBNP test on their 2nd-3rd day of weightlessness. Also decreased were cardiac ejection rates and changes in several phases of the cardiac cycle without adequate changes in heart rate, arterial pulse or other parameters. Reactions to the LBNP test of the CDR became less marked during the mission, approaching preflight measurement. This indicated stabilization of changes induced by LBNP and virtually complete adaptation to 0 G. However, the FLE's reaction to LBNP remained elevated, maximum changes were seen during the last inflight test on the 92nd day. During preflight and the last inflight tests, he showed inadequate vascular reaction to the induced redistribution of blood, attributed to insufficient physical exercise. The decreased cardiac output with LBNP in the FLE might have prevented complete adaptation to 0 G. The authors noted that changes in a number of parameters of the FLE during LBNP were almost the same as with an orthostatic test, especially the

last inflight test. They also commented on lower tolerance to LBNP in weightlessness, maintaining it is only valid for diminished orthostatic stability during flight. If orthostatic stability is retained during flight, LBNP should be tolerated as it is on ground. The conclusion reached was that the 1st 2 wks were indicative of diminished tolerance to LBNP from incomplete adaptation to weightlessness; subsequent adaptation of the cardiovascular system should be accompanied by an increased tolerance.

Key words: Salyut 6, cardiac relaxation

Alferova et al. (1980) studied the dynamics of cardiac relaxation during spaceflights. They examined the dynamics of systolic parameters from results of kinetocardiography performed on the 2nd main crew of the Salyut 6 station during a 140-day spaceflight. The total duration of diastole (D), phases of isometric relaxation (IR), rapid and slow filling (RF, SF), pulsed filling (PN), and atrial systole were measured 4 times preflight, 16 times during flight, and twice postflight. All parameters were averaged for each mo; both ventricles responded in essentially the same manner. 2 phases of changes in duration of total D, PN, and SF were noted; other parameters changed in the same direction throughout flight. D increased in the 1st mo of flight, then decreased. PN and SF phases increased substantially in the 1st mo, and to a lesser extent in the 2nd mo. They then decreased. RF phases of the left ventricle increased in the commander (CDR) but decreased in the flight engineer (FLE). IR phases of the left ventricle decreased; in the right ventricle, they decreased in the CDR but increased in the FLE. Diastolic relaxation was thought to result from the increased force of cardiac contraction due to fluid redistribution to the upper body. The elevated pressure in the atria was believed to cause the IR phase shortening, while the initial increase in duration of FN was interpreted as the result of increased blood influx and ventricle filling during D. D structure changes developed in the 2nd mo of flight, reflecting adaptation of the cardiovascular system to long-term weightlessness. Therefore, the adaptive reactions are directed toward efficient hemodynamics by an increase in heart output (longer period of ejection and RF phase) and a decrease in the duration of physiological rest of the myocardium.

Key words: EKG, Salyut 5, heart rate, neurohormonal regulation, vagus

Degtyarev et al. (1980) presented the results of an electrocardiographic (EKG) study of 2 Salyut 5 crews. Correct sinus rhythms were retained by all cosmonauts during their missions. Heart rate (HR) reached preflight levels by the end of the 1st wk of flight in the commander of the 1st crew (CDR-1) and by the end of the 3rd wk in the flight engineer (FLE-1). It remained 15-20% higher than preflight values in the 2nd crew, however. All crewmembers showed respiratory arrhythmia which intensified against a background of bradycardia in CDR-1 and FLE-1. FLE-1 and FLE-2 exhibited isolated atrial extrasystoles both preflight and inflight. The time of atrioventricular conduction remained at preflight levels in the 2nd crew. The 1st crew, starting the 2nd 10-day period of the mission, presented an increase in atrioventricular conduction time and a transient increase in ventricular depolarization time. Since both cosmonauts exhibited sinus bradycardia, the slower conduction could be from intensification of parasympathetic regulation, although intensification from vagal influences has not been explained. Other parameters remained in the normal range. By the end of the 1st mo, CDR-1 developed changes in the terminal part of the

ventricular complex in the left thoracic leads. The T wave acquired a symmetrical flattened form, which became more marked, while the ST segment decreased by 1-1.5 mm and its slope in relation to the isoline disappeared. By the end of the mission, similar changes began to be observed in the FLE-1; they regressed to normal after landing in both men. No such EKG changes were seen in the 2nd flight's crewmembers. These observed changes in the repolarization process were not due to positional changes. Changes in the terminal portion of the ventricular complex in the left thoracic leads, seen in the 1st crew, were probably from metabolic disturbances in the neurohumoral regulation from weightlessness and the large work load. Biochemical tests were advised.

