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USSR Space Life Sciences Digest

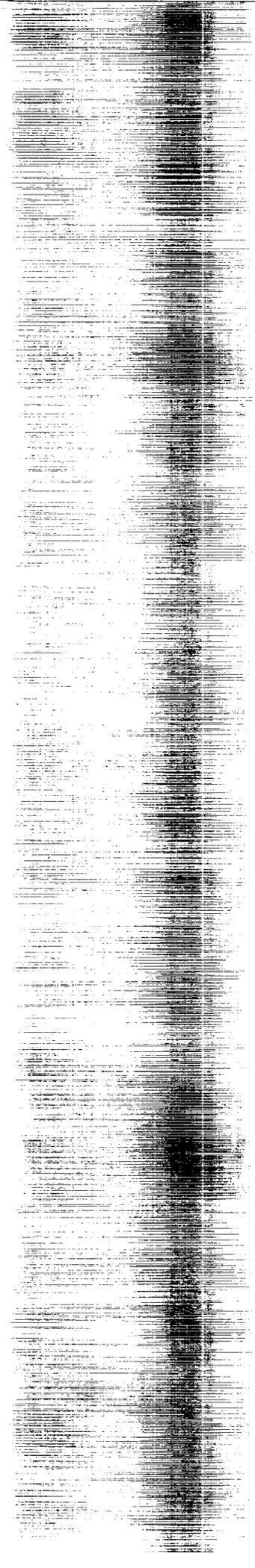
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NASA Contractor Report 3922(22)

USSR Space Life Sciences Digest

Issue 19

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1988

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USSR Space Life Sciences Digest: Issue 19 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 #	Incorrect or contextually inappropriate word or phrase:	Suggested rendering: ("??" is an acceptable entry)
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PLEASE RETURN TO: Dr. Lydia Hooke
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FROM THE EDITORS

This is Issue 19 of the USSR Space Life Sciences Digest. The following abstracts in this issue contain or discuss space flight data: Botany P903; Developmental Biology P892; Endocrinology P891; Exobiology P883; Genetics P879; Musculoskeletal System P865; Operational Medicine P904; Radiobiology P900; Space Biology and Medicine P859.

We were most gratified to receive almost 200 replies to our reader survey and especially want to thank those who indicated willingness to assist us with technical terminology. We are currently considering various modifications in format and changes in emphasis suggested by readers response. It is certainly not too late to return the surveys. Readers should be aware that a Russian-English space life sciences glossary is not now available; the question on the reader survey was an attempt to assess demand rather than an offer to provide a product.

Please address requests for subscriptions and other correspondence to:

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ADAPTATION

(See also: Neurophysiology P887; Space Biology and Medicine BR14)

PAPER:

P901(19/88) Meyerson FZ, Tverdokhlib VP, Lobanova GT, Golubeva LYu, Nikonorov AA.

Preventing stress-induced dyslipidemia by means of adaptation to short periods of stress.

Fiziologicheskiy Zhurnal.

33(6): 3-8; 1987.

[19 references; 8 in English]

Authors' Affiliation: Institute of General Pathology and Physiopathology, USSR Academy of Medicine, Moscow.

Psychology, Stress

Rats

Adaptation, Stress; Pharmacological Countermeasures

Abstract: "Emotional pain stress" was induced in male Wistar rats using a procedure for creating experimental neurosis developed by Desiderato (paradigm described in Digest Issue 9). The stress adaptation procedure lasted 15 days according to the following schedule: day 1 - 15 minutes; day 2 - 30 minutes; day 3 - 45 minutes; following 11 days - 1 hour per day. Long-term stress was induced by exposing animals to the "emotional pain stress" treatment for a period of 6 hours. Animals were divided into 9 groups as follows: group 1 - intact control; groups 2 and 3 - animals exposed to 6 hours of stress and examined 2 and 24 hours after its termination, respectively; group 4 - animals adapted to stress through the above procedure; groups 5 and 6 - animals exposed to 6-hour stress after undergoing preliminary adaptation and studied after 2 and 24 hours, respectively; group 7 - intact animals given the antioxidant ionol (2,6-Di-tert-butyl-4-methylphenol); groups 8 and 9 - animals exposed to emotional pain stress after receiving ionol, and studied 2 and 24 hours after treatment termination, respectively. Each group contained 8 to 10 animals. Ionol was administered orally 3 days in succession at a dose of 20 mg/kg dissolved in 0.5 ml sunflower oil. Animals were sacrificed by decapitation, blood was taken and the liver was removed immediately and frozen in liquid nitrogen. To evaluate lipid metabolism, the concentrations of total cholesterol and triglycerides were measured in blood. High density lipoproteins were measured and the "arthrogenic index" (Low and Very Low Density Lipids/ High Density Lipids). One of the products of lipid peroxidation, malon dialdehyde (MDA), was measured in liver homogenate, as was activity of one of the antioxidative enzymes, superoxide dismutase (SOD). Rate of lipid peroxidation was evaluated in the liver.

