

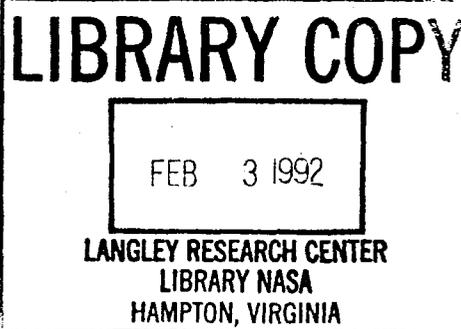
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# USSR Space Life Sciences Digest

*Issue 32*

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# USSR Space Life Sciences Digest

*Issue 32*

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## TABLE OF CONTENTS

<i>Reader Feedback Form</i>	v
<i>From the Editors</i>	vi
<b>ADAPTATION</b>	1
The role of photoperiodism in development of adaptive changes in the human endocrine system in the north.	1
Adaptation to natural and technogenic extreme factors in trained and untrained humans using adaptogens.	3
<b>AVIATION MEDICINE</b>	4
Psychophysiological and Medical Problems of Flight Safety	4
<b>BIOLOGICAL RHYTHMS</b>	6
Chronobiological (biorhythmic) approaches to study of functional asymmetry in balance and spatial orientation systems.	6
<b>BIOSPHERICS</b>	7
Information Processing Problems in the Study of the Biosphere. The Ubsu-Nur Depression — A Natural Model of the Biosphere.	7
<b>BOTANY</b>	9
Characteristics of <i>Triticum vulgare</i> under space flight conditions.	9
Lipid peroxidation of plants at various hierarchical levels under exposure to microgravity.	11
The Force of Gravity in Processes of Plant Growth	15
<b>CARDIOVASCULAR AND RESPIRATORY SYSTEMS</b>	18
Reactive changes in the myocardium in response to low frequency subsonic oscillations.	18
Systemic and regional hemodynamics in alert rats during a 24-hour period of head-down tilt.	20
Changes in ultrastructure and actomyosin complex of cardiomyocytes in response to experimental hypergravity.	22
<b>DEVELOPMENTAL BIOLOGY</b>	24
Embryonic development of birds in weightlessness.	24
<b>EXO BIOLOGY</b>	26
On a possible mechanism of prebiotic synthesis of peptides.	26
<b>HABITABILITY AND ENVIRONMENT EFFECTS</b>	28
The effect of spaceflight factors on dynamics of human emission of trace contaminants.	28
<b>HEMATOLOGY</b>	29
The effect of epinephrine on activity of succinate dehydrogenase in functionally modified (lympholeukotic) lymphocytes of mice.	29
Cellular interaction and changes in the composition of leukocytes in peripheral blood of rats exposed to hypokinesia.	30
<b>HUMAN PERFORMANCE</b>	32
Study of resistance to interference of flight personnel from the standpoint of selection decisions.	32
Aviation Medicine and Ergonomic Aspects of the Human Factor in Civil Aviation: A Collection of Scientific Papers.	33

<b>MATHEMATICAL MODELING</b>	39
Determining duration and amplitudes of high level linear acceleration acceptable for human exposure.	39
Mathematical model of dynamics of the semicircular canals of the vestibular system in response to caloric stimulation in weightlessness.	40
<b>METABOLISM</b>	41
Level of glycogen and activity of enzymes of carbohydrate metabolism in the liver of rats in the readaptation period following a 20-day period of hypokinesia.	41
Metabolic parameters of a group of water-soluble vitamins during the readaptation period after long-term space flights.	42
Comparison of parameters of metabolism of water-soluble vitamins during a readaptation period after long-term space flight and hypokinesia with head-down tilt.	43
<b>MICROBIOLOGY</b>	44
Gravitational sensitivity of eukaryotic unicellular organisms.	44
Crystallization of neuraminidases of the flu virus on the Soviet Mir space station in June-September 1988.	46
Study of genetic characteristics and sensitivity to antibiotics of opportunistic microorganisms isolated in sealed environments.	48
Microbiocenosis of higher plants under conditions of space flight.	49
<b>MUSCULOSKELETAL SYSTEM</b>	51
Study of the state of bone tissue in monkeys flown on COSMOS-1887.	51
Morphology of skeletal muscles after long-term hypokinesia and laser acupuncture.	53
Use of the diphosphonate Xydiphon to correct posttraumatic regeneration of bone tissue during long-term hypodynamia.	55
<b>NEUROPHYSIOLOGY</b>	57
Vestibular function and sensory interaction after space flight.	57
The effect of weightlessness on vestibular function.	63
Antiepileptic drugs in complex pharmacological prevention of motion sickness.	68
The effect of whole-body low frequency vibration on the righting reflex, static endurance and structure of vestibular receptor organs in rats.	70
Gaze fixation in civil aviation pilots.	72
Structure and function of the semicircular canals.	73
<b>OPERATIONAL MEDICINE</b>	74
Early diagnosis of functional disorders of the cardiovascular and central nervous systems in seamen.	74
<b>REPRODUCTIVE BIOLOGY</b>	75
Hormonal reaction of the adrenal cortex of female primates to long-term hypokinesia.	75
<b>KEY WORD INDEX</b>	76

**USSR Space Life Sciences Digest: Issue 32 Reader Feedback Form**

To our readers: We are working in a large number of highly technical, specialized areas for which adequate Russian-English glossaries have yet to be compiled. We ask your help in improving the accuracy and specificity of our English terminology. Please fill out the form below whenever you encounter an incomprehensible, incongruous, awkward or otherwise inappropriate term. While we solicit all suggestions for improved renderings, the statement that a term is inappropriate provides us with useful information, even when no better alternative can be suggested. A copy of this form will appear in all future issues of the Digest. Thank you for your help.

Abstract Number rendering	Incorrect or inappropriate term	Suggested

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FROM THE EDITOR

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### PAPERS:

P1472(32/91)\* Sukhanov SG

***The role of photoperiodism in development of adaptive changes in the human endocrine system in the north.***

Fiziologiya Cheloveka.

17(3): 110-114; 1991.

[21 references; 5 in English]

Adaptation, Endocrinology, Biochemical Parameters of Blood

Humans, Males

Far North, Photoperiods, Seasonal Variation

**Abstract:** A total of 1000 apparently healthy men were studied in the far north, north of the polar circle. Subjects were either members of the aboriginal population, ethnically Russian natives of the region, or Russians born elsewhere. Radioimmune assay and biochemical methods were used to determine the following parameters in venous blood taken in the morning: level of corticotropin (ACTH), hydrocortisone (HC), thyrotropin (TTH), thyroxine-binding globulin (TBG), thyroxine ( $T_4$ ), triiodothyronine ( $T_3$ ), testosterone (TT), total lipids (TL), triglycerides (TG), and cholesterol. Levels of these substances were compared to the age norms and duration of daylight at the time blood was taken was noted. Data were subjected to a multifactor principal component analysis.

During the polar night, levels of HC and  $T_4$  were elevated in the immigrant population by 20-30 % and TT was depressed by 50% - 60% compared to control. The indigenous Russian and aboriginal population showed a much clearer process of reorientation with activation of the pituitary-adrenal cortex system during the period of maximum daylight and the pituitary-thyroid system during the polar night.

Principal component analysis revealed that in the indigenous populations hours of daylight showed high negative correlations with principal components. In the aboriginal group principal component 1 (accounting for 22% of the variance) included TTH, TT and hours of daylight. In the native Russian population component 3 (accounting for 11% of the variance) was composed of hours of daylight and TT.

The authors conclude that the functional systems that form in the Russian population during adaptation are different from analogous mechanisms in aborigines. Seasonal reorientation of hormonal patterns in the local Russian population externally resemble shifts in aborigines, but are achieved by different routes.

## ADAPTATION

Table: Blood levels of hormones in three groups of men during minimal (1) and maximal (2) hours of day light

Hormone and hours of daylight		Immigrants	Native Russians	Aborigines
ACTH, pg/ml	1	47.8	53.7	54.7
	2	38.6	36.5	31.6
HC, nmole/l	1	562.6	492.3	421.7*
	2	546.2	567.6	576.4
TTH, mUnit/l	1	2.28	3.45	2.50
	2	2.65	3.40	3.33
T <sub>4</sub> , nmole/l	1	109.8	121.6	125.4
	2	105.2	107.8	101.1
T <sub>3</sub> , nmole/l	1	1.84	2.22	2.72
	2	1.83	2.09	1.84
TT, nmole/l	1	11.7	16.5*	18.4
	2	10.8	21.0	18.3

\* within-group seasonal differences statistically significant,  $P < 0.05$

Figure 1: Changes in levels of hormones during the polar night and polar day in various groups of inhabitants of the far north

Figure 2: Structure of correlations of principal components in men of three groups

## ADAPTATION

P1473(32/91)\* Lupandin AV.

***Adaptation to natural and technogenic extreme factors in trained and untrained humans using adaptogens.***

Fiziologiya Cheloveka.

16(3): 114-119; 1990.

[24 references; 5 in English]

Author's affiliation: Institute of Physical Culture, Khabarovsk

Adaptation, Exercise Capacity, Human Performance, Cognitive Parameters

Humans, Males, Athletes, Females

Adaptogens, Tocopherol, Stress, Competition, Workload

**Abstract:** Subjects in this experiment consisted of a group of highly trained athletes (rowers) (n=62) and untrained soldiers engaging in physical exercise (n=58). Parameters studied were the specific power (W/kg) developed at a heart rate of 170 beats per minute in a PWC<sub>170</sub> test on a step-ergometer. The test was administered during an initial period and on days 1, 2, 4, 7, 14, and 21 during a course of adaptogens (preparations believed to facilitate adaptation) and in the athletes also after emotional stress induced by participation in a race. Adaptogens used were magnolia extract (2 g), Saparal (extract from the root of the Manchurian aralia plant) (200 mg), vitamin E (tocopherol) (100 mg), or their combination. A second experiment used as subjects female airline flight attendants adapted to work in an environment containing extreme technogenic factors after completion of long (7-9 hours) nonstop flights. These subjects were rated for visual memory, spatial perception and imaging, attention allocation and switching, and sensorimotor response to a moving object. Their heart rate and blood pressure were measured at rest, and a Romberg test administered 5 times. Subjects were tested during a baseline period and twice after a flight, first untreated and then after administration of 0.5 g magnolia extract or placebo. The study was performed during the spring and autumn.

In the first experiment, for trained subjects use of adaptogens increased power during exercise only after a 7-14-day period of repeated administration. Tocopherol enhanced the effects of adaptogens and this synergism increased with time. In untrained subjects, increase in power was observed during the first few days of the course of adaptogen and, after reaching a certain level, increased no further. Tocopherol did not have a synergistic effect on untrained subjects. The authors argue that the synergism of tocopherol and adaptogens in trained individuals may be associated with the antioxidant action of the polyphenol adaptogens - the lignans of magnolia and saponins of aralia. This is consistent with the fact that the effects develop only slowly in trained subjects. In untrained subjects, the immediate increase of performance associated with adaptogens is mainly associated with activation of the sympathetic adrenal system.

In the second experiment, in flight attendants, magnolia extract appeared to have a reliable effect only on visual memory and attention allocation and sharing and only in the spring. The authors argue that in exposure to technogenic extreme factors, the effect of polyphenol adaptogens is primarily realized through correction of regulatory systems optimizing behavioral adaptation and partly through their antioxidant action.

Table 1: Dynamics of power in trained subjects taking adaptogens

Table 2: Dynamics of power in trained and untrained subjects taking adaptogens

Table 3: Dynamics of functional parameters of the CNS in flight attendants after long flights after administration of magnolia extract

**MONOGRAPH:**

P181(32/91) Zakharyants Yu.Z. (editor)  
 Psikhofiziologicheskiye i Meditsinskiye Problemy Bezopasnosti Poletov, Психофизиологические и  
 Медицинские Проблемы Безопасности Полетов [*Psychophysiological and Medical Problems of  
 Flight Safety*].  
 Leningrad: Order of Lenin Academy of Civil Aviation; 1989.  
 [63 pages]

**Key Words:** Aviation Medicine, Flight Safety, Humans, Pilots, Psychology, Human Performance,  
 Cardiovascular and Respiratory System, Noise, Perception, Visual, Fatigue, Drugs, Group Dynamics

Paper summaries are provided in lieu of annotation and table of contents.

Kopanev VI. **Aviation medicine and flight safety.** [7 references]. This paper describes  
 theoretical and practical accomplishments of aviation medicine in improving flight safety. Particular  
 attention is devoted to the human factor in various type of flights.

Potiyevskiy BG, Pazoslov NA. **Means of improving expert evaluation of the  
 cardiorespiratory system in pilots.** [6 references]. Presents results of research seeking a  
 composite indicator of functional stress on the cardiorespiratory system in pilots. The proposed  
 method of qualitative evaluation — an index of cardiorespiratory stress — elevates the flight  
 certification examination to the level of modern science.

Yegorov VA, Frantsen BS. **Functional state and work capacity of pilots as factors in  
 performance reliability.** This paper describes experimental work that established that a pilot's  
 work capacity can be used as a parameter of reliability of crew performance. Particular attention is  
 given to a comprehensive approach to evaluating work capacity.

Latenin KN, Beskorovyniy V.D. **The effect of noise on members of training crews while  
 piloting helicopters and before take-off.** [12 references] Reviews material from research on  
 the negative effects of helicopter noise on members of training crews. Recommendations are given to  
 decrease the perceived level of sound pressure.

Zakharyants Yu.Z., Kurpyakov VF, Nikulin NF, Tokarev VF. **Mental rehearsal of a flight as a  
 factor increasing the psychophysiological and professional flight readiness of a crew.**  
 [1 figure; 14 references] This paper describes theoretical and practical developments indicating that  
 mental rehearsal of a flight improves psychological and professional flight readiness of crewmembers.

Voytenko AM, Ishutin VN. **Change in certain visual functions in operators during a  
 simulation of a flight across several time zones.** [1 table; 5 references] Results are cited  
 from the study of changes in certain visual functions in operators participating in simulations of  
 inter-time zone flight from west to east with displacement of the "sleep-wakefulness" cycle by 9  
 hours.

Bodachenko TP, Yustova VD. **Study of professional performance of pilots on night flights,**  
 [1 table; 6 references]. As a result of analysis of experimental data it was established that after night  
 flights the quality of analysis of instrument readings decreases in aircraft commanders and fatigue  
 develops.

V.Yu. Cheprasov, Ishutin VN. **Study of experience using contrasting temperature  
 stimulation on pilots,** [1 figure; 6 references] Data is cited attesting to the high effectiveness of  
 the use of stimulation with contrasting temperatures for eliminating symptoms of fatigue and  
 improving functional state and job performance of pilots after difficult flights.

Blagin, A.A., Alekseyev AA, Stepanchuk V.P. **Dynamics of nervous system parameters after pharmacological correction of operator performance under extreme conditions.** [9 references] Because correction of functional state is a critical problem, the authors undertook a study of the potential for pharmacological correction with operators. Results of the study showed that the most effective correction is obtained through the use of Pyracetame, a cyclic analog of GABA and activator of RNA polymerases.

Laletin K.N. **The atmosphere of working environments of the crews of heavy helicopters.** [12 references]. This paper reviews published material on the effect of ecological factors on operators of aircraft and describes the working environment of crews of various helicopters.

Akimov S.N. **Reactions of the cardiovascular system to day and night flights during various period of flight activity.** [2 tables]. It is shown that during flight activity, fatigue and exhaustion can occur, accompanied by feelings of malaise in pilots, changes in their EKGs, and impairments of myocardial metabolism. The signs of cardiac pathology detected were confirmed by measurement of a number of biochemical parameters in blood serum and daily urine in response to a loading test.

Sokolov VA. **Systems evaluation of pilot job performance.** [1 table; 2 references]. To evaluate the efficiency of pilot performance the author proposed a coefficient of efficiency computed from parameters of productivity and stress index. The coefficient is used for the comparative analysis of a set of measures to decrease fatigue and neuroemotional stress of flight personnel, including central electroanalgesia, physical exercise, and automassage of biologically active points.

Mokrov A.Yu. **Distortion of conceptual thought in pilots in emergency situations.** This paper analyzes instances of the disorganizing effects of emergency situations on the cognitive performance of pilots. It is noted that the consequence of distortion of conceptual thought may include impairment not only of cognitive skills, but also of other psychological processes.

Perevoznikov N.A. **Psychosocial climate of flight crews as a management factor.** [1 table; 11 references]. It is shown that in work groups with good psychosocial climate the number of commendations are significantly greater than the number of demerits.

**PAPER:**

P1476(32/91) Galichiy VA.

***Chronobiological (biorhythmic) approaches to study of functional asymmetry in balance and spatial orientation systems.***

Fiziologiya Cheloveka.

17(2): 17-23; 1991.

[18 references; 2 in English]

Author's Affiliation: Institute of Biomedical Problems, Moscow

Biological Rhythms, Diurnal Dynamics

Humans, Males

Musculoskeletal System, Neurophysiology, Perception, Balance, Spatial Orientation, Asymmetry, Acceleration Tolerance

**Abstract:** Subjects in this experiment were three healthy males aged 20-21. In a room with twilight lighting making it possible to see the outline of objects, a subject initially assumed a sitting position on a couch. While the subject was in this position a visual after-image was formed by a short-duration (1/100 sec) vertical flash of light 40 cm from his face. Then he closed his eyes and slowly lowered himself to his left side. After 30 seconds had passed he was told to open his eyes and position a vertical marker (a black linear indicator /hand/ on a white disk) to correspond to the after-image. The indicator device was constructed to allow the experimenter to determine deviation of the marker from the horizontal. After the experimenter had recorded the deviation, the subject closed his eyes and after a short pause again set the indicator. After 3-5 repetitions the results were averaged. If the visual after image was still clear, the analogous procedure was repeated with the subject lying on his right side. If not the electric light was turned on and then the entire procedure was repeated for the right side. Three to five sessions with each subject occurred during the morning (9:35-10:35), afternoon (13:40-15:50), evening (19:45-20:45) and night (3:30-3:55) over a period of several days. In one subject the scope of the experiment was curtailed somewhat due to headache. After completion of the described procedures, a subject was tested for tolerance of intermittent cumulative Coriolis acceleration. The test involved a session of rotation (1 revolution every 2 seconds) in sitting position, first to the left (1 minute) then, after a minute's pause, for 1 minute to the right, etc. During rotation, a subject nodded his head and body and then straightened up. Each subject was tested twice: once in the morning and once at night. The morning test was performed first and the night one followed at an interval of 3-4 days.

Two subjects showed a tendency for left dominance in the visual estimation tests, that is deviation of the indicator from the horizontal was greater when subject lay on his left side than on his right. The remaining subject showed a tendency to right dominance. The subject with right dominance showed a higher tolerance of acceleration than those with left dominance, confirming previous data using different methodologies. In the subjects with left dominance, asymmetry was greater during the night and in the subject with right dominance asymmetry was greater during the day.

Figure 1: Dynamics of individual values of deviation of indicator from horizontal on different test days

Figure 2: Average curves for each individual of diurnal dynamics of values of deviation of indicator from horizontal

Figure 3: Mean group curves of diurnal dynamics of deviation of indicator from horizontal and derived asymmetry parameter

**MONOGRAPH:**

M179(32/91) Voronov AA, Kefeli VI, Bugrovskiy VV (editors)  
 Informatsionnyye problemy izucheniya biosfery. Ubsunurskaya kotlovina - Prirodnaya model biosfery; Информационные проблемы изучения биосферы. Убсунурская котловина - Природная модель биосферы.

**[Information Processing Problems in the Study of the Biosphere. The Ubsu-Nur Depression — A Natural Model of the Biosphere.]**

Pushchino: Scientific Center for Biological Research, USSR Academy of Sciences; 1990.

[over 300 pages]

Affiliation: Pushchino: Scientific Center for Biological Research, USSR Academy of Sciences.

Biosphere, Remote Sensing Data, Composite Indicators  
 Mathematical Modeling  
 Ecosystems, Ubsu-Nur Depression, Anthropogenic Changes

Annotation: This collection is the second in a series of scientific works written by participants in the "Biosfera" and the "Ubsu-Nur" joint Soviet-Mongolian research programs. The goal of these programs was to identify composite indicators for evaluating the state of the natural ecosystem and their changes in response to natural and anthropogenic factors on the basis of remote sensing information from space, mathematical modeling, and ground measurements.

At this stage of the research, attention has been focused on developing methods for obtaining, processing, and storing remote sensing data from space, as well as methods of ground-based measurements supporting space results, the use of the most advanced technological development (artificial satellites, powerful computers) for biospheric research, and rational natural resource utilization. Some papers are devoted to development of quantitative composite indicators reflecting the state of natural ecosystems.

Material in the collection will be of interest to a wide range of scientists working in the areas of ecology, bioecology, mathematical modeling of natural processes, environmental conservation, and rational natural resource management.

CONTENTS

Introduction: Bugrovskiy VV. The Ubsu-Nur Depression: A natural biospheric laboratory (5)

SECTION I. MATHEMATICAL MODELING OF NATURAL SYSTEMS AND PROCESSING OF REMOTE SENSING IMAGES FROM SPACE

Vosotokova YeA. Identification of anthropogenic changes in mountain forests using remote sensing photographs from space (9)

Gan-Ochir Zh, Ganzoriy M, Galsan P. Some features of the geological structures in the vicinity of the Ubsu-Nur basin (based on interpretation of space photographs) (22)

Khrutskiy VS. Principles for classifying vegetation of the pastures of Central Asia as applied to the use of photographic information from space (30)

Bugrovskiy VV, Dmitriyev EV. A computer algorithm for route? selection (46)

Dubovskikh VM. Automated data origination for a geographical data bank (51)

Deyeva VM, Ilyina AA, Khakimov FI. Characteristics of the formation of soil cover of the Ubsu-Nur Depression linked with the structure of the Earth's surface (65)

Bugrovskiy VV, Butusov OB, Lozovskaya LA, Mikhaylenko YeV. Quasi-two-dimensional mathematical modeling of atmospheric circulation in the Ubsu-Nur Depression (77)

Bokshteyn IM, Matveyeva YeK, Smirnova YeV. Automated processing of mid-range space photographs of the Ubsu-Nur Depression for the purpose of thematic cartography (87)

Dmitriyev EV, Saandar M. Supporting network of aerospace polygons of the Mongolian People's Republic for developing standards for aggregate cartography (98)

Gilmanov TG. Mathematical modeling of ecosystems of the dry and desertified steppes of the Ubsu-Nur depressions. I. General structure and description of the "Vegetation" module (106)

Mongush K. Ch-D, Polulyaz YuG, Tebleyeva UTs. The natural resource management information processing center of the Tubinsk Autonomous Republic (137)

Kerzhentsev AS, Kuznetsova YeV. Model of transformation of organic substances in soil (152)

Gorshkova AA, Mongush LT. Geobotanical characteristics of the desertified steppes of the Ubsu-Nur Depression in the Tuvinsk Autonomous Republic (158)

Orlov VI, Sokolova NV. Classification of the interaction of components of nature for the purposes of ecology, taking account of the nature of movement of substances of the Earth's surface (164)

## SECTION II. GROUND STUDIES AND BIOGEOCENTOTIC DESCRIPTIONS OF NATURAL SYSTEMS

Gorshkova AA. Development of productivity by the steppe communities of Central Tuva (184)

Golubeva Yel, Polyanskaya AV. Pasture digression? of the vegetation of the Ubsu-Nur Depression steppes (201)

Pivovarov ZhF, Stebayev IV. Principles of full-scale modeling in the Ubsu-nur Depression of Tuva using the example of monadnocks (212)

Malgin MA, Puzanov AV. The status of trace elements in the northeastern portion of the Ubsu-Nur Depression (243)

Oreshkin VN, Khakimov FI, Kuzmenkova VS, Kurbatskaya SS, Deyeva NF, Ilyina AA, Guryeva SN. Distribution of heavy metals in the soil of morphological structures of the Ubsu-Nur Depression (260)

Kurbatskaya SS, Fedorov KN. Zonal provincial characteristics of the micromorphology of grassland swamp soils of the Ubsu-Nur Depression (279)

Shilkort GS, Kretova SP, Smirnova YeV. The ecosystems of Lake Ubsu-Nur - potential and water quality (286)

Surov AV, Vasilyeva NYu, Telitsyna AYu. Ecological communities of rodents of the northeastern Ubsu-Nur Depression (315)

Nazarova YuS. Some characteristics of the group of *Conophagidae* in the larch forests of the southwest slopes of the Snagilen highlands (323)

## PAPERS:

P1465(32/91)\* Mashinskiy AL, Alekhina TP, Bozhko AN, Derendyayva TA, Ivanovna IYe, Nechitaylo GS, Rummyantseva VB, Chernova LS.

