USSR Space Life Sciences Digest

A QUARTERLY REVIEW

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Prepared for the

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

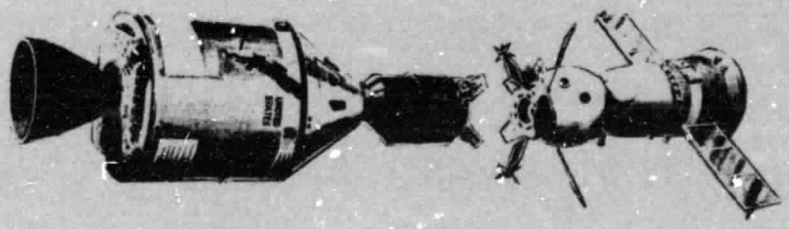

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TABLE OF CONTENTS

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.
- *USSR Report, Biomedical and Behavioral Science*–Translated articles and abstracts in biochemistry, radiobiology, aerospace biology, and medicine, from a variety of Russian language sources. Published in the U.S. by Joint Publications Research Service.
- *USSR Report, Space*–Translated articles and abstracts of formal scientific reports and news items on the Soviet space program, from a variety of foreign language sources. Published in the U.S. by Joint Publications Research Service.
- *USSR Report, Life Sciences–Effects of Nonionizing Electromagnetic Radiation*–Translated articles, abstracts, and news items from USSR scientific and technical journals on the effects of nonionizing electromagnetic radiation on organisms and biological tissues. Published in the U.S. by Joint Publications Research Service.

- *Aviation Week & Space Technology*—Weekly periodical published by McGraw-Hill, Inc. Abbreviated *AW&ST*.

- *Astronautics and Aeronautics*—Monthly periodical published by the American Institute of Aeronautics and Astronautics, Inc.

- *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:

BioTechnology, Inc.
ATTN: Soviet Digest
3027 Rosemary Lane
Falls Church, VA 22042

or

The Library of Congress
Federal Research Division
John Adams Building
NASA Unit II-G
ATTN: Mr. Joseph Rowe
Washington, D.C. 20540

HIGHLIGHTS

Launches and Recoveries

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

Spacecraft	Launch	Crew	Return	Comments
Cosmos 1237	January 6, 1981	Unmanned		Space research
Molniya 3	January 9, 1981	Unmanned		Communication satellite
Cosmos 1238	January 16, 1981	Unmanned		Space research
Cosmos 1239	January 16, 1981	Unmanned		Space research
Cosmos 1240	January 20, 1981	Unmanned		Space research
Cosmos 1241	January 21, 1981	Unmanned		Target vehicle for Cosmos 1243 and 1258
Progress 12	January 24, 1981	Unmanned	Decayed, March 21, 1981	Docked with Salyut 6 on Jan. 26; delivered fuel and consumable materials necessary for functioning
Cosmos 1242	January 27, 1981	Unmanned		Space research
Molniya 1	January 30, 1981	Unmanned		Communications satellite
Cosmos 1243	February 2, 1981	Unmanned		Killer satellite interceptor
Intercosmos 21	February 6, 1981	Unmanned		Meteorological investigation of ocean and Earth surfaces; testing systems of automatic collection of scientific data
Cosmos 1244	February 12, 1981	Unmanned		Space research
Cosmos 1245	February 13, 1981	Unmanned		Space research
Cosmos 1246	February 18, 1981	Unmanned		Space research
Cosmos 1247	February 19, 1981	Unmanned		Space research
Cosmos 1248	March 5, 1981	Unmanned		Space research
Cosmos 1249	March 5, 1981	Unmanned		Nuclear reactor powered ocean surveillance satellite
Cosmos 1250, 1251, 1252, 1253, 1254, 1255, 1256, 1257	March 6, 1981	Unmanned,		Space research. The 8 satellites were launched by 1 booster rocket.
Soyuz T-4	March 12, 1981	Kovalenok, Savinykh		Docked with Salyut 6-Progress 12 on March 14; purpose to repair and do preventive maintenance and carry out scientific-technical research
Cosmos 1258	March 14, 1981	Unmanned		Killer satellite interceptor
Cosmos 1259	March 17, 1981	Unmanned		Imaging reconnaisance satellite
Raduga	March 18, 1981	Unmanned		Television and telegraph communications satellite
Cosmos 1260	March 21, 1981	Unmanned		Ocean surveillance satellite conventionally powered
Soyuz 39	March 22, 1981	Dzganibekov, Gurragcha	March 30, 1981	Docked with Salyut 6-Soyuz T-4 on March 23; part of Intercosmos program
Molniya	March 24, 1981	Unmanned		Communications satellite
Cosmos 1261	March 31, 1981	Unmanned		Space research

Mission News

- Equipment jointly designed by Soviet and French scientists has been successfully tested and deemed ready for employment in the study of physical phenomena in the Earth's ionosphere and magnetosphere. These experiments, designated "Arcade-3," will be conducted after the instruments are installed on a Soviet satellite.

- Prognoz 8, launched December 25, 1980, obtained information on solar wind and its interaction with the Earth's magnetosphere. Data are also being received concerning HZE particle radiation levels.

- A platform with scientific laboratories in the Black Sea off the Crimean research town of Katsiveli has been constructed to coincide with the launching of the Cosmos series of satellites carrying instruments for the study of oceans. One, Cosmos 1151, is gathering information from monitoring buoy stations placed in different parts of the world's oceans. The station in the Black Sea is one such monitoring station linked with the satellites. It is used for direct measurements of currents, water and air temperatures, and heat exchange between the surface of the sea and the atmosphere.

- Soviet scientists reported that by analyzing pictures taken from orbit, it is possible to appraise the soil conditions of a given area and estimate any danger presented from desert advancement. The Institute of the Desert of the USSR Academy of Sciences has issued special instructions for the use of space pictures for compiling thematic charts. A spokesman expressed confidence that the wide use and exchange of space photos would facilitate successful halt of desert expansion throughout the world by 2000.

- The expedition ship "Kosmonavt Georgiy Dobrovol'skiy" departed from Leningrad in February 1981. Its destination is the Atlantic Ocean to replace specialists who have completed tours of duty onboard spacecraft-tracking ships of the USSR Academy of Sciences. These ships are reportedly continuing the monitoring and control of the flight of Salyut 6 orbital station.

- The Salyut 6-Soyuz T-4-Progress 12 crew, Kovalenok and Savinykh, performed repair and preventive maintenance chores aboard the Salyut 6 station. Power supply, thermal regulation, and gaseous composition ensuring systems were reactivated, and cargos aboard Progress 12 were unloaded.

  Medical studies aboard the Salyut 6-Soyuz T-4-Progress 12 included an experiment that investigates the vestibular disturbances and their symptoms in weightlessness, an initial measurement of the crew's body mass, and an estimate of muscle condition. Exercises on the veloergometer are performed as scheduled. Overall, the cosmonauts are reported to feel well.

  Cardiovascular and respiratory responses to physical loads in weightlessness were monitored in the Soviet and Mongolian cosmonauts aboard the orbital space station. Other biological experiments were aimed at the study of biorhythms and changes in the acuity and depth of eyesight during spaceflight.

Biological experiments were initiated on Salyut 6 investigating spaceflight factors on higher plant development. Arabidopsis seeds were planted and a space "conservatory" was readied for other experiments. Ongoing plant experiments include the development of onions and peas onboard the station. Barley seeds are being used to study the effects of gravity on growth.

Dielectric detectors of cosmic particles were installed on Salyut 6 to intitiate an experiment on primary cosmic radiation. After the experiment is concluded, the equipment will be returned to Earth for analysis of registered atomic nuclei traces and to determine their charge and energy.

Errors of photography from Earth's atmosphere were analyzed by the visiting Soviet-Mongolian crew using a spectrophotometer and photographic equipment. The optical characteristics of the distortion take into consideration changes in the station's windows from age and exposure to outer space.

"Hologram" studies were undertaken using equipment that includes a helio-neon laser and recording devices. Kovalenok and Savinykh made a holographic photograph of 1 window with traces of micrometeorite hits. Dzhanibekov and Gurragcha filmed the dissolution of a common salt crystal in weightless conditions.

Continuing the study of behavior of materials in outer space, 2 experiments were performed: "Erdenet" and "Altay-2." The first recorded on film the processes of diffusion and redistribution of admixtures when they dissolve in water and the crystallization of copper sulfate. Altay-2's goal is to grow crystals of vanadium pentoxide in conditions of microgravitation in the "Splav" unit.

The experiment "Resonance" was an analysis of the orbital complex where samples of air and microflora were obtained for study.

Personnel Notes

- *Vladimir Kovalenok*: The commander of Soyuz T-4 was born on March 3, 1942, in Veloye. He graduated in 1963 from the Balashovskoye Higher Military Aviation School and served in military transport aviation. He has been in the cosmonaut program since 1967 and concomitantly studied and graduated from the Yuriy Gagarin Airforce Academy. He flew aboard the Soyuz 25 in October 1977, and served as commander of the second main mission to Salyut 6.

- *Viktor Savinykh*: The flight engineer of Soyuz T-4 was born on March 7, 1940, in Berezkiniy. After graduating in 1960 from the Perm Technical School of Railway Transport, he worked at the Sverdlovsk Railway, and then served in the Soviet army. In 1969 he graduated from the Moscow Institute of Engineers of Geodetics, Aerial Photography and Cartography, and then worked on designing equipment for spacecraft and mission flight control. Savinykh joined the cosmonaut program in 1978.

- *Vladimir Dzhanibekov*. Soyuz 39's commander was born on May 13, 1942, in Iskandar. A 1965 graduate of Yeisk Higher Military Flying School, he subsequently served as an air force instructor pilot. He joined the cosmonaut program in 1970, making his first spaceflight in January 1978 as commander of Soyuz 27, with the first crew to visit Salyut 6.

- *Jugderdemidiyn Gurragcha*: A Mongolian citizen, Captain Gurragcha was born on December 5, 1947, in the Bulgan Province. He graduated from a military school of aircraft technicians in the Soviet Union and, in 1972, enrolled at the Zhukovskiy Airforce Academy. Following graduation, he worked as an engineer for aircraft equipment. Gurragcha joined the Intercosmos program in 1978.

Meetings

- A 3-day all-Union conference on "Ultrasonics in Physiology and Medicine" was held December 1 through 3, 1980, in Tashkent. Papers and reports summarized the results of research and outlined new fields of ultrasound application and use as a medical treatment.

(Material in the "Highlights" is drawn from FBIS, January-March, 1981; Daily SNAP, January-March, 1981; and *AW&ST*, January-March, 1981.)

GROUND-BASED RESEARCH

Space Medicine and Physiology

Metabolism

Key words: hypoxia, hyperthermia, hypothermia, circulatory system, pulmonary system

Vasilenko (1981) reviewed current literature concerned with human cross-resistance to hypoxia, hyperthermia, and hypothermia based on maximum oxygen uptake (MOU). MOU is considered a criterion of human efficiency or fitness; the body's resistance to various factors can be extrapolated from MOU. Studies were cited that demonstrated even mild hypoxia lowers MOU but regular exercise reduced the influence of hypoxia on performance. Other studies, not described, were said to prove that people with high MOU but not adapted to heat show greater heat resistance than individuals with low MOU. Physical training was again associated with increasing resistance, in this case to hyperthermia. Marathon running, which leads to very high MOU, was correlated with increased cold and heat resistance. The author maintained that the data were sufficient to propose that an increase of MOU is associated with physiological conditions that prevent the development of hypoxia, hyperthermia, and hypothermia, or increase tolerance to these states.