Hematology and Immunology

Key words: immunofluorescence, autoantibodies, osseomusculature, myocardial muscles, weightlessness, atrophy

Tashpulatov et al. (1979) examined the sera of 15 cosmonauts for the presence of autoantibodies after spaceflight. In light of the regular occurrences of (reversible) skeletal muscle atrophy under conditions of weightlessness, the authors looked for a response of autoantibody production to the tissue destruction. The technique of indirect immunofluorescence was used in reacting the sera with sample of group G human cardiac tissue or beef heart tissue. 45% (7) of the cosmonauts studied exhibited positive reactions to 1 or more of 4 elements of human heart tissue: inserted platelets, sarcolemma, sarcoplasm, cells of interstitial connective tissue. No change from preflight reactions was noted with the bovine tissue. 3 of the 7 positively reacting cosmonauts had especially strong reactions to heart tissue; 2 of these men were being examined after their 3rd flight. Although the autoantibodies in 1 cosmonaut persisted after 5 wks postflight, the autoimmune response tapered off with readaptation to Earth's gravity in all other subjects.

Metabolism

Key words: hematology, urology, endocrinology

Tigranyan (1980) compares and discusses the exchange of methodology between the US and USSR space medical teams of studies of blood and urine content of space travelers. Pre- and post-flight analyses are advocated by both teams in a series of electrolytic, enzymatic, and hormonal determinations.

Key words: osmoregulation, electrolyte, ADH, angiotensin, aldosterone

Gazenko et al. (1980) discussed the causes, mechanisms, and significance of disturbances in electrolyte metabolism during spaceflight. Results from both USSR and US flights were examined. Volume regulation and osmoregulation are controlled by the concentration of sodium (Na) and chlorine (Cl) in extracellular fluids. Weightlessness results in a redistribution of blood to the thoracic vessels and the distention of the atria; a reflex increase in renal excretion of fluid follows. Also exhibited are diminished thirst and fluid intake and a lessened desire for salt which persist some time after flight return. Postflight there is increased fluid intake but a decrease in diuresis.

Since measured blood osmolarity is normal, the fluid retention is apparently in response to diminished body fluid volume. This is reflected by a significant level of antidiuretic hormone (ADH) in blood and urine. Flights where volumes of fluid phases of the body were monitored produced contradictory results. In some crews there were drastic volume decreases, in others there were no changes from base values. A correlation was noted: the decrease in total fluid content during short-term flights is attributable to loss primarily of extracellular fluid. On longer flights, extracellular fluid is probably gradually restored but there is an overall decrease of intracellular fluid, attributable to atrophic processes in some muscle groups. A review was made of US flight crew results of a hormone study. Blood aldosterone levels were found to increase 2.5 times in the Skylab crew. Upon return to Earth, blood angiotensin exhibited an almost 3-fold increase, although during flight it was virtually normal. There was also a 339% increase in ADH urine excretion postflight. It was postulated that intensified secretion of these hormones upon return to Earth was a manifestation of compensatory reactions related to augmenting the intravascular fluid volumes. ADH is probably instrumental in fluid retention, aldosterone in the retention of Na, while angiotensin leads to conformity of the vascular bed with the volume of blood and stimulates aldosterone secretion. US inflight studies of potassium (K) balance were also reviewed. Negative K balances were recorded, even 5 days postflight. The decrease in total K content was significant; after the 28-day mission aboard Skylab, a 7.4% decrease was observed. Diets with increased K content did not circumvent this phenomenon. The additional K normalized K content of extracellular fluid but did not eliminate the negative K balance. This is probably the result of atrophic processes in muscle from weightlessness and hypodynamia. Reduction of cell mass results in the removal of K from cells, the excess of which is secreted. A gradual increase in calcium (Ca) excretion starting the 2nd wk of flight has also been documented. The Ca excretion reaches a maximum after 3-4 wks of flight and holds at this level. Analogous results have been obtained from hypokinetic experiments. Ca loss is about 4 g/mo. Since Ca content of the human body is about 1.5% of its total weight, the authors feel this is no cause for alarm during long-term flights. Increased Ca excretion is attributable to the change in bone condition in weightlessness. A negative balance of phosphorus, sulphur, and magnesium also reflects the catabolism in bone and muscle. Such functional deconditioning of the skeletomuscular system is transient and does not impair the mechanical strength of the skeleton. It was concluded that disturbances of ion metabolism are attributable primarily to changes in tissues that are richest in these electrolytes and, to a lesser extent, to changes in the endocrine system. The overall effect of weightlessness for varying periods on renal function is not critical. Following long-duration flights, the concentration of osmotically active substances in urine and the reabsorption of osmotically free water were lower than preflight, even during high ADH secretion. Therefore, prolonged weightlessness affects the concentrating capacity of the kidney and its reaction to ADH, but reversibly. The final conclusion is that changes in fluid-electrolyte metabolism are reflections of changes caused by 0 G in the above-mentioned physiological systems and neuroendocrine mechanisms. Therefore, the main line of preventive measures should be counteracting the development of atrophic processes.