***Characteristics of Triticum vulgare under space flight conditions.***

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

25(1): 39-42; 1991.

[22 references; 4 in English]

Botany, Development, Microbiology, Pigments, Minerals

Wheat

Space Flight, Mir

Abstract: The goal of this experiment was study of initial phases of development (until appearance of the third leaf) of wheat plants on the space station Mir. The experiment was performed in the "Svetoblok-M" unit with fluorescent light providing 30-40 W/m<sup>2</sup> photosynthetically active radiation as a function of plant height. The cultivation substrate was a fabric form of the "Bion-B-2" ionite substrate. Wheat of the "Eritrospermum-84" variety was used. At the landing site, samples were taken and placed in sterile tubes for microbiological analyses, plants were measured, and plant material was fixed for biochemical analysis. Microbiological analyses were performed of the surface of the plants, and rhizosphere (substrate in the vicinity of the plant roots). Koch's plate assay method with meat peptone agar was used to measure microbial contamination. Specific groups of microorganisms were studied on selective media using standard methods. The portions of the wheat biomass remaining after samples were taken were subjected to wet assay. Levels of nitrogen, phosphorus, potassium, calcium, magnesium, iron, zinc, copper, and manganese were measured. Total lipids and pigments were extracted from the plant tissue. Measurement of pigments (chlorophylls and carotenoids) was performed spectrophotometrically. Activity of volatile phytocides of the wheat plants was studied using an Infusorium (*Paramecium candidum*) test system and modified classical methodology. Paramecia were placed in a hanging drop on a cover glass at the bottom of a glass cylindrical chamber. The time at which the cell became immobile was noted.

The biometric parameters presented in Table 1 show significant delay in wheat development in space. Analysis of mineral components of the biomass showed significant changes in delivery of ions to root cells. Flight plants contained more nitrogen and phosphorus and significantly less calcium and manganese than control plants. These data do not agree with data obtained on plants flown on Salyut. Flight plants contained less chlorophyll and carotenoid. Changes in the composition of membrane lipids and pigments suggested that space flight factors stimulate free radical processes of destruction of lipids and pigments of plants and that this damages their photosynthetic apparatus in a way similar to chlorosis.

Phytocidal activity of flight plants was diminished and this was confirmed by microbiological analyses. Bacterial contamination of leaf surfaces was found to be an order of magnitude higher in flight plants, while that of the roots was equivalent to controls. The number of fungi and cellulose-lysing bacteria on the roots of flight plants exceeded that of the control by 1-3 orders of magnitude. *E. coli* were found only in flight plants.

Table 1: Biometric characteristics of wheat plants

Parameter	Control	Flight
Mean plant height, cm	39.9±2.51	17.5±3.64
Dry biomass of one plant, g	0.033	0.017
Leaf area of one plant, cm <sup>2</sup>	9.10	3.52

Table 2: Levels of mineral nutrients in wheat plants (in mg per 1 g dry weight)

Element	Control	Flight	Flight:Control, %
Nitrogen	40.0±2.3	56.0±5.2	140.0
Phosphorus	7.5±0.33	12.0±0.5	160.0
Potassium	68.0±4.2	62.5±3.4	91.9
Calcium	2.5±0.2	0.5±0.02	20.0
Magnesium	2.25±0.1	2.0±0.1	88.8
Iron	2.55±0.2	2.72±0.1	106.6
Trace elements:			
Manganese	0.075±0.04	0.05±0.02	66.6
Copper	0.075±0.02	0.075±0.03	100.0
Zinc	0.225±0.1	0.255±0.01	100.0 (sic.)

P1475(32/91) Baraboy VA, Zhalko SI, Kordyum YeL, Sidorenko PG.

***Lipid peroxidation of plants at various hierarchical levels under exposure to microgravity.***

Izvestiya Akademii Nauk SSSR: Seriya Biologicheskaya

1991(3): 368-375.

[21 references; 1 in English]

Authors' affiliation: N.G. Kholodnyj Institute of Botany, Ukrainian Academy of Sciences, Kiev

Botany, Microbiology, Metabolism, Lipid Peroxidation, Antioxidant Protection

*Chlorella*, *Haplopappus*, Peas, Wheat

Space Flight, COSMOS-1887, Bion 9, Mir, Salyut, Clinostatting

**Abstract:** The goal of this work was to study the dynamics of components of equilibrium between lipid peroxidation and biological antioxidant protection in cells of plants at different hierarchical levels exposed to microgravity in space flight or to clinostatting, which partially replicates the biological effects of microgravity. Subjects included the one-celled green alga *Chlorella vulgaris*, a culture of *Haplopappus gracilis*, and also pea (*Pisum sativum*) and wheat (*Triticum aestivum*) seedlings. The roots were the objects of study in the seedlings. *Chlorella* and tissue cultures were grown on solid media. Pea seeds and wheat grains were germinated on filtered paper in a moist chamber at a temperature of 24°C. *Chlorella* and *Haplopappus* tissue cultures were 8-11 days old; 2-4 days had elapsed from the moistening of the pea and wheat sprouts. Pea plants and *Chlorella* and *Haplopappus* were grown on horizontal clinostats revolving at a rate of 2 revolutions/minute for 0.25, 0.5, 1, 3, 6, 12, 24, hours and, 3, 5, 7, 9, 12, 14, and 21 days. Each condition was replicated 4-7 times. Space experiments with *Haplopappus* and wheat were performed on the COSMOS-1887 and Bion 9 biosatellites and space stations Mir and Salyut for 2, 9, 13, and 28-day flights, respectively. *Haplopappus* cultures were grown in Petri dishes. After landing, the plants were maintained in thermostatic conditions (2-3°C) during transport to the laboratory.

Rate of spontaneous chemiluminescence (SCL) was measured in a chemiluminometer in impulses 1 second in duration. When SCL could not be recorded, the signal was amplified with luminol and luminol-dependent chemiluminescence (CL) was measured. Levels of lipid peroxidation products were measured with 2-thiobarbituric acid (TBA), and lipofluorescent compounds, antioxidant activity, and amount of protein were also measured. Results were processed statistically using *t*-tests and analysis of variance.

Results show that the various subjects differed considerably in parameters of lipid peroxidation and antioxidant activity when grown under stationary conditions. Clinostatting of *Chlorella* for 24 hours or less led to only insignificant changes in parameters studied. After 3 days of clinostatting, luminol-dependent CL decreased by 19%. In *Haplopappus* cultures, luminol-dependent CL decreased reliably (by 12%) after 6 hours and level of TBA-active product decreased by 11% after 24 hours. On day 3 decrease in luminol-dependent CL was 29%, and levels of TBA-active product and antioxidant activity were depressed by 8-10%. In 2-day old pea seedlings after 24 hours, there were significant decreases in TBA-active products (by 30%) and SCL (by 24%), while antioxidant activity exceeded control by 11%. In the roots of 4-day old seedlings there was a significant decrease in SCL (by 21%) after 0.5-1 hour of clinostatting, which was maintained at 24 hours. Other parameters were less sensitive: decrease (by 12%) in TBA-active products was detected only after 24 hours; at this period antioxidant activity was above control level. After 3 days of clinostatting, SCL and TBA-active products exceeded control values, while antioxidant activity was depressed. Evidently, since TBA-active products are the final products of a long chain of lipid peroxidation, they accumulate more slowly than rate of change in SCL. Thus SCL produces more immediate and accurate information concerning the equilibrium of lipid peroxidation and biological antioxidant activity.

Thus under short-term exposure to clinostatting, *Chlorella*, *Haplopappus* cultures and roots of pea seedlings displayed oscillating changes in lipid peroxidation  $\longleftrightarrow$  biological antioxidant activity equilibrium, eventually stabilizing at a depressed level of lipid peroxidation and activation of antioxidant activity. The stabilized period in pea was followed by activation of lipid peroxidation and depressed antioxidant activity. The rapidity and amplitude of changes was greatest for plants higher up in the hierarchy and those with increased capacity to induce lipid peroxidation. The oscillation in early changes are due to reactive activation of antioxidant activity in response to initial induction of lipid peroxidation. Increase in speed and amplitude of the response with increases in phylogenetic level represent enhancement of the stress response of plants to clinostatting. However, this should be considered to be only the early stage of the stress reaction.

Between 3-14 days of clinostatting, *Haplopappus* cultures displayed some stabilization of lipid peroxidation rate (at 15-20% below control, while antioxidant activity was elevated by 14%). After 14 days, rate of lipid peroxidation increased and by day 21 it exceeded control level (by 19-21%). Antioxidant activity decreased during this period (by 13-15%), which may be considered a result of exhaustion of the antioxidant system. When pea seedlings were clinostatted for 7 and 12 days there were significant increases in SCL, luminol-dependent CL, and TBA-active products by 7, 16, and 23%, respectively, on day 7; and by 79, 68, and 54 % on day 12. During this period antioxidant activity decreased gradually.

The authors argue that the *Haplopappus* culture and pea seedling roots show three phases of the stress reaction. In phase one (days 0-3 for *Haplopappus*, and hours 0-1 for pea) there is a significant decrease in the process of lipid peroxidation due to activation of antioxidant activity. The primary mediator of antioxidant activation are products of peroxidation forming during the initial spurt of lipid peroxidation in response to the stress agent. The methodology of the experiment did not permit identification of this initial spurt. Phase 2 (days 3-14 for *Haplopappus*, and hours 1-24 for peas) was marked by stabilization of equilibrium between lipid peroxidation and biological antioxidant activity at a level close to control, with slight dominance of antioxidant activity. This period can be considered to be a state of heightened resistance of plants to clinostatting. During phase 3 (days 14-21 for *Haplopappus*, and day 1-3 for peas), as the reserve capacities of the antioxidant system are exhausted, there is a second induction of lipid peroxidation. The substrate here is evidently free polyene fatty acids, which increase during phase 2.

*Haplopappus* cultures exposed to space for 9, 13, 14 and 28 days showed a tendency to increased lipid peroxidation, which was most extreme after the 9- and 14- day exposures (accompanied by increases in TBA-active products). At the same time the levels of final products of lipid peroxidation - lipofluorescent compounds — increased sharply. This parameter increased in all spaceflight experiments. Experiments with wheat plants flown in space for 2, 9, and 14 days showed more fluctuations in lipid peroxidation. During a 2-day flight, level of TBA-active products decreased by 51% and during 9- and 14-day flights increased to exceed the control by 30 and 40%, respectively. Therefore it may be assumed that microgravity induces in plants oscillations in the rate of lipid peroxidation analogous to those in clinostatting, but more extreme in magnitude and with more rapid alternation of phases of stress response. The stable accumulation of lipofluorescent compounds reflects a tendency for cell aging to accelerate.

Table 1: Intensity of spontaneous chemiluminescence (SCL), level of thiobarbituric acid active products (TBAAP) and antioxidant activity (AOA) in plants in stationary conditions of growth

Subject	SCL		TBAAP		AO	
	imp/sec/g	tissue	nmole/g	tissue	mequiv/g	tissue
<i>Chlorella</i> culture						
8-10 day	Not detected		0.192±0.20		0.454±0.039	
<i>Haplopappus</i> tissue culture						
8-18 days	Not detected		10.43±0.91		0.294±0.032	
22-28	12.33±0.93		12.09±1.03		0.279±0.021	
Pea seedling roots						
2-6 days	503.10±48.3		171.20±14.2		0.731±0.059	
7-13 days	552.70±43.7		179.98±16.3		0.707±0.061	

Table 2: Rate of SCL, level of TBAAP and lipofluorescence in cells of *Haplopappus* tissue culture in space flights

Flight duration, days	SCL		TBAAP		AO	
	imp/sec/g	tissue	nmole/g	tissue	mequiv/g	tissue
	control	flight	control	flight	control	flight
9 (Salyut-6)	- -	- - -	11.91±0.9	22.4±1.9	100±8	130±11
13 (COSMOS 1887)	18.5±1.7	20.4±1.2	12.40±1.1	15.5±1.3	100±12	136±9
14 (Bion 9)	22.1±1.8	27.3±2.3	12.02±0.8	19.76±1.6	100±9	120±11
28 (Mir)	- - -	- - -	12.51±0.9	8.9±0.5	100±11	141±18

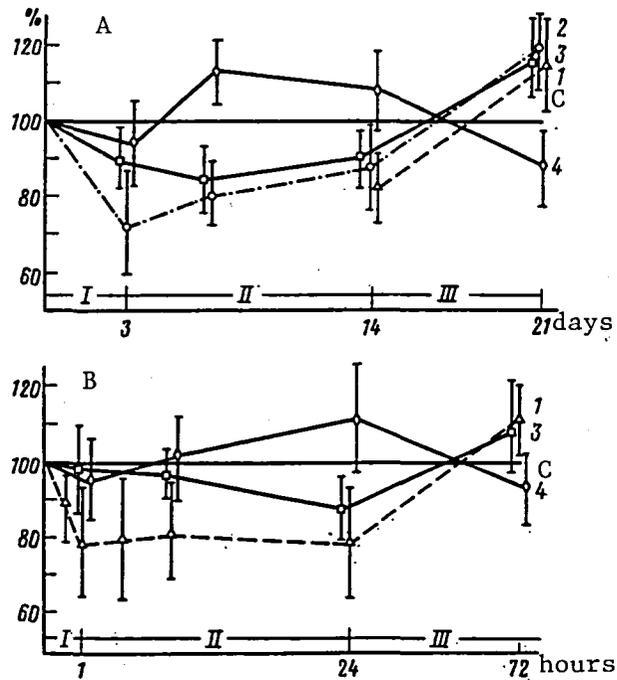


Figure: Phases of gravitational stress in cell of a *Haplopappus* tissue culture (A) and roots of pea seedlings (B) during clinostatting at 2 rev/min: I - phase of mobilization of antioxidant reserves; II - phase of relative stabilization of lipid peroxidation - biological antioxidation activity equilibrium; III - phase of secondary activation of lipid peroxidation; 1 - spontaneous chemiluminescence; 2 - luminol-dependent chemiluminescence, 3 - thiobarbituric acid active products; 4 - antioxidant activity; C- control. Ordinate: spontaneous and luminol-dependent chemiluminescence, TBA-active products, antioxidant activity in percent of control.

**MONOGRAPH:**

M180(32/91)\* Merkis Al.

Sila Tyazhesti v Protsessax Rosta Rastenii; Сила Тяжести в Процессах Роста Растении; [*The Force of Gravity in Processes of Plant Growth*]. Volume 68 in Series Problemy Kosmicheskoy Biologii; Проблемы Космической Биологии  
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[185 pages; 12 Tables; 50 figures; 439 references]

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**Key Words:** Botany, Gravity, Plant Growth, Space Flight, Gravitropism, Phylogeny, Ontogeny, *Arabidopsis*

**Annotation:** This monograph reviews published and original experimental data on the effects of gravity on the growth processes of plants, emphasizing the gravitropic response of plants. Data from plant experiments in microgravity on space stations and biosatellites are reviewed. The book is intended for biologists, physiologists, and medical personnel.

Contents

Foreword (5)

Chapter 1: The origin of plant response to the Earth's gravity (7)

The role of the factor of weight in early biological evolution (9)

The appearance of a response to the Earth's gravity during the process of eukaryote phylogeny (13)

The response of the plant stem to the Earth's gravity (22)

The formation of roots and the origins of response to gravity (27)

Chapter 2. Methodological principles in the study of the effects of gravity on the growth and spatial orientation of plants (31)

Experiments of T.A. Knight (31)

Threshold values of a stimulus (34)

Amount of stimulation (37)

Clinostats and their use (37)

Use of space vehicles (45)

Gravitropic stimulation. The Nemets-Haberlandt theory (52)

Gravitropic induction. The Kholodnyy-Went theory (66)

Molecular principles of organization of gravitropic movements (70)

Gravitropic movement of plants, the significance of IAA

Electrochemical gradient of cells and tissues (88)

Reasons for the occurrence of REP? (93)

Physiology of the gravitropic reaction. General concepts (101)

The functions of IAA in the gravitropic reaction (109)

The effect of IAA on the synthesis of protein and generation of bioelectric potentials (120)

Gravitropism and growth of cell walls (124)

On the dependence of growth on gravitropism (137)

Chapter 3. The growth and development of plants under conditions of altered gravity (141)

The growth and development of plants on a clinostat (142)

Study of the growth and development of plants in a field of centrifugal force (149)

The growth of isolated cells and tissues (153)

The growth of integrated plants (156)

Conclusion (163)

References (169)

### CONCLUSION

This monograph is a continuation of previously published work (1973, 1982). It develops ideas presented in these earlier works, retaining the major theoretical thrust of the research, with only minor changes in the subjects we studied.

In essence, in this work we attempted to determine at what point in phylogeny the system that responds to the Earth's gravity arose. This property manifested itself very early and is already established in eukaryotic fungi and algae. It is possible that there were pre-eukaryotes unknown to us that transmitted this property (response to the Earth's gravity) to the eukaryotes.

With regard to the significance and mechanisms of gravitropic stimulation, we adopted the Nemets-Haberlandt theory, that special tissue cells with their inclusions — amyloplasts, and in some cases barium sulfate derivatives — are responsible for the stimulation that occurs when the axial organs of the plants (stems or roots) deviate from the vertical axis. Under conditions of microgravity, it has been established that the threshold value of gravitropic stimulation is about  $1.5 \times 10^{-3}$  g for stems and approximately  $2.9 \times 10^{-4}$  g for roots.

It has been established that apical organs of plants do not grow strictly vertically. The earlier a deviation from vertical occurs, the more rapidly is the growth vector rectified to accord with the vector of the Earth's gravity. A perfect "error-correction" system is a great achievement of phylogeny, establishing the optimal positions of the organs in space during the growth process.

The gravitropic stimulation induces a reaction. The nature of gravitropic stimulation and gravitropic induction has been studied only superficially. Only the following facts have been well-established: gravitropic induction determines the polarization of growth processes in the lateral direction of axial organs. Activation of growth of sites at opposite sides of the shoot and root begins only if the system contains auxin-IAA. This is the final, motor, phase of the gravitropic reaction.

In plant growth physiology the focus has been on explaining the initial effects of hormones. This problem in actuality is derived from the study of tropic movements of plants.

In the early 1960s we formulated the view that the initial action of the phytohormone IAA occurs on induction or modification of protein synthesis during transcription. This view was justified using the example of the gravitropic reaction. More IAA is transported to one side of a gravitropically induced stem or other axial organ. This IAA combines with a special protein-receptor in the plasmalemma. This complex is transported to the nucleus where it acts on chromatin so that no fewer than two proteins — one long and one short-lived — are formed. Only in the presence of both proteins is activation of growth by stretching possible.

Through experiments in microgravity it was established that there is no direct connection between the appearance of the gravitropic reaction and growth. However, in the gravitropically induced axial organ, the same systems of growth are used in sequence, one of which ends with the motor phase of the reaction.

Understanding of the gravitropic reaction led to the formulation of new questions. Can plants grow in weightlessness? Is the force of gravity an essential ecological prerequisite for their growth, morphogenesis, and generative development?

## BOTANY

Using biosatellites and manned spacecraft, which create a microgravity environment, it was established that microgravity (it is assumed that the gravity that exists is below the threshold stimulation value) does not have a significant effect on vegetative growth and morphogenesis.

Tissues, the hypocotyl of the *Arabidopsis*, for example, may dedifferentiate in microgravity in a special nutrient medium, after which new tissues are formed. In a carrot cell culture growing in microgravity completely viable embryos can form. That new tissues and organs can form under conditions of microgravity has been demonstrated with whole plants (peas, barley, *Arabidopsis*, and others).

For a considerable period we had no answer to the question of whether plants can progress through the entire process of ontogeny [in space] — from seeds to the generation of new, biologically viable seeds. Experiments performed with *Arabidopsis* in the Fiton-3 device in an agarized nutrient medium at illumination of 7000 lx showed that 69 days of exposure to microgravity on the Salyut-7 station did not impede the progress of the plants throughout the entire course of their growth and development, i.e., from the formation of formative organs to fully viable seeds. However, we still do not have the final answer to whether the force of gravity has a significant effect on growth processes. This is because the seeds sown in space may carry in their "memories" the effect of the Earth's gravity on seed formation.

PAPERS:

P1470(32/91)\* Alekseyev SV, Glinchikov VV, Nekhoroshev AS.

***Reactive changes in the myocardium in response to low frequency subsonic oscillations.***

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

25(1): 49-51; 1991.

[5 references; none in English]

Cardiovascular and Respiratory System, Microcirculatory Tract, Myocardium  
Rats, Guinea Pigs  
Subsonic Sound Waves

**Abstract:** The goal of this work was to study the effects of sound waves of subsonic frequency on the microcirculatory system of the myocardium and cardiomyocytes. A special device was used, consisting of a generator of subsonic sound waves and an isolation chamber. The device could generate sound waves with frequency between 0.5 and 50 Hz and sound pressure of up to 150 dB. Experiments were performed on guinea pigs and male white rats. The animals were subjected to subsonic sound waves at frequencies of 8 and 16 Hz for 3 hours daily. Sound pressure was 90-145 dB. Ten animals each were exposed to the waves for periods of 3 hours, 5, 10, 15, 25, and 40 days and were then decapitated. Samples of the myocardium were prepared for light and electron microscopy.