Key words: hyperbaric oxygenation, acid-base balance, altitude caisson disease, apnea, external respiration

Glazkova and Chernyakov (1981) investigated external respiration under conditions of hyperbaric oxygenation (HBO). The parameters of external respiration and the acid-base balance (ABB) during different HBO conditions were examined for use in treatment of altitude caisson disease. Males, aged 19-28 yrs, were subjected to pressure up to 3 atmospheres-absolute (ata) in 3 experiments. The first involved breathing oxygen for 90 min during compression to 3 ata (20 min) and decompression to 1 ata (10 min). A significant increase in voluntary apnea was observed, from 32 sec at the start to 42-58 sec by the end of the study, indicating a diminished sensitivity to CO_2. A slowing of respiration by 2-3 cycles/min was also recorded. No differences in lung volume, respiration mechanics, or perfusion-ventilation ratios were demonstrated after 90 min of breathing oxygen under pressure. Analysis of blood ABB showed a reliable change only in arterial blood pO_2. All other indices (pH, pCO_2, etc.) were within base value range, although some build-up of acid metabolic products was noted. The second experiment tested the parameters of external respiration during longer exposure to 3 ata. The subject changed from breathing oxygen to air while under 3 ata. There were 6 cycles, each consisting of 20 min of oxygen and 10 min of air breathing, for a total of 180 min. There were no indications of oxygen toxicity. No changes in total volume, vital capacity, forced expiration, or residual volume were noted outside the range of physiological levels. ABB of blood did not exhibit any significant deviations from base values and there was no increase in acid metabolic products. The third experiment examined external respiration during longer HBO. For the first 2 hrs the subject was under pressure of 3 ata, breathing oxygen for 20 min and air for 10 min. Pressure was then dropped to 2 ata and the subject breathed oxygen for 30 min, then air for 10 min, for 4 hrs total (6-hr experiment). The results were analogous to the preceding tests. The only significant change was an increase in apnea duration from 47 sec at the start to 80-98 sec at the end. They concluded that hyperbaric oxygenation can be used for treatment without impairing external respiration.

Key words: gas density, respiratory function, hypercapnia, pulmonary ventilation, cat

The effect of altered gas density on the respiratory function with respect to gas flow velocity in the airways was investigated by Breslav et al. (1981). The responses of 2 men and 33 anesthetized, tracheostomied cats were observed while breathing gas mixtures of differing densities. N_2 was replaced with He or SF_6. Gas flow rate through the airway was altered in men by voluntary rhythm and depth changes, and in the cats by induced hypercapnia. Under free breathing conditions, the men adjusted to unusual densities by changing the rate of pulmonary ventilation. Inhalation of $He-O_2$ resulted in faster respiration from shortened inspiration and expiration; SF_6-O_2 caused an increase in metabolic rates for 1-liter ventilation. Density differences had no effect on ventilation or rate of inspiratory flow in calmly breathing cats. During hypercapnia (from addition of CO_2 to inhaled mixtures), the decreased density gas mixture caused a decrease in inspiration; SF_6-O_2 breathing resulted in increased inspiratory breathing and higher energy expenditure. The results illustrated that helium mixtures are applicable only when respiratory function is intensified; e.g., from hypercapnia or muscular activity. The researchers recommended the observations as useful for predicting limiting densities of respiratory mixtures for people performing certain levels of work under the sea or in aerospace situations.

Key words: ionized air, hormone, adrenosympathetic system, thyroid

Tigranyan et al. (1981) evaluated the effect of ionized air on the human hormonal system. Four men, aged 25-35 yrs, spent 16 days in a 24 m^3 pressure chamber. O_2 concentration was 21%, relative humidity was 50-70%, and temperature was 22°. After the first 89 hrs from the start of the test, the first ionization session lasted 24 hrs; 31 hrs elapsed between the first and second sessions, with the second session lasting 60 hrs; there were 36 hrs between the second and third 60-hr sessions; and another 36 hrs between the third and fourth sessions, the latter lasting 48 hrs. The subjects worked and rested on schedule. Venous blood and 24-hr urine specimens were analyzed before, during, and after testing. Adrenosympathetic (AS) activity was evaluated from blood epinephrine (E) and norepinephrine (NE) content, and excretion of E, NE, dopamine (DA), and dopa in urine. Hypophysioadrenocortical system (HAC) activity was assessed from blood levels of adrenocorticotropic hormone (ACTH) and cortisol (F) and the excretion of total 17-hydroxy-corticosteroids and 17-ketosteroid (17-KS) in urine. Hydrophysiothyroid system activity was based according to blood levels of thyrotropic hormone (TTH), thyroxin (T4), and triiodothyronine (T3). Background levels were physiologically normal. Long-term ionization was associated with the elevation of E, ACTH, and F in blood and increased excretion of E, DA, and 17-KS with a corresponding decrease in TTH, T3, and T4 blood content on the 13th day of testing (end of the 60-hr ionization cycle). Therefore, they concluded that the ionized air environment caused activation of the AS hormonal system, an increase in the HAC system activity, and stimulation of the Islets of Langerhans while inhibiting the mediator element effect of the AS and hypophysiothyroid systems.

Key words: seasons, leukocytes, immunological resistance, closed environment

Novikov and Timofeyev (1981) studied seasonal changes and the corresponding functional state of leukocytes on people working for long periods in closed environments with elevated ambient

temperature and noise. Surveys were performed in October, January, April, and July on 43 operators, aged 19-22 yrs, who spend 8 hrs in sealed-off rooms with temperatures of 24-42° and noise from 87-108 dB. They determined the absolute leukocyte count, loss and absorption capacity and intensity of phagocytes, and effectiveness of phagocytes using staphylococcus as the microbe of absorption. Leukocytes, especially neutrophils and monocytes, were found to increase in the winter months and decrease in spring and summer. Similar changes were noted in controls, although the experimental group usually had a lower leukocyte count. Eosinophil content was higher in the experimental group, but neither of the differences from the control group exceeded physiological fluctuations. Leukocytolysis was 21-35% higher than control values at all times in the closed environment group, but absorptive capacity was 22-36% lower. The seasonal changes observed in leukocytes were characterized by a decline of resistance, absorptive, and digestive leukocyte functions in spring and summer. People in closed environments exhibited more marked responses than those in open environments.

Key words: mathematical model, electrocardiogram, bioelectric activity

Titomir (1980) wrote a book on mathematical descriptions of cardiac bioelectrical activity. The book addresses biophysical substantiation of electrocardiographic measurements. Mathematical modeling of the heart as an electrical generator, from the cellular level to the functional unit of the heart, is presented. The equations of classical electrodynamics for steady state currents in a volume conductor are applied for the descriptions and are presented for direct solving of electrocardiological problems.

Hypokinesia

Key words: joint Soviet-American working group, antiorthostatic position, weightlessness

Gazenko and Grigor'yev (1980) discussed the joint Soviet-American experiments on the effects of hypokinesia and weightlessness. A brief history of such studies and the simultaneous experiments conducted in the two countries was presented and explained. The goals of these experiments were the evaluation of antiorthostatic hypokinesia as a physiological model of weightlessness; comparison of horizontal and antiorthostatic bedrest as models; standardizing experiments on hypokinesia as performed by both countries; standardizing physiological measurements; and standardizing the mode of analysis, especially statistical parameters. Joint publications of the experimental results were anticipated.

Key words: bone mineral content, hydroxyapatite, cadavers

Volozhin et al. (1981) analyzed the mineral content of human vertebrae and calcanei. Samples were obtained from cadavers whose cause of death was accidental (control group) or complications of conditions that had necessitated strict bedrest 20-40 days before expiration (hypodynamic group). The volume of sodium (Na), potassium (K), calcium (Ca), magnesium, and phosphorus (P)

was measured from the ash. Osteoporosis was not a manifestation of the hypokinesic group; however, vertebral Ca content was lower and Na and K were higher than the controls. The authors hypothesized that the decreased Ca and Ca:P ratio observed in conjunction with hypodynamia resulted from an increase in the amorphous phase of bone calcium phosphate, which is not metabolized. The composition of calcanei did not differ from controls.

Key words: spatial perception, antiorthostatic position

Taranenko (1981) investigated the visual tracking accuracy of 12 volunteers briefly subjected to orthostatic and antiorthostatic positions. The volunteers were immobilized on a table that could be tilted in the frontal plane. They were then asked to line up a colored mark that randomly appeared on a cathode ray screen with a stationary guide line. After 30 min in the orthostatic position, operator errors increased. More frequent errors occurred when the operators were restrained in an antiorthostatic position (120° from the vertical). He proposed the decrease in spatial tracking accuracy following a change in body orientation was caused by a lack of stimulation of mechanoreceptors.

Key words: antiorthostatic position, dry immersion, weightlessness

Gogolev et al. (1980) studied models simulating weightlessness. Seven men spent 7 days in an antiorthostatic position (-6° head tilt) while another 13 were subjected for 7 days to unsupported dry immersion. Fluid metabolism, hydrocolloid composition of blood, hematocrit, total protein, albumin and globulin levels of plasma, intensity of foot perspiration, and measurement of extremity volumes were examined. The experiments confirmed that both test models caused changes related to fluid redistribution. Immersion induced longer-lasting changes, however, serving as a better simulation of the physiological effects of weightlessness on man.

Key words: cardiovascular system, head-up tilt, head-down tilt, intravascular pressure

Katkov and Chestukhin (1980) investigated the effects of head-up and head-down postures on the pressure, oxygenation, and acid-base equilibrium of blood in different cardiovascular components. Ten healthy males were fitted with catheters in the upper bulb of the internal jugular vein, right atrium, coronary sinus, pulmonary artery, left ventricle, femoral artery and vein, and foot artery and vein. They were then exposed to head-up and head-down tilts of 0, 10, 30, and 75°. In the head-up position, pressure in the jugular vein was found to vary independently of right atrium pressure, which became negative, while the transpulmonary gradient of the intravascular pressure increased. Pressure in the leg artery was always observed to increase more than in the leg vein. In the head-down position, pressure in the jugular vein, cardiac cavities, and pulmonary artery increased, while that in the leg vessels decreased and pressure in the foot approached zero at the 75° angle. Arteriovenous oxygen differences remained constant in the brain and myocardium but increased in the leg, foot, and systemic circulation.

Exercise

Key words: motor activity, recovery, hypokinesia, hypodynamia

Panferova and Pervushin (1981) studied the relationship between the decline of muscular activity and the degree of hypokinesia. They examined the hypothesis that motor activity remains constant for different animals and, if restricted, the animals will engage in compensatory activity. Two experiments were performed. In the first, 4 men were restricted in an armchair for 5 days during which movement was monitored. In the second experiment, 4 men lived in a 50 m^2 pressure chamber: 2 for 120 days, 1 for 86 days, and 1 for 37 days. Movement was not physically restricted and motor activity was measured with pedometers. The men confined to chairs performed only small, unconscious movements unrelated to duration of hypokinesia. This movement retained a circadian rhythm: i.e., minimal at night (7-9 movements/hr) and maximal during the day (20-70% more than at night). The subjects in the pressure chamber underwent a 3- to 4-fold decrease in motor activity. No subject, however, desired to be more active, although exercise equipment was provided. A gradual restoration of activity after the experiment was observed in 8-13 days. The results indicated a significant decrease in motor activity when restricted with no attempts from the subjects to compensate for the diminished muscular movement. The authors caution that when designing physical exercise countermeasures to hypodynamia, most people's lack of desire to be actively engaged in exercise should be considered.

Key words: hypokinesia, muscle mass, adipose tissue

Tishler et al. (1981) examined the redistribution of body mass of 18 subjects who underwent 6 months of hypokinesia. Six subjects did not exercise and showed decreases in muscle mass and increases in adipose tissue of the abdomen and thighs. The subjects who exercised did not exhibit significant muscle mass loss, although they too had increased fat deposits in the abdomen and thighs. Certain experimental flaws were noted by the researchers, especially concerning the volunteers' diet and the two exercise regimes used.

Key words: ergometry, aerobic performance, cardiopulmonary system

Machinskiy (1981) supervised bicycle ergometry studies of 120 healthy males, aged 20-40 yrs. Aerobic performance was found to depend upon the subject's normal motor activity. Those men leading an active life exhibited a significantly higher oxygen uptake and work capacity than those leading sedentary modes of life, regardless of age. Based on these observations, it was recommended that people with diminished muscle activity be urged to undertake regular exercise to achieve increased cardiorespiratory function and efficiency.