Key words: otolith reflex, vestibular system

Kronilova et al. (1979) investigated the effects of conditions of long-term and short-term spaceflights on the otolith function of cosmonauts by means of pre- and postflight examinations. The results revealed that after long-term flight, the intensity of the otolith reflex increases and

asymmetry occurs in the indicators of the otolith function. Large changes in terms of expression and duration in the indicators after long-term flight, as compared with short-term flight results, were noted.

Nutrition

Key words: weightlessness, metabolism, minerals, vitamins

Ushakov (1980) reported on the principles of cosmonaut nutrition, based on the physiologic and biochemical investigations in weightless environments. Factors considered are energy expenditures, loss of fluid and concomitantly, electrolytes, and reduced activity, resulting in muscle atrophy. The daily diets consist of slightly more than 3000 kilocalories to balance energy expenditures. Electrolyte losses are treated with a complex of vitamins in 2 to 3 times the normal doses, amino acids, and minerals. The reduction in erythrocyte mass has led to the practice of saturating the cosmonauts preflight and during flight with assimilable iron.

Psychology Research

Key words: stress, control systems, flight conditions, book

Beregovoy et al. (1978) considered the theoretical and applied aspects of human psychology in the control systems involving man and machine. Data are drawn from cosmonauts and pilots in different control regimes. Cognitive processes are disclosed in the human reactions to unusual and emergency flight conditions. The main requirements for methods of including man in automatic control systems are formulated as well as internal and external information modes for emergency procedures. The results of engineering psychological studies are explained from the point of view of providing reliability and effectiveness from the human operator.

Space Biology

Mission Reviews

Key words: Cosmos 1129, physiology, Circadian rhythms, embryogenesis, chromosomal aberration, rat, lettuce seeds, quail eggs, Drosophila

Il'in (1980) discussed the results of the biological experiments executed on Cosmos 1129, with primary emphasis on the studies done with rats. Aboard the spacecraft, food consumption and anabolism were monitored and found identical with the ground controls. Upon return, analysis of body mass revealed higher fat content, a decrease in total weight, skin, muscle, and spleen mass, reduced creatine, increased liver mass, lower levels of hydration, and increased circulating insulin, compared with control animals. Cellular analyses showed no irreversible structural or genetic changes in the cell generation formed in flight. Mating that occurred 5 days postflight yielded more female progeny than normal; no abnormalities were noted in any progeny. Moderate reductions in conditioned reflex activity in the rats were observed and found reversible. The biorhythms of

motor activities and body temperature were recorded, as were Circadian rhythms in a group subjected to reversed light/dark cycles. Embryogenesis experiments with Japanese quail eggs failed because of a breakdown in the incubator's humidification system. The gravitational preference of *Drosophila*, hatched in flight, was negligible and had no effect on embryonal development or genotype. Chromosomal abnormality frequency in lettuce seeds exposed to space radiation increased 2-2.5 times; the most sensitive region was the root meristem.

Key words: Cosmos 1129, metabolism, musculoskeletal system, stress, rat, plant tumor, embryology, radiation

The Soviet Ministry of Health (1980) issued preliminary results of research on biosatellite Cosmos 1129. Tables are included for data from many of the experiments. Wistar rats were used to study the mechanisms of weightlessness, adaptation/readaptation connected with stress, metabolism, support-motor changes, and nonspecific changes. A triple set-up, flight/vivarium/biosatellite mock-up, was used. Extensive tables present weight, blood, enzyme analysis, etc. The 2nd biological study dealt with plant tumors and fowl embryo development. The condition of the tumor, accumulation of dry mass, tissue respiration, and permeability of cellular membranes were examined. The embryo-genetic experiment, using Japanese quail eggs, was unsuccessful. The 3rd study on radiation dosimetry and effects on lettuce seeds presents little tabular data but lists satellite detector units of different kinds and from different countries.