Changes in the myocardium could be seen with an optical microscope even after one 3-hour exposure to the subsonic sound waves. Light microscopy revealed areas of disrupted circulation, localized particularly in the apex of the heart: widening and hyperemia of capillaries, localized bleeding around veins, swelling of the endothelium of the capillaries and narrowing of their lumens. Areas with disrupted circulation and venous engorgement, also displayed edema of the stromata and swelling of collagen fibers. Muscle fibers stained intensely with eosin and picric acid; transverse striations were weak or absent, distances between A bands were shortened or the bands fused forming anisotropic areas. After 10 and 15 days of exposure, changes were similarly localized in the apex of the heart, but were more severe than after one exposure. Blood flowed from the vessels into surrounding connective tissue and there was marked edema of stromata and permeation of muscle fibers by plasma. The lumens of small arterial vessels contained coagulated protein, and the capillaries showed erythrocyte and leukocyte stasis. Nuclei with altered muscle cells sometimes were displaced to the cell periphery and became pyknotic. The most severe changes occurred with sound level of 140 dB. After 25 and 40 days of exposure, in addition to the changes noted, there were signs of granular dystrophy of the cardiomyocytes.

Electron microscopy revealed polymorphous changes after a single 3-hour exposure, especially in protofibrils. Myofibril zones showed excessive contraction and areas of lysis and fragmentation. As duration of exposure increased to 5, 10, and 15 days, there were increased signs of over-contraction of sarcomeres, separation of myofibrils and myofilaments, lysis and fragmentation of myofibrils, and also changes in the mitochondria. Lipid drops and granules of lipofuscin accumulated around polymorphic mitochondria. The cisternae of the sarcoplasmic reticulum were widened in places and contained lightened areas. Amount of ribosome increased. Glycogen was diminished or even absent in the cells. There were cells with deformed nuclei and polymorphous hypertrophied mitochondria. Some cardiomyocytes displayed signs of both hypertrophy and disintegration. Such changes progressed as duration of exposure to subsonic sound waves increased, and more and additional groups of cells began to be involved. Changes in the mitochondria increased in severity and elements of the T-system and the membrane of the sarcoplasmic reticulum and sarcolemma disintegrated; intercalated discs underwent vacuolization. In summary exposure to subsonic sound waves at 8 and 16 Hz led to severe

## CARDIOVASCULAR AND RESPIRATORY SYSTEMS

microcirculatory disorders combined with destructive-dystrophic changes in cardiomyocytes. There were no differences in responses of guinea pig and white rats. Severity of changes was a direct function of duration of exposure.

Figure 1: Changes in the myocardium after a 3-hour exposure to subsonic sound waves at a frequency of 8 Hz at sound pressure of 110 dB: edema of myocardial stromata, stasis of erythrocytes in capillaries, granular dystrophy of cardiomyocytes

Figure 2: Reaction of the myocardium on day 10 of exposure to subsonic sound waves at frequency of 8 Hz and sound pressure of 140 dB: severe granular dystrophy of cardiomyocytes, patchy contracture, stasis of erythrocytes in capillaries.

Figure 3: Ultrastructure of cardiomyocytes damaged by subsonic sound waves at a frequency of 8 Hz with level of sound pressure of 120 dB: Destruction of myofilaments, destruction of mitochondria (5 days of daily 3-hour exposure)

Figure 4: Intracellular regeneration of a cardiomyocyte after exposure to subsonic sound waves at 8 Hz and sound pressure of 120 dB (exposure duration 40 days): neoformation of mitochondria, neoformation of myofilaments.

P1477(32/91) Bychkova YeYu, Martynova YeR, Medvedev OS, Krotov VP, Meyertsuk FYe.  
***Systemic and regional hemodynamics in alert rats during a 24 hour period of head-down tilt.***

Byulleten' Eksperimental'noy Biologii i Meditsina.

119(1):20-23; 1990.

[7 references; 2 in English]

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Cardiovascular and Respiratory System, Hemodynamics, Systemic, Regional  
 Rats  
 Head-Down Tilt

**Abstract:** The goal of this work was to study the dynamics of cardiac output and its redistribution among organs during a 24-hour period of head-down tilt. Polyethylene catheters were implanted in the left ventricles of male Wistar rats through the carotid artery and in the abdominal aorta through the femoral artery. The ends of the catheters were fixed on the animals backs. The experiment began 48 hours after implantation. The animals were suspended by their tails at an angle of 30° to the horizontal. Blood flow was measured in 23 areas of the body using microspheres 15 μm in diameter labelled with <sup>57</sup>Co, <sup>46</sup>Sc, <sup>113</sup>Sn, or <sup>85</sup>Sr. Each administration introduced approximately 100,000 microspheres suspended in a saline solution. Five seconds before introduction of the microspheres, 0.9 ml of blood was removed and replaced by 0.6 ml of a 13.4% solution of phycol-70. Microspheres were introduced into the body four times, each administration lasting 20-seconds. The first administration took place during a baseline period with the rat in horizontal position, the second 2 hours after their suspension, the third 5 hours after suspension, and the fourth 24 hours after suspension. [Evidently, a different labels was used in each administration.] During the first 2 hours of the experiment, heart rate and blood pressure in the abdominal aorta were recorded constantly. After completion of the experiment, the rats were sacrificed and their organs isolated, weighed and samples examined for microspheres using a γ-counter. Cardiac output and regional blood flow were computed using a microcomputer by undescribed formulas. Results were tested using *t*-tests for paired samples.

Transfer to head-down position induced increased pulse rate in all subjects by a mean of 70 beats/min. However after 15 minutes heart rate had returned to baseline. The response of blood pressure to suspension did not exceed 10 mm Hg, but changes were more persistent than heart rate change. At the end of the 2-hour period, blood pressure remained elevated, cardiac output was at baseline, and peripheral resistance showed a tendency to increase. After 5 hours in the position circulatory parameters had returned to normal, but after 24 hours blood pressure decreased by 12 mm Hg, and cardiac output had increased by 40 ml/minute due both to increased heart rate and increased stroke volume; peripheral resistance decreased by 0.7 units compared to baseline. After 2 hours of head-down tilt, blood flow in the gastrocnemius muscle was depressed (to a mean of 81.7% baseline) in 9 of 11 subjects; after 5 hours this parameter was 65.6% baseline and after 24 hours 75.6% baseline. This parameter changed in the opposite direction in muscles of the front legs (biceps and triceps) increasing by nearly a factor of 3 after 2 and 5 hours, and had increased eightfold after 24 hours in head down position. The sharp contrast in blood flow in front and hind leg muscles may be associated not so much with their positions *per se* as with differences in functional activity (gravitational loading). Thus, information about blood flow in the neck may be of more significance. After 2 and 5 hours there was no significant change in blood flow in this region, however after 24 hours it exceeded baseline by a factor of 3.5 Blood flow in the cerebrum showed only a tendency to increase in 7/11 animals after 24 hours, however at this period blood flow in the cerebellum was 130% baseline. Blood flow in the stomach and pancreas decreased by 35.5% and 51.3% respectively

## CARDIOVASCULAR AND RESPIRATORY SYSTEMS

after 2 hours, recovering in the stomach after 5 hours, and in the pancreas after 24 hours. In the liver, blood flow increased markedly (amount differs in article text and table) after 2 hours and then decreased to one fifth baseline after 24 hours. In the spleen, blood flow remained depressed throughout the experiment. In the kidneys it progressively decreased, possibly associated with fluid resorption. During the initial hours of the experiment blood flow in the myocardium of the right and left ventricles and the septum was unaltered, but after 1 day had increased by a factor of 1.5. Blood flow in the adrenal gland decreased initially and remained below baseline.

It is notable that the results obtained here are not the direct opposite of those obtained on rats in head-up position (decrease in cardiac output and increase in peripheral resistance). The reason that increase in cardiac output occurred only after 24 hours is not known.

Table 1: Dynamics of blood flow in rats after varying exposure to head-down tilt

Figure 1: Changes of heart rate and blood pressure as a function of duration of exposure to head down tilt

Figure 2: Change in parameters of systemic circulation after 2, 5, and 24 hours of head-down tilt

Figure 3: Change in blood flow in the muscles of the legs and neck after 2, 5, and 24 hours of exposure to head-down tilt

## CARDIOVASCULAR AND RESPIRATORY SYSTEMS

P1478(32/91) Nikogosova M, Kayfadzhyan MA, Barinyan SB, Akopyan AA.

***Changes in ultrastructure and actomyosin complex of cardiomyocytes in response to experimental hypergravity.***

Byulleten' Eksperimental'noy Biologii i Meditsiny.

121(4): 417-420; 1991.

[13 references; 5 in English]

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Cardiovascular and Respiratory System, Cardiomyocytes, Actomyosin,  
Rats  
Hypergravity, Acceleration

**Abstract:** This study investigated the ultrastructure of cardiomyocytes, some parameters of contractile function, and physicochemical properties and protein composition of the actomyosin complex of the cardiac muscle after gravitational acceleration and subsequent rest. Subjects were outbred rats of both sexes. Animals were exposed to acceleration of +5-g for 15 days for 25-30 minutes daily. They were then sacrificed either on the day after their last exposure (group 1) or after 30 days had elapsed (group 2). Intact animals (group 3) served as controls. Specimens of the myocardium of the ventricles were taken from 3 animals in group 1 and 4 from group 2 for electron microscopy. Samples were fixed in buffered OsO<sub>4</sub>, dehydrated and embedded in a mixture of eron and araldite. After double contrast staining, ultrathin sections were subjected to electron microscopy. Contraction of myocardial strips isolated from the left ventricles of 20 animals of each group was investigated using an unspecified method. Components of the actomyosin complex were identified with electrophoresis. Quantitative ratios among components were estimated using densitometric processing of an electrophoregram. ATPase activity of the actomyosin complex was studied using the potentiometric method. A total of 67 subjects in group 1; 54 in group 2; and 25 in group 3 served as subjects.

In rats in group 1, many ventricle cardiomyocytes showed signs of hypertrophy: increased diameter of myofibrils with separation, neof ormation of contractile structures involving ribosome, hyperplasia of mitochondria and other organelles of the cell, activation of the nuclei, and formation of deep longitudinal invaginations of the sarcolemma, suggesting possibility of division of the cardiomyocytes through splitting. Such cells frequently also contained lysosomes and well developed Golgi complexes. The minority of the cells showed signs of myofibril damage and disruption of sarcolemma integrity. These cells contained more lysosome than undamaged myocardial cells. After 30 days (group 2) there were more damaged cells compared to hypertrophied cells. Destruction included complete disorganization and even disappearance of contractile structures in some areas. Maximal amplitudes of contraction and relaxation developed by an isolated strip of myocardium were somewhat diminished in rats of groups 1 and 2, but not to a statistically significant extent. Group 1 displayed increased ATPase activity of natural actomyosin and desensitized actomyosin and also a decrease in relative concentrations of heavy chains of myosins and actin, and an inhomogeneous increase in the relative level of components of tropomyosin, troponin-I, and L-meromyosin types 1 and 2. L-meromyosin of type 3, which was absent in control subjects, was present here. Group 2 displayed incomplete normalization of ATPase activity of natural and desensitized myosins and differing rates of recovery of the components of the actomyosin complex, not yet reaching baseline. The changes noted in the actomyosin complex foster retention of the function of the myocardium despite destruction of a portion of the myofibrils. The increase in the amount of type 2 L-meromyosin and the relative level of troponin-S combined with type 3 L-meromyosin may increase the affinity of these structures to Ca<sup>2+</sup> and the activity of Ca<sup>2+</sup>-dependent Mg-ATPase, which in turn would inhibit the process of relaxation and increase the duration of myofibril activation.

## CARDIOVASCULAR AND RESPIRATORY SYSTEMS

It is notable that the recovery of physicochemical properties of myocardial proteins after 30 days of rest is not accompanied by normalization of the ultrastructure of cardiomyocytes.

Table: Concentrations of components of native actomyosin

Figure 1: Signs of hypertrophy in cardiomyocytes

Figure 2: Destructive changes in cardiomyocytes

Figure 3: Destruction of myofibrils during the rest period

## PAPER:

P1464(32/91)\* Meleshko GI, Shepelev YeYa, Guryeva TS (USSR), Boda K, Sabo W.(Czechoslovakia)

***Embryonic development of birds in weightlessness.***

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

25(1): 37-39; 1991.

[5 references; none in English]

Developmental Biology, Embryogenesis, Adaptation

Birds, Quail

Space Flight, Mir, Inkubator-2

Abstract: This paper traces the study of avian embryology in space. The Japanese quail (*Coturnix coturnix japonica*) was the species selected for these studies, partially because these birds are considered good candidates for supplying crew protein in biological life support systems. This research started with the 1975 launch of 60 quail eggs on COSMOS-1129. For technical reasons, the space incubation period could only be 11.5 days, so only 2/3 of the complete developmental cycle was completed in space. After this period, the satellite landed by parachute creating an unexpectedly great impact and damaging the majority of eggs. Even eggs suffering no visible damage failed to develop further on incubation. Analysis of material and comparison of actual developmental level of embryos to their incubation period revealed that there was significant mortality at early stages of development and those embryos that were alive at landing impact were significantly retarded in their development. In addition, high levels of morphological damage were found. Subsequent analysis established that these results could be attributed completely to nonoptimal conditions of egg storage and incubation and were not necessarily related to exposure to space. The apparent reason for the developmental delays was a decrease in relative humidity for technical reasons on day 6 of development. However, the fact that 33% of the embryos did achieve approximately normal development in space indicated that space flight factors do not in principle preclude embryonic development.

The second experiment in this program (Inkubator-2) was flown on Mir in 1990. Like the first one, the second incubator was developed by Czechoslovakian scientists. Incubation of 43 eggs occurred between March 8-24. Eight of the total were removed and fixed at various times during incubation for subsequent laboratory study. At the end of the incubation period, 8 out of the remaining 35 eggs hatched, with 6 chicks emerging from the egg unaided. These six chicks were studied further. They showed every evidence of normal development, reacted to visual and auditory stimuli, displayed motor activity, vocalized, and took food from the cosmonauts' hands. This completed the purely embryonic stage of the study and confirmed the possibility of normal embryonic development in space.

The second stage of this experiment focused on further growth and development of the chicks. A special pastelike feed containing adequate dietary water was developed for this purpose; the "floor" of the cage was a grating to allow the birds to maintain a position near the feed dish by grasping with their feet. An air stream directed at this floor was intended to facilitate the chicks' orientation. However, the chicks were unable to adapt to the conditions of weightlessness and develop skills allowing them to obtain food without help. They somersaulted continually in space, and failed to grasp the grating when they accidentally touched it with their feet. Measures taken by the cosmonauts failed to remedy the situation, and the chicks were sacrificed as an alternative to natural starvation. This stage of the experiment posed a new topic for gravitational biology — that of initial adaptation of neonates to conditions not corresponding to genetically determined orientation and not compatible with the motor programs that have developed during the course of evolution.

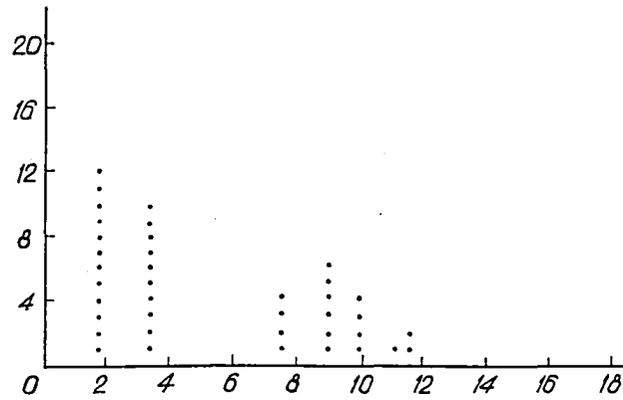


Figure: Distribution of embryos by age (flight experiment). Abscissa: stages of development of embryos (in days), ordinate: number of embryos. Dots — developing embryos, triangles {missing on figure}: eggs without signs of embryonic development

**PAPER:**

P1474 (32/91) Basyuk VA, Glukhoy AM, Gromovoy TYu, Golovatyy VG.

*On a possible mechanism of prebiotic synthesis of peptides.*

Zhurnal Evolyutsionnoy Biokhimii i Fiziologii.

27(2): 129-133; 1991.

[15 references; 4 in English]

L.V. Pisarzhevskiy Institute of Physical Chemistry, Ukrainian Academy of Sciences, Kiev

Exobiology, Prebiotic Synthesis

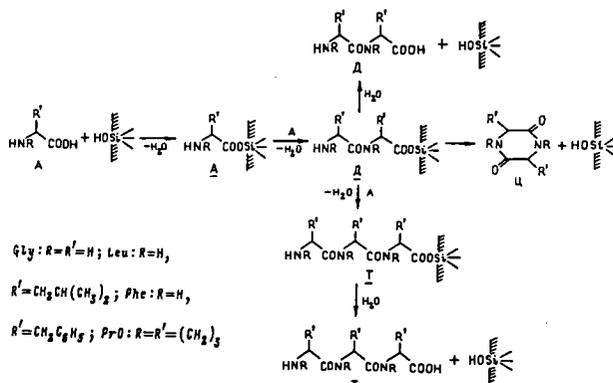
Peptides

Polycondensation of Amino Acids, Silicon Dioxide, Water

**Abstract:** According to the adsorption theory of origin of life on Earth, the formation of peptides by means of polycondensations of amino acids could most easily occur on an interface between a mineral and water. One of the most widespread compounds in the Earth core is silicon dioxide, suggesting that it was this compound that might have adsorbed formed amino acids forming previously and act as catalyst for their condensation. This has been confirmed by numerous simulation experiments: peptides in these systems do indeed form under the influence of impact waves and thermoprocessing at low and high pressure. However these results do not indicate what sequence of chemical transformation occur on the silicon dioxide matrix. The authors attempted to answer this question using previously obtained IR-spectral data on interactions of amino acid vapors with a dehydrated surface of highly dispersed silicon dioxide (vacuum, >150° C). It is known that under these conditions there is condensation of the carboxyl groups of amino acids with silanol groups of silicon dioxide forming the connection ≡ SiOCO—. Such products, unlike the surface ether of other aliphatic carbonic acids, are thermally unstable and, in the process of thermovacuum processing, gradually desorb from the surface of the matrix.

To obtain information about the composition of desorption products, amino acids were sublimated in the presence of highly dispersed silicon dioxide and in its absence, and the sublimes condensing in the cold zone of the reactors were studied by mass spectroscopy with bombardment with fast atoms. The use of this "soft" technique of ionization guarantees the absence of chemical transformations of biomolecules in an ion source.

The mass spectra showed ions of protonized molecules of the initial amino acids and products of condensation (short peptides and diketopiperazines), sometimes in the form of clusters with molecules of glycerine matrices. In products of amino acid sublimation in the presence of completely dehydrated silicon dioxide, only diketopiperazines, i.e., completely dehydrated dipeptides, were found in addition to the initial compounds. Thus, for linear products of amino acid condensations to form, silicon dioxide must be present on the surface, if only in a hydrated monolayer sheath (temperature of the preliminary matrix was < 500°C). The authors propose the following schema for the condensation of amino acids on the surface of silicon dioxide.



This schema made the following assumptions: 1. Chemosorption of amino acids (A) is accompanied by the formation of surface compounds of the complex ester type (A); 2. The final products of condensation found in sublimates are di- (D) and tripeptides (T) and diketopiperazines (DP); 3) These compounds form under different conditions but in the absence of SiO<sub>2</sub> (with the exception of proline diketopiperazine). For this reason the precursors of D, T and DP can only be surface ethers of the peptides D and T forming from A.

Although in theory it is possible for longer molecules to condense, the mass spectra peaks did not suggest the presence of such ions. Although optically active amino acids racemize fairly readily in general, during their sublimation in the absence of silicon dioxide, there was no evidence of loss of optical activity. The method of ligand exchange chromatography of enantiomorphs established that in the presence of SiO<sub>2</sub> there is only insignificant racemization.

Thus the formation of linear peptides on the surface of silicon dioxide matrixes is only possible in the presence of water, if only a very small quantity (adsorption monolayer). Nevertheless, the presence of water in the system as a separate phase is not obligatory for this stage of molecular evolution to occur. This argues in favor of the possibility of prebiotic synthesis of peptides either long before the formation of the envelope of water or else in space.

Table: Mass numbers of molecular and cluster ions in mass spectra after bombardment with rapid atoms of products of sublimation of amino acids in the presence and absence of silicon dioxide, first dehydrated at 200°C

Figure 1: Stages of sublimation of amino acids in the presence of a silicon dioxide matrix

Figure 2: Rapid atom bombardment mass spectra of L-leucine sublimated in the absence and presence of silicon dioxide

Figure 3: Chromatographic description of enantiomorphous composition of leucine

**PAPER:**

P1486(32/91) Mikos KN, Shklarov SA, Ryzhkova VYe.

***The effect of spaceflight factors on dynamics of human emission of trace contaminants.***

In: Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

Tezisy Dokladov IX Vsesoyuznoy Konferentsii. [Космическая Биология и Авиакосмическая

Медицина. Тезисы Докладов IX Всесоюзной Конференции. [Space Biology and Aerospace Medicine: IXth All-Union Conference]

Kaluga: 19-21 June 1990.

Affiliation: Scientific Council on Space Biology and Physiology, USSR Academy of Sciences; Institute of Biomedical Problems, USSR Ministry of Health

Page 464-465.

Habitability and Environment Effects, Trace Contaminants, Expired Air, Metabolism, Volatile Metabolites, Adaptation

Humans, Cosmonauts

Space Flight, Short-Term, Long-Term, Hypokinesia With Head-Down Tilt, Long-Term

**Abstract:** The authors studied the effects of habitability factors characteristic of space flight on dynamics of levels of certain trace contaminants in expired air of crewmembers. Gas chromatography was used to measure hydrocarbons C1-C4, acetaldehyde, methanol, ethanol, acetone, and isopropanol with p-pentane in the expired air of cosmonauts on orbital flights varying in duration and subjects under conditions of long-term hypokinesia with head-down tilt.

Results of studies of the cosmonauts showed that after long-duration orbital flights the levels of volatile metabolites increased for all the substances studied. The greatest increases in concentrations (by a factor of 7) involved ethane and ethylene. Analogous changes in levels of volatile metabolites were observed in subjects after a 120-day period of hypokinesia with head-down tilt. Periodic examinations of subjects undergoing hypokinesia showed that human adaptation to changes in living conditions, as measured by level of anthropotoxins in expired air, takes approximately 1 month. For this reason in cosmonauts participating in short-term space flights the increase in levels of endogenous substances (acetone, ethane, and ethylene) in expired air was lower than in participants in long-term flights, i.e. on short-term flights (up to 7 days) adaptative changes had not yet reached the maximal level.

Thus, during manned space flights, levels of volatile metabolites increase reliably in expired air of cosmonauts and the role played by humans in influx of microcontaminants into the cabin atmosphere increases.

## PAPERS:

P1468(32/91)\* Davydov VI, Gaydamakin AN, Lvova TS, Romanyuk NN.

*The effect of epinephrine on activity of succinate dehydrogenase in functionally modified (lympholeukotic) lymphocytes of mice.*

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

25(1): 46-49; 1990.