Acceleration, Simulated Gravity

Key words: pulse blood filling, dry immersion, EKG, photoplethysmogram, cardiac arrhythmia, earlobe vessels

Vil'-Vil'yams (1981) studied the relationship between pulsed filling of earlobe vessels and cardiac arrhythmias during exposure to 3 G_z. Eighteen healthy males, aged 23-36 yrs, were involved in 91 tests: 29 tests were analyzed in the normal environment; 18 recordings were made following 3-day dry immersion; and 44 tests were conducted after combining immersion with 0.8, 1.2, and 1.6 G_z for 40-60 min, 2-3 times a day on a short-arm centrifuge (SAC). The 3-G_z load was created by 5 min on a 7.25-m radius centrifuge. EKG in the Neb leads, photoplethysmograms (PPG) of pulsed filling of earlobe vessels, and arterial pressure (AP) in the shoulder region were recorded. A decline in PPG amplitude to the isoelectric line and report of visual disturbances of "gray" or "black" veil were criteria of acceleration resistance. Two main reactions were observed: normosthenic and asthenic. The former was characterized by a drop of PPG amplitude to 30-70% of base values, heart rate (HR) around 149/min, and reproducible changes in the EKG; it was seen before immersion, in 39% of the "pure" immersion cases, and in 71% of the tests with both immersion and SAC. The asthenic reaction involved a decrease in PPG amplitude to the baseline and a drop of AP level in the earlobe vessels to less than 40 mmHg. Average HR was 162/min, but the EKG configuration was the same as the normosthenic. The weakened reaction was observed in 61% of the cases after "pure" immersion and in 29% after combination of immersion and SAC rotation. In both reactions, extrasystolic arrhythmia was the main cardiac rhythm disturbance. The most serious forms of arrhythmias were seen during centrifuge slowing and the first few min of the recovery period. Vil'-Vil'yams proposed the subjects were undergoing a complex effect involving shifting of the heart in the chest during centrifugation, fluctuation of tonus of extracardiac nerves and filling of heart chambers with blood, myocardial hypoxia, and electrolyte imbalance. The long-term exposure to G_z accelerations after simulated weightlessness exacerbated the breakdown of heart rhythm regulation.

Radiation

Key words: gamma-neutron radiation, human modeling, computer simulation, book

Gozenbuk et al. (1978) authored a book that addressed the tissue distribution of radiation dosage from an external gamma-neutron source in a model of the human body. Calculated tissue dosages from nuclear reactors, outer space, and military warfare were presented and analyzed with emphasis on dosage loads in critical organs and tissues. Localized irradiation was not covered. The book represents the fourth in a series on external radiation dosage being planned under the auspices of the Institute of Biophysics of the Ministry of Health USSR.

Space Motion Sickness

Key words: cholinolytic, adrenomimetic, antihistamine, seasickness

Shashkov and Sabayev (1981) reviewed pharmacological agents used to treat or prevent motion sickness (MS). The drugs were divided into 6 main groups: (1) cholinolytics, (2) adrenomimetics, (3) antihistamines, (4) central nervous system (CNS) depressants and tranquilizers, (5) products referable to other pharmacological groups (e.g., vitamins, antiemetics), and (6) combined products. Within the first group, belladonna alkaloids, including scopolamine, atropine, and hyoscIamine, have been the most intensively studied. It was noted that those cholinolytics that cannot cross the blood-brain barrier do not alleviate the symptoms of MS, and was proposed that blocking central cholinergic synapses plays a significant role in motion sickness treatment. Adrenomimetics (e.g., ephedrine, phenamine) have been used successfully in treating seasickness but not airsickness. They are frequently used in combination with other drugs to counteract side effects. Some antihistamines have been found to be useful in preventing or treating MS, although the most potent of this class are least effective of MS prophylactics. Their anticholinergic activity rather than peripheral antihistamine activity was cited as the probable mode of action in attenuating MS. There is not as much data on CNS depressants and tranquilizers as MS treatments, although products of the phenothiazine class have sedative and antiemetic properties that might be useful. Tests have also been performed on the efficacy of vitamins, sodium bicarbonate, diphenidol, local anesthetics, and spasmolytics; all were judged ineffective in the treatment or prevention of MS. Combining drugs to eliminate undesirable effects of the main product(s) was deemed most useful. Scopolamine and cyclizine mixtures have been found to be highly effective, the latter compound attenuating the side effects of the scopolamine. Combinations of scopolamine and lomotil or sympathomimetics have also proved effective. The authors urged special attention for dopaminergic substances, metabolites, and antimetabolites to delineate the pathogenesis of MS and to develop a safe, effective pharmaceutical treatment of motion sickness.

Key words: vestibular analyzer, seasickness

Barnatskiy et al. (1981) recorded the accelerations of a ship in a storm in order to characterize their role in inducing seasickness in humans. They demonstrated that during rough weather, sailors are subjected to linear and angular accelerations from ship movement that change constantly in magnitude and direction. These accelerations are many times greater than threshold levels for vestibular system stimulation; further movement as a man moves and performs his work simply intensifies vestibular stimulation.

Key words: mathematical model, vestibular system, seasickness

Gusev et al. (1981) studied the reactions of the semicircular canals to periodic ship rolling using a mathematical model. The data indicate that during ship rolling, linear combinations of reactions of all semicircular canals may describe changes in the angular velocity of a person's movements in an absolute (static) space, while the common segment of the vertical semicircular canals allows a description of time changes in angular velocity. The model illustrated a dependence of absolute angular velocity as approximated by the semicircular canals upon head orientation in relation to the body.

Circadian Rhythms

Key words: sleep disorders, schedule changes, diurnal rhythms

Litsov (1981) analyzed the influence on man of changing the usual sleep-wake schedule. Thirty-five healthy men, aged 25-42 yrs, were divided into 6 groups. The first group of 2 slept from 10 a.m. to 6 p.m.; the second group of 12 slept from 2 p.m. to 11 p.m.; the third group of 2 slept from 6 p.m. to 2 a.m.; the fourth group of 8 slept from 11 p.m. to 8 a.m. (considered the control); the fifth group of 2 slept from 2 a.m. to 10 a.m.; and the sixth group slept from 5 a.m. to 2 p.m. Reactions were analyzed immediately after changing the schedule on the first day. All subjects adhered to a strict schedule of activities. EEGs and heart rates (HR) were recorded as were mental productivity and quality and duration of sleep. When the waking period was extended (groups 5 and 6), sleep disorders were seen primarily in the second half of the sleep period, which coincided with the usual schedule's waking period. A shift of sleep to an earlier time with shorter waking periods before (groups 1, 2, and 3) affected the first half of the sleep period, primarily in falling asleep. As the phase shift neared inversion (groups 1 and 2) disorders became more marked. The fourth group presented a distinct diurnal rhythm to pulse parameters with elevation of values in daytime and decline at night. The second group presented the most noticeable pulse disturbance: HR became flatter and differences in physiological parameters were slight. Groups 3 and 5 showed similar changes. The first group had very low values during the middle waking period of 1 to 6 a.m.; no decline in HR in the middle of the waking schedule occurs normally. Two distinct minimums were also seen on curves reflecting the correlation of group 1 between fast and slow EEG rhythms. Therefore, the first group had appreciable changes in HR and EEG parameters just as the 9-hr shift (group 2) did. Groups 3, 5, and 6 with 5-, 3-, and 6-hr shifts had no significant disturbances in EEGs. Mental productivity of groups 1, 2, 3, 5, and 6 as measured by arithmetic operations was poorer than group 4; however, group 6 subjects had better accuracy of estimating specific time intervals. Litsov concluded that shifts of more than 3 hrs from normal cycles can lead to appreciable worsening of sleep even in the first 24 hrs. Phase shifts close to inversion may be associated with impairment of circadian dynamics of HR and some EEG features as well as poor performance of some intellectual operations.

Key words: work-rest schedules, EEG, sleep disturbances

Litsov (1980) investigated the aspects of human sleep in people on differing daily schedules in a confined space, and after prolonged continuous wakefulness. Two series of 30-day experiments were conducted on 6 healthy subjects, 28-42 yrs old. At any one time, 1 of the participants was awake. Schedules of the subjects required wakefulness from 1000 to 0200 hrs, 0200 to 1800 hrs, or 1800 to 1000 hrs. Each subject had to serve continuous watch once for 64 hrs in the first series and 72 hrs in the second. EEG data were collected 1 night every 4-5 days and subjective assessment of the subject's sleep was obtained by daily questionnaires. When cycles were shifted only slightly (1000 to 0200 hrs schedule), fewer sleep disturbances were manifested. The greater the cycle shift, the more disturbances experienced. The prolonged continuous wakefulness was followed by greatly improved quantitative and qualitative sleep characteristics in all subjects, regardless of their schedule. This was especially obvious from the growth in the proportion of deep slow-wave stages. The development of daily cyclograms for the activity of operators doing stressful work in isolated spaces and for predicting their functional capabilities was suggested.

Psychology Research

Key words: ergonomics, control systems, modeling

Lomov et al. (1980) edited a book dealing with psychological problems from man-machine situations. A systems theory and methodologies of mutual adaptation of man and machine were proposed to obtain more efficient interaction. The problems, forms of training, adaptation to man-machine systems, and modeling of these processes were among the topics discussed in this monograph.

Pharmacology

Key words: stimulants, exercise, heart rate

Shashkov and Lakota (1981) compared the effects of various pharmacological compounds on physical exertion. Over 30 drugs and compounds were tested in 63 male volunteers, 23-40 yrs old, using a bicycle ergometer as the functional test and forced breathing for quantitative measurement of gas exchange. Four groups of products were tested: central nervous system (CNS) stimulants (e.g., phenamine, ephedrine, strychnine); adaptogens (e.g., eleuterococcus, saparal); biologically active agents and tonics (e.g., anaprilin, glutamic acid); and prescriptions combining CNS stimulants and anabolics (e.g., glutamic acid and nerobol, panangin, potassium orotate and strychnine). The authors suggested pretreatment with amino acids and anabolics to enhance the stimulants' influence on energy forming capacity and neuromuscular function without nerve cell damage during extremely heavy loads and resultant fatigue.

Key words: antiorthostatic hypokinesia, analgesia, acupuncture, hemodynamics

Stazhadze et al. (1981) analyzed two means of analgesia as possible treatments for traumas incurred in space. Their primary concern in evaluating the pain killing abilities of peridural anesthesia (PA) and electroauricular analgesia (EAA) was the effect of the procedures on physiological systems already destabilized by spaceflight conditions. Six healthy men, aged 26-38 yrs, underwent 7 days of antiorthostatic hypokinesia (-8°) to simulate spaceflight conditions. After the 7 days, 3 men received PA while the others received EAA. PA was found to produce a stable and prolonged analgesic effect but was accompanied by arterial hypotension, peripheral vasodilation, and diminished cardiac output. EAA was consistently more effective in anesthetizing specific "target" zones of the body. There was a relatively high stability of hemodynamics as a whole when acupuncture was used. Both analgesic methods were considered simple enough to use aboard spacecraft and to present minimal danger to traumatized cosmonauts, although acupuncture was deemed the better of the two.

Key words: phenamine, phenylbut, cancellation test, illumination levels

Bogatova et al. (1981) tested the influence of different levels of illumination and psychotrophic pharmacological agents on mental performance. Twelve subjects, aged 23-40 yrs, were involved in

2 series of tests. Testing was conducted under 3 illumination conditions: 53 lux, 32 lux, or 140 lux. In the first series, the varying illumination levels alone were used in conjunction with the testing. In the second series, phenamine, phenylbut, or fepiron (sic), as well as combinations of the drugs, were given before taking the test with different illumination levels. It was found that performance was lower with less light and virtually the same at the other 2 levels. Phenylbut was not found to optimize quality or level of performance of the test, although in combination with the other 2 drugs an increase in efficiency was observed.

Nutrition

Key words: histamine, serotonin, histaminopectic binding, allergenic response

Kalandarov et al. (1981) studied histamine and serotonin blood levels in men subjected to stress. Two groups of 5 males, aged 23-41 yrs, underwent 60 days in model situations of spaceflight. Stress factors used were simulated ascent in a pressure chamber to an "altitude" of 8000 m, anticipation of accelerations on a centrifuge, and time testing. The first group had a diet worked out for the Salyut orbital crews, which consisted of a 6-day menu of about 3300 kcal/day and a vitamin supplement. The second group's diet included 3 sets of food supplements of vitamins, glucose, minerals, and phosphatide concentrate. These supplements were given 5 days before each stress situation and on the day of exposure. Blood histamine and blood serum binding capacity (histaminopectic activity) were assayed on the test days and 1 day afterward. An elevation of histamines was noted in group 1 during simulated ascent, with a concurrent decrease in histaminopectic activity. Group 2 evinced no changes under this form of stress. With the other 2 forms of stress, both groups showed a decrease in blood histamine content, although histaminopectic activity did not change. Simulated ascent had no effect on blood serotonin concentration in group 1. Anticipation of accelerations produced an increase in serotonin levels both on the day of exposure and the day after. The stress produced some elevation of blood serotonin levels, which decreased on the following day. An increase in serotonin concentration during simulated ascent was noted in group 2; this remained elevated on the next day. A decline in serotonin levels was observed in response to the other 2 forms of stress. The authors postulated that simulated ascent results in an alteration between histamine and its inactivating systems, which include histaminopectic activity. This alteration might cause changes in the body's allergenic responses. Elevation of serotonin levels was interpreted as the result of diminished activity of the enzyme system, especially monoamine oxidase. The use of food supplements apparently restored equilibrium to the histamine system and the enzyme-serotonin system.