Pulmonary System

Key words: body position, weightlessness, cat

Pogodin and Mazhbich (1980) monitored the body positions of a cat during spaceflight and measured the responses of regional blood volume and flow in the lungs. They reported the presence of a gradient in the gravitation direction. Blood volume and flow of different lung portions changed qualitatively and quantitatively. These changes occurred only in the direction producing an equality of regional hydrostatical and hemodynamic loads in the lungs.

Musculoskeletal System

Key words: osteoporosis, tortoise

Stupakon et al. (1979) reported that after a 60-90 day spaceflight, mild osteoporosis developed in the epiphyses and metaphyses of long tubular bones of tortoises, which was not attributable to reduced mineral saturation of the preserved bone tissue microstructures. The diminished strength of the cancellous bone of the epiphyses in tortoises after spaceflight was due to the reduction of its structure; the strength of the compact substance did not change under the effects of weightlessness.

Metabolism

Key words: weightlessness, Cosmos biosatellite

Gazenko et al. (1980) investigated the morphological and biochemical changes in rats subjected to weightlessness during flight in one of the Cosmos biosatellites. They examined the adaptive changes to 0 G in the hypothalamic-hypophyseal-adrenal system, the lymph organs, the musculo-skeletal system, cardiovascular and renals systems. Increased activity in the neurosecretory processes of the hypothalamus was noted; however, there were no changes in catecholamine levels or their regulators. The lymph organs demonstrated a loss of weight: there was a mass breakdown of lymphocytes, atrophy of the follicles and light centers in the spleen and lymph nodes, and a drop in thymus and spleen RNA content and DNA synthesis. Atrophic changes occurred especially in the muscles of the extremities. The degree of atrophy directly corresponded to the degree of muscle participation in antigravitational support on Earth. Changes in these bones bearing the maximum weight load on Earth were noted, as were aberrant aspects of calcium and potassium metabolism. All changes observed from the 18-22 day flights were reversed by the 25th day postflight.

Key words: Cosmos 1129, rat, mitochondria, gluconeogenesis, malate dehydrogenase, isocitrate dehydrogenase, lactate dehydrogenase, liver

Tigranyan and Vetrova (1980) described studies of the effects of spaceflight aboard Cosmos 1129 on the oxidizing metabolism in rat liver. Contrary to results from Cosmos 936, a decrease in malate dehydrogenase and isocitrate dehydrogenase and cytoplasmic lactate dehydrogenase were observed in rats 6 hrs postflight and in synchronous controls subjected to all conditions of spaceflight except 0 G. The decreased enzyme levels disappeared within 6 days postflight. Similar dynamics of flight and ground-based synchronous experiments indicate that weightlessness is probably not the cause. The authors postulated a change in the gas medium, especially an increase in carbon monoxide content, to be responsible. They hypothesized that the observations are tied to an intensification of gluconeogenesis.

Microbiology

Key words: Soyuz 12, 16, 19, 22, Salyut 6, weightlessness

Smirnov (1980) briefly discussed the experiments done aboard spacecraft on unspecified microorganisms. The morphological changes in ultrastructure that are exhibited after growth in weightless conditions were emphasized although not described. The importance of being able to grow and utilize microorganisms in space was mentioned.

Key words: Soyuz 22, Proteus vulgaris, weightlessness

Kordium et al. (1978) presented results of the Soyuz 22 experiment concerning the effects of space environment on growth of the bacterium *Proteus vulgaris*. Following growth under anaerobic conditions in a growth chamber, bacteria inoculated onto growth medium under space conditions

were observed to be inhibited relative to ground-based laboratory and transported controls, with the experimental cultures containing fewer and smaller cells. Chemotaxis investigations have shown the experimental cells to be less responsive to the products of their own metabolism, while exhibiting inhibited colony growth on solid media with varying agar concentrations. It was noted that the differences found in the present experiment were more pronounced than decreases in viability and growth rate observed in previous experiments aboard Soyuz 16 and 19.