[4 references; 1 in English]

Hematology, Lymphocytes, Enzymology, Succinate Dehydrogenase, Blood Pathology  
Mice  
Endocrinology, Epinephrine

**Abstract:** The goal of this experiment was investigation of the effect of epinephrine on the respiratory enzymes, particularly succinate dehydrogenase (SDH), as one of the Krebs cycle enzymes and a "marker" of oxidative processes in mitochondria. Subjects were 41 mice of the AKR line with a high probability of developing spontaneous lymphoid hemoblastosis. Activity of SDH was measured in peripheral lymphocytes, the number of leukocytes was counted, and a hemogram studied. Testing with epinephrine occurred when the animals were 7-10 months old during the period of active development of hemoblastosis. Blood was taken from the caudal vein in a quantity of 0.3 ml before intraperitoneal administration of epinephrine hydrochloride in a dose of 1 mg/kg and in minutes 2, 4, 6, 8, and 10 afterward. Activity of SDH was estimated in lymphocytes from the number of granules of p-nitrotetrazole of formazan violet in a sample of 50 cells.

The subject population was distinguished on the basis of the presence or absence of hemoblastosis and the reaction of SDH in lymphocytes to epinephrine. In animals with hemoblastosis, the number of blast cells was between 0.5 and 30%, with number of polymorphocytes from 1 to 10%, number of lymphocytes 68% and total number of leukocytes =  $34.5 \pm 16.6 \times 10^9/l$ . Mortality of these animals during their first year of life is 94%. Overt symptoms of the diseases are not evident before month 7-8 of life. The animals could be divided into 4 groups: mice with hemoblastosis and diminished (group 1) or heightened (group 2) levels of reaction of SDH to epinephrine and mice without hemoblastosis with these two types of SDH reactions (groups 3 and 4). Animals with high initial levels of SDH tended to show a negative reaction to epinephrine and those with low levels, a positive reaction. Older animals were more likely to show a negative reaction. The hypothesis that reaction of SDH to epinephrine would be diminished in lymphocytes of animals with hemoblastosis was not confirmed. However, there was a significant difference between responses of those animals with the most severe hemoblastosis and those animals without symptoms who subsequently lived the longest. The authors conclude that an epinephrine test can provide supplementary information about the functional state of lymphocytes in early prepathological development of diseases, especially blood cancer.

Table Reactions of SDH of peripheral lymphocytes to epinephrine in mice with hemoblastosis and "healthy" animals and the correlations of these parameters with life span

Figure: Reaction of SDH in lymphocytes to administration of epinephrine in mice with blast cells and without them

P1479(32/91) Belchenko DI.

***Cellular interaction and changes in the composition of leukocytes in peripheral blood of rats exposed to hypokinesia.***

Patologicheskaya Fiziologiya i Eksperimental'naya Terapiya.

1990(5):26-28; 1990.

[7 references; none in English]

Author's Affiliation: Kalinin Medical Institute

Hematology, Leukocytes, Cellular Interaction

Rats. Males

Hypokinesia

**Abstract:** Blood from 25 male Wistar rats was studied. Animals were exposed to hypokinesia by confinement in immobilization cages for 30 days. Blood was taken from the caudal vein 30 hours, and 18 and 30 days after the beginning of hypokinesia and 1 week after its termination. Blood smears were stained. Controls were intact rats maintained under normal vivarium conditions.

After 30 hours of hypokinesia, the blood smears contained numerous large cells with broad light blue cytoplasm and a large rounded centrally located nucleus with homogeneous pink chromatin and nucleoli or traces of them. Concentration of these cells was 3.2%. They resembled large lymphocytes or lymphoblasts, but the chromatin in their nuclei was coarser and darker. Some of them were surrounded by erythrocytes, in a cluster resembling rosette formation. There were areas of intercell contact between the large mononuclear cells and erythrocytes. Some mononuclear cells formed outgrowths in the direction of neighboring erythrocytes. There were also signs of a process similar to phagocytosis with erythrocytes becoming partially ingested. These phenomena could be observed throughout the hypokinesia period and 7 days afterward. On the average 10-24 attacks on erythrocytes by large mononuclear cells could be observed in every 200 leukocytes of peripheral blood. There were more attacks during the first two measurement periods than on day 30 of hypokinesia. Injury from repeated taking of blood was ruled out as a cause of this phenomenon by use of a small control group for which blood was only taken once. Activation of mononuclear cells and rosette formation in peripheral blood could have resulted from alteration of the properties of erythrocytes occurring during hypokinesia.

Blood count revealed moderate but statistically significant leukocytosis after 30 hours and 18 days. By the end of the period, numbers of leukocytes had returned to normal. Throughout hypokinesia the relative concentration of small lymphocytes was depressed; the absolute value was depressed only after 7 days of recovery. Both the relative and the absolute concentrations of medium sized lymphocytes were sharply increased at all measurement points. Absolute levels of total lymphocytes were elevated, but due to the leukocytosis, their relative numbers were depressed.

Table: Levels of leukocytes and change in blood count of rats in hypokinesia

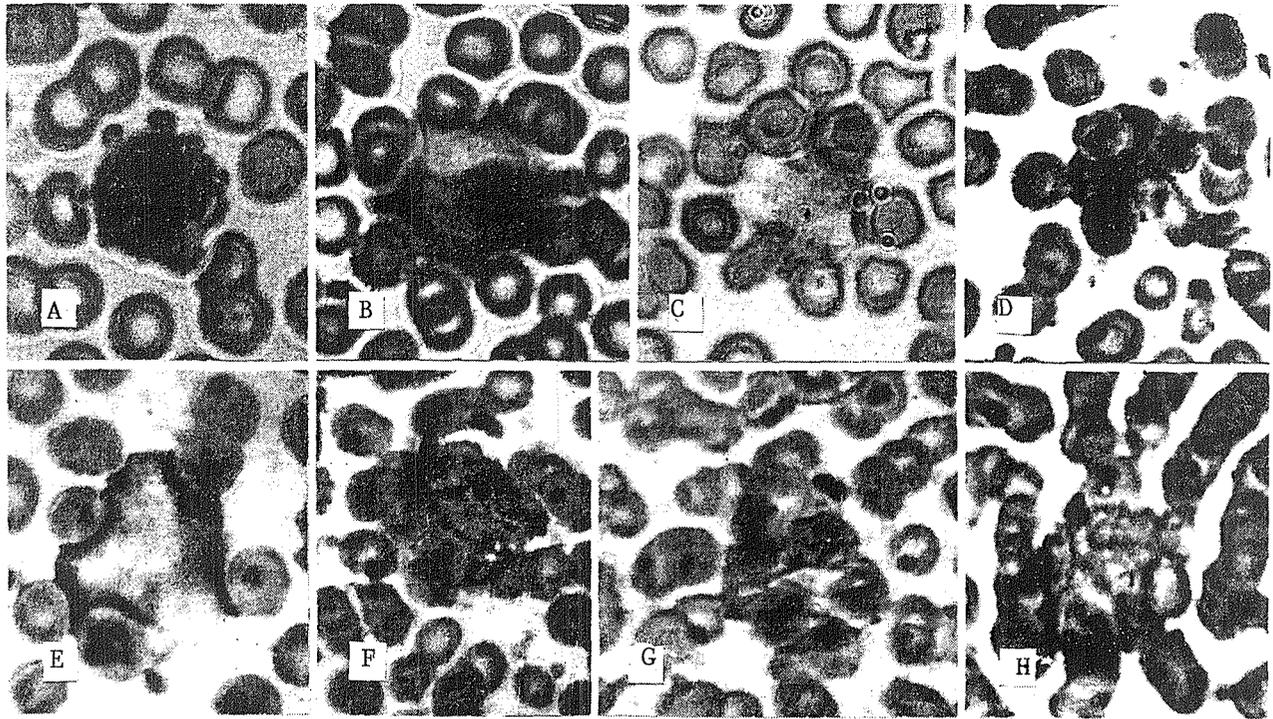


Figure: Peripheral blood of rats exposed to hypokinesia

A - large mononuclear cell forming outgrowths; B, C, D — intercellular contacts between mononuclear cells and erythrocytes forming rosettes; E — partial immersion of the erythrocytes in the mononuclear cells; F,G,H— ingestion of erythrocytes by mononuclear cells. Mag. obj. 90, oc. 7, stained according to Romanowsky-Giemsa

**PAPER:**

P1462 (32/91) Ioseliani KK, Narinskaya AL.

***Study of resistance to interference of flight personnel from the standpoint of selection decisions.***

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

25(1): 30-33; 1991.

[9 references; none in English]

Human Performance. Resistance to Interference, Cognitive Performance, Attention Switching  
Humans, Flight Personnel  
Personnel Selection, Individual Differences

**Abstract:** Resistance to interference during performance of cognitive tasks is an important characteristic of good flight performance. This study investigated dynamics of complex performance of flight personnel in the face of interference from an information bearing signal. The task used was one involving search for numbers with switching in a table with black and red numbers. This task permits study of distribution, switching, and span of attention as well as of working memory. Subjects were 120 healthy individuals aged 24-50, of whom, 76% were pilots and 24% navigators. Subjects were told to locate black and red numbers alternatively, black in the order from 1-25 and red in the order 25-1. This task is most difficult in its central portion, where the numbers in the black and red series are close to each other, but require opposite treatment. In the midst of the task a voice from a tape recorder began to read the numbers in the table from beginning to end, gradually catching up with the task so that the numbers read were close to those being dealt with by the subject. Analyses were based on observational data and subjective reports as well as task performance at its most difficult stage without interference and during interference.

The greatest difficulty with task performance occurred in 25% of the subjects. These individuals displayed increased emotionality, tension, anxiety, and delay. In 10% of the cases, subjects forgot the instructions, leading to perseveration in the middle, most difficult portion of the task making it take considerably longer. In 15% of the cases there were isolated errors, violating distinctions between colors with some increase in time between answers. If subjects successfully reached the central point of the task (13 black, 12 red) they were generally able to complete it rapidly and without special stress. Subjects were divided into three groups on the basis of whether interference improved, did not affect, or hurt their performance. These groups contained 10%, 54%, and 36% of subjects respectively. Of the 36% showing poorer performance, 27% displayed increases in errors and reaction time, and 9% refused to continue. Of the 54% showing unaltered performance, some (16%) showed initial signs of interference, but were able to compensate rapidly and correct their mistakes. The 10% who improved evidently did so due to increased motivation. The authors suggest that the attention to resistance to interference during psychological selection and certification procedures should be a good supplement to the results of the clinical psychological examination in predicting psychological productivity under difficult circumstances.

Figure 1: Graphic depiction of error-free performance of number search task

Figure 2: Performance of number search task with frequent perseverations

Figure 3: Performance of number search task with increased response time

Figure 4: Performance of number search task in case of a "blockage effect"

MONOGRAPH:

M178(32/91) Kovalenko PA (editor)  
Aviameditsinskiye i Ergonomicheskiye Issledovaniya Chelovecheskogo Faktor v Grazhdanskogo Aviatsii. [Авиамедицинские и Эргономические Исследования Человеческого Фактор в ГражданскогоАвиации] [*Aviation Medicine and Ergonomic Aspects of the Human Factor in Civil Aviation*]: A Collection of Scientific Papers].  
Moscow: Red Banner of Labor Institute of Civil Aviation; 1988.  
[172 pages]  
Affiliation: Red Banner of Labor Institute of Civil Aviation, Ministry of Civil Aviation

Key Words: Human Performance, Ergonomics, Aviation Medicine, Civil Aviation, Psychology, Man-Machine Systems, Rehabilitation, Provocative Tests, Metabolism, Cardiovascular and Respiratory System, Perception, Visual, Displays, Pilots, Air Traffic Controllers, Performance Monitoring, Work-Rest Schedule, Sleep, Neurophysiology, Autonomic Parameters, Training, Display Design, Stress, Flight Safety

Annotation: This collection contains papers concerned with research enabling medical and ergonomic support of aviation technology, modern methods for diagnosing and treating various ailments of flight personnel, requirements for work and rest schedules for these personnel, and ergonomic testing and use of complex "pilot-aircraft," "air traffic controller-control devices" and "trainer-crew-training simulator" systems.

A number of papers are devoted to the issue of selection, assignment and training of flight personnel. The collection considers various methodological approaches to evaluating the effect of the human factor on flight safety.

(NOTE: Translations of abstracts provided in the collection are presented here in lieu of a table of contents.)

Brusnikina RI, Skrypnikov AI, Agapova LV, Rybakov ND. **Scientific/methodological aspects of restoring the performance of flight and air traffic control personnel.** [pages 3-8, 1 figure, 1 table, 3 references].

This paper considers approaches to developing systems for restoring performance capacity of flight and air traffic control personnel. It presents a detailed description of the stages and directions of rehabilitation measures, and describes standard forms of controlled relaxation and individualized measures for correcting psychophysiological functioning.

Andriyako LYa. **The potential of provocative tests in evaluating operator status.** [pages 9-15; 8 references]

This paper considers the need to use provocative tests both for evaluating operator status, and for revealing occult metabolic disorders in the myocardium and other tissues. The use of training programs involving tilt tests is a possible way to normalize the relationships among the parameters of cardiovascular contraction.

Kalinina AN. **Ergonomic descriptions of the performance of air traffic controllers during taxiing and line-up.** [pages 20-24, 4 references]

This paper considers the visual perception of air traffic controllers during taxiing and line-up and presents a task analysis of the operation of the visual system under various conditions of observation. A major prerequisite for error free performance of controllers is design of the air traffic control work stations to ensure optimal conditions of visual perception.

## HUMAN PERFORMANCE

Chertok VB, Tertychnyy VV, Shebanov VD. **The effect of the human factor on the efficiency of use of oxygen equipment.** [pages 24-27, 1 table; 3 references].

This paper describes a method for evaluating the efficiency with which passengers use oxygen equipment during certification tests. The method is based on evaluation of the equipment as a "man-machine" system using criteria of reliability, and estimated probability of correct use.

Tomarchenko IS. **Health status of pilots performing aerial crop dusting and other chemical spraying.** [page 27-31].

This paper provides information about the health status of pilots working in aerial chemical spraying (based on statistics on professional disqualification, occupational diseases, temporary unfitness for flight duty, and outpatient observations). A number of recommendations for minimizing disease rate are derived, the specific causes of disease identified, and the relationship between incidence of diseases and age is discussed.

Boyko EV, Shapovalov SL, Volkov VV, Shelepin YuYe, Pavlov NN, Yevseyev YeA, Malyavskaya GA. **Evaluating visual perception during work with displays.** [pages 31-39, 3 figures, 1 table, 4 references].

This paper cites the results of research to evaluate physiological mechanisms determining the optimal conditions for working with various displays. The role played by visual "noise" in disrupting visual perception and the effect on quality of perception of features of the screen are discussed.

Bolotova MZ, Lapkis LYe, Meshcheryakov SV, Remberga LA. **Psychophysiological rationale for methods of on-line monitoring of performance.** [pages 39-43; 1 table; 3 references].

This paper considers approaches to developing a rationale for methods of on-line monitoring of performance of air traffic controllers. The functioning of controllers is estimated on the basis of biochemical and physiological parameters. Gradations of tension in physiological functions during job performance are discussed.

Meshcherskiy VN, Kovalev YeI. **Specialized physical training for students in the air traffic control department of flight school and air traffic controllers.** [pages 43-48, table 5].

The paper describes a program of specialized physical training that the authors developed for flight school air traffic control students and air traffic controllers. The proposed program, combined with active relaxation, facilitates successful learning, improves health and well-being, and has a positive influence on the development of most important physical characteristics for air traffic controllers.

Mirzoyev BM. **Characteristics of sleep in pilots performing long-duration night flights.** [pages 48-52; 2 references].

Disruption of the work rest schedule may give rise to sleep disorders and affect general state and performance. This article discusses the desirability of selecting for long-duration night flights crewmembers for whom one night of sleep deprivation does not significantly affect subsequent quality of sleep, general status, and performance.

Pomogaylo YeYu, Pankova AYe, Glukhovskiy VD. **Ergometric evaluation of a two-pointer altimeter.** [pages 52-58, 1 figure, 4 tables; 1 reference]

This paper presents the results of an ergonomic evaluation of a two-pointer altimeter with an improved face. The evaluation of the instrument face was based on use of a portable apparatus for recording speed and accuracy characteristics of performance and content of the verbal response and did not disrupt the piloting of the aircraft. Comparative data concerning read-out from various modifications of the two-pointer altimeter are presented.

Rats AYa, Spitsyn IG. **Design of a system for evaluating physiological status of pilots.** [Pages 58-65; 2 references]

This paper describes the structure of a channel for evaluating the psychophysiological status of pilots. The levels of information processing corresponding to physiological processes, signals, parameters, indexes, indicators and evaluations are listed. Methods for standardizing indices for obtaining indicators of functional stress on various physiological systems are considered, as are issues of scaling and resistance to interference of the measurements.

Skvortsov SA, Landraf LA. **Individual differences in the correlation of certain operator characteristics and autonomic parameters.** [pages 66-69; 1 table]

With reference to a great deal of empirical material, this paper considers the association between performance level on a test reflecting certain job-related psychological functions and autonomic parameters. Analysis of the material includes the evaluation of statistical parameters of distributions and correlation analysis. It is concluded that performance can be monitored on the basis of autonomic parameters.

Izyumskij VG, Ivanova BL, Zharkova IYa. **Computation of norms for evaluating piloting skills during landing approach and landing with one inoperative engine in the process of training on a simulator.** [pages 72-77; 1 reference]

This article describes a method for computing norms for evaluating piloting skill during approach and landing with one inoperative engine and demonstrates numerical computation of norms as applied to the complex simulator of the Il-86 aircraft.

Makarov RN, Lepikhov VK. **Methodological problems in professional training of air traffic controllers.** [pages 77-81].

The acceleration of scientific and technological progress requires improvement of professional reliability of air traffic controllers. For this reason increased attention is being paid to the training of these personnel. This paper argues for the need for a scientifically justified structuring of the training of air traffic controllers.

Fedulova OA, Massarskiy VI. **Development of methodological approaches for evaluating displays showing air traffic conditions.** [pages 82-87; 2 tables; 2 references].

This paper considers methodological approaches to the experimental and ergometric evaluation of onboard information displays that provide warnings of collisions in the air. The authors describe an experiment to evaluate a "controller indicator" display of air traffic conditions to the pilot and methods for representing command information on actions to avoid collision.

Ivanov FYe. **Methodological principles of psychological analysis in the study of aviation accidents and incidents**, [pages 87-92; 6 references].

This paper describes the use of traditional procedures and a newly developed set of "goal-directed" methods of psychological analysis of aviation incidents. Identification of factors (causes) of aviation incidents through psychological analysis facilitates their prevention and increases flight safety.

Rodionov ON. **The course of hypertrophic cardiopathy in flight personnel**. [pages 92-96; 3 references].

This article describes the course of hypertrophic cardiopathy in two flight crew members over a period of 10 years. Possible causes of this disease are discussed.

Prudkiy NA, Panferov SV. **Prognostic significance of laser refractometry in examining applicants for civil aviation schools**. [pages 96-99; 2 tables].

Refraction parameters in applicants to civil aviation flights schools who have high visual acuity without glasses is analyzed for the first time by the method of laser refractometry. The results of the study suggest that laser refractometry can be used as a method for dynamic observation of students in flight schools to prevent development of myopia.

Vinogradskiy EV, Paskova IV, Molchanova DA. **The potential of display tests in aviation ophthalmology-ergonomics**. [pages 100-104; 1 figure; 1 table].

The authors formulate a general approach to creating a class of display tests to optimize research in aviation ophthalmology-ergonomics. They argue for the inclusion of such tests in the system of occupational selection, in flight certification examinations, and in the development of work-rest schedules. The use of tests also makes it possible to improve experiments with training simulators and improve training conditions.

Nachatkina LN, Varshavskiy VL. **Use of soft contact lenses for evaluating the effect of the atmosphere of a pressurized cabin on the eyes**, [pages 104-107].

This paper considers a method for studying the effects of conditions of the atmosphere of a pressurized cabin on visual performance. A modeling principle using micro-contact lenses, which can serve as tests in ophthalmology-ergonomics is used.

Kovalenko PA. **Selecting a principle for displaying pitch and bank in a flight indicator**, [page 107-122; 2 figures; 2 tables].

This paper describes a new approach to the problem of selecting a principle to underlie display of pitch and bank in flight indicators. It discusses the results of multiyear studies of the psychological characteristics of spatial orientation of pilots based on bank and pitch during various legs of a flight and with different flight indicators. A conclusion is drawn concerning the desirability of displaying these parameters according to the principle of "view of the aircraft from the Earth."

**Babenko VA. The image of aircraft velocity, [pages 122-128; 4 references].**

This paper considers the construction of the working image of aircraft velocity in three-dimensional space. The effects of the constructive formation of an information-processing model and changes in the content of the "goal image" on the time required to construct the image are analyzed. The leading role played by the goal image in construction of the working image of aircraft velocity is shown.

**Mikheyev YuV, Yakovleva IL. Prediction of the timeline for Soviet adoption of training simulators providing the full range of training and testing operations, [pages 128-135; 1 figure, 1 table; 2 references.]**

This paper is devoted to prediction of the timeline for Soviet adoption of training simulators providing the full range of training and testing operations. It describes a prediction derived using the method of analytic approximation and a combined prediction based on two predictions derived through an improved method of expert interview in 1983 and 1987. Based on verification of the prognostic information, it is concluded that it is sufficient for practical purposes.

**Galaktionov AI, Yanushkin VN. Structuring the instruction of operators in control of complex objects [pages 135-141; 2 references]**

This paper discusses an approach to the creation of a system of continuous real time monitoring and on-line control of the parameters of the instruction process for operators of technological objects. The authors propose two ergonomic principles. The first is the principle of correspondence between the instructional method and the method of depicting the information being taught with the conceptual model of reality formed by the operator at a given time. The second is the principle of continuous monitoring and control of the process of instruction.

**Tarasov IN, Andryukhin VA, A study of the occurrence of negative factors in the operations of flight service, [pages 141-148; 2 figures; 5 references].**

This paper argues for the place of statistical analysis in work on flight safety and proposes a method of on-going evaluation of the frequency of occurrence of negative factors in the work of flight services.

**Shevchenko VV, Continuous control of an aircraft in a stationary flight regime [pages 148-153; 6 references]**

This paper proposes a method for computing information-processing characteristics of pilot performance for modeling flight, with a pilot in the control loop in a pilot training simulator. The information-processing characteristics of pilot performance and his psychophysiological characteristics are compared quantitatively. The results of empirical research are presented.

**Voloshin NV, Dudnik GS, Koltsov SYe. An automated system for teaching and monitoring knowledge (Using the example of the Kirovograd Advanced Flight School), [pages 153-157; 1 figure].**

This paper uses the example of the Kirovograd advanced flight school to consider one of the variants for organizing an automated system for instruction and monitoring knowledge. The structure of a system based on a DVK-3 minicomputer is presented, and the basic functions of the system and also its advantages are discussed.

Ortynskiy AN, Yefimov AN, **The potential use of laser systems in aviation**, [pages 157-160; 2 figures; 1 reference].

The use of laser systems in aviation as light technology and radiotechnology systems for landing gives rise to biomedical problems associated with the safety of looking directly at laser radiation. This problem may be solved through use of an optical filter with altered optical density throughout the filter.

PAPERS:

P1467(32/91)\* Mazurin YuV, Stupakov GP.

***Determining duration and amplitudes of high level linear acceleration acceptable for human exposure.***

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

25(1): 44-46; 1991.