Key words: Salyut 6, stress, leukocytosis, lymphopenia

Markaryan (1981) studied the effects of diet and stress on peripheral blood. Forty-two males, 19-49 yrs old, adhered to a diet either like that given to Salyut 6 inhabitants or consisting of various preserved foods. During the 60-day experiment, the subjects continued their usual daily activities. At certain intervals they were challenged with stressful situations of simulated ascent to 8000 m in a pressure chamber, anticipation of centrifugation, and psychological testing. Markaryan demonstrated that the diets were satisfactory for maintaining health and had no effect on peripheral

blood morphology. Among the simulated stress situations, the anticipation of centrifugation was accompanied by an increase in leukocytes and segmented neutrophils. Similar but less pronounced alterations were induced by the other challenges. Erythrocyte and thrombocyte counts remained unaffected. Those subjects receiving dietary supplements of vitamins, minerals, and glucose did not show neutrophil leukocytosis or lymphopenia in response to stressful situations.

Key words: antiorthostatic hypokinesia, digestion, readaptation

Bychkov et al. (1981) examined the acceleration of physiological readaptation after 49 days of antiorthostatic hypokinesia (AOH) (-4°). Body weight, metabolism, and digestive system functions were monitored in 8 men, 36-40 yrs old. During the period of AOH, all subjects experienced weight loss and metabolic changes indicative of catabolism. The volunteers who received food supplements (animal protein, polyunsaturated fatty acids, mineral salts) after AOH exhibited faster normalization of digestive parameters, e.g., nitrogen balance, the albumin fraction of blood serum, and enzyme levels. The experiment revealed that recovery of many AOH-altered parameters is facilitated by dietary supplements.

Crewmember Selection and Training

Key words: survival training, Arctic

Soldatenko (1980) reported survival training exercises on Arctic ice by cosmonaut trainees as a follow-up to instruction given in Moscow. The trainees and their spaceship reentry vehicle were flown to a remote region of the Arctic, where the primary activity was igloo construction in the -45° surroundings. At the end of the exercise, the trainees were located by search helicopter. The article indicated the exercise was to be repeated within 2 days.

Key words: perception, pilot experience

Kniga (1981) investigated the perception of instrument data as related to pilot flying experience. Sixty pilots, class I, II, or III, were shown 12 color slides with pictures of an aircraft instrument panel, each for 4 sec, with a 30-sec interval between each slide. During the study, EKG, heart rate, and minute volume of respiration were recorded. The pilots were required to remember the readings of flight and navigation instruments, and determine the position of the aircraft in space and the stage of flight. They were graded on a 5-point scale, with 5 being the highest score. Classes I and II obtained the same grades for perception and processing of instrument data. The class III pilots (less experienced) had lower quality of perception and processing of information. On the basis of the physiological parameters measured, the most experienced pilots exhibited the least tension while class III showed the most. Kniga concluded that pilot skill in perceiving and processing information in the laboratory can be quantitated objectively and is related to pilot experience.

Key words: ergonomics, military specialists, examination methods

Rimanova (1973) edited a handbook on human factors for the screening of military specialists. Contained were methods of ascertaining the requirements for certain technical positions, the modes of classifications of these positions and their requisite personality structures, and tests for actual examination. The tests address perception, memory, attention, thought, psychomotor functions, and physiological tests. The formation of conclusions was to be based on the interpretation of these tests and mathematical evaluation tables.

Space Biology

Pulmonary System

Key words: hyperoxia, electron microscopy, atelectases, rat, mouse

Gramenitskiy et al. (1981) studied the effect of long-term exposure to moderately elevated oxygen (O_2) concentrations on animal resistance to subsequent hyperoxia. The animals were 138 albino Wistar rats and 171 C57B mice, divided into control and experimental groups. The 24-day experiment was conducted in a pressure chamber with an O_2 concentration of 32.6-37% (pO_2 = 250 mmHg). Hemoglobin and erythrocytes of peripheral blood and oxygen uptake were monitored. After the exposure, the rat lungs were examined by light and electron microscopy, and the mice were further exposed to elevated O_2 pressure (4 atm) for 30 or 60 min to assess adaptive effects or latent lesions from the prolonged stay in the moderately hyperoxic atmosphere. No changes in the animals' main physiological parameters (O_2 uptake, body temperature, weight, blood parameters) were demonstrated following the 24-day exposure. Lung examination revealed different reactions. Of the 7 rats used for morphological studies, 3 appeared the same as the controls: well-expanded alveoli with isolated small areas of dys- and atelectases. The other 4 rats exhibited areas of dystelectases and an increased number of areas with atelectases. Changes in the surfactant system were also seen. Brief exposures to high concentration of O_2 at high pressure (up to 4 atm) were conducted on 41 controls and 70 experimental mice. A set of 15 controls and 15 experimentals was exposed for 60 min; another set was exposed for 30 min. All animals exposed to 60 min of hyperoxia died. Test results from 30 min of exposure were found dependent upon the time the test was performed. All controls survived. When the hyperbaric test was done on the termination day of the 24-day experiment, 10 of the 15 animals died; 7 of the 15 died after day 1; 1 of 10 animals died on the third day; and 1 of 15 died on the tenth day. The lungs of mice that died differed from controls: air-bearing parenchyma and large airless regions of dark cherry color were observed, as was pulmonary edema. It was concluded that prolonged exposure to moderate hyperoxia lowers animal resistance to the toxicity from high O_2 pressures.

Key words: hyperbaria, hypercapnia, nitrogen, respiratory center, cat

Breslav et al. (1981) studied the activity of the respiratory center under hyperbaric conditions involving high partial nitrogen pressures. Fifteen cats were exposed to nitrogen-oxygen atmospheres of 7, 11, or 21 atm (normal PO_2) for 10 min. Recordings of diaphragmatic (phrenic) neurons

(ADN), intrathoracic pressure (ITP), and respiratory volume (VT) were made in the third min of exposure, after which readings were repeated under hypercapnic conditions (2 min of breathing CO_2 from a bag in the chamber). At 7 atm, ADN increased; further elevation of atmospheric pressure was associated with a decline of ADN. ITP rose under all pressures, while VT increased slightly up to 11 atm. Therefore, respiratory center activity increased with a moderate increase in atmospheric pressure. However, the overall exertion of the respiratory muscles increased much more than ADN, indicating other mechanisms are involved in the compensatory reaction to increased breathing resistance. Since these mechanisms continued to function at the highest pressure tested, they might be reflexes from intercostal muscles or the fibers to an increase in strength of contractions in response to thoracic cavity expansion. These responses apparently held the respiratory volume at a level similar to controls, while activity of the respiratory center, measured by ADN, dropped at higher pressures. The latter phenomenon, depression of the central system of respiration regulation, probably involved the anesthetic effect of nitrogen combined with the anesthesia used on the cats initially. Depression of the respiratory center was especially noticeable in the presence of hypercapnia: CO_2 enhances the anesthetic effect of nitrogen.

Hypokinesia

Key words: vastus lateralis, musculus soleus, EM, Z bands, rat

Kurash et al. (1981) investigated the morphological changes in white (upper musculus vastus lateralis), red (inner m. vastus lateralis), and intermediate (m. soleus) muscles during immobilization. Ten male Wistar rats were confined in cages for 30 days; 5 others served as controls. Muscle secretions were then obtained and prepared for light and electron microscopy. The white muscle exhibited the fewest changes, with only a few cases of more subsarcolemmic nuclei. No increase in connective tissue was seen. Red muscle was observed to have aberrations in the contractile elements, including lesions in the Z bands. Increased numbers of nuclei were seen; some formed rows and were enlarged, vesiculate, and possessed distinct nucleoli. There was also an increased amount of connective tissue. The most pronounced changes were observed in the m. soleus muscle fibers, where degenerative and atrophic changes were seen in virtually all fibers and involving all structural elements. A large amount of connective tissue around the muscle fibers was also observed.

Key words: adrenals, corticosteroids, exercise

The adrenocortical activity of rats following long-term hypokinesia was examined by Zagorskaya (1981). Male albino Wistar rats were used in 2 series of experiments, with 4-10 rats in each group. In the first series, rats were immobilized for 46, 53, or 60 days. The 60-day group was exercised on a treadmill for 10-15 min once just prior to sacrifice. The second series of experiments immobilized the animals for 53 or 60 days; some of the latter group was exercised daily for 8 days before sacrifice. Vivarium animals were used as controls, with or without exercise. Corticosterone, 11-dehydrocorticosterone, and 11-deoxycorticosterone fractions were assayed in each adrenal pair from the first series; overall 11-oxycorticoid (11-OC) content was assayed in the second series. No

glandular hypotrophy or hypertrophy was observed in any group. In the first series of experiments, the rats that underwent 46-day hypokinesia exhibited no change in the 3 hormonal fractions. After 53 days of restricted movement, there was a slight decrease in corticosteroid content in both series. After 60 days, the animals in the first series showed an increase in corticosteroid content, especially the corticosterone fraction. The 11-OC content in the second series rats without exercise almost doubled; the combination of 60-day hypokinesia and exercise produced a further increase in 11-OC adrenal content. 11-OC levels were also elevated in the controls that were exercised as compared to controls that were not, although not to the degree of the exercised hypokinetic rats. It was concluded that corticosteroid content possesses a periodicity during long-term hypokinesia. Although not observed, it was assumed that a decline of corticosteroids on the 53rd day of hypokinesia was preceded by an elevation earlier in the experiment. The corticosteroid content increase seen after 60 days of strict immobilization was believed to be indicative of the glands' retained ability for active steroidogenesis. The 2-fold increase in 11-OC in the adrenals of exercised rats demonstrated the reserve capabilities of the adrenal system remain intact during hypokinesia, although the higher levels of the hormones observed in exercised animals suggested to the author changes in adaptational mechanisms. This was taken as proof of an increase in sensitivity of the adrenohypophysial system in the presence of a long-term stressor.

Key words: bone tissue, mineral content, thyrocalcitonin, rabbit

Didenko and Volozhin (1981) analyzed the mineral composition of bones of rabbits exposed to 30 days of hypokinesia. The levels of Ca, P, Mg, Na, and K were determined under normal conditions, restricted movement, and with or without thyrocalcitonin (TCT) administration. Ca/P, Na/K, Na/Ca, K/Ca, and Mg/Ca ratios were also calculated. The particular tissues studied were the humerus, scapula, femur, calcaneus, second vertebra, and mandible. Hypokinesia for 30 days did not result in changes of Ca, P, or Ca/P levels in the skeletal bones. There was a slight increase in Mg concentration of the humerus and femur, but a decrease in the other bones. Na and K content dropped in all bones except the femur and mandible. The administration of TCT to hypokinetic rabbits was accompanied by less marked changes in chemical composition. K and Na blood levels did not change although increased excretion was noted. Didenko and Volozhin suggested that these data reflect a mechanism of redisposition of electrolytes in bone tissue, preserving normal Na and K levels in blood under hypokinetic conditions. The constant bone Ca content in the presence of increased excretion might characterize an inhibition of bone reorganization from hypokinesia, leading to reduced skeletal mass without alterations in crystalline structure.

Key words: cyclic AMP, phosphodiesterase, adenylate cyclase, muscle, rat

Antipenko et al. (1978) studied the components of the cyclic adenosine monophosphate (cAMP) system in muscle tissue of white rats during 70-75 days of hypokinesia and the readaptation period. During the immobilization, cAMP levels and the activities of phosphodiesterase and adenylate cyclase in muscle tissue increased. The values for these indices were roughly equal for controls and experimental animals during the initial period, but on the 70th day of the experiment, cAMP levels dropped, phosphodiesterase activity increased, and the stimulative effect of epinephrine on adenylate cyclase activity dropped. These indices normalized during the readaptation period.