Key words: Soyuz 22, Proteus vulgaris, ultrastructure, electron microscope

Bochagova et al. (1978) presented the results of an electron microscopic analysis of the ultrastructure of *Proteus vulgaris* grown both on Soyuz 22 and in the laboratory. 4 types of cells were observed corresponding to types I, III, IV, and VI, which are characterized by differing amounts of electron-transparent deposits of easily dissolved formazan, fibrillar-granular formations, and membrane structures. A number of other cell types were also observed, without formazan deposits but showing a great deal of internal lysis. The ultrastructures of the experimental and control cells were similar, with signs of premature aging from the experimental manipulation. Ultrastructural observations were also found to coincide with the observed growth patterns of the cells, with formazan deposits in 3% of the experimental cells, 6.8% of the lab controls, and 1.5% of the transported controls.

Key words: Proteus vulgaris, morphology, ultrastructure

Kordium et al. (1979) presented growth data and EM analyses for *Proteus vulgaris* cultures which were grown during spaceflight in polyethylene packets in a semi-solid medium with Tryptose for 96 hrs. In the suboptimal culture conditions, growth and morphological characteristics of the flight and ground control variants were nearly identical, but differences between the cellular ultrastructure were found. These differences testify to changes in the bacterial cell metabolism during flight.

Key words: agar, support medium, Proteus vulgaris

Babskii et al. (1978) studied the effects of spaceflight environment on the physicochemical and biological properties of the weak gel of nutrient agar used to support bacterial growth during space experiments. *Proteus vulgaris* growth properties, viscosity, and sedimentation characteristics of the indicator-containing nutrient medium were measured for samples flown on Soyuz 20 for 3 mos, and for laboratory and transported controls. The researchers found the transport of the medium to the launch facility and spaceflight conditions resulted in a significant decrease in the mechanical strength of the agar, and a concomitant decrease in the ability to support bacterial growth and mobility.

Psychology

Key words: Cosmos 782, rat, central nervous system, sensory impulse

Livshits et al. (1980) reported the impairment of preflight food-procuring skill in rats subjected to a 19.5-day flight on Cosmos 782 biosatellite. Compared to a control group 2 to 12 days post-flight, the rats demonstrated increased erroneous movements, failures to negotiate a maze, and maze travel time. The authors discounted reduced hunger stimulation as a primary cause, citing the similarity of the control group's response to failures to negotiate the maze and subsequent feeding behavior. Pavlov's premise that reduction in food reinforcement during an experiment is often evidence of an alteration in the strength of basic nervous processes was invoked. Diminished muscle strength was found to be poorly correlated with the rats' behavior. The authors postulated changes in the central nervous system resulting from prolonged reduction of sensory impulses while in flight.

Radiation Effects and Protection

Key words: ionizing radiation, weightlessness, rat, skeleton, phosphorus, calcium, Cosmos 690

The effects of ionizing radiation during spaceflight on the calcium and phosphorus content of bones were examined by Prokhonchukov et al. (1979). Rats aboard Cosmos 690 were irradiated throughout the 10-day flight; the bone ash prepared 2 and 26 days postflight was analyzed. A decrease of 3-10% in ash content in all bones following spaceflight was observed. Whereas weightlessness apparently causes a redistribution of calcium and phosphorus, ionizing radiation is responsible for a decrease in phosphorus content, as much as 29% less than controls. The phosphorus level remained significantly depressed in calcified tissue after the 26th day postflight. Calcium metabolism exhibited less effect from the irradiation. Following readaptation, calcium content equalled the content in control animals.

Plant Research

Key words: Muscari racemosum, Anethum graveolens, Soyuz 20, gametophyte, germination, gametogenesis

Kordium et al. (1978) reported the effects of spaceflight conditions on the growth of male gametophytes of the herb *Muscari racemosum* and on the formation of the reproductive structures of dill plants, *Anethum graveolens*. The plants were grown from seeds exposed to space conditions aboard Soyuz 20 during its 3-month flight; they were compared microscopically with plants grown under natural and laboratory conditions. Spaceflight conditions apparently lead to an acceleration of male gametophyte development in *M. racemosum* and a decrease in germination rate and percent of shoot formation in dill. Nevertheless, the other facets of dill development appeared unchanged: number of buds and leaves and characteristics of sporogenesis and gametogenesis, fruiting, embryogenesis, and endosperm development were essentially identical to controls. Seeds produced by the experimental plants were similar to controls.