[4 references; 1 in English].

Mathematical Modeling

Humans

Acceleration, Quasi-static, Linear

Abstract: This paper describes a model for predicting the effects of high levels of linear acceleration on humans based on establishment of statistical associations and derivation of functions relating vectors of effects and response parameters of a mathematical model of the human body describable as a vector of reactions. This method was improved over an earlier version by modeling the effects of "quasi-static" acceleration of up to 3 seconds in duration. The model was used to derive areas of acceptable angular orientation of the linear acceleration vector for a given amplitude and duration. The authors conclude that their model is promising for developing physiological rationales and standards for direction and duration of linear acceleration acceptable in rescue equipment (e.g. ejection seats).

Figure 1: Cross section of equal effect surfaces

Figure 2: Norming of impulses of linear acceleration

P1480(32/91) Kondrachuk AV, Sirenko SP.

***Mathematical model of dynamics of the semicircular canals of the vestibular system in response to caloric stimulation in weightlessness.***

In: Abstracts of Papers presented at the Second Republic Conference on: Fundamental and Applied Problems of Cosmonautics.

Kiev: 1990.

Affiliation: Ukrainian Federation of Cosmonautics.

Page 120.

Mathematical Modeling, Neurophysiology, Semicircular Canals  
Humans  
Caloric Nystagmus, Weightlessness

Abstract: Experiments performed on Spacelab in 1983 on caloric nystagmus in weightlessness cast doubt on the belief that the convective flow of endolymph in the semicircular canals of the vestibular system is the sole reason for nystagmus, and suggested that the nystagmic response may also be induced by flow resulting from thermal expansion of endolymph. This was confirmed in principle in [1: reference not cited] that showed that in some orientations of the semicircular canals relative to gravity which would preclude convective flow of endolymph, the receptor structures of the semicircular canals are still stimulated. Based on this experiment, the present authors developed a mathematical model which includes, in addition to convective flow of endolymph, the flow induced by thermal expansion of endolymph. Model-based calculations are in good quantitative agreement with data from experiment [1], making it possible to interpret nystagmus observed in weightlessness as a result of thermal expansion of endolymph. The mathematical model demonstrates that the greater the temperature gradient along the semicircular canals, the greater the role of the flow due to endolymph expansion. This flow begins as soon as there is an inhomogeneous distribution of temperature throughout the semicircular canals, and only then does the role of convective flow increase and remain dominant. For a particular orientation of the semicircular canals with respect to gravity, this model can compute the compensation time, i.e., the time required for convective flow of endolymph to compensate for thermal expansion of endolymph after a temperature inhomogeneity occurs. Appropriate modifications of this model would make it possible to interpret the results of caloric stimulation of the vestibular system in simulations of short-term weightlessness in parabolic flight.

PAPERS:

P1483(32/91) Khasina EI, Kirilov OI.

***Level of glycogen and activity of enzymes of carbohydrate metabolism in the liver of rats in the readaptation period following a 20-day period of hypokinesia.***

Voprosy Meditsinskiy Khimii.

36(3): 43-45; 1990.

[14 references; 3 in English]

Authors Affiliation: Institute of Marine Biology, USSR Academy of Sciences, Vladivostok

Metabolism, Carbohydrate, Glycogen, Enzymology, Liver

Rats, Males

Hypokinesia, Readaptation, Stress

Abstract: Male Wistar rats were subjected to a 20-day period of limited motor activity in immobilization cages after which they were moved to normal cages. Control rats were maintained in the latter throughout the experiment. Eight rats from each group were decapitated on day 20 of hypokinesia, and then 12 hours, 1, 3, 5, 10, 20, 30, 45, and 65 days during the readaptation period. Levels of glycogen and activity of hexokinase (HK) and glucose-6-phosphate dehydrogenase (G6PDH) were measured in the liver. The *t* test was used to assess results.

Immediately after treatment, liver glycogen was identical to control levels. Activity of HK was nonsignificantly higher than control, but activity of G6PDH was significantly elevated. These changes are characteristic of the resistance stage of chronic stress. Body weight was depressed by 14% in these rats. During readaptation, recovery of parameters of carbohydrate metabolism underwent a number of phases. During phase 1 (first 12 hours), glycogen levels decreased, possibly due to the stress of transfer into new cages (readaptation stress). Activity of HK and G6PDH were significantly below that of animals undergoing hypokinesia, but did not differ from control. In phase 2 (from 1 to 7 days) glycogen level exceeded control; HK activity was somewhat above control level on days 1 and 3, and equivalent to it on days 5 and 7. Activity of G6PDH was above control level throughout this phase. The authors consider the possibility that this anabolic phase may be associated with a resistance stage in a chronic stress response to readaptation conditions. The fact that the experimental animals were not beginning to regain the weight they lost during this stage indicates that the anabolic processes activated during this period were limited. On day 10 all parameters were at control level. However, on day 20 all three parameters were below control level, suggesting that liver metabolism had again become primarily catabolic. On day 30 differences from control were not significant. Body weight only returned to control level at day 30. During the last phase (from 45 to 65 days) all parameters including body weight returned to control level. The authors conclude that these data indicate that normalization of carbohydrate metabolism in the liver after long-term hypokinesia is not a linear process. The nature of the different phases of readaptative changes in carbohydrate metabolism in the liver are determined, on one hand, by stress mechanisms, and on the other by the state of the other metabolic processes in the body.

Figure: Level of glycogen and activity of hexokinase and glucose-6-phosphate dehydrogenase in control and experimental rats

P1488(32/91) Pastushkova LKh.

***Metabolic parameters of a group of water-soluble vitamins during the readaptation period after long-term space flights.***

In: Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

Tezisy Dokladov IX Vsesoyuznoy Konferentsii. [Космическая Биология и Авиакосмическая Медицина. Тезисы Докладов IX Всесоюзной Конференции.] [Space Biology and Aerospace Medicine: IXth All-Union Conference]

Kaluga: 19-21 June 1990.

Affiliation: Scientific Council on Space Biology and Physiology, USSR Academy of Sciences; Institute of Biomedical Problems, USSR Ministry of Health

Pages: 541- 542.

Metabolism, Vitamins, Water-Soluble, Nutrition, Enzymology

Humans, Cosmonauts

Space Flight, Long-Term

Abstract: Cosmonauts completing short-term flights displayed a decrease in daily excretion of the group of water-soluble vitamins, which is usually treated as an increase of physiological need for these biologically active substances. At the same time parameters indicative of tissue saturation with these substances did not undergo significant changes.

For a series of long-term space flights (64-326 days) involving 24 cosmonauts, parameters of thiamine, riboflavin, niacin, and pyridoxine metabolism were studied. The amount of daily excretion of vitamins and their metabolites, activity of erythrocyte vitamin-dependent enzymes and the ratios among them were studied. Throughout the period of the study the cosmonauts consumed a controlled diet. Studies were made during the preflight period and on days 1-7 postflight.

During the preflight period, no deviations were observed in parameters indicative of metabolism of the vitamins studied: they remained within the norms established for healthy individuals. After completion of the flight, there was diminished diurnal excretion of vitamins and their metabolites compared to preflight values, which showed a stable tendency to normalize between days 1 and 7 postflight. Ratios among activation levels of vitamin-dependent enzymes in blood suggested a tendency for their saturation with the corresponding cofactor to decrease between days 1 and 7 postflight.

Thus, analysis of data suggests the complexity of the effects of space flight factors on vitamin-dependent reactions of metabolism. Evidently, under these conditions, the efficiency of the vitamin dependent processes depends on more than adequate dietary intake of water-soluble vitamins and tissue saturation. The changes observed in parameters of vitamin metabolism in the readaptation period after long-term space flights under conditions of controlled dietary intake of vitamins does not reflect the level of intake of these substances, but rather changes in catabolic and anabolic metabolic processes.

P1489(32/91) Pastushkova LKh, Kornelyuk VA.

***Comparison of parameters of metabolism of water-soluble vitamins during a readaptation period after long-term space flight and hypokinesia with head-down tilt.***

In: Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

Tezisy Dokladov IX Vsesoyuznoy Konferentsii. [Космическая Биология и Авиакосмическая Медицина. Тезисы Докладов IX Всесоюзной Конференции.] [Space Biology and Aerospace Medicine: IXth All-Union Conference]

Kaluga: 19-21 June 1990.

Affiliation: Scientific Council on Space Biology and Physiology, USSR Academy of Sciences; Institute of Biomedical Problems, USSR Ministry of Health

Pages 542-544.

Metabolism, Vitamins, Water-Soluble, Nutrition, Enzymology

Humans, Cosmonauts

Space Flight, Long-Term, Hypokinesia With Head-Down Tilt, Exercise, Drugs

**Abstract:** Introduction. One of the methods of studying the effects of spaceflight factors on humans, including biochemical parameters, is simulation of certain space flight factors. The simulation most used is the method of hypokinesia with head-down tilt in combination with physical exercise, drugs, and other prophylactic measures. However the issue of which of these simulations is most similar to actual spaceflight, has not been adequately studied. This work attempted to determine the most appropriate method of simulating spaceflight factors in a series of experiments with hypokinesia with head-down tilt combined with physical and pharmacological prophylactic measures, and also the effect of these prophylactic measures combined on metabolism of water soluble vitamins.

**Method.** This study measured parameters of the group of water-soluble vitamins (B<sub>1</sub>, B<sub>2</sub>, B<sub>6</sub>, and nicotinic acid) in 24 cosmonauts after completion of from 64 to 280 days of space flight. In a series of ground-based simulations, metabolic parameters were also studied in 21 subjects undergoing hypokinesia with head-down tilt (-5°) for 120 days. The following subgroups were created: 1 - control without additional treatment, 2 - hypokinesia with head-down tilt combined with physical exercise, which in its intensity and cycle corresponded to that recommended for long-term flights; 3 - hypokinesia with head-down tilt combined with promising drugs; and 4 - hypokinesia with head-down tilt, exercise, and drugs. Metabolism of water soluble vitamins was assessed on the basis of their diurnal renal elimination, activity of erythrocyte vitamin-dependent enzymes and levels of their activation. The method of stepwise discriminant analysis was used to process results.

**Results and discussion.** In all ground studies and after completion of space flights, it was revealed that metabolic parameters of this group of vitamins reflect significant shifts in the nature of biochemical processes during recovery after long-term hypokinesia with head-down tilt or space flight. Stepwise discriminant analysis confirmed (at the 0.95 confidence level) that parameters for group 2 (where hypokinesia with -5° head-down tilt was combined with exercise) were virtually indistinguishable from those of cosmonauts on day 7 postflight. The exception was excretion of vitamin B<sub>6</sub>, which in the experimental (flight?) group was significantly higher. The closest to these data were the results obtained from the group receiving drugs. In the subgroup with combined prophylactic measures, metabolism of these vitamins was closest to normal. The greatest adverse changes were noted in the control group, that is the group not receiving any prophylactic measures.

**Conclusions.** The recovery period after hypokinesia with -5° head-down tilt combined with a set of prophylactic exercises was the closest simulation to the recovery period after long-term space flight according to parameters indicative of metabolism of the vitamins studied. Use of prophylactic exercises during long-term hypokinesia with head-down tilt has a significant effect on the course of the recovery period with respect to parameters of metabolism of water soluble vitamins.

## PAPERS:

P1463(32/91)\* Gabova AV, Tabakov VYu, Tairbekov MG.

***Gravitational sensitivity of eukaryotic unicellular organisms.***

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

25(1): 33-37; 1991.

[19 references; 9 in English].

Microbiology, Eukaryotic Organisms, Growth

*Tetrahymena pyriformis*, *Euglena gracilis*.

Hypergravity

Abstract: This paper describes the results of research performed in the laboratory using artificial gravity from 2- to 5-g with one-celled eukaryotic organisms, *Tetrahymena pyriformis* and *Euglena gracilis*. These organisms were selected because they differ in size, weight, distribution of intracellular organelles, means of locomotion and orientation in space. *Tetrahymena pyriformis* belongs to the Ciliata class and is a highly organized one-celled heterotrophic organism with analogs of all the organs and systems of multicellular organisms. This organism shows a marked negative geotaxis and positive oxytaxis. The cell are elongated and pear-shaped with the center of gravity displaced to the posterior end; mean size is 30 x 50  $\mu\text{m}$ , mean rate of locomotion is 400  $\mu\text{m}/\text{sec}$ , and density is 1.076  $\text{g}/\text{cm}^3$ . Their cilia are evenly distributed over the cells. The other organism, *Euglena gracilis*, is a unicellular flagellate alga, which has an intermediate type of metabolism, either auto- or heterotrophic, depending on environment. The cells are generally cylindrical, 90-100  $\mu\text{m}$  and larger, with a specialized organ of motion — the flagellum. Intracellular elements are distributed asymmetrically, with a single large nucleus and many chromatophors displaced toward the posterior pole of the cell, shifting the center of gravity in this direction, determining the cell's orientation in space and marked negative geotaxis. The locomotive mechanism has the same molecular basis in both these organisms, consisting of contractile protein elements with ATPase activity.

Cultures of *T. pyriformis* were grown under axenic conditions in sterile test tubes. Before the beginning of each experiment 0.5 ml cultures were placed in a 50 ml flask containing 20 ml medium. One day later an inoculate was taken from this flask and centrifuged for 120 hours. The initial concentration of cells in the test tube was approximately  $10^4$  per 1 ml. Samples were taken for analysis after 16, 24, 48, 64, 98, and 120 hours. *E. gracilis* were grown in a heterotrophic sterilized medium containing minerals and organic additives. The cultures was transferred to flasks with a liquid medium and incubated in the dark for 2 days at a temperature of 26-28°C. At the end of the period the density of the culture reached  $2.5 \times 10^4$  cells/ml. One ml inoculate was introduced into a test tube containing 9 ml of medium, so that the final concentration would be  $2.5 \times 10^3$  cells/ml. The tubes were centrifuged for 120 hours, with samples taken every 24 hours. Rotation rates were 87, 108, and 142 rev/min, corresponding to acceleration of 2-, 3-, and 5-g. Control cultures were placed in a temperature controlled environment with temperature matched to that in the centrifuge. Culture density of samples analyzed was measured using standard methods. Before counting, the cells were fixed with a 4% solution of formaldehyde in the case of *T. pyriformis* and Lugol's iodine solution in the case of *E. gracilis*. Cell size was measured immediately after determination of culture density. Two parameters — length and width were measured in the *T. pyriformis*, and volume was computed as  $\frac{4}{3} a^2 b$ , with a the width and b the length. Since *E. gracilis* are close to cylindrical in shape and width variation is very slight, volume was computed from the formula  $a^2 b$  in which a is a constant equal to 10  $\mu\text{m}$  and b is the length of the cylinder. Data were processed statistically using standard methods.

Throughout almost the entire logarithmic growth phase (64 hours) cultures of *T. pyriformis* exposed to 2-g had higher concentrations than control cultures. At 5-g this growth acceleration was present only at the very beginning of the logarithmic growth phase; by the beginning of the second day rate of biomass increase was equivalent for the two cultures. At 2-g the point of intersection of the growth curves occurred at the end of day 3. Subsequent to the intersection point accumulation of biomass was depressed in the experimental culture compared to the control, especially during the phases of slowed growth and stationarity. Overall, magnitude of gravity was inversely related to biomass growth, and the greater the gravity the sooner did growth of exposed cultures start to lag behind nontreated ones. In *E. gracilis*, at acceleration of both 3- and 5-g, culture density was below that of the control during the slowed and stationary growth phases. The inhibition began at 36 hours for 3-g, and at the very beginning of growth at 5-g. With time, experimental cultures lagged further and further behind the control. For the 3-g condition, however, acceleration appears to have had a stimulating effect on culture growth during the initial growth phase. Initial growth stimulation associated with increased gravity is attributed by the authors to initial increased bioconvection. However, with increased gravity, as bioconvection continues, the relative number of cells in the lower layers increases progressively, worsening aeration conditions and leading to delay in growth.

For *E. gracilis* acceleration was associated with diminished size of cells, and to an even greater extent with increased asymmetry. Results with *T. pyriformis* are not reported.

Figure 1: Growth dynamics of cultures [*Tetrahymena pyriformis*] at acceleration of 2- and 5-g

Figure 2: Growth dynamics of cultures [*Euglena gracilis*] at acceleration of 3- and 5-g

P1481(32/91) Kharitonov IG, Guskov IA, Laver W. G (Australia), Abashev YuP, Smith K.D.(U.S.), Shapkin VI, Sinyakov MS.

***Crystallization of neuraminidases of the flu virus on the Soviet Mir space station in June-September 1988.***

In: Trudy XXIV Chtennii Posvyashchennykh Razrabotke Nauchnogo Naslediya i Razvitiyu Idey K.E. Tsiolkovskogo; Труды XXIV (Чтении Посвященных Разработке Научного Наследия и Развития Идей К.Э. Циолковского) [*Proceedings of the XXIVth Lecture Series Devoted to Development of the Scientific Heritage of K.E. Tsiolkovskiy*]. Kaluga 12-15 September, 1989.

Section on: Problems of Prospects for Space Industrialization  
Moscow: USSR Academy of Sciences; 1990

Microbiology, Neuraminidase, Crystallization, Biotechnology  
Flu Virus

Space Flight, Mir, Equipment and Instrumentation, Biokrist Device

**Abstract:** To study the structure of viral proteins, monocrystals must be grown for X-ray analysis. Understanding of these structures is critically important for developing treatments for viral diseases. It has been demonstrated in the West that protein structures suitable for analysis are easier to grow in microgravity. In June-September, 1988 a Soviet-Australian experiment on crystallizing neuraminidases of the flu virus was flown on Mir. Neuraminidase is one of the two surface antigens of flu viruses and makes up 5-10% of total viral protein. It is known to have the following three functions in the infection cycle: 1) postranslational modification of hemagglutinin in new virions grown in the infected cell; 2) facilitation of the process of budding of new mature virions from the surface of the cell, splitting neuraminic acid that attaches the virion to the cell surface; 3) prevention of virion aggregation and reabsorption of the virus on cell membranes. Neuraminidase of flu virus is highly susceptible to antigenic variability, which attenuates the effectiveness of existing flu vaccines.

For the microgravity crystallization experiments, neuraminidases of the B/Leningrad/179/86 (USSR), B/Hong Kong/8/73, whale A virus, and two mutant viruses OX02 and NS-34 (Australia) were used. Protein crystallization occurred in the Biokrist devices. These devices used the principle of the hanging drop, previously used unsuccessfully in space crystallization experiments by American scientists. Considering the American experience, the authors used two devices: one with a freely hanging drop and one with a protected drop. In the latter instance the drops were enclosed in a bag of semipermeable membrane, which did not impede the process of crystallization, but guaranteed maintenance of the solution of protein with crystals growing in them during the experiment itself and on return to Earth. The experiment was performed over the course of 3 weeks in space, and in identical conditions on the ground.

The experiment was begun on June 10, 1988, when the joint Soviet-Bulgarian crew (A. Solovyev, V. Savinykh, A. Aleksandrov) transported two Biokrist crystallizers to Mir, which had been previously seeded with proteins on the ground (total duration 87 days). The experiment in orbit was conducted by Musa Manarov.

After the experiment, the crystalizers were returned to Earth on 7 September 1988.

Then the protein solutions were extracted from the four crystallizers. Crystals were not obtained in the free hanging drops either on Earth or in space. In the protected drop devices viral neuraminidase crystals were obtained on Earth for the B/Leningrad virus and OX-2 and NS-34 viruses. In space, crystals were obtained for the OX-2, NS-34, and B/Hong Kong/8/73 viruses. The size of space crystals was 15%-25% greater than those on Earth. Each type of neuraminidase was crystallized only in a single cell and the probability of obtaining crystals in a cell was extremely small, since it was not known how microgravity affects the process of

## MICROBIOLOGY

protein crystallization. The quality of two crystals was studied in Birmingham, Alabama in the Center for Macromolecular Crystallization.

It was established that the crystals obtained in space had a more regular structure: the coefficient  $R_{sym}$  representing symmetry had a value of 5.4% for space crystals and 9-10% for crystals grown on the ground. When the crystals were irradiated, they dispersed the rays in the same way at the beginning and end of the experiment, indirectly suggesting that the stability and symmetry of the space crystals. Resolution of 2.5 Å was obtained for space crystals, compared to 3 Å for ground crystals, this difference could be significant from the standpoint of X-ray structure analysis. It is concluded that the device used was suitable for growing crystals in space and that space crystals were bigger and more regular in structure than those grown on the ground.

The crystal growing apparatus has been improved: decreased in weight, and the number of cells increased.

Table: Crystals grown in Biokrist crystallization device

Type of neuraminidase	Size of the crystals grown, mm	
	in space	on Earth
B/Hong Kong	0.5	- - - -
OX-2	0.75x0.5x0.2	0.5x0.5x0.1
NS-34	0.55x0.2x0.1	0.5x0.2
A/whale	-----	- - - -
B/Leningrad	-----	0.7x0.53

Figure 1: Photographs of neuraminidase of flu virus crystals [too poor to reproduce]

P1485(32/91) Ilyin VK.

***Study of genetic characteristics and sensitivity to antibiotics of opportunistic microorganisms isolated in sealed environments.***

In: Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

Tezisy Dokladov IX Vsesoyuznoy Konferentsii. (Космическая Биология и Авиакосмическая Медицина. Тезисы Докладов IX Всесоюзной Конференции). [Space Biology and Aerospace Medicine: IXth All-Union Conference]

Kaluga: 19-21 June 1990.

Affiliation: Scientific Council on Space Biology and Physiology, USSR Academy of Sciences; Institute of Biomedical Problems, USSR Ministry of Health

Page 442.

Microbiology, Immunology, Genetics, Antibiotic Resistance

Opportunistic Microorganisms, Intestinal Microflora, Human Indigenous Microflora, Humans, Cosmonauts

Space Flight, Habitability and Environment Effects, Closed Environments

Abstract: The author measured sensitivity to antibiotics and genetic characteristics of 3233 cultures of opportunistic microorganisms isolated from cosmonauts on five space flights and from subjects in nine simulation experiments on the ground. The results obtained suggested the following.

1. Under conditions of inhabitation of closed environments, human beings exchange intestinal microflora.

2. In the process of this exchange a number of strains of intestinal microflora accumulated determinants of antibiotic resistance from the gene pool of the indigenous microflora of individuals in the sealed environment.

3. The process of accumulation of resistance determinants in strains of opportunistic human intestinal microflora occurs at a rate that is directly associated with the rate of influx of "immigrant strains" containing new determinants of resistance from outside the closed environment.

4. The polyresistant strains that form have properties of "hospitalism," that is the capacity to become dominant in closed environment and immunity to drugs and are donors of R-plasmids.

These principles support the following conclusions:

1. Use of antibiotics on spacecraft without allowing for the sensitivity of indigenous microflora of cosmonauts to them, may itself become a factor increasing risk of infection.

2. Strategies and tactics of treatment and prevention of infections in space crews must be based on principles of selective decontamination.

P1487(32/91) Chernova LS, Mashinskiy AL.