Acceleration, Simulated Gravity

Key words: chick embryo, embryogenesis, myocardium, contractile units, calcium pump

Oganesyan et al. (1981) studied the effect of simulated gravity on the myocardium of 390 Leghorn chick embryos. The embryos were incubated at 37.5°, humidity 55-65%. Altered gravity fields were simulated by daily centrifugation for 20 min from the 5-8th day of development (first group) or from the 11-20th day of development (second group). The centrifuge consisted of a rotating disk, 21.3 cm in diameter, turning at 170 r/min (7 G). Embryonic myocardial cells were isolated and contraction amplitude and frequency were recorded. The degree of myocardial hypertrophy was also estimated from the cardiac index. Myofibrillar proteins and subunits were separated with 10% polyacrylamide gel electrophoresis. The experimental group of chicks weighed more (9.3%) and their hearts were 30% larger. It was concluded that repeated exposure to a gravity load during embryonic development elicits myocardial hypertrophy. Frequency of ventricular cell contraction in a culture of embryonic myocardium increased by 35.1% and amplitude decreased by 32.5% in the 1st group of embryos. Atrial pacemaker cells remained unaffected, perhaps due to earlier differentiation. Centrifuged embryos also exhibited decreased effect of calcium (Ca^{++}) on contraction amplitude. This was attributed to damage of the membrane Ca^{++} transport system from the altered gravity field during the development period. The embryos centrifuged between the 11-20th day showed an increase in cathepsin activity of purified myocardial myofibrils (by 40%), femoral muscles (46%), and thoracic muscle (25%). Therefore, protein catabolism of all types of muscles under the altered gravity influence are changed. The contractile components were also shown to be affected: actin content was lower, as were light chain of myosin and troponin-C in hatched chicks. Tropomyosin content was much higher than controls and a third light myosin chain was regularly detected. The actin/troponin-C ratio, however, was normal, as was troponin-T content. The results indicate a strong dependence of membrane and contractile surface differentiation and formation during embryogenesis upon gravity. The authors proposed genetic control of protein synthesis depends on gravity, while protein activity is highly sensitive to gravity factors.

Key words: rotation, radioresistance, vestibular analyzer, nystagmus, rabbit

Arlashchenko and Shipov (1981) studied the reactions of the vestibular analyzer, the state of barrier function of eye vessels, and radioresistance of 54 chinchilla rabbits after a rotation regime. The rabbits were split into 3 groups: experimental, synchronous control, and vivarium control. The experimental group was subjected to repeated rotation at 7.5 r/min for 7-8 hr/day (110-cm arm radius) for a total of 14 days of rotation time. The reactivity of the animals was assessed from nystagmus, impairment of barrier function of vessels of the ciliary tract in response to acute irradiation, and radiation resistance. Radiation was delivered in dosage of 7000 R (^{60}Co). Two hrs later, vessel barrier function was analyzed by giving the animals fluorescein, IV; for 3.5 hr, the passage of the dye into the humor was recorded. After a period of rotation, experimental animals exhibited diminished nystagmic reactions compared to controls. They were also observed to have less marked impairment of barrier function following radiation. Further, no deaths occurred among the experimental group on the 30th postradiation day; mortality reached 38% in the control groups. The radioresistance in the experimental rabbits decreased later: reexposure to radiation resulted in a death rate of 71%, while the control groups' mortality remained at 38%. It was concluded that long-term rotation increased systemic resistance to physical environmental factors.

Key words: caloric nystagmus, centrifugal force, semicircular canal, mathematical model, pigeon

Gusev et al. (1978) examined the features of caloric nystagmus during experimental G-forces. Adult pigeons were positioned in adjustable stands and subjected to caloric and rotational stimuli. The resulting nystagmus was explained in terms of the direct effect of centrifugal forces (CFF) on endolymph currents in the semicircular canal. These proposed hydromechanical processes were further defined by a mathematical model. The researchers suggested that the effects of CFF on caloric nystagmus be taken into account when evaluating such tests under altered gravity conditions.

Radiation

Key words: helium ions, gamma rays, cobalt, tilorone, interferon, radioprotection

Fedorenko et al. (1981) made a comparative study of mortality rates of mice after exposure to helium (He) ions and gamma rays. Prior to He exposure, some mice received administration of tilorone (2,7-di(2-diethylaminoethoxy)fluoren-9,1-dihydrochloride). Tilorone is reported to be an interferon inducer with some effect on radiation lesion development; it is also reported to have mild radioprotective action. Four-month-old mice were exposed to He ions of 500, 600, 700, or 800 rad. Another group was exposed to ^{60}Co gamma rays equaling 500, 600, 700, or 800 rad. Some animals were given intragastrically a 200 mg/kg solution of tilorone 18 hrs before He irradiation. Thirty-day mortality was recorded. The preadministration of tilorone did not decrease postradiation death rate following He ion irradiation; in fact, it was observed to shorten the animals' life span. Further, greater mortality was seen following exposure to He ions than gamma rays. It was concluded that prior administration of tilorone actually enhances radiation lesion from He ions and that irradiation with He ions at the energies used is biologically more effective (according to mortality) than ^{60}Co gamma radiation.

Key words: radioprotection, mutagenicity, DNA repair, yeast, pyridoxine analog

Kol'tover et al. (1980) studied yeast cell (*Saccharomyces ellipsoideus*) recovery from radiation injury and the radioprotective properties of the pyridoxine analog, 2-ethyl-6-methyl-3-oxypyridine chlorhydrate (AOP). They also evaluated the use of this system as a means of assessing radiation injury and recovery. Cells were radiated with 0 or 800 rads using ^{60}Co while suspended in sterile tap water (no buffer). Before or after irradiation, AOP was added. The cells were held in the same water and periodically plated onto standard nutrient medium; survival was determined by the number of colonies that formed. Only survival was scored; no genetic tests were performed. Those cells transferred immediately to agar following irradiation exhibited very low survival due to insufficient repair time for the DNA before growth. The addition of AOP was found to reduce the estimated number of DNA lesions by 25% when added before irradiation and by 15% when added after. Pyridine analogs such as AOP inhibit RNA-polymerase and other enzymes dependent on pyridoxal phosphate. This, the researchers postulated, could cause a delay in cell division, during which further genetic repair might occur. AOP in concentrations exceeding 10^{-6} M, however, was found to increase the number of estimated lesions and inhibited cell division. The use of AOP did appear to provide some radioprotection for the yeast cells; it was further concluded that the

holding reaction as applied to yeast was a feasible test for radioprotective, geroprotective, and antimutagenic properties of physiologically active compounds.

Key words: radiowaves, adrenohypophysis, somatotropic hormone, gel electrophoresis

Demokidova (1980) studied the effect of nonthermal radiowaves on the endocrine system of Wistar rats. The content of somatotropic hormone (STH) in the adrenohypophysis was assayed by polyacrylamide gel electrophoresis. Sodium (indirectly measured by chloride levels) in the urine was also assayed, and adrenal and thyroid organs were morphologically characterized. Exposing the rats to radiowaves resulted in a phasic response: a decline in adrenohypophysial STH content first occurred, associated with an increase in sodium excretion and reduced thyroid mass. STH content then increased after 2 wks, but gradually decreased by the end of the 3-month experiment, while thyroid mass increased to physiological ranges. Young rats appeared to grow normally, in spite of the irradiation. Demokidova concluded that the first response to nonthermal radiowave exposure is a discharge into the blood of STH and decreased release of the thyroid's thyrotropic hormone (TTH); subsequently, STH secretion diminished while TTH secretion increased. Such dynamics are also observed in stress states.

Key words: electromagnetic field, industry, calcium ions, magnesium ions, rat

Dyshlovoy et al. (1980) studied calcium and magnesium (Ca, Mg) ion concentrations in tissues and organs of animals exposed to an intense electromagnetic field of industrial frequency. Two male Wistar rats, 1 control and 1 experimental, were studied simultaneously; 7 pairs total were examined. The experimental rats were exposed to an electromagnetic field, 50 Hz frequency, and 50 kV/m voltage for 5 hrs. The animals were decapitated immediately afterward. Tissues were dessicated and the ash dissolved in 3 N HCl. This was diluted 1:50 with 0.36 N HCl; lanthanum chloride was added to a concentration of 0.01 mg/ml and salt content was read on a spectrophotometer. A 2-fold decrease of Ca and Mg ion concentrations was recorded in the liver and thymus; more than a 2-fold increase was noted in the brain, testes, prostate, and lingual and femoral muscles. Ca decreased in the kidneys; Mg content was essentially unaffected. The heart, lungs, stomach, spleen, large and small intestines, and adrenals appeared normal. The biological influence of an electromagnetic field of industrial frequency, based on these alterations of ion concentrations, was considered significant.

Key words: nucleic acid, leukocyte, low dose radiation, rat

Kritskiy and Aleksandrov (1980) reported a procedure for detecting leukocyte nucleic acid content to measure injury from small doses (e.g., 5 rad) of radiation. Exposure of rats to various levels of radiation was followed, after a period, by decapitation, and blood was collected. Heparin and saponin solutions were added and leukocytes precipitated out. Acid extracts were made of the leukocytes and read at 230, 260, and 290 nm on a spectrophotometer. Curves were plotted with percent concentration of nucleic acids on the ordinate and days after exposure on the abscissa. The data showed parallelism in the changes with doses as low as 5 rad up to 500 rad; 2 rad of irradiation revealed little reduction in the nucleic acid content. The authors concluded that the sensitivity of the technique recommended it as a valuable assay.

Key words: radioprotection, chemical protection, X-rays, gamma rays, proton irradiation, dogs, rodents

Vorob'yev et al. (1981) reviewed Soviet literature on chemical protection against X-rays, gamma rays, and high-energy proton radiation. Most of the studies considered were survival trials of animals (rodents, dogs) treated with pharmaceutical compounds, biological factors (e.g., anoxia, glycerin), or combinations thereof, with less emphasis on genetic damage. They concluded that the degree of radioprotection from these chemicals or factors of animals exposed to comparable doses of proton or electromagnetic irradiation was the same. Such information was reported to have been used in the development of pharmacochemical protection of cosmonauts during Soyuz missions.

Space Motion Sickness

Key words: turning reflex, vestibular analyzer, motor analyzer, rat

Ayzikov et al. (1981) reported the development of a device for immobilizing an animal for periods of time in any position and rapidly releasing it for a free fall (and nontraumatic landing) to study turning reactions of intact and delabyrinthectomied small animals. The device consists of a container for animal confinement, a holder for the container, a guided braking device for container placement, a flexible rod for container opening, a connecting line, and a safety net. Tests of turning reactions of rats confirmed the efficacy of this device's use. It was also recommended for other laboratory animals such as guinea pigs.

Pharmacology

Key words: ototoxicity, kanamycin, vestibule, cochlea, guinea pig, rabbit

Anichin and Pakunov (1980) studied the mechanisms of kanamycin ototoxicity. For 5 days, 5 guinea pigs and 5 rabbits were given intraperitoneally 50,000 IUs per kg per day. The acoustic labyrinths were fixed and cochlear and vestibular portions of the membraneous labyrinth were isolated. Electron microscopy revealed changes in all receptor areas, the most marked alterations being the preganglionic myelinated nerve fibers. They suggested that aminoglycosides are selective for the vestibulocochlear nerves. Since the observed changes in the vestibular portion of the labyrinth were similar to those in the cochlea, it was recommended that vestibular excitability be monitored in patients treated with ototoxic antibiotics.

Closed Life Support

Key words: artificial atmosphere, toxic impurities

Savina et al. (1981) examined atmospheric pollution from gaseous trace contaminants exhaled in a sealed, pressurized compartment. They conducted 16 tests, each lasting 7-8 days, with 36 men participating. The enclosures were designed as a function of free volume per person; i.e., 6, 8, 12, and 24 m^3 per person. The artificial environment was maintained at a comfortable temperature and humidity in most of the tests, higher temperatures and humidities were maintained in four tests. Levels of acetone, acetaldehyde, methanol, ethanol, methane, diethyl ether, carbon monoxide, ammonia and amino compounds, and fatty acids from general oxidation were determined from the air and condensates of atmospheric moisture in the enclosure. Toxic impurities in the air were found to be inversely proportional to the specific volume per person: as the volume increased, the pollution from metabolic end-products decreased.

SPACEFLIGHT RESULTS

Space Medicine and Physiology

Mission Reviews

Key words: Salyut 6, 175-day flight, LBNP, EKG, rheography, adaptation, hydroxyapatite, electrolyte, recuperation

Gazenko and Yegorov (1980) reported medical results from the crew of the third main expedition to the Salyut 6 orbital station that occurred in 1979. Commander V.A. Lyakhov (CDR) and flight engineer V.V. Ryumin (FLE) were in space for 175 days. Medical objectives consisted of maintaining the crew's health with sufficient work capability, performing medical research, administering a complex of prophylactic measures to prevent unfavorable flight factor effects, and preparing the cosmonauts for their return to 1 G. The spacecraft environment contained a gas medium similar to Earth's; total radiation exposure was 3.2-5.7 Rem.