Exposure to a 6-hour period of stress was found to decrease high density lipids in blood as well as the ratio of high to low density lipids. This effect was most pronounced after 24 hours, when HDL were decreased by more than a factor of 2. Preliminary adaptation to short periods of stress did not affect total lipids, but prevented or substantially decreased stress-induced dyslipidemia. Administration of the antioxidant ionol had an effect on blood lipids very similar to that of preliminary adaptation. Preliminary adaptation to stress substantially lowered blood triglycerides, which were further reduced by long-term stress. This did not occur after

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administration of ionol. Liver tissue showed that stress increases activation of lipid peroxidation in the liver as manifested by increased (by a factor of 2) concentration of MDA, a sharp decrease in SOD activity, and increased concentration of the liver-specific enzyme fructose-1-phosphate aldolase in blood serum. This set of symptoms, testifying to activation of lipid peroxidation and liver damage, peaked at 24 hours. Both of the countermeasures tested (preliminary adaptation and ionol) attenuated these effects to a similar extent. Both factors also decreased lipid peroxidation when given to control animals.

The authors conclude that stress, by activating lipid peroxidation, damages the key organ for cholesterol metabolism, the liver. Development of arteriosclerosis under the influence of unavoidable and heterogeneous environmental stressors, all else being equal, will be prevented or enhanced as a function of the state of the stress limiting systems of the body.

Table 1: Effects of "emotional-pain stress" and preadaptation to short-term stress on concentration of lipids in blood serum and the ratio of high to low density lipids

Condition	N	Cholesterol, mg/dl		Triglycerides mg/dl	<u>LDL+VLDL</u> <u>HDL</u>
		Total	HDL		
Control (1)	10	70.8	52.6	52.8	0.35
Stress:					
after 2 hours (2)	9	66.4	43.6	46.3	0.52
after 24 hours (3)	9	58.6	22.7*	40.8	1.6
Adaptation (4)	9	65.4	48.4	20.2*	0.35
Adaptation + Stress:					
after 2 hours (5)	8	55.8	42.7	10.2*	0.3
after 24 hours (6)	8	55.4	32.7**	8.8**	0.7
Ionol (7)	8	68.2	50.2	50.8	0.36
Ionol + Stress:					
after 2 hours (8)	9	70.2	50.4	44.2	0.39
after 24 hours (9)	8	65.8	34.7***	34	0.8

* Differs significantly from group 1;

** Differs significantly from group 4;

*** Differs significantly from group 7.

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Table 2: Effects of emotional pain stress and adaptation to short-term exposure to stress on concentration of MDA and activity of SOD in liver homogenate and activity of fructose-1-phosphate aldolase (FPA) in blood serum

Condition	N	MDA, nmole/ /mg protein	SOD, activity unit X mg protein	FPA, activity unit X mg protein
Control (1)	10	2.8	64.6	2.7
Stress:				
after 2 hours (2)	9	3.4	30.84*	4.1*
after 24 hours (3)	9	5.6*	50.33	10.2*
Adaptation (4)	9	3.6*	93.8*	3.2*
Adaptation + Stress:				
after 2 hours (5)	8	3.7	85.5	4.5**
after 24 hours (6)	8	3.8	80.6	5 **
Ionol (7)	8	2.2	96.2*	1.7
Ionol + Stress:				
after 2 hours (8)	9	2.0	78.1	2.4
after 24 hours (9)	8	2.3	68	3.6***

* Differs significantly from group 1;
 ** Differs significantly from group 4;
 *** Differs significantly from group 7.

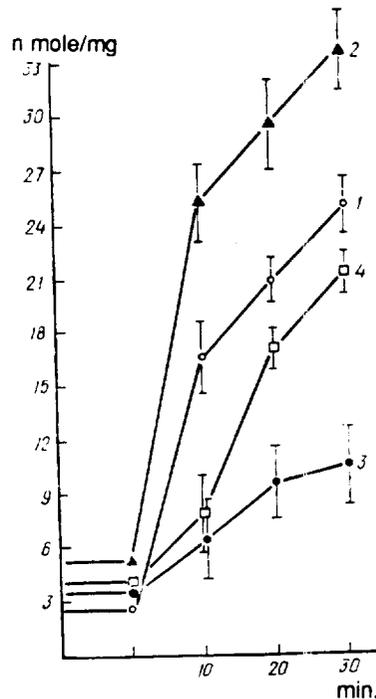


Figure: Effect of long-term emotion pain stress and adaptation to short-term stress on the induction of lipid peroxidation in the liver by a system of Fe^{2+} + ascorbate
 1 - control; 2 - stress; 3 - adaptation; 4 - stress + adaptation