***Microbiocenosis of higher plants under conditions of space flight.***

In: Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

Tezisy Dokladov IX Vsesoyuznoy Konferentsii. (Космическая Биология и Авиакосмическая Медицина. Тезисы Докладов IX Всесоюзной Конференции). [Space Biology and Aerospace Medicine: IXth All-Union Conference]

Kaluga: 19-21 June 1990.

Affiliation: Scientific Council on Space Biology and Physiology, USSR Academy of Sciences; Institute of Biomedical Problems, USSR Ministry of Health

Pages 513-515.

Botany, Higher Plants, Wheat  
Microbiology, Microbiocenoses  
Space Flight, Mir, Svetoblok

**Abstract:** Introduction. One of the critical issues in the development of space greenhouses for long-term orbital complexes is the study of the microbiocenoses accompanying higher plants, a group of microorganisms that perform a definite ecological function. Microbial biocenoses for successful functioning in the system, must have a certain degree of stability - the size of physiological groups should not undergo fluctuations that could disrupt equilibrium or even destroy the ecosystem.

**Methodology.** Wheat plants were grown in the Svetoblok-M unit, which included a device to provide water, mineral nutrients and aeration of the area of the roots. Seeds were placed in the unit in a dry substrate, which was moistened only after being loaded on board the spacecraft. An artificial ion-exchange substrate in the form of fabric was used to grow the plants.

This work provides general data on microbiological studies of higher plants in three experiments on board Mir from 1987-1989. Samples were taken on day 19 of plant vegetative growth on board, as well as on the ground, after the plants were returned to Earth. To measure the total number of microorganisms, Koch's plate assay method was used. Beef extract agar was used as the nutrient medium for the heterotrophs, and cabbage agar for the autoflora. When specific groups of microorganisms were studied the following selective media were used: starch-ammonia agar for actinomycetes, acidified Ashby's agar for fungi; Endo's medium for *E. coli*. The method of limiting dilutions was used to conduct a group analysis of the following functional groups of microorganisms: ammonia fixers were isolated on peptone water, denitrifiers on Hilt's medium, and cellulolytic bacteria on Vinogradsky's medium. Identification of the pure cultures isolated included study of their morphological and physiological/biological properties. Traditional statistical methods were used.

**Results.** It was established that on a manned spacecraft, bacterial contamination of the leaf surfaces (phyllosphere) was higher than for the ground control. Among the physiological groups of microorganisms participating in transformation of nitrogen-containing substances studied, the group of ammonia fixers dominated, as occurred for plants on the ground. The number of ammonia fixing organisms, denitrifiers and oligonitrophils in the flight cultures exceeded the controls, which is evidently associated with physiological and biological changes in the plants. Nitrogen fixers and actinomycetes did not develop.

Study of the plant roots showed that the bacterial contamination was of the same order of magnitude in control and flight conditions. The amounts of fungi and cellulolytic bacteria were 2-3 orders of magnitude higher in the flight condition. Evidently the amount of cellulose, which is a source of nourishment for this group of microorganisms, increases in the substrate. This indirectly confirms the data obtained earlier indicating that the aging process of plants is accelerated in space flight.

## MICROBIOLOGY

Bacteria of the *E. coli* group developed on the roots of flight plants, *E. Coli* were not observed. [in the ground experiment?].

Identification of the isolated pure cultures showed a relatively high degree of similarity between the bacteriocenoses in the laboratory and flight conditions, with the same microorganisms dominant. At the same time, spore-forming bacteria occurred in flight conditions, and the composition of microflora was more heterogeneous. *Flavobacteria* were absent in flight cultures, which may be due to ambient conditions on the space station.

Conclusions. The results of studies of the microbiocenosis of wheat under conditions of manned space flight showed that despite the increase in total number of microorganisms and the heterogeneity of microflora in space, the microbiocenosis was not disrupted. This suggests it functions normally in a space environment.

PAPERS:

P1466(32/91)\*Rakhmanov AS, Bakulin AV, Dubonos SL, Novikov VYe, Cann C (U.S.A.), Nogues S (France)

***Study of the state of bone tissue in monkeys flown on COSMOS-1887.***

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

25(1): 42-44; 1991.

[6 references; 3 in English].

Musculoskeletal System, Bone Tissue,  $\gamma$ -Photon Absorptiometry, Tibia, Iliac Monkeys  
Space Flight, COSMOS-1887

Abstract: Noninvasive and direct methods of study were used to evaluate quantitatively the effects of a 13-day space flight on growth and development of the skeleton in monkeys. Joint U.S./USSR studies included X-ray measurements of the lower leg and analysis of the following parameters of the tibia: bone length, thickness of the diaphysis wall (at a level 25 and 50% of the length from the proximal epiphysis), diameter of the marrow canal (at a level 50% of the bone length). Levels of bone minerals were determined by  $\gamma$ -photon absorptiometry at a level 50% of the bone length. Noninvasive studies of the two monkeys flown (Drema and Yerosha) were performed 60 days preflight, and also 16 and 37 days postflight. These animals were placed in a biosatellite mock-up 42 days postflight to run a ground-based control experiment of the same duration as the flight. The last examination of these monkeys was made 16 days after completion of the control experiment. Data from four control monkeys of the same age maintained under vivarium conditions were also analyzed. All measurements were made on the right legs. Assessment of isomorphometric parameters of biopsies of the iliac bone (Soviet-French experiment) was performed in the flight condition only, using calcein<sup>35</sup> administered orally (20 mg/kg) as a bone marker pre- and postflight, and also before and after the ground control experiment.

Osteometry showed that the rate of longitudinal growth of the tibia was homogeneous throughout the period for the control group and equalled 0.04 mm per day. This parameter was virtually identical to the control in Drema. In Yerosha rate of growth was depressed by approximately a factor of two during the period of the space flight. During the experimental period thickness of diaphysis wall decreased in the control animals at a mean rate of 0.003 mm/day, as is normal for a certain phase in long bone growth. At the same time the width of the marrow canal increased. In flight animals the diameter of the marrow canal increased more than in the control, while the mean rate of decrease in diaphysis wall thickness exceeded that of control animals (in Drema 0.008 mm/day, in Yerosha 0.006 mm/day). In the proximal area of the tibia, the width of the cortical layer decreased faster in flight than in control animals.

Mineral levels did not change in the tibial diaphysis in control animals during the period of the flight and increased slightly during the period of the ground control experiment. In both flight animals, mineral level decreased during the flight but increased during the control treatment, suggesting that weightlessness *per se*, rather than hypokinesia led to the decrease.

The results of the experiment on iliac biopsied materials indicate that rate of calcification of spongy bone in the period including the 13-day flight was below that occurring during the ground experiment and the interval between the two experiments.

## MUSCULOSKELETAL SYSTEM

Table 1: Results of noninvasive methods of studying the tibia in monkeys flown on COSMOS-1887

Subject	Period	Length of bone, cm	Thickness of wall of medial diaphysis, mm	Diameter of marrow cavity, mm	Thickness of wall of proximal diaphysis, mm	Mineral level, mg/cm
Drema	F-60	12.35	5.60	4.4	5.50	634
	F+16	12.75	4.40	5.4	4.70	586
	F+37	12.85	4.20	5.7	5.20	585
	C+16	12.90	4.50	5.8	5.60	733
Yerosha	F-60	11.10	5.10	2.7	5.00	555
	F+16	11.35	4.60	2.9	4.30	468
	F+37	11.45	4.50	3.7	3.30	476
	C+16	11.60	4.30	3.8	3.20	529
Control group (n=4)	F-60	11.94±0.13	5.33±0.53	4.02±0.19	5.05±0.95	597±35
	F+16	12.30±0.15	4.88±0.39	4.48±0.30	4.83±0.78	600±45
	F+37	12.40±0.20	5.05±0.34	4.73±0.60	5.23±0.81	607±12
	C+16	12.51±0.25	4.90±0.36	4.71±0.51	5.30±0.59	658±43

Table 2: Results of histomorphometric studies of biopsied material of the iliac bones of monkeys flown on COSMOS-1887

Subject	Period (time between markers, days)	Rate of calcification of spongy bone tissue, mm/day
Drema	Flight (16)	1.250±0.109
	Postflight (41)	1.397±0.114
	Flight & postflight(51)	1.355± 0.111
	Ground exper. (15)	1.649±0.130
Yerosha	Flight (16)	----
	Postflight (41)	----
	Flight & postflight(51)	1.217± 0.175
	Ground exper. (15)	1.765±0.457

P1482(32/91) Kozlov VI, Samoylov NG.

***Morphology of skeletal muscles after long-term hypokinesia and laser acupuncture.***

Arkhiv Anatomii Gistologii i Embriologii

99(11): 50-54; 1990.

[32 references; 18 in English]

Authors' affiliation: Institute of Laser Surgery, Moscow; Pedagogic Institute, Kharkov

Musculoskeletal System, Skeletal Muscles, Morphology, Soleus, Common Extensor

Rats, Males

Hypokinesia, Long-Term, Prophylactic Countermeasures, Laser Acupuncture

**Abstract:** The goal of this study was to investigate the ultrastructure of skeletal muscles in animals exposed to hypokinesia combined with irradiation of the acupuncture points with a laser. Subjects were 156 male Wistar rats, divided into a control group, a group confined in immobilization cages without further treatment for up to 150 days, and animals confined in immobilization cages for the same period and treated with laser irradiation of acupuncture points. Laser treatments used a helium-neon laser operating in a continuous mode with wave length of 638.2 nm and output power? of 25 mV/cm<sup>2</sup>. Data in the literature suggests that these parameters create the optimal effects on living tissue. Two acupuncture points (identified in Chinese) were irradiated daily. Duration of exposure was controlled by finding the duration corresponding to the strongest sympathetic activity of the heart (determined using EKG). This was found to be 15 seconds. Distance between the laser and the body was 30 cm and diameter of the light circle was 0.5 cm. Animals were sacrificed by decapitation after 10, 20, 50, 100, or 150 days. The soleus muscle and *extensor digitorum communis* were isolated. The former was selected because it consists primarily of red muscle fibers and the latter of white fibers. After fixation, pieces were embedded in a mixture of epon and araldite. Sections were studied under an electron microscope. Destructive changes were counted in standard histological sections. Destructive changes were considered to include: 1) disappearance of lateral and longitudinal striation; 2) distension; 3) thinning and contorting?; 4) tears; 5) necrosis. Destructive changes were counted using a grid. Stereological studies were performed using a test grid on standard slides. The proportion of volume of myofibrils and mitochondria were computed. Data were tested statistically.

During the initial period of hypokinesia, edema occurred in the muscle fibers. The vessels reacted by dilation and swelling of the basement membrane. Many lost their turgor and became convoluted (coiled). At the ultrastructural level, there were signs of fibrinolysis in the Z-lines: myofibrils (MF) disintegrated and separated into fragments, while the Z-lines themselves lost their strict parallel arrangement. The most extreme change occurred after 50 days of hypokinesia, when many fibers were thinned and fragmented. Mitochondria (MC) were much affected, showing edema, lightened matrices and dramatically reduced numbers of cristae. After longer periods of hypokinesia (100-150 days) less extreme ultrastructure changes were noted in muscle fibers. Stereological analysis showed that the amount of destructive processes was correlated with decrease in volume of both MF and MC.

Study of destructive changes and shifts in ultrastructure components in muscle fibers of animals exposed both to hypokinesia and laser puncture revealed dramatic decreases in destructive changes compared to hypokinesia alone and an increase in the ultrastructures responsible for contraction and energy transformation compared to control. Thus laser puncture would seem to have a protective effect.

The red fibers of the soleus muscle underwent greater destructive changes in association with hypokinesia than the predominantly white-fiber *extensor digitorum*.

## MUSCULOSKELETAL SYSTEM

The authors conclude that laser stimulation of acupuncture points prevents development of destructive processes in muscles occurring under hypoxic conditions during long-term immobilization and stimulates formation of the most important ultrastructures of muscle fibers — the myofibrils and mitochondria.

Table: Kinetics of percentage by volume of myofibrils and mitochondria after hypokinesia and laser puncture

Figure: Kinetics of destructive processes in the soleus muscles of 4-month old rats after hypokinesia and laser puncture

## MUSCULOSKELETAL SYSTEM

P1484(32/91) Alekseyeva IV.

***Use of the diphosphonate Xydiphon to correct posttraumatic regeneration of bone tissue during long-term hypodynamia.***

Patologicheskaya Fiziologiya i Eksperimentalnaya Terapiya.

1990(6): 46-48.

[11 references; 9 in English]

Authors' Affiliation: Semashko Medical Stomatological Institute, Moscow

Musculoskeletal System, Bone Tissue, Post-traumatic Regeneration, Femur

Rats

Hypodynamia, Amputation, Trauma, Pharmacological Countermeasures, Disphosphonates, Xydiphon

**Abstract:** This study investigated the effects of administration of Xydiphon— a salt of hydroxyethylidenediphosphonic acid — on impairment of posttraumatic bone regeneration caused by long-term hypodynamia. Subjects were 121 white outbred rats of both sexes divided into eight groups. Group 1, the control group, was untreated; group 2 received Xydiphon but was otherwise untreated; group 3 was exposed to hypodynamia; group 4 — hypodynamia and Xydiphon; group 5 — trauma; group 6 — trauma + Xydiphon; group 7 — trauma + hypodynamia; group 8 —trauma + hypodynamia + Xydiphon. Hypodynamia of the limbs was produced by amputation of the bottom two thirds of the left lower leg. Trauma was induced in the diaphysis of the left upper leg by drilling two holes 0.3 mm in diameter into the medullary cavity with a dental drill. Distance between the holes was 5 mm. The wound was sewn up. Amputation and wound induction were performed at the same time in anesthetized animals. Xydiphon was administered daily in a dose of 5 mg per 100 g body weight. On days 20 and 40 some animals were sacrificed and the femurs isolated, cleaned of soft tissue, and fixed. X-rays were taken in lateral and frontal projections. Cross sectional dimensions were measured in the medial portion of the diaphysis on the X-ray, using a microscope fitted with an ocular micrometer. Thickness of the cortical layer and width of the diaphysis and medullary cavity were measured. A fragment was removed from the center of the diaphysis and the density (in g/cm<sup>3</sup>), ash content (in %), and mineral saturation (in g/cm<sup>3</sup>) were measured.

On day 20 after treatment use of Xydiphon was associated with slight decrease in the thickness of the cortical layer, width of the diaphysis, and medullary cavity in otherwise untreated rats (group 2). On day 40 these changes were even slighter. After 20 days this group displayed no changes in biophysical properties of bone, and after 40 days these parameters were slightly diminished compared to control. Rats treated only by amputation (group 3) displayed significant thinning of the cortical layer of the diaphysis of the femur and some increase in the width of the medullary canal at both measurement times, suggesting slowed bone growth. Bone density increased by 10.4% and mineral saturation by 16% after 20 days, and decreased to below control after 40 days, due to resorption sites, suggesting spongification. After 20 days, animals subjected to amputation and given Xydiphon, displayed normalization of the thickness of the cortical layer and decrease in the width of the medullary cavity. On day 40, thickness of the cortical layer and width of the diaphysis and medullary cavity had increased compared to animals treated with Xydiphon alone. Administration of Xydiphon caused these animals to differ less in bone density, ash content, and mineral saturation than animals in group 3. These data are taken to suggest that Xydiphon inhibits bone resorption resulting from hypodynamia.

Animals with injured femurs (group 5) displayed some increase in thickness of cortical layer on day 20 and normalization of this parameter on day 40 in the injured posterior area of the femur and no changes on the front surface. Width of the diaphysis and medullary cavity were depressed on day 20 and especially day 40, suggesting inhibition of cross-sectional growth of the diaphysis during posttraumatic regeneration. Density, ash content, and mineral saturation

## MUSCULOSKELETAL SYSTEM

were unchanged on day 20, and all three were significantly elevated on day 40. Thus, at this period mineral substances dominated organic ones. When Xydiphon was administered to traumatized rats (group 6) there was significant decreases in width of the cortical layer in both the front and rear surfaces of the diaphysis on day 20, with changes diminished on day 40. Bone density was the same in this groups as in group 5. However, ash content, reflecting mineralization of the organic component, decreased, as did mineral saturation on day 20. On day 40 these parameters increased. Density of the diaphysis reached control levels, while ash content and mineral saturation decreased.

Trauma combined with loss of support loading (group 7) led to very large decreases in the widths of the cortical layer, medullary cavity, and especially of the diaphysis on day 20. On day 40 these changes were even more pronounced. When Xydiphon was administered to animals suffering both trauma and amputation (group 8) parameters approached those of groups 5 and 6. On day 40, width of the cortical layer in group 8 rats was higher than that of group 7, but had not yet reached the level of group 5. Trauma+ hypodynamia led to changes in state of bone tissue in group 7: on day 20 density ash content, and mineral saturation of the diaphysis fragment increased. This may be explained by predominance of resorption of bone tissue from the area of the endosteum, which has a low degree of mineral saturation. On day 40 the opposite changes occurred, decrease in these parameters, evidently due to increased resorption in the center of bone tissue of the diaphysis. Marked osteopenia in this group was manifest in significant decreases in the cross sectional area of the diaphysis.

As a result of administration of Xydiphon for 20 days, in group 8 all these changes tended to normalize and approached those of animals suffering trauma alone (group 5). On day 40, this partial normalization held only for cross sectional area, while there were significant decreases in mineral saturation and ash content, indicating low mineralization.

The author suggests that the effect of Xydiphon in inhibiting osteoporosis is due to its inhibition of resorption of bone tissue.

Table: Effects of Xydiphon on posttraumatic regeneration of the diaphysis of the femur bone in rats with or without elimination of supporting function (hypodynamia)

## PAPERS:

P1457(32/91)\* Kornilova LN, Goncharenko AM, Korsunskiy SB, Tarasov IK, Alekseyev VN.  
*Vestibular function and sensory interaction after space flight.*  
 Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.  
 25(1): 12-17; 1991.  
 [12 references; 6 in English].

Neurophysiology, Vestibular Function, Sensory Interaction, Electro-oculography, Nystagmus,  
 Cerebellar Coordination, Gaze Fixation, Tracking  
 Humans, Cosmonauts  
 Space Flight. Salyut-7, Mir, Long-Term, Short-Term

**Abstract:** This paper describes postflight studies of vestibular and sensory functioning of a total of 30 cosmonauts (16 after their first flights) completing spaceflights varying from 7 to 366 days on Salyut-7 and Mir. These functions were studied using electro-oculography performed 30 days preflight and on postflight days 0-1, 2-3, 5-6, 8-10, and occasionally, 14-15 and 75. Recordings were made of spontaneous and positional nystagmus in seated, horizontal, head-down (-30°), and head-up (+30°) positions, and during passive tilt on the tilt table. Eye movement reactions were recorded with eyes closed, open without opaque glasses, and with eyes open in opaque glasses. In addition the fixation capacity (time to fixate a visual target) and accuracy of fixational movements of the eye when visual stimuli less than 0.5° in size were moved +10° vertically or horizontally were measured at all the body positions listed above with standard head position. Smooth tracking of a target undergoing pendular oscillations in the horizontal dimension with frequency 0.5 and 1 Hz and amplitude of ±10° was also studied under all these conditions. After these studies were completed, eye movement responses to vestibular, optovestibular, and proprioceptive stimulation and eye movements during performance of tests of cerebellar coordination were investigated.

Vestibular stimulation was created through active head movements in the sagittal and frontal planes and rotation of the head around the long axis of the body with eyes closed or open in dark glasses (6-10 movements, at a rate of 1 every 8 seconds, with amplitude of 90°). Optovestibular stimulation was created through analogous rotation and shaking of the head with open eyes without dark glasses, with and without fixation of a visual target. Proprioceptive stimulation was created by having the subject support himself on his hands and feet and through active muscle tension with eyes closed or open with or without target fixation. Cerebellar coordination was tested in various positions using the finger-to-finger and finger nose tests with eye movements recorded continuously.

Measured parameters of nystagmus included total and mean amplitude, total and mean rate of the slow and rapid phases, frequency, and rhythm. Standard deviations for each parameter and correlations between parameters with closed and open eyes were also computed.

Before the flight no signs of vestibular dysfunction were observed. Postflight spontaneous nystagmus was observed in only two subjects, who had completed 75- and 237-day flights. In 83% of subjects, preflight responses of oculomotor and vestibular systems to the set of stimuli were normal and symmetrical. The remaining 17% (n=5) displayed microsaccadic activity in all positions, especially head-down. Four of these five subjects displayed vestibuloautonomic reactions in flight, viz. illusions and motion sickness symptoms, in response to head movement. The two cosmonauts displaying spontaneous nystagmus preflight, denied experiencing autonomic discomfort, but did experience illusions in flight.

Postflight all cosmonauts completing long-term flights (with the exception of the commanders of the 327- and 366-day flights) and 4 (out of 16) completing short-term flights displayed

## NEUROPHYSIOLOGY

signs of vestibular dysfunction on days 0-1 and 2-3 postflight, with varying severity of illusions, motor and autonomic reactions. Dysmetric and dysrhythmic spontaneous nystagmus was recorded in the vertical leads of the electrooculogram directed downward and in the horizontal leads directed to the right in resting subjects, and also during active and passive changes in position. Changes in position did not alter nystagmic direction but did affect intensity (which increased in head-up and decreased in head-down positions). In the two cosmonauts displaying spontaneous nystagmus preflight, it was unaltered postflight. The majority of cosmonauts displayed altered eye movement responses to optovestibular and proprioceptive stimulation and tests of cerebellar coordination. All cosmonauts completing long-term flights showed changes in the tracking reflex involving replacement of smooth movements with jerky, abrupt ones. After long-term flights virtually all cosmonauts suffered from impaired accuracy in changes of fixation.

Subjects were divided into four groups on the basis of their eye movement response to the various types of stimulation during the first few days postflight. Group 1 contained 11 subjects in whom the nature of postflight spontaneous nystagmus changed in response to all types of stimulation. Vestibular and eye movement responses in head-down position were more appropriate than in head-up. Group 2 contained 5 subjects in whom characteristics of spontaneous nystagmus changed only in tilt tests. Group 3 contained 6 subjects in whom changes in nystagmus did not occur when body position was changed, but did do so in response to vestibular, optovestibular and proprioceptive stimulation. Group 4 contained 8 subjects in whom nystagmic reactions were present only in response to optovestibular and proprioceptive stimulation and during the tests of cerebellar coordination. Subsequently subjects in group 1, who displayed altered nystagmus to all stimulation, began to show responses characteristic of groups 2 and 3. In the majority of cosmonauts vestibulo-oculomotor reactions normalized by day 8-10 postflight, and in virtually all of them by day 14. Only the two subjects displaying spontaneous nystagmus preflight continued to display it after this period. Thus, in the vast majority of cosmonauts eye movement response to space flight was transitory in nature.

It is suggested that changes in vestibular function occurring postflight in some subjects, although resembling clinical symptoms of vestibular dysfunction, are actually indicative of the normal course of adaptation to a new sensory environment for these individuals. Subjects who do not respond to vestibular stimulation (head movements with eyes closed) may be considered to display a kind of "functional deafferentation" as part of adaptation, resulting from a mechanism of "central inhibition" developing during flight. Such a mechanism would inhibit transmission of "inappropriate" (due to weightlessness) vestibular signals to effector mechanisms. Changes under certain conditions in eye movement responses to various types of sensory stimulation would reflect change in the nature of interactions of the vestibular and other sensory systems. The occurrence of eye movement responses only to optovestibular (head movement) and proprioceptive, but not vestibular, stimulation would reflect a change in the contributions of various sensory channels to the formation of eye movement responses, a kind of "shift in roles". This in turn emphasizes the integrative nature of what are traditionally called vestibular reactions, but which are actually based on the activity not only of the vestibular, but also of other sensory systems.