The cosmonauts ate from a 6-day menu of 70 products, 3100 Cal/day, with vitamin supplements. Cargo ships delivered fresh products according to the crew's wishes. Water consumption was about 1.4-1.8 liters/day/man. The work and rest regime allocated 9 hrs/day for sleep, 2.5 hrs for physical training, 2.5 hrs for eating the 4 meals, 8 hrs for experiments and other work, and 2 hrs of free time. Weekends were days off. The crew exercised 3 days and rested on the 4th; LBNP training exercises (using "Chibis" vacuum complexes) were done on the 4th "rest" day and started 2 wks before flight termination. The cosmonauts drank 300 ml of water 20 min before the start of the training. Neither man reported any unpleasant sensations during training; maximum systole rate during rarefaction usually did not exceed 85-95 beats/min. On the day of landing, 3 g of table salt in 300-400 ml of water, 3 times a day, was used to maintain the liquid in the body and increase circulating blood volume. The postflight prophylactic suit was worn during descent, creating excessive pressure on the lower part of the body to prevent deposition of blood after landing, improve the venous return of the blood, and maintain orthostatic stability. To prevent metabolic changes in the heart muscle, the cosmonauts took inosin-F and panangin (2 bid on the 90-99th days, and 2 tid on the 147-161st days); in the last 2 wks they took alimentary corrective additives including a complex of decamevit, methionine, and glutamic acid for intensification of the metabolism, synthesis of catecholamines, and normalization of intestinal flora and lipid exchange. Overall, the men's condition was good. Transitional changes to 0 G disappeared after 3 wks. After the adaptation, no changes in states of health were observed.

The FLE's body mass, as determined by the massmeter, did not change, while the CDR's body mass decreased gradually by 5.5 kg total. The CDR's loss in shin volume during the first 100 days was 13-15%; later it was 16-19%. For the FLE, the loss was 11-19% after the first 12 days, then 20-24%. The oxygen regime of the tissues during flight showed a reduction in pO_2 and the rate of its consumption in forearm skin of both cosmonauts, which progressed throughout the flight. O_2 consumption also decreased. The authors postulated the oxygen regime of peripheral tissues indicated the development of venous congestion phenomena and changes in microcirculation resulting from the increase in tissue liquid pressure in the upper part of the body.

Both men's systole rates remained in the preflight range except during the space walk on the 172nd day of flight. Data from rheography showed the beating volume of the heart and instantaneous blood circulation volume were lower in the CDR during the first 3 months, but did not differ from preflight levels after that. The FLE's indicators increased until the 114th day, then decreased. The FLE's pulsed blood filling of the brain exceeded preflight levels for 3 months. Pulsed blood filling of the shin decreased, while measurement of the forearm increased in both men. Venous pressure in the jugular increased throughout flight. EKGs revealed no bioelectric changes except for an intensification of sinus arrhythmia in the CDR after physical load. After flight, there was a reduction of the T spike for all 12 leads.

Endurance to physical load from the veloergometer was good for both cosmonauts throughout the flight. Recorded data indicated no deconditioning, as opposed to the 140-day and 96-day flights. LBNP tests caused a circulation reaction similar to preflight as far as heartbeat rate and arterial pressure data. Inflight, there was a pronounced development of functional hypodynamia of the myocardium and an increase in the pulse wave's rate of propagation along the aorta. The FLE also experienced a pronounced reduction in the heart's pulsating volume and instantaneous blood circulation volume in comparison to preflight levels.

After landing, the cosmonauts felt tired; skin paleness, increased perspiration, limited locomotor function, moderately pronounced fatigue and asthenia, and reduced orthostatic stability were noted. Examination showed changes in the cosmonauts' gaits, increased tendon reflexes (FLE), dilation of veins in the bottom of the eye, lowering of otolithic apparatus sensitivity thresholds, accentuation of the pulmonary artery's second tone (CDR), and deconditioning relative to physical and orthostatic loads. A resting exocardiographic examination revealed both men had a transient increase in left auricle volume and reduction in left ventricle volume and pulsating volume, without myocardium contractility changes. Loss of tone, size, and strength were noted in the leg muscles. On the fifth day postflight, hydroxyapatite in the calcaneus was measured with direct photon absorptionmetry, revealing a reduction of 8.3% for the CDR and 3.2% for the FLE.

Upon landing, less liquid was excreted, but this normalized in the next few days. Increased calcium (Ca) and magnesium (Mg) excretion and increased blood Ca content were observed. The CDR also showed a reduction in potassium (K) concentration. A water-K load to study the kidneys' ion-regulating function established an irregularity, as seen by increased excretion of K, Ca, and Mg and reduced liquid and sodium excretion.

Reduced numbers of erythrocytes and hemoglobin and a reduction of 16-18% total hemoglobin mass were observed, as was transient leukocytosis during the first few days of readaptation. The CDR was shown to have fewer thymus-dependent lymphocytes; both cosmonauts had reduced reactivity of these immunocompetent cells. The CDR showed signs of sensitization to streptococci; the FLE developed delayed hypersensitivity to staphylococcus and and streptococcus. These reactions gradually normalized. No changes in upper respiratory passage or intestinal staphylococcal flora were found, but lactobacillus content was reduced and provisionally pathogenic enterobacteria were increased. Overall, changes in microflora were less pronounced than observed after the 96-day and 140-day flights.

Recuperative measures to enhance recovery included physical therapy and psychological support.

Cardiovascular System

Key words: Salyut 6, heart rate, arterial pressure, phasic structure, rheogram

Yegorov et al. (1981) examined the phasic characteristics of the cardiovascular system's response to weightlessness in the second crew of the Salyut 6 orbital station. During the 140-day flight, heart rate (HR), arterial pressure (AP), velocity of pulse wave propagation in the aorta, stroke and minute volumes of circulation, and rheographic parameters of pulsed filling and vessel tone were measured. In both cosmonauts, HR declined initially, but stabilized in the third-fourth wk; an increase from day 41 continued to the end of the flight. The HR change was within 12-35% for the commander (CDR) and 12-27% for the flight engineer (FLE) of preflight levels. AP declined in the first 2 months in the CDR, then seemed to be returning to preflight levels. A similar change was seen in the FLE in lateral systolic pressure. A redistribution of pulsed filling of vessels between upper and lower body parts was observed; pulsed filling of head vessels increased 70-101% by the 50-85th day, then reverted to base levels or decreased. Upper extremity filling also increased, while lower body filling decreased throughout the flight. The observed changes varied phasically throughout the flight, but caused no noticeable pathologies in the cardiovascular system.

Key words: erythropoiesis, hemoglobin, plasma, hypokinesia

The decrease in concentration and mass of hemoglobin observed in cosmonauts participating in spaceflights of more than 2 wks duration was investigated by Balakhovskiy et al. (1981). Cosmonauts were examined pre- and postflight. Blood reticulocytes were assayed and hemoglobin mass was measured using the carbon monoxide method; i.e., the subject breathed air with an amount of carbon monoxide, and hemoglobin mass was calculated from the amount of blood carboxyhemoglobin. Also, hypokinetic experiments were performed on young men who spent up to 1 month in bedrest; in some cases, a -6° head angle was used. Hemoglobin mass decreased during spaceflights, probably from decreased erythropoiesis. Since hemoglobin concentration did not change, there is probably a concurrent decrease in serum albumin formation, lowering plasma levels but keeping hemoglobin concentration constant. Postflight results have revealed a hemoglobin content decrease in most cosmonauts of 25-33% of base levels. The maximum decrease was seen 1-2 months after flight initiation, with no stabilization of hemoglobin mass during longer flights. Erythrocyte and hematocrit levels remained low for 2 wks postflight. Readaptation included a marked reticulocyte reaction, the most reticulocytes being measured at the end of the 2nd wk postflight. After long-term flights, this count was frequently 5-7 times higher than preflight levels. Following flights longer than 3 months, the reticulocyte count returned to normal on the first day postflight; it increased 1.5-2 times by the third day. After flight, erythropoiesis intensified, but hemoglobin concentration and erythrocyte number still reached a minimum level on the 9th-25th day postflight. This indicates blood plasma volume restoration occurs faster than erythropoiesis. The same changes were observed in bedrest studies, although not the extreme degree noticed in returning cosmonauts. Cosmonaut recovery was achieved 1 month postflight without complications, but the question of whether decreased hemoglobin mass presents a hazard inflight because of reduced resistance to hemorrhage remains unanswered.

Key words: LBNP, cardiac cycle, ventricular ejection, orthostatic testing

Degtyarev et al. (1981) proposed using the degree of deviation of a parameter from its theoretical value as a criterion for evaluating a subject's response. The relationship between duration of cardiac cycle (C) and left ventricular blood ejection (EP), at rest and during exposure to lower body negative pressure (LBNP), was investigated. Cardiovascular measurements of EP and C were made on 19 cosmonauts at rest, preflight, and inflight; 17 cosmonauts were also tested with LBNP. The relationship was described by an equation of linear regression, the same formula being applicable to ground-based and weightless studies. The LBNP test was performed both on the ground and inflight. Normal endurance to LBNP produced EP values within the confidence range of the theoretical values. With poor endurance or diminished endurance from spaceflight factors, they were considerably shorter than theoretical values, closer to values in the orthostatic test. Good endurance of LBNP was characterized by a heart rate reaction conforming with the theoretical value; the dynamics of blood flow rate decrease did not differ much from preflight values. They concluded that estimation of duration of EP compared to C is a reliable indicator for assessing LBNP test endurance and for evaluating the condition of cosmonauts during flights.

Key words: electrocardiogram, Soyuz, integral repolarization vector

Golubchikova et al. (1981) presented observations from electrocardiographic (EKG) examinations of 4 cosmonauts. Tests were run before, during, and after the 96- and 140-day flights to assess general patterns and mechanisms of change in bioelectrical activity of the myocardium. During flight, no appreciable deviations from preflight EKGs were noted. In the postflight period, all 4 men exhibited a decrease in the integral repolarization vector, which was most pronounced on the day of landing. This parameter increased but did not reach preflight levels in 3 cosmonauts within 1 month. The 4th participant's MT vector increased rapidly and exceeded the preflight level. These characteristics of myocardial activity indicate no significant disturbances of the depolarization process from weightlessness. The marked decline in magnitude of the integral vector of repolarization upon landing might reflect a deconditioning from flight conditions that is exacerbated by the stress of Earth's gravity.

Hematology and immunology

Key words: cellular immunity, lymphocyte, readaptation, Salyut 5

Lesnyak and Tashpulatov (1981) addressed the nature and degree of cellular immunity impairment in cosmonauts during readaptation from spaceflight. The criterion used was the blast transformation reaction of peripheral blood lymphocytes obtained from 7 cosmonauts. Phytohemaglutinin (PHA) and *Staphylococcus aureaus* culture filtrates were used as mitogens. The functional activity of the lymphocytes was measured by incorporation of ^{3}H-thymidine into lymphocyte DNA. An increase in spontaneous lymphocyte activity and some decrease when challenged with RNA were observed in all 7 men. These values reached preflight levels within 1 month. No differences were noted for 5 of the 7 when staph filtrates were used as mitogens; the

cells from the other 2 increased blastogenesis in culture with staph filtrates both before and after flight. Therefore, a brief alteration in lymphocyte function of increased spontaneous activity and slightly decreased capacity for blastogenesis from PHA were recorded following spaceflight conditions.

Neurophysiology

Key words: vestibular apparatus, spatial perception, otolithic reflex, angular acceleration, Soyuz, nystagmus, weightlessness

Yakovleva et al. (1980) reported the results of vestibular and spatial perception examinations of 24 Soyuz cosmonauts. The studies were made preflight, during flight, and postflight and involved short (4-10 days) and long (30-75 days) duration flights. The evaluation of function was based on the following techniques: counterrevolution reaction to measure otolithic reflex; nystagmus; spatial coordinate perception as measured with a portable "Vertikal" instrument; angular accelerations to study the interaction between the otolithic organ and semicircular canals; and a questionnaire to record sensations during flight. These indicators in most cosmonauts were within the physiological range before flight. During flight, three classes of adaptation were noted, based on the questionnaires: (1) very little or no sensory discomfort (9 men); (2) intense discomfort for only a short period of time (8 men); and (3) a protracted period of adaptation without sharply pronounced symptoms (7 men). Two cosmonauts in the latter group did not adapt at all during their 7-day flight. After landing, almost all cosmonauts were observed to have unstable gaits and changes in the studied vestibular indicators. Although these alterations were present in participants of all flights, they were more pronounced in those returning from longer flights. Spatial perception was unchanged in individuals returning from short flights but was anomalous in all cosmonauts returning from long flights. All measured indicators returned to normal postflight.