Key words: Haplopappus gracilis, Soyuz 22, electron microscope

The effects of spaceflight on growth, reproduction, and structure and function of tissue changes of *Haplopappus gracilis* were investigated by Sidorenko and Mashinskii (1978). The cultures were grown on solid agar aboard Soyuz 22 for 9 days. Optical and EM analyses indicated tissue growth was slower than controls, with some disruption of tissue structure evidently due to inflight vibrations. No substantial differences were noted between nature of growth, formation of reproductive cells, mitotic frequency, nuclear size, or population karyotypes in experimental and control cultures grown at 18^o, although controls grown at 26^o showed a greater increase in biomass.

Key words: barley, Soyuz 5, Soyuz 9, cytology, radiation

Nuzhdin and Dozortseva (1980) reported on barley seeds of the 1969 harvest that were taken into space aboard Soyuz 5 and 9. A cytological study of the mitoses in meristematic cells of the roots revealed that spaceflight factors on nonirradiated seeds induced about 3% aberrant cells. After irradiation, the effect of spaceflight factors increased over 2-fold.

Key words: Spirodela polyrhiza, kinetin, tritiated thymidine, Soyuz 12, 13

Kutlakhmedov et al. (1978) examined the effects of spaceflight on the emergence of turions from the dormant state to active growth in the duckweed, *Spirodela polyrhiza*. Specimens of dormant turions were placed in growth chambers on board Soyuz 12 and 13 and Cosmos 656 spacecraft; they were activated during flight by growth factor, kinetin. Subsequent growth was monitored by tritiated thymidine uptake and fascicle growth. The early stages of meristematic cell division were found to be inhibited in experimental specimens when compared to controls; there was also an irregular suppression of the function of the 1st daughter fascicle. The authors concluded that the early stages of the duckweed growth appear sensitive and convenient models for the investigation of spaceflight environment effects.

Key words: electron microscope, Chlorella pyrenoidosa, Salyut 6

Kordium et al. (1979) presented data from an electron microscopic analysis of *Chlorella pyrenoidosa* cultures after 5 days of growth in the dark on a semiliquid mineral/glucose medium on board the Soyuz 27-Salyut 6-Soyuz 28 orbital research station. Spaceflight of 5 days duration influenced no discernable ultrastructural reorganization within cells, testifying to normal cell function.

Key words: basidiomycete, Polyporus brumalis, Salyut 5, Salyut 6, weightlessness

The development of *Polyporus brumalis* cultures, both in the dark and light, was studied in the 17-day experiment on Salyut 5 and in the 20-day experiment on Salyut 6. In the 1st experiment, test tube cultures were exposed to 0 G beginning from the stage of the fruiting body primordia. In the 2nd experiment the culture was exposed in large containers at the mycelial stage. Fruiting bodies in the 1st experiment that had formed in light had stems and caps approaching appearance

and anatomical structure of the control culture. The fruiting bodies and caps were oriented toward the light. Some structural changes in the hymenophore were observed. Fruiting bodies developed in the dark had twisted stems and no caps. The 2nd experiment produced no fruiting bodies in the dark.

Life Sciences Technology

Bioinstrumentation

Key words: rheology, vascular system, musculoskeletal system, weightlessness

The development and use onboard spacecraft of rheographic monitors were discussed by Kas'yan and Turchaninova (1980). The measurement of fluid redistribution in the human body in response to weightlessness is made possible through rheographic use. Recordings during flight have been obtained from the trunk, forearm, crus, and both brain hemispheres. Blood flow and cardiac output during the weightless condition can thus be studied, as well as the adaptive processes that occur in 0 G. These studies were briefly compared to the ground-based studies that created negative pressure on the lower body and measured the consequent blood flow pattern.

Key words: massmeter, weightlessness, calibration

Sazonov et al. (1980) examined the properties of a massmeter—a device for measuring the human mass during space missions—and assessed the measurement accuracy. The calibration and testing of the device under terrestrial conditions were described, along with the measurement procedure under conditions of weightlessness. Some data obtained for crewmembers of Salyut 5 and 6 are examined.

Extravehicular Activity

Key words: crewmember training, personal protection

Khrunov (1980) commemorated the 15th anniversary of the 1st space walk with an article describing the history of such maneuvers. The necessity to the space program of crewmembers being able to leave a spacecraft and function outside enables the performance of routine inspection and maintenance, replacement of equipment on the exterior surface of a station, and technical and operational servicing of nonpiloted satellites. It also represents an escape mode in the event of an accident.

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