## NEUROPHYSIOLOGY

Table 1: Parameters of post-agravitational spontaneous nystagmus in 16 subjects (days 0-1 postflight)

Position	EOG lead	Nystagmic parameter ( $M \pm \sigma$ )		
		Amp, °	Freq., Hz	Slow phase rate, %/sec.
1. Sitting	H	6.1±2.1	1.2±0.7	22.6±3.0*
	V	5.0±1.6	0.9±0.5	18.3±2.8**
2. Horizontal	H	5.0±1.1*	1.0±0.2	18.3±2.1*
	V	3.9±0.8**	0.5±0.2	8.1±0.8**
3. Head-down (-30°)	H	0.0	0.0	0.0
	V	3.5±0.5	0.7±0.1	6.0±0.5
4. Head-up (30°)	H	8.1±2.3*	1.2±0.5	26.1±2.9*
	V	9.5±1.9**	1.0±0.5	30.2±3.1**

Notes: 1, 2, 3, and 4 - represent the order of conditions. Analysis of EOG was performed during the first minute of recording at each position. H - horizontal, V - vertical. \* - significant difference between parameters in the horizontal lead ( $p < 0.05$ ), \*\* - significant different between parameters in the vertical lead ( $p < 0.05$ )

Table 3: Distribution of subjects with respect to nature of eye movement reactions to stimulation

Group	Stimulation				
	Vestibular	Optovestibular	Proprioceptive	Postural	Coordination test
1: (5 long + 6 short)	altered	altered*	altered	altered	altered*
2: (4 long + 1 short)	---	---	---	altered*	---
3: ( 6 short)	altered	altered	altered	---	---
4: (5 long+ 3 short)	---	altered	altered*	---	altered

Notes: Altered is defined with respect to preflight reaction; --- — unaltered; \*  $p > 0.05$ .

## NEUROPHYSIOLOGY

Table 2: The nature of eye movement responses in cosmonauts postflight (distribution of subjects with respect to type of reaction)

Flight Duration	Spontaneous eye movements			Opto-oculomotor reactions				Vestibulo-oculomotor (head movement with eyes closed)					
	Unalt	Increase	Spont. nystag.	Fixation		Tracking		Rotation <sup>1</sup>		Shaking <sup>2</sup>		Shaking <sup>3</sup>	
				Unalt.	Alt.	Unalt.	Alt.	Unalt	Alt.	Unalt.	Alt.	Unalt.	Alt.
Long (n=14)	2	-	12	2	12	-	14	9	5	9	5	9	5
Short (n=16)	10	2	4	12	4	13	3	3	13	4	12	4	12
Total (n=30)	12	2	16	14	16	13	17	12	18	13	17	13	17

Flight Duration	Optovestibular reactions (head movements w. eyes open)						Proprio-oculomotor reactions				Positional oculomotor reactions					
	Rotation <sup>1</sup>		Shaking <sup>2</sup>		Shaking <sup>3</sup>		Pressure on foot		Muscle tension		on back		on right side		on left side	
	Unalt	Alt.	Unalt	Alt.	Unalt	Alt.	Unalt	Alt.	Unalt	Alt.	Unalt	Alt.	Unalt	Alt.	Unalt	Alt.
Long (n=14)	-	14	1	13	1	13	2	12	-	14	2	12	2	12	2	12
Short (n=16)	5	11	4	12	4	12	3	13	5	11	10	6	12	4	12	4
Total	5	25	5	25	5	25	5	25	5	25	12	18	14	16	14	16

Flight Duration	Postural oculomotor reactions				Oculomotor reactions during tests of cerebellar coordination			
	Passive tilt 90° → 120° (-30°)		Passive tilt 120°-60° (+30°)		Finger-nose		Finger-to-finger	
	Unaltered	Altered	Unaltered	Altered	Unaltered	Altered	Unaltered	Altered
Long (n=14)	4	10	4	10	3	11	3	11
Short (n=16)	10	6	10	6	8	8	8	9
Total (n=30)	14	16	14	16	11	19	11	19 [sic.]

Notes: <sup>1</sup> - around the long axis of the body, <sup>2</sup> - in the sagittal plane, <sup>3</sup> - in the frontal plane  
 Altered is defined with respect to preflight responses.

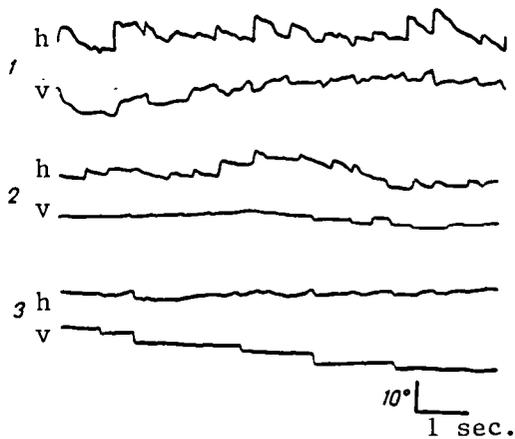


Figure 1: Spontaneous nystagmus with eyes open in opaque glasses after a 211- day flight (day 1 )  
 1 - in head-up (+30° tilt), 2 - in horizontal; 3 - in head-down (-30°tilt). Here and in Figures 2 and 3: a - horizontal EOG lead; b - vertical EOG lead.

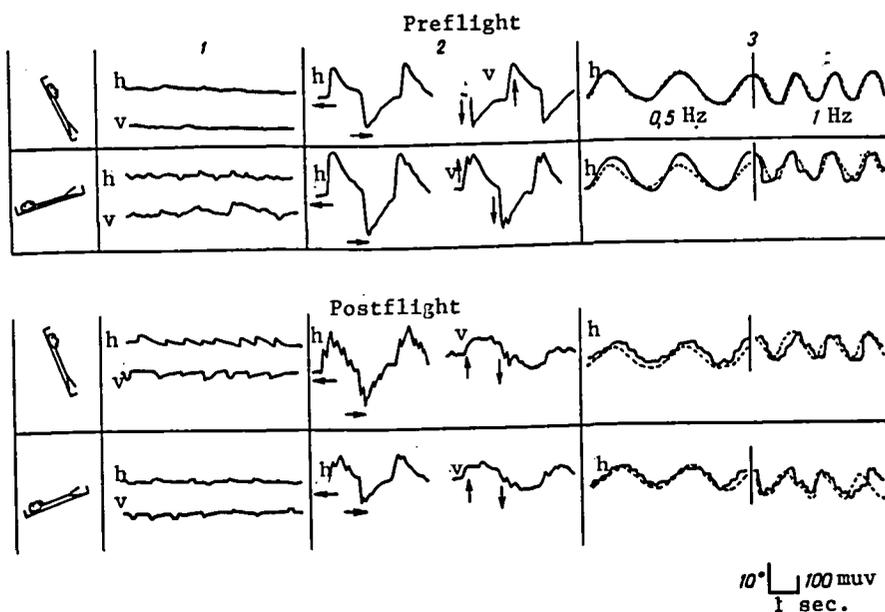


Figure 2: Forms of EOG recording spontaneous eye movement activity (1), change in fixation (2) and tracking (3) before and after (day 1) a 366-day flight in head-up (+30°) and head-down (-30°) positions. Direction of arrows indicates gaze.

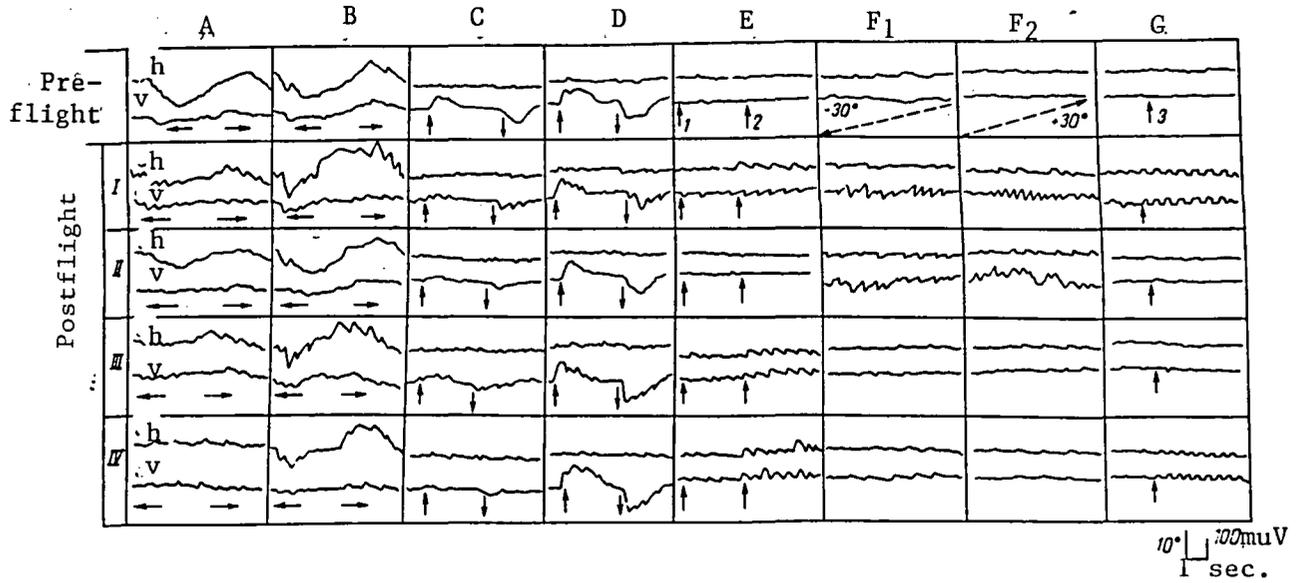


Figure 3: Effect of type of stimulation on nature of EOG in subjects in various groups in horizontal position on the back

A - vestibulomotor reaction turning head with eyes closed around the long axis of the body; B - optovestibulo-oculomotor reactions to turning head with eyes open; C - vestibulo-oculomotor reaction to shaking head with eyes closed in the sagittal plane; D - optovestibulo-oculomotor reaction while shaking the head with open eyes. E - proprio-oculomotor reactions (with eyes closed). Arrow with number 1 - foot support, arrow with number 2 - overall muscle tension, F<sub>1</sub> - postural oculomotor reactions moving from horizontal to head-down position (-30°); F<sub>2</sub> - shift from head-down to head-up position (+30°); G - oculomotor reactions during test of cerebellar coordination; arrow with number 3 - finger-nose test.

Arrow to the left - rotation of the head around the long axis of the body to the left; arrow to the right — rotation of the head around the long axis of the body to the right; arrow down - nodding of the head in the sagittal plane forward and down; arrow up - nodding of the head in the sagittal plane up and back.

P1458(32/91)\* Gorgiladze GI, Matveyev AD.

***The effect of weightlessness on vestibular function.***

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

25(1): 17-21; 1991.

[18 references; 6 in English].

Neurophysiology, Vestibular Function, Electro-oculogram

Humans, Cosmonauts

Space Flight, Soyuz-T-4-Salyut-6, Soyuz-T-7-Salyut-7, Long-Term, Short-Term

Abstract: Studies were performed on the commander and flight engineer of the crew of Soyuz-T4-Salyut-6 immediately and on day 56 after completion of a 75-day orbital space flight; and on the payload specialist of Soyuz-T7-Salyut-7 preflight, on day 2 of exposure to space, and on day 2 after completion of a 7-day orbital flight. Eye movements were recorded by electro-oculography with time constants of 1, 1.5, and 4 seconds. The procedures used four silver electrodes, three of which were mounted on a rubber helmet worn by the subject, while one was attached to the lower edge of the orbit of the right eye. In the first two cosmonauts an electro-oculogram (EOG) was recorded in opaque glasses with the gaze fixed, and also in response to optokinetic stimulation. In the payload specialist, an EKG and pneumogram were recorded along with the EOG. The subject wore opaque glasses with fixed gaze at rest and while shaking the head in the frontal plane at a rate of one shake per second. Amplitude of one cycle of head shaking from one shoulder to the other was 90°. Parameters were recorded throughout a 2-minute period of head shaking and for 1 minute after its cessation. For optokinetic stimulation, the subject in a seated position looked into a binocular device with head restrained by a strap. Inside the device, 20 cm from the illuminated background, there was a rotating tape with alternating black and white stripes. The width of each stripe was 10 mm. The tape could be moved to the left or right at speeds of 40, 60, 80, 100, or 120 stripes per minute.

The pre-, in-, and postflight EOG of the payload specialist at rest showed no signs of spontaneous eye movements with the head fixed or in opaque glasses. Preflight head shaking evoked characteristic movement of the eyeball. In the dark, rapid jerky movements of low amplitude were recorded in the vertical EOG lead, in addition to slow compensatory movements with amplitude of 15-18°. No significant movements were recorded in the horizontal lead. When the gaze was fixed during head shaking, compensatory movements increased in amplitude and became sinusoidal with saccades absent. The horizontal lead recorded movement. Eye movements stopped immediately after cessation of head shaking. In weightlessness, during head shaking, slow compensatory eye movements were suppressed. Nystagmus arose in both EOG leads in the dark as well as under conditions of gaze fixation. Amplitude of rapid movements reached 11° in the horizontal lead and 15° in the vertical. These values increased with gaze fixation. When head shaking stopped, eye movements persisted for some period. On day 2 postflight head shaking again evoked compensatory movements, but their amplitude was reduced by a factor of 1.5 to 2, and they were virtually absent in the horizontal lead. In addition, slow eye movements were continually interrupted by low-amplitude saccades. Eye movements disappeared when head movement ceased. In all cases head movement led to increase in heart and respiration rate. This effect was somewhat more pronounced on day 2 postflight. These parameters normalized immediately when head movement stopped. No symptoms of discomfort were noted.

Immediately after return, one cosmonaut of the Soyuz-T4—Salyut-6 crew registered clear spontaneous nystagmus in both horizontal and vertical leads while wearing opaque glasses, inhibited somewhat when the eyes were closed. In addition, his gaze drifted when he attempted to fix it on something in front of him. The other cosmonaut did not display these symptoms. Both cosmonauts displayed significant changes in eye movement responses to optokinetic stimulation, compared to responses on day 56 postflight. The commander showed a normal response when tracking a slow moving stripe, but when tape speed increased (80+ stripes per minute)

## NEUROPHYSIOLOGY

nystagmic movement virtually disappeared and was replaced by slow eye movements. The response of the engineer to movement in different directions was highly asymmetrical. The normal alternation of fast and slow movements was disrupted. The authors interpret these phenomena as manifestations of vestibular asymmetry arising as a result of disruption of the paired functioning of the labyrinths during space flight.

Table: Heart and respiration rate in the payload specialist of the Soyuz-T7-Salyut-7 orbital complex at rest and during head shaking in the frontal plane preflight, in microgravity and after completion of a 7-day space flight

Period	Heart rate			Respiration rate		
	at rest, in dark	in dark	head shaking fixed gaze	at rest, in dark	in dark	head shaking fixed gaze
Preflight	76	88	86	11	23	20
Inflight (day 2)	60	65	70	13	24	27
Postflight (day 2)	75	79	80	16	27	29

Figure 1: Diagram of the location of electrodes for recording EOG, EKG and pneumogram in orbital flight

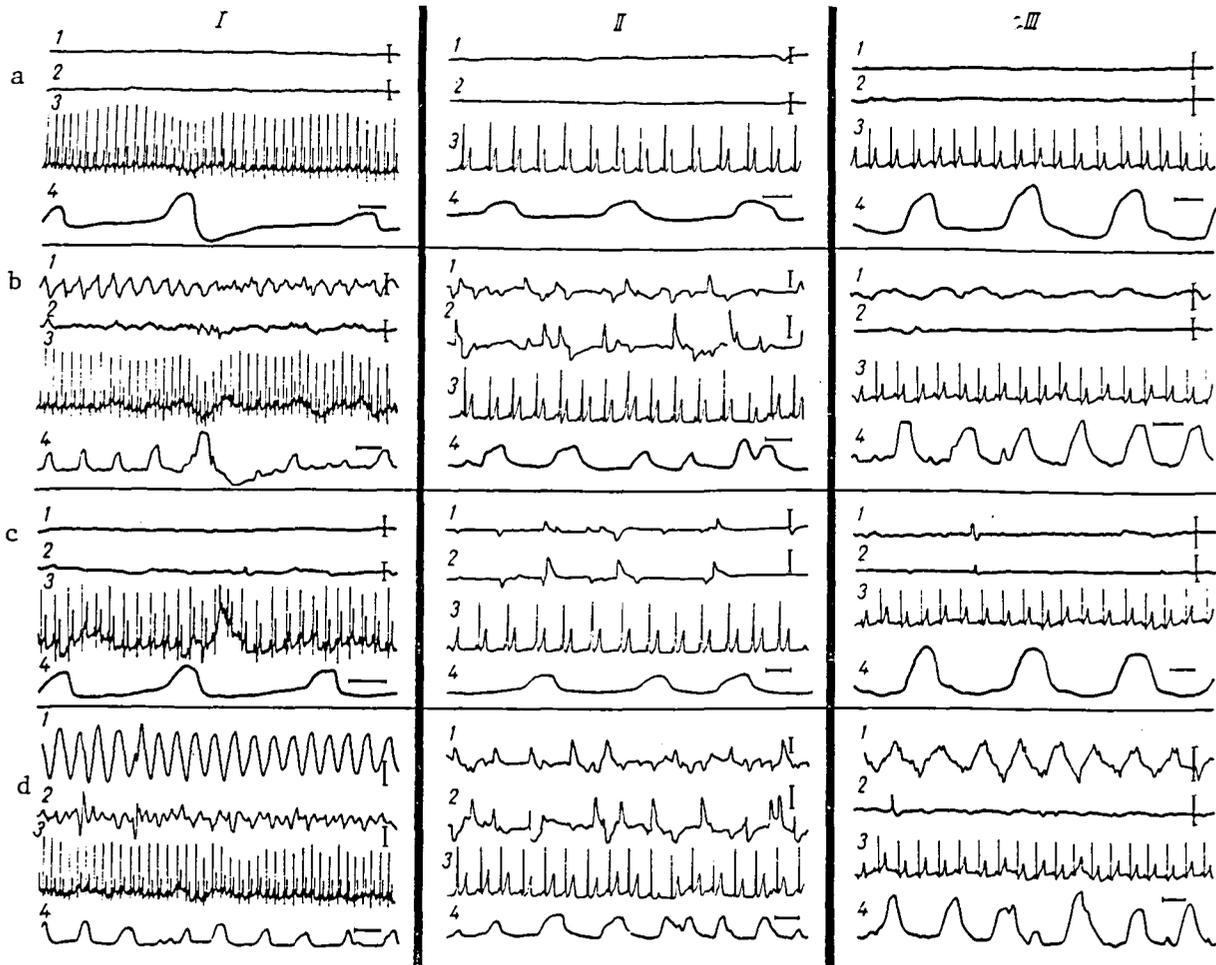


Figure 2: Eye movement reactions in the payload specialist of the Soyuz-T7-Salyut-7 orbital complex

During shaking of the head in the frontal plane with a frequency of 1 per minute preflight (I), on day 2 of flight (II) and on day 2 after a 7-day flight (III); a - EOG, recorded in opaque glasses at rest; b - during head shaking; c - immediately after cessation of head shaking; d - shaking head in the light with fixed gaze. Recording with time constant = 1 second. 1 - EOG in vertical lead; 2 - in horizontal lead. 3 - EKG, 4 - pneumogram. Calibration for I and III — 18°, for II — 11°; time scale for I - 2 seconds, for II and III — 1 second.

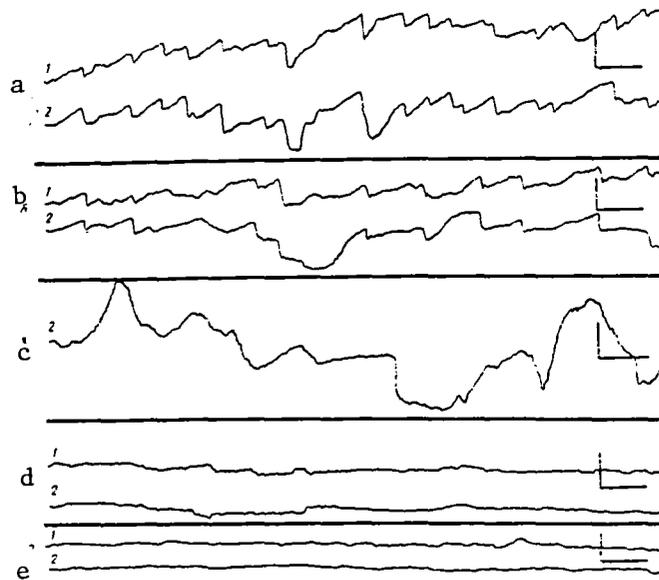


Figure 3: Eye movement in the flight engineer of the Soyuz-T4-Salyut-6 orbital complex. Spontaneous nystagmus in opaque glasses in a seated position with head erect and open eyes (a), with closed eyes (b) and involuntary slow eye movements during gaze fixation (c) 1 hour after completion of a 75-day orbital flight; d - absence of nystagmus and "drifting" eye movements in opaque glasses on day 56 post flight, e - the same thing during gaze fixation. 1 - EOG in vertical lead, 2 - in horizontal lead. Recording with time constant of 1.5 seconds (a, b) and 4 seconds (c). Calibration for a, b, d, e - 15°, 1 second; for c - 20°, 2 seconds.

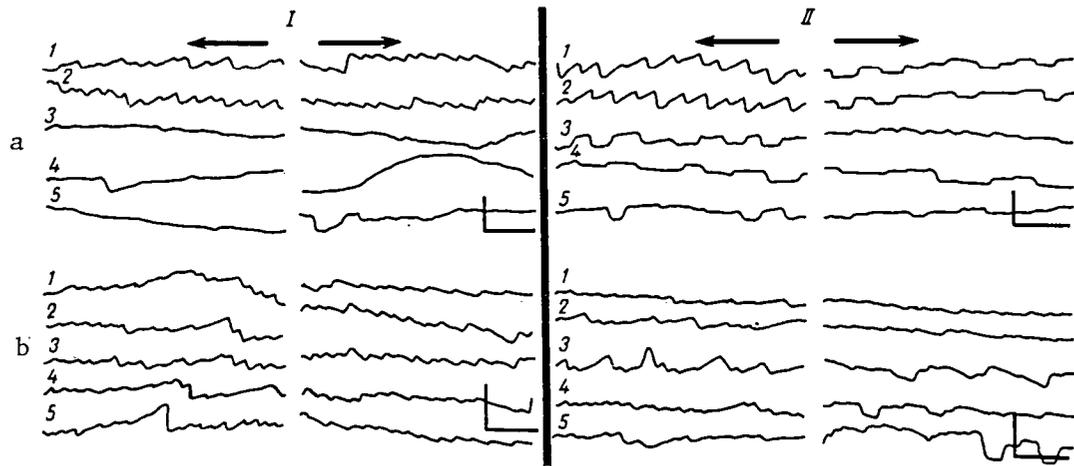


Figure 4: Optokinetic reaction in the commander (I) and flight engineer (II) of the Soyuz-T—Salyut-6 orbital complex

Displacement of black and white stripes to the left and right (shown by arrows), at rate of 40 (1), 60 (2), 80 (3), 100 (4) and 120 (5) stripes per minute, 80 minutes (a) and 56 days (b) after completion of a 75-day orbital flight. Time constant — 1.5 second. Calibration — 20°, 1 second.