Metabolism

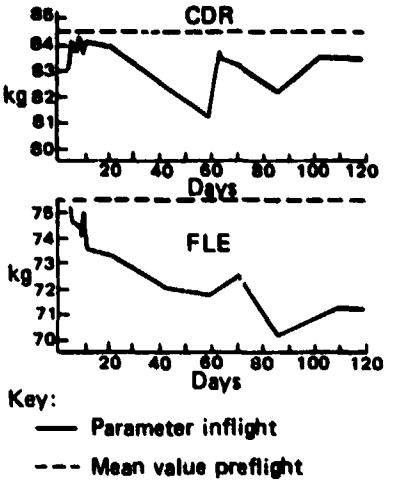
Key words: water load, 17-hydroxycorticosteroid, ACTH

Noskov et al. (1981) examined glucocorticoid activity by measuring 17-hydroxycorticosteroid (HCS) excretion before and 1 day after spaceflight using the standard water load test (20 ml/kg). After flights of 2-140 days, 22 cosmonauts were examined; all presented consistent increases in HCS excretion of 1.5-2 times preflight levels regardless of flight duration. It was proposed that HCS excretion was a manifestation of decreased reabsorption and/or increased glomerular secretion. The latter phenomenon might be due to the hyperproduction of ACTH that has been observed postflight.

Key words: body mass, Salyut 6

The changes in body mass of 2 cosmonauts during a 140-day spaceflight were monitored by Yegorov et al. (1981). As shown below, patterns of mass loss observed in the commander (CDR)

and flight engineer (FLE) differed and were not attributable to flight duration. Factors that might have contributed to the decrease in body mass include body fluid redistribution, high levels of physical activity, poor eating, stress, and loss of muscle mass from inadequate use.



Dynamics of body mass in the second main crew during the mission. (From Yegorov et al., 1981)

Nutrition

Key words: dehydrated food, preserved food, protein content, nitrogen metabolism, Soyuz 30, Soyuz 31, Salyut 6

Nitrogen metabolism in 16 subjects and 8 cosmonauts on a diet of dehydrated products and preserved food was studied by Bychkov et al. (1981). The overall health and the excretion of end-products of nitrogen metabolism were analyzed under normal working conditions, simulated spaceflight, and actual spaceflight. Protein content in the diet was found to be adequate for those undergoing normal lifestyles and simulated flight. Nitrogen metabolism in cosmonauts was found to vary but was attributed to nervous and emotional stress and flight-induced electrolyte imbalances. The protein content of the prepared ratios was consequently confirmed to be of sufficient quality and quantity.

Mission Reviews

Key words: weightlessness, Cosmos biosatellites, physiology, morphology, metabolism, rat

Gazenko et al. (1980) reviewed the results of animal experiments aboard Soviet biological satellites Cosmos 605, 690, 782, 936, and 1129. The experiments were performed on rats, including pathogen-free Wistar rats on the last 3 flights. Histological, histochemical, and biochemical examinations of the various body tissues and organs were summarized; many structural and metabolic changes noted were similar to those observed in ground-based simulation experiments. Among the conclusions were the contentions that spaceflight-induced stress is moderate, not extreme, and that exercise can lessen or prevent some of the physical alterations.

Key words: artificial gravity, Cosmos 936, rat

Kotovskaya et al. (1980) reported the effects artificial gravity had on experimental rats during a 19.5-day spaceflight. Rats were flown aboard Cosmos 936 either in a weightless state or in a short-arm centrifuge that generated 1 G. Those animals that experienced weightlessness exhibited major changes during recovery, including passive behavior and altered movement and postures. The rats exposed to artificial gravity were more active and moved normally. The rats in a weightless state showed moderate stress responses (e.g., hypoplasia of thymus and spleen, increase in segmented neutrophils), while centrifuged rats exhibited few if any changes in peripheral blood. The water load test and potassium load test revealed no differences in fluid excretion except rats in 0 G lost more Na and K than the other group. Thus, artificial gravity exerted a normalizing effect on renal excretion of Na and K. Muscle atrophy and metabolic alterations (e.g., LDH pattern changes, accumulation of glycogen) were evident in the rats exposed to weightlessness; less atrophic changes were seen in the centrifuged animals and no metabolic disturbances were seen. Osteoporosis, decreased density and mineral content, and a 30% decrease of bending strength were found in the femurs of rats from the 0 G environment, whereas artificial gravity seemed to prevent Ca and P content changes. Centrifuged rats, however, exhibited less ability postflight to negotiate a maze, especially the more complicated ones. They also did not attempt to turn around when dropped back downwards with closed eyes. It was inferred that in a rotating system, the role of vision in spatial orientation has great importance. The researchers concluded that artificial gravity was a practical countermeasure against adverse effects of prolonged spaceflight. They recommended identifying the minimum value of centripetal force required to maintain good health and high performance.

Cardiovascular System

Key words: electron microscopy, heart muscle, Cosmos 936, mitochondria, endoplasmic reticulum, glycogen, rat

Barnaski et al. (1980) examined cytoplasmic structures in the heart muscle of rats flown aboard Cosmos 936. Two groups of experimental animals were aboard: one was exposed to weightlessness,

the other to artificial gravity of 1 G. Morphometric analyses were performed on relative volumes of mitochondria (mt) and smooth endoplasmic reticulum (ER); the average number of mt and glycogen grains/100 um^2 were also calculated. Tissue from both experimental groups revealed decreases in relative volume of mt and smooth ER, and average numbers of mt. In addition, the rats completing spaceflight in artificially induced gravity exhibited an increased number of glycogen grains. Myofilament atrophy was noted in some tissue specimens. The results seemed to indicate that animals experiencing spaceflight underwent disturbances in the glycolytic pathway, with the group exposed to artificial gravity showing additional alterations. The authors emphasized that the artificial gravity did not prevent ultrastructural changes in heart tissue during spaceflight.

Key words: myocardium, mitochondria, Cosmos 936, weightlessness, rat

Rokhlenko and Mul'diyarov (1981) used electron microscopy to study the deconditioning from spaceflight factors of the myocardium in rats. Cosmos 936 carried 20 rodents for 18.5 days. Half were exposed to artificial gravity of 1 G while the rest were maintained in weightlessness. Another 15 rats were used in a synchronous ground-based experiment and 10 served as controls. The animals were sacrificed 4.5-9 hrs or 25 days postflight, and a layer of myocardium from the left ventricular apex was excised and prepared for microscopic examination. Tissue from animals exposed to weightlessness was found to have changes in the capillaries and venules, such as edema of endothelial cytoplasm, endothelial breaks, and mitochondrial swelling. The ultrastructural changes observed were very similar to those caused by tissular hypoxia of the heart. It was postulated that microcirculatory disturbances are the result of the change from weightlessness to gravity: the heart experiences a drastic increase in load without sufficient blood supply, leading to hypoxia. No atrophy, necrosis, or lysis was observed in rats exposed to 0 G, and all tissues were normal 25 days postflight. The animals exposed to artificial gravity showed few of the tissue changes seen in the other Cosmos rats, which led the authors to conclude the artificial gravity provided a significant degree of prevention of myocardial disturbances.

Musculoskeletal System

Key words: triceps, brachialis, soleus, extensor, Cosmos biosatellites, rat

Oganov et al. (1980) considered physiological mechanisms of adaptation of rat skeletal muscles to weightlessness. Under study were animals that had flown aboard Cosmos 605, 690, 936, and 1129. After each flight the animals were sacrificed within 24 hrs of recovery from spacecraft or 25 days postflight. Experiments were performed on the triceps and brachialis muscles of the forelimbs and the soleus and extensor of the hindlimbs. The contractile properties of the muscles *in vitro* were recorded and revealed a loss of tissue elasticity and strength. Similar alterations were seen in the tissues of rats subjected to synchronous hypodynamia, suggesting that unloading (i.e., removal of requirement to counteract gravity and maintain posture) is the major factor causing the alterations in muscle strength and response. The authors also discussed the involvement of the nervous system, citing the reduced impulsation from various proprioreceptors. Such reductions in stimuli might ultimately result in modifications of the mechanisms that control muscle protein synthesis and, therefore, alter tissue response and metabolism.

Key words: soleus, gastrocnemius, Cosmos 936, weightlessness, rat

Rokhlenko and Savik (1981) reported their observations of spaceflight effects on skeletal muscle ultrastructure. The Cosmos 936 biosatellite carried 20 rats for 18.5 days. They were sacrificed 4.5-9 hrs or 25 days after the flight. During flight, half were maintained in 0 G and the other half were maintained in artificial gravity of 1 G. A synchronous ground-based experiment used 15 animals, with simulation of all spaceflight factors except weightlessness; 10 rats served as controls. Samples of red (soleus) and mixed (gastrocnemius) muscles were analyzed by electron microscopy. Some parts of the soleus of animals subjected to 0 G exhibited a loss of striations and widening of spaces between fibers. Aberrant contractile and mitochondrial elements were also noted. The animals that experienced weightlessness were also found to have excessive deposits of glycogen and lipid globules. Some soleus fibers were dying or atrophied, and an increased amount of connective tissue was found between such fibers. Focal changes were noted in the red muscles of the animals subjected to artificial gravity and the ground-based experiment, but the damage was less marked and less extensive. Examination of the muscles 25 days postflight did not reveal any altered tissues; any damage that existed was repaired or in the process of resynthesis. No ultrastructural disturbances were observed in the gastrocnemius either a few hours or 25 days postflight. It was concluded that the artificial gravity aboard the biosatellite prevented, in part, the development of structural and metabolic changes in soleus muscle from weightlessness.

Key words: mineralization, resorption, ulna, radius, Cosmos 936, acid and alkaline phosphatase

Popova and Tigranyan (1981) investigated the effects of spaceflight on acid and alkaline phosphatase activity. The enzymes analyzed were from the radii and ulnas of rats flown aboard biosatellite Cosmos 936 under conditions of weightlessness or artificial gravity of 1 G. Animals were sacrificed within 10 hrs or 25 days postflight. A reliable increase in acid phosphatase activity and decrease in alkaline phosphatase activity in both bones of rats sacrificed right after landing were observed. The correlation suggested to the authors that spaceflight factors resulted in a shift of bone metabolism so that demineralization was prevalent. Weightlessness apparently was not a factor since the levels of the phosphatases were the same in both sets of rats aboard Cosmos. A synchronous ground-based experiment revealed only a decline in alkaline phosphatase activity of radii and ulnas, with no demonstrable changes in acid phosphatase activity. It appeared that alkaline hydrolysis, involved in the formation of crystallization nuclei in the bone matrix, is sensitive to various non-specific factors. Bone tissue from animals sacrificed after 25 days showed normal phosphatase activity. They concluded that the 18.5-day spaceflight caused a substantial change in acid and alkaline phosphatase activity in the antebrachial bones of rats, possibly affecting mineralization and resorption processes in bone tissue.

Key words: body composition, Cosmos 1129, weightlessness

Ushakov et al. (1980) presented results from a study on body composition of rats flown aboard Cosmos 1129. Comparisons were made among the animals subjected to the 18.5-day flight (F), animals involved in a ground-based synchronous control experiment (S), and animals maintained

under standard vivarium conditions (V). Comparison of F rats with V animals allowed evaluation of the influence of weightlessness and spaceflight factors on body composition. F animals exhibited a higher fat content throughout the body and decreased amounts of creatine, phosphorus, and calcium in lean body mass. The comparison of S and V animals emphasized the role nongravitational factors exert on body composition: the fat content was significantly higher in the synchronous controls, while lean body mass and musculoskeletal system values were reduced. The latter parameter reflected the decline in water content. The effect of weightlessness was inferred by contrasting F and S rats. The two groups differed primarily in the lower water content, especially in skin and musculoskeletal system, of the flight group. F rats also possessed larger kidneys and smaller spleens, two fat-free organs.

Key words: biosatellites, morphological changes, weightlessness, atrophy, rat

Kaplansky et al. (1980) summarized the results of inflight morphological changes in response to weightlessness observed in rats flown aboard the Cosmos biosatellite. Functional rearrangements of the musculoskeletal system were characterized by inhibition of periosteal neoformation and tubular bone growth, development of osteoporosis of the spongy and compact substance of tubular bones, and bone demineralization. These alterations occurred mostly in weight-bearing tubular bones and led to a decline in bone strength. Muscle atrophy involving reduced muscle mass and myofiber changes was also a manifestation of exposure to 0 G, with hindlimb muscles more affected than forelimb muscles. This disturbance was accompanied by metabolic changes, including glycogen and lipid accumulation. Such aggregation might be associated with decreased energy expenditures; the synthesis of the two substances appeared unimpaired but neither compound was being reduced as rapidly as on Earth. The observation suggested to the authors that by 18.5 days in space, adjustment of muscle metabolism to weightless conditions was incomplete. Suppressed erythropoiesis and increased thrombocytopoiesis were also noted in animals exposed to weightlessness. The former condition, in conjunction with increased hemolysis and decreased erythrocyte survival time, might have reflected lowered oxygen requirements of muscles. Heart muscle, however, did not reveal any structural changes of the myocardium, although electron microscopic analysis indicated fewer mitochondria were present. Morphological studies of the neuroendocrine system revealed no physical signs of dysfunction at the cellular level of the adenohypophysis. This was consistent with biochemical data suggesting no alterations in hormone content. Exposure to weightlessness did induce involution of the thymus and hypoplasia of the lymphoid tissue of the spleen and lymph nodes. This stress reaction was absent in rats flown on Cosmos 936 but centrifuged, therefore subjected to artificial gravity. All observed morphological alterations from weightlessness were associated with diminished function of various organs and systems, reflecting adaptation to the new environment.

Metabolism

Key words: weightlessness, Cosmos biosatellites, catabolism, lymph organ involution, rat

Serova (1980) discussed the effect of 18- to 22-day spaceflight on the resistance and reactivity of animals. Rats that had been aboard Cosmos 605, 782, 936, and 1129 were analyzed after

recovery. They all exhibited low motor activity and weight loss, although food consumption had been normal. The latter parameter seemed to depend on their preflight condition: initially larger animals had more marked daily weight gains in space and barely differed from controls. Enhanced catabolic activity was indirectly discerned by muscle weight loss and the activation of proteolytic enzymes throughout the digestive system. Activation of anabolic processes was also noted: food was assimilated better than controls and oxygen consumption was somewhat higher. The author postulated that the anabolic reaction would cease with increased flight time and the continued rate of catabolism. Involution of lymph organs in the form of decreased thymus and spleen weights and reduced thymocyte and splenocyte counts was observed. Lymphopenia and fewer lymphocytes in bone marrow were also characteristic of rats postflight. However, when challenged with immobilization 3, 4, 5, and 6 days after recovery, the lymphocyte and neutrophil responses of these animals did not qualitatively differ from rats that had not been aboard the satellites. Spaceflight was not found to shorten life spans of the animals that had flown and it did not affect the offspring of males from the experiments. Serova concluded that 18-22 days of spaceflight did not greatly reduce the resistance of the rats, or exert any long-term effects.

Key words: stress, hormone, adrenal, hypothalamus, liver, Cosmos 936, weightlessness, rat

Tigranyan et al. (1980) analyzed hormones and metabolic by-products in the blood and organs of rats recovered after flight aboard Cosmos 936 as a means of assessing spaceflight-induced stress. Blood was analyzed for corticosterone (CS), epinephrine (E), norepinephrine (NE), ACTH, and testosterone; myocardium was analyzed for total catecholamine content (CA), dopamine-B-hydroxylase (DBH), monoamine oxidase (MAO), and catechol-o-methyl transferase (COMT); adrenals were analyzed for catecholamine content, corticosterone content, DBH, and tyrosine hydroxylase (TH) activity; hypothalamus was examined for NE content, DBH, TH, and MAO activities; and liver was analyzed for tyrosine aminotransferase (TAT), tryptophan pyrolase (TP), fructose-1,6-diphosphase (FDP), glucose-6-phosphatase (G6P), aspartate aminotransferase (ASAT), and alanine aminotransferase (ALAT). Assays were performed postflight on rats flown in weightlessness (F) or exposed to artificial gravity (FC) aboard the biosatellite. NE levels in the blood of F and FC rats increased 2-3 times, but E levels remained within the normal range, suggesting that 0 G did not act as a stressor on the sympathoadrenal system. Indicators of the adrenomedullary system (TH, DBH, CA) were unaltered as was CS, the adrenocortical system's indicator. TH, DBH, and MAC activities of the hypothalamus of flight rats remained unchanged, providing further evidence that spaceflight had not produced chronic stress. Myocardial CA concentration increased significantly in comparison to controls in both F and FC rats. Since DBH, MAO, and COMT did not vary, however, it was postulated that the increase was from augmented uptake or reduced excretion, possibly due to altered sympathetic nerve function. The hepatic enzymes TAT and TP, indicators of short-term acute stress, were elevated postflight. ASAT, ALAT, FDP, and G6P levels, indicators of long-term glucocorticoid effects from chronic stress, were also raised in the F animals, but not those exposed to artificial gravity. From the above data, it was proposed that spaceflight of 18.5 days was not a powerful stressor. The information suggested acute stress occurs in conjunction with biosatellite recovery operations; the increased activity of ASAT, ALAT, FDP, and G6P were the only data obtained indicating that weightlessness-induced chronic stress exists. They concluded that the animals adapted well to prolonged weightlessness and spaceflight.

Key words: biosatellite, Purkinje cells, glial satellites, RNA, protein, cholinesterase, rat

Dyomin et al. (1980) studied the effect of weightlessness and spaceflight on brain metabolism of rats flown on the Cosmos biosatellites. RNA and protein content per cell of Purkinje cells and their glial satellites were calculated; cholinesterase activity was assayed from various parts of the brain. RNA content in Purkinje cells was found to be reduced immediately postflight, although protein content was normal. Both RNA and protein content were lower in certain glial satellites. This suggested to the authors that protein synthesis in these neurons was inhibited or becoming so. An observed decrease in cholinesterase activity supported this hypothesis. Exposure of some rats to artificial gravity aboard Cosmos 936 did not prevent these changes, but merely lessened their manifestation. After 25-26 days of readaptation to Earth's gravity, no differences in protein or RNA content of cerebellar cells, as compared to control animals, were found. It was proposed that the changes might represent suppression of brain activity from a lack of external stimuli rather than a result of stress.

Key words: stress, epinephrine, tyrosine hydroxylase, Cosmos 1129, rat

The effect of spaceflight on sympathetic-adrenomedullary activity of rats after Cosmos 1129 recovery was studied by Kvetnansky et al. (1980). The scientists sought to answer whether spaceflight induced chronic stress in the animals. Immediately postflight and 6 days later, two groups of animals were sacrificed and epinephrine (E) levels and tyrosine hydroxylase (TH) activity were measured. A third group of rats was repeatedly stressed by subjection to forced immobilization for 6 days after recovery and likewise analyzed. Postflight, neither the R+0 or the R+6 group showed any substantial changes in E or TH levels, suggesting that spaceflight did not influence the sympathetic-adrenomedullary system as a stressor. However, rats exposed to repeated immobilization were found to have significantly decreased E content and increased TH activity as compared to controls and synchronous repeatedly immobilized rats. Since other animals did not show any postflight indications of chronic stress, the response of stressed rats was thought to reflect a sensitized sympathetic-adrenomedullary system. This sensitization might have been caused by diminished requirements of the organism upon the system's activity in weightlessness. The implications of this observation upon postflight readaptation were emphasized.

Circadian Rhythms

Key words: Cosmos 1129, motor activity, body temperature, light-dark cycle

Klimovitsky et al. (1980) executed experiments on rats aboard Cosmos 1129, examining phasic rearrangements of the circadian cycle of motor activity (MA) and body temperature (BT). Preflight, animals were kept on a 12 hrs:12 hrs light-dark cycle. MA and BT were recorded during and 36 hrs, and 2, 7, 12, and 17 days postflight. During flight days 1 through 9, the MA and BT phases were stable. On day 10, the light-dark cycle was inverted; a rearrangement of rhythms started immediately and developed at similar rates in flight and synchronous experiment animals. During recovery, the circadian rhythms of MA and BT of flight and synchronous animals was indiscernible; the phasic characteristics reappeared on the 3-4 observation days. Similar results were obtained on

the circadian rhythms of urination and electrolyte excretion. After recovery, the rhythms changed from the inverted cycle to normal. The correlation of data from flight and synchronous experiments suggested weightlessness exerted no adverse effects on the formation and stability of circadian rhythms of rats inflight.

Key words: electrolytes, diuresis, weightlessness, Cosmos 1129, rat

Kwarecki et al. (1980) investigated the periodicity of excretory rhythms of electrolytes and hydroxyproline of rats exposed to weightlessness and inverted light-dark cycles aboard Cosmos 1129. The experimental animals were kept in a 12 hrs:12 hrs light-dark cycle preflight. Inflight, they showed normal circadian rhythms for the first 9 days. On the tenth day, the light-dark cycle was inverted, and remained so for the rest of the 18.5-day flight. Postflight analysis showed urine diuresis and sodium and potassium excretion become synchronized to the preflight lighting pattern within 10 days after recovery. However, the excretory rhythms of calcium, phosphate, and hydroxyproline remained out of phase, with individual differences among animals studied. The mutual coupling among these urinary rhythms was also disturbed. Phosphate and hydroxyproline excretion, coupled during the initial postflight period, were decoupled by the end of the experiment. The authors proposed this as evidence of persisting disturbances in bone tissue functions, both mineral and organic components. Increased nitrogen and phosphate excretion reflected muscle atrophy. They postulated the loss of normal hormonal circadian periodicities in adjusting systems might account for the observed aberrations. Therefore, spaceflight conditions appear to weaken regulatory mechanisms in exposed animals.

Life Sciences Technology

Space Cabin Environment

Key words: heat transfer, weightlessness, homothermal body, convection, forced ventilation, radiation

Novak (1981) reported the results of the joint Czech-Soviet "heat transfer 1" experiment, conducted aboard the Cosmos 936 biosatellite. The objective was to test direct measurement of the effect of 0 G on heat loss by a homothermal body and the influence of forced air convection on heat loss for application in spacecraft cabins. An automatic electrodynamic psychrometer with a calibrating device was used. The machine heats up, then takes readings when air velocity within the enclosing cylinder is 0, 0.7, 1.2, 2.0, and 3.0 m/s. The theoretical assumption was that maximum decrease in heat loss occurs in weightlessness in still air. Without air mixing from convection, overall heat loss by the psychrometer decreased by 47% of that measured on Earth. Forced convection at velocity of 0.7 m/s raised the cooling effect; velocities of 2 and 3 m/s showed no differences between heat loss in weightlessness and on the ground. It was calculated that without convection, radiation makes up 58% of overall heat loss in still air. With natural convection, radiated heat loss is 27%; with forced ventilation, it is insignificant. The authors concluded that the influence of 0 G on heat loss is greatest in still air or forced ventilation up to 1 m/s. With greater air movement, the effect of weightlessness is negated.

Key words: water regeneration, oxygen regeneration, plant growth, Salyut 6

Adamovich (1980) explained the Salyut 6 life support system in an article for laymen. The primary problems of providing food, water, and oxygen to crews were recounted, especially in terms of their weight and bulk. Food and water are delivered into space packaged, while oxygen is in a chemically bound form. At present, water that has been used for washing is purified in a regeneration system while exhaled moisture is condensed in a cooling unit and then regenerated. Oxygen is obtained by separation from water by electrolysis; the hydrogen reacts with carbon dioxide, forming water which is fed back into the electrolyzer. Methane, a by-product, is expelled into space. Food consists of sterile products packed in dishes or aluminum tubes, although experimentation is presently being undertaken with "sublimated" food. When complete regeneration of water from wastes is possible, Adamovich believes this food will be the primary form used. All unregenerated wastes are now put in sealed containers that are periodically ejected into space where they are supposed to burn up as they reenter the atmosphere. To complete closed life support, successful growth of plants is essential. Greenhouses are being tested for their inclusion aboard spacecraft. One greenhouse where plants were grown hydroponically was carried onboard the Cosmos 1129 biological satellite. The results showed that plants orient themselves in the direction of light, even in the absence of gravity. No morphological differences were seen in plants grown under these conditions when compared to control plants. Other models of greenhouses are also being tested.

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