P1459(32/91)\*Karkishchenko NN, Dimitriadi NA.

***Antiepileptic drugs in complex pharmacological prevention of motion sickness.***

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

25(1): 21-23; 1991.

[19 references; 10 in English]

See: Abstract 1205 (Neurophysiology) Digest Issue 27

Neurophysiology, Space Motion Sickness, Human Performance, Mental Work Capacity  
Humans, Patients, Vestibular Tolerance, Diminished  
Rotation, Pharmacological Countermeasures, GABA-ergic System

**Abstract:** The goal of this work was to investigate whether antiepileptic drugs affecting the GABA-ergic system when used in combination would prevent motion sickness.

Healthy male volunteers, aged 20-26, with diminished vestibular tolerance participated in the experiment. Motion sickness was induced through rotation and vestibular stimulation on a vestibulometric stand. Rotation was continued until the subjects developed symptoms of level II-III in severity. The signal to terminate vestibular stimulation was the onset of nausea or vomiting. Drugs were taken in a single dose 1-1.5 hours before the beginning of the experiment. Subjects were assigned to conditions including a placebo condition through a double blind procedure. Scopolamine in a dose of 1 mg was used as a standard. The anti-motion sickness efficacy of the drugs was assessed by recording length of time a subject tolerated exposure to acceleration and by the dynamics of development of clinical motion sickness symptoms. A conditioned evoked potential was established in a darkened isolated chamber through the pairing of a rap and a light flash. The experiment was controlled by computer. EEG was measured in the frontal, central, temporal, and occipital zones. First conditioned evoked potential was developed and analyzed. On the next day motion sickness was induced. Immediately after termination of rotation, conditioned evoked potential was tested and studied. The study was repeated after 14 days. The results were processed and tested using the Wilcoxon paired measurements test. Drugs used and their efficacy with respect to endurance time are described in the Table.

A single dose of Diphenin (Dilantin, phenytoin) or Dapakene (valproic acid) [both anticonvulsants] were associated with significant anti-motion sickness effects. These effects included longer tolerance of complex acceleration, and faster reduction of symptoms of motion sickness. Pantogam (calcium homopantothenate, an anticonvulsant) alone did not have such effects. [omitted from table]. The antimotion sickness effects of the former drugs is associated with their action on the GABA-ergic system. The anticonvulsant effects of these drugs can be enhanced by activation of other mechanisms. The use of the so-called nootropic drugs may potentiate the effects of anticonvulsants. The nootropic agent Piracetame (a cyclic analog of GABA) has a significant anti-motion sickness effect. Preliminary studies failed to find a positive effect of the following combinations of drugs: phenytoin (300 mg)+ valproic acid (450 mg) alone, or in combination with Diazepam (Valium, 5 mg); Clonazepam (an antiseizure agent, 2 mg); phenytoin (300 mg) + Piracetame (2000 mg); valproic acid (450 mg) + calcium homopantothenate (1000 mg), with or without 2000 mg Piracetame.

The combination of phenytoin in a dose of 300 mg and calcium pantothenate in a dose of 100 mg had a strong anti-motion sickness effect and also accelerated attenuation of motion sickness symptoms. In studies of conditioned evoked potential it was determined that unlike scopolamine, the above combination did not decrease the amplitude of evoked potential, suggesting less detriment to associative mental processes.

Table: The effects of drugs on endurance time for complex acceleration

Drug	Endurance time, seconds M±m		
	1	2	3
Placebo	118.3±10.7	123.3±11.3	104.2±9.6
Scopolamine	136.1±9.2	167.8±10.0**	123.3±7.3
Phenytoin, 200 mg	123.2±11.9	187.8±22.3*	146.3±17.4
Phenytoin, 300 mg	104.4±16.0	170.0±28.3**	162.8±27.1
Placebo	144.1±7.8	153.2±7.6	106.5±5.3
Scopolamine	139.3±8.2	162.7±11.4*	116.8±8.2
Valproic acid, 300 mg	99.1±9.6	131.7±18.7	132.9±18.7
Valproic acid, 450 mg	99.3±12.0	166.4±17.3	167.6±17.5
Placebo	125.9±17.8	138.4±16.5	109.9±13.1
Scopolamine	128.5±15.9	161.8±22.7**	125.9±17.6
Pyracetame, 2000 mg	120.0±22.0	230.0±57.7	191.7±48.1
Placebo	85.0±13.8	89.4±13.7	105.2±16.1
Scopolamine	85.6±8.0	94.4±10.2	110.2±11.9
Phenytoin 300 mg + calcium homopantothenate 100 mg	104.4±18.6	211.3±22.8**	202.4±21.8

1 - endurance time before drug (seconds)

2 - endurance time after drug (seconds)

3 - 2 as a percentage of 1

\* -  $p < 0.05$ ; \*\*  $p < 0.01$  {Note: not all significant appearing differences are flagged}

Figure: The effect of diphenin and calcium pantothenate and scopolamine on changes in conditioned evoked potential parameters caused by motion sickness induction.

P1460(32/91)\* Lychakov DV, Pashchinin AN.

***The effect of whole-body low frequency vibration on the righting reflex, static endurance and structure of vestibular receptor organs in rats.***

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

25(1): 23-28; 1991.

[14 references; 6 in English]

Neurophysiology, Righting Reflex, Static Endurance, Vestibular Organs

Rats

Vibration, Low-Frequency, Whole-Body

Abstract: Subjects in this study were 16 healthy Wistar rats. In the first experiment rats were subjected to whole body vibration with frequency of 18 Hz and acceleration of 2.4-g for an average of 5.8 hours per day, 5 days a week for 2 weeks. In the second experiment the animals were submitted to vibration at a frequency of 30 Hz with acceleration of 9.6-g for a mean of 5.1 hours per day for 11 days. Vibration was in the vertical direction. During the experiment rats were unrestrained in individual cages. Control rats were maintained under vivarium conditions. A special device was constructed to allow study of the righting reflex. The rats held on to a bar with their paws in an upside down position; when the bar was jerked the animals fell downward and a series of photographs were taken of their descent. The photographs were used to measure the angle of the head and trunk to the horizontal during the fall. This procedure was repeated 5 times for each animal. Static endurance was measured by the maximum time animals could hold onto a bar before falling. Before the experiment the animals were weighed, since static endurance depends on weight. Animals fell into an elastic net so as to prevent injury. Material for morphological studies was taken 21-22 hours after conclusion of the experiment. The status of the otolith membrane was evaluated using a light microscope. The size of the saccular otoconia was measured under a fluorescent electron microscope. Serial sections of the maculae of the utricle and saccule and cristae of the posterior semicircular canal 5 and 10  $\mu\text{m}$  thick were studied with a light microscope. The severity of edema of the calyform nerve endings in the receptor epithelium of the saccule and posterior ampulla was measured.

Animals exposed to vibration gained weight more slowly than those in the control group. Those exposed to faster vibration gained more weight than those exposed to slower vibration. As animals in the control group gained weight their static endurance decreased in a normal manner. In the 18 Hz group, although animals gained weight, their static endurance increased. Animals in the 30 Hz group decreased in static endurance, but to a lesser extent than in the control group. Animals exposed to vibration had higher endurance than animals of identical weight in the control group. In the control group indicators of the righting reflex were unaltered over the two week experimental period. After exposure to vibration, animals fell with their bodies at a greater angle to the horizontal than before the exposure. This effect appears to be cumulative in nature as it was not detected after 7 days of vibration exposure. Morphological examination revealed no significant qualitative changes in the structure of the otolith membrane, maculae, cristae, nerve fibers or capillaries. Morphometry was performed only on material from rats undergoing vibration of 18 Hz. In the central portion of the receptor epithelium of the posterior ampullae, the calyform nerve endings were more swollen in experimental than in control animals. The asymmetry coefficient with respect to swelling of these endings in the posterior ampullae was greater for the experimental rats. No differences were found in the saccule.

Table 1: Results of measurement of mass and static endurance of rats exposed to vibration of 18 and 30 Hz

Table 2: Static endurance of experimental and control rats with the same body weights

## NEUROPHYSIOLOGY

Table 3: Dimensions of the otoconia of the otolith membrane of the sacculus in rats exposed to vibration of 18 Hz

Table 4: Relative sizes of the calyform nerve endings in the striola of the sacculus and central area of the posterior ampulla in rats exposed to vibration of 18 Hz

Table 5: Effects of vibration on the vestibular apparatus of animals

Figure 1: Righting reflex in rats from the control and experimental groups

Figure 2: Angles of the head and body to the horizontal after 4/15, 5/15, and 6/15 seconds of fall

P1461(32/91)\* Panferov SV, Milyavskaya TI, Yevseyev YeA, Shapovalov SL.

***Gaze fixation in civil aviation pilots.***

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

25(1): 28-30; 1991.

[9 references; none in English]

Neurophysiology, Gaze Fixation, Phoria

Humans, Pilots

Aviation Medicine

**Abstract:** Studies of visual functions were performed on 284 pilots in transport aviation who had been referred for corrective treatment. Studies involved determining binocular interaction at a state of rest (phoria) and measuring reserves and amplitude of fusion. Phoria was studied by mechanical separation of the visual field. Fusion reserves? and amplitude were measured using a synoptophore, a device to measure stability of fusion, and a new method using lasers.

A total of 201 pilots were found to have myopic refraction and 83 hyperopic. The mean phoria in the hyperopic group corresponded to esophoria of 0.86 diopters and did not differ from the norms for the age. The mean phoria of pilots with myopic refraction corresponded to exophoria of 2.3 diopters, suggesting diminished binocular interaction. Thus, at rest, pilots with myopic refraction tended to show divergence of lines of sight. Of the 201 subjects studied with the synoptophore, 39 myopic pilots and 24 of the hyperopic pilots required correction of phoria. An important parameter of binocular vision is the fusion reserve; the capacity for a compensatory outward movement determines the size of negative fusion reserve, while compensatory inward movement capacity determines positive fusion reserve.

The authors conclude that the results of their study indicates that examination of pilots in civil aviation with normal and mildly deviant refraction showed that qualitative parameters of visual fixation have significance for evaluating status of visual performance. A significant number of pilots with exo- and esophoria exceeding 5.0 prism diopters required training procedures for restoration of the normal parameters of binocular fixation. The discovery of a significant decrease in fusion reserve requiring rehabilitation measures among pilots with mild myopia that is not sufficient to render them unfit for flight is of significance. It was established that study of central monocular fixation is significant for evaluation of the quality of visual performance.

P1471(32/91)\* Kondrachuk AV, Sirenko SP, Shipov AA.  
***Structure and function of the semicircular canals.***  
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina  
25(1): 4-12; 1991.  
[88 references; 64 in English]

Neurophysiology, Vestibular System, Semicircular Canals, Structure, Function  
Humans  
Review Article, Mathematical Modeling

Abstract: This review describes current understanding of the structure and functioning of the semicircular canals of the vestibular system. It is argued that the canals are best considered a system with distributed parameters and that any understanding of their function should include consideration of canal-otolith interactions, as well as internal interactions. The majority of the review is devoted to discussion of mathematical models of the semicircular canals or more specifically the cupulo-endolymph system. The authors conclude that further progress in understanding the functioning of this system, as well as the vestibular system as a whole will come through study of the mechanisms of mechano-electric processing of information in the cupulo-endolymph system, including that at the level of the hair cell, study of functional-informational linkages between the semicircular canals and the otoliths, and integration of information on body position and movement at various levels of the central nervous system.

Figure: Structure of the semicircular canals

Figure 2: Potential of receptor cells as a function of magnitude of displacement of hairs of receptor cells

Figure 3: Models of cupula displacement

**PAPER:**

P1469(32/91)\* Shimanovich YeG.

***Early diagnosis of functional disorders of the cardiovascular and central nervous systems in seamen.***

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina  
25(1): 49; 1991.

[9 references; 1 in English]

Operational Medicine, Early Diagnosis, Prognostic Tests, Exercise.  
Humans, Seamen

Cardiovascular and Respiratory Systems, Neurophysiology, Functional Disorders, Psychology, Neuroticism; Biological Rhythms, Diurnal Dynamics

Abstract: This paper describes an attempt to develop prognostic tests performable by a ship's doctor to identify individuals prone to neuropsychological and cardiovascular disorders. Martinet's test (20 knee bends in 30 seconds) was administered to 73 seaman aged 21 to 34, certified fit for service or with chronic illness. The test was conducted during a period between cruises twice a day between 3 and 5 a.m., and 10 and 12 a.m. At this time subjects also filled out Eysenck and Taylor questionnaires and were tested for emotional reactivity. Subjects were observed during a subsequent long cruise and after it.

During the day all subjects showed a normotonic cardiovascular response to the exercise test with pulse and blood pressure returning to normal within 3 minutes. During the night 37 subjects showed normotonic reactivity, 16 hypertonic, and 5 asthenic reactions. One subject displayed stepwise increase in systolic pressure and 14 required 8-10 minutes for BP normalization. All these symptoms were considered atypical. After a 3 month cruise 14 subjects from the group with atypical reactions manifested various forms of asthenoneurotic complaints, and one developed a situational neurotic reaction. Levels of neuroticism, anxiety, and emotional reactivity were higher in the atypical than in the normal group in the midst of the cruise. After 6 months, 5 seamen from the atypical group were diagnosed as suffering from neurocirculatory asthenia, with 1 disqualified for service. The authors recommend administering exercise tests at night as a means of identifying subjects prone to various cardiovascular and neurotic disorders.

PAPER:

P1456(32/91) Shekhova AN, Goncharov NP.

*Hormonal reaction of the adrenal cortex of female primates to long-term hypokinesia.*

In: *Abstracts of Papers presented at the International Symposium of the Physiology of the Pituitary-adrenocortical System. Leningrad, 1-4 October 1990.*

Leningrad: USSR Academy of Sciences; 1990.

Authors' affiliation: Laboratory of Experimental Endocrinology, Institute of Experimental Pathology and Therapy, USSR Academy of Medicine, Sukhumi.

Endocrinology, Adrenal Cortex

Primates, Baboons, Females

Reproductive System, Biological Rhythms, Menstrual Cycle, Hypokinesia, Long-Term

Abstract: This work present results of the study of the endocrine function of the adrenocorticoid system of hamadryas baboons under conditions of 28-day horizontal hypokinesia begun during various phases of the menstrual cycle.

Long-term hypokinesia evoked a two-phase response with respect to adrenal steroidogenesis: intense stimulation of the secretion of hydrocortisone, corticosterone, 11-desoxyhydrocortisone, 17-oxyprogesterone, 17-oxyprogesterone and aldosterone during the first day was replaced by depression of adrenocortical function throughout the next period of immobilization and the first 1-2 weeks of the recovery period. The intensity and duration of the activating effect of hypokinesia was clearly determined by the initial phase of the menstrual cycle: the reactivity of the adrenal cortex in the follicular phase was significantly higher than in the luteal phase. Differences in the degree of depression of individual fractions of corticosteroids were established: the inhibiting effect of hypokinesia was more extreme for the precursors of hydrocortisone, and also for corticosterone and aldosterone than for hydrocortisone itself; the androgenous activity of the adrenal cortex was unaltered.

Under conditions of hypokinesia, the normal pattern of circadian rhythms was maintained with respect to secretion of corticosteroids, while the amplitude and level of their fluctuations decreased sharply.

Additional acute stress factors combined with depressed endocrine function of the adrenal cortex had an activating effect on adrenocortical steroidogenesis.

The inhibiting effect of hypokinesia was transitory. Recovery of hormonal function of the adrenal cortex occurred 1-2 weeks after hypokinesia at the same time as normalization of the motor activity of the primates.

Thus, the results obtained unambiguously indicate that the decreased secretory activity of the adrenal cortex during long-term hypokinesia is adaptive in nature. It may be hypothesized that the decrease in the flow of sensory information under conditions of hypokinesia, in the final analysis, leads to establishment of a new, more economic level of functioning of the hypothalamo-pituitary-adrenocortical system.

Acceleration 6, 22  
 Acceleration Tolerance 6  
 Actomyosin 22  
**Adaptation** 1-3, 24, 28  
 Adaptogens 3  
 Adrenal Cortex 75  
 Air Traffic Controllers 33  
 Amputation 55  
 Antibiotic Resistance 48  
 Antioxidant Protection 11  
 Antropogenic Changes 7  
*Arabidopsis* 15  
 Asyymetry 6  
 Athletes 3  
 Attention Switching 32  
 Autonomic Parameters 33  
**Aviation Medicine** 4, 33  
 Baboons 75  
 Balance 6  
 Biochemical Parameters of Blood 1  
 Biokrist Device 46  
**Biological Rhythms** 6, 74, 75  
 Bion 9  
**Biospherics** 7  
 Biotechnology 46  
 Birds 24  
 Blood Pathology 29  
 Bone Tissue 51, 55  
**Botany** 9-15, 49  
 Carbohydrate Metabolism 41  
 Cardiomyocytes 22  
**Cardiovascular and Respiratory System** 4, 18-22, 33, 74  
 Cellular Interaction 30  
 Cerebellar Coordination 57  
*Chlorella* 11  
 Civil Aviation 33  
 Clinostatting 11  
 Closed Environments 48  
 Cognitive Parameters 3  
 Cognitive Performance 32  
 Common Extensor 53  
 Competition 3  
 Composite Indicators 7  
 Cosmonauts 28, 42, 43, 48, 57, 63  
 COSMOS-1887 11, 51  
 Development 9  
**Developmental Biology** 9, 24  
 Disphosponates 55  
 Display Design 33  
 Diurnal Dynamics 6, 74  
 Drugs 4, 43  
 Early Diagnosis 74

## KEY WORD INDEX

Ecosystems 7  
Electro-oculography 57, 63  
Embryogenesis 24  
Endocrinology 1, 29, 75  
Enzymology 29, 41, 42, 43  
Epinephrine 29  
Equipment and Instrumentation 46  
Ergonomics 33  
*Euglena gracilis*. 44  
Eukaryote Organisms 44  
Exercise 43  
Exercise Capacity 3  
Exobiology 26  
Expired Air 28  
Far North 1  
Fatigue 4  
Females 3, 75  
Femur 55  
Flight Personnel 32  
Flight Safety 4, 33  
Flu Virus 46  
Functional Disorders 74  
 $\gamma$ -Photon Absorptiometry 51  
GABA-ergic System 68  
Gaze Fixation 72  
Genetics 48  
Glycogen 41  
Gravitropism 15  
Gravity 15  
Group Dynamics 4  
Guinea Pigs 18  
**Habitability and Environment Effects 28, 48**  
*Haplopappus* 11  
Head-Down Tilt 20  
**Hematology 29-30**  
Hemodynamics 20  
Higher Plants 49  
Human Indigenous Microflora 48  
**Human Performance 3, 4, 32-33, 68**  
Humans 1, 3, 4, 6, 28, 32, 39, 42, 43, 48, 57, 68, 72, 73, 74  
Hypergravity 22, 44  
Hypodynamia 55  
Hypokinesia 28, 30, 41, 43, 53, 75  
    With Head-Down Tilt 28, 43  
    Long-Term, 53, 75  
Iliac 51  
Immunology 48  
Individual Differences 32  
Inkubator-2 24  
Intestinal Microflora 48  
Laser Acupuncture 53  
Leukocytes 30  
Lipid Peroxidation 11  
Liver 41

## KEY WORD INDEX

Low-Frequency Vibration 70  
Lymphocytes 29  
Males 1, 3, 6, 41, 53  
Man-Machine Systems 33  
**Mathematical Modeling** 7, 39, 73  
Menstrual Cycle 75  
Mental Work Capacity 68  
**Metabolism** 11, 28, 33, 41-43  
Mice 29  
Microbiocenoses 49  
**Microbiology** 9, 11, 44-49  
Microcirculatory Tract 18  
Minerals 9  
Mir 9, 11, 24, 46, 49, 57  
Monkeys 51  
Morphology 53  
**Musculoskeletal System** 6, 51-55  
Myocardium 18  
Neuraminidase 46  
**Neurophysiology** 6, 33, 40, 57-73, 74  
Neuroticism 74  
Noise 4  
Nutrition 42, 43  
Nystagmus 57  
Ontogeny 15  
**Operational Medicine** 74  
Patients 68  
Peas 11  
Peptides 26  
Perception 4, 6, 33  
Performance Monitoring 33  
Personnel Selection 32  
Pharmacological Countermeasures 55, 68  
Phoria 72  
Photoperiods 1  
Phylogeny 15  
Pigments 9  
Pilots 4, 33, 72  
Plant Growth 15  
Polycondensation of Amino Acids 26  
Post-traumatic Regeneration 55  
Prebiotic Synthesis 26  
Primates 75  
Prognostic Tests 74  
Prophylactic Countermeasures 53  
Provocative Tests 33  
Psychology 4, 33, 74  
Quail 24  
Rats 18, 20, 22, 30, 41, 53, 55, 70  
    Males 30  
Readaptation 41  
Regional Hemodynamics 20  
Rehabilitation 33  
Remote Sensing Data 7

## KEY WORD INDEX

### Reproductive System 75

Review Article 73  
Righting Reflex 70  
Rotation 68  
Salyut 11  
Salyut-7 57  
Seamen 74  
Seasonal Variation 1  
Semicircular Canals 40, 73  
Sensory Interaction 57  
Silicon Dioxide 26  
Skeletal Muscles 53  
Sleep 33  
Soleus 53  
Soyuz-T4-Salyut-6 63  
Soyuz-T7-Salyut-7 63  
Space Flight 9, 11, 15, 24, 28, 42, 43, 46, 48, 49, 51, 57, 63  
    Long-Term 28, 42, 43, 57, 63  
    Short-Term 28, 57, 63  
Space Motion Sickness 68  
Spatial Orientation 6  
Static Endurance 70  
Stress 3, 33, 41  
Subsonic Sound Waves 18  
Succinate Dehydrogenase 29  
Svetoblok 9, 49  
Systemic Hemodynamics 20  
*Tetrahymena pyriformis* 44  
Tibia 51  
Tocopherol 3  
Trace Contaminants 28  
Tracking 57  
Training 33  
Trauma 55  
Usu-Nur Depression 7  
Vestibular Function 57, 63  
Vestibular Organs 70  
Vestibular System 73  
Vestibular Tolerance, Diminished 68  
Vibration 70  
Visual Perception 4, 33  
Vitamins, Water Soluble 42, 43  
Volatile Metabolites 28  
Water 26  
Weightlessness 40  
Wheat 9, 11, 49  
Whole-Body Vibration 70  
Work-Rest Schedule 33  
Workload 3  
Xydiphon 55

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