ADAPTATION

MONOGRAPH:

M133(19/88) Braun AD, Mozhenok TP.
Nespetsificheski Adaptatsionnyy Sindrom Kletochnoy Sistemy [**Nonspecific adaptive syndrome of the cell system**]
Leningrad: Nauka; 1987.
[232 pages; 16 tables; 49 figures; 983 references]
Affiliation: Institute of Cytology, USSR Academy of Sciences.

Key Words: Adaptation, Cytology, Extreme Factors, Musculoskeletal System

Annotation: This book summarizes the results of research on morphological, physicochemical, and biochemical changes in the cell in response to exposure to extreme environmental factors. It examines the role played by the cytoskeleton, particularly its microfilament (actin) component, and also the conditions required to increase cell resistivity and the ways damage is repaired. The book is intended for biologists with a broad range of specialties and agricultural specialists.

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M136(19/88) Aydaraliyev AA, Maksimov AL.

Adaptatsiya Cheloveka k Ekstremal'nyim Usloviyam: Opyt Prognosirovaniya
[**Human Adaptation to Extreme Conditions: A Case Study in Prediction**]

Leningrad: Nauka; 1988.

[120 pages; 31 Tables; 19 Figures 315 references]

Affiliation: Division of Physiology, USSR Academy of Sciences

KEY WORDS: Adaptation, Hypoxia, Tolerance, High Altitude, Antarctic, Human Performance, Work Capacity, Individual Differences, Personnel Selection

Annotation: This monograph presents data on the functioning of human physiological systems in individuals with varying levels of tolerance for hypoxia in the high altitudes of Central Asia and the Antarctic. The authors examine the predictive aspects of evaluating human work capacity at various altitudes as a function of duration of adaptation and climatic region and make practical recommendations for selection of individuals sent to high altitude regions.

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CONFERENCE REPORT:

CR10(19/88) Beloshitskiy PV, Lanovenko II.
Report on Conference on **Adaptation and Resistance at High Altitudes**
5-8 August, 1986; Terskol, Kabardino-Balkarsk Autonomous SSR.
In: Fiziologicheskii Zhurnal.
33(6): 107-109; 1987.

Key Words: Adaptation, High Altitudes, Hypoxia; Neurophysiology, Hematology, Hemopoiesis; Cardiovascular and Respiratory Systems, Immunology, Resistance, Radiobiology, Enzymology, Physical Exercise, Operational Medicine; Human Performance; Endocrinology; Biological Rhythms

The most recent convention of "Elbrus Discussions," was devoted to the topic of "Adaptation and Resistance at High Altitudes." It was organized by the A.A. Bogomolets Institute of Physiology, of the Ukrainian SSR Academy of Sciences, the Ministry of Health of the Kabardino-Balkarsk Autonomous SSR (KBASSR) and the Kabardino-Balkarsk State University. A total of 55 scientists from Moscow, Kiev, Nal'chik, Zaporozh'ye', Kuybyshev, and other cities, including an academician of the USSR Academy of Medicine and 15 doctors of science participated in the discussions.

The meeting was opened by the director of the Kabardino-Balkarsk Institute of History, Philosophy, and Economics, Kh. I. Khutuyev, who, in the name of the government and social organizations of the KBASSR, expressed satisfaction with the development of research on the problems of high-altitude physiology on Mount Elbrus. These studies are not only of theoretical interest, but also of practical significance.

The first session was devoted to the 90th anniversary of the birth of N.N. Sirotinin, academician of the USSR Academy of Medicine and corresponding member of the Ukrainian Academy of Sciences. A paper by V.T. Antonenko (Kiev), "Reactivity and resistance in the works of N.N. Sirotinin," analyzed work that contributed to the solution of the most important problems in biology and medicine which permitted N.N. Sirotinin to create a well-formed theory of physiological reactivity and resistance, which is still highly relevant today.

An early stage in Sirotinin's research on the problem of hypoxia was described in a paper by Academician of the USSR Academy of Medicine, A.D. Ado (Moscow), entitled "On adaptation to hypoxia, a reminiscence about a Kazbek expedition led by N.N. Sirotinin." This stage in the research was marked by the study of the effect of high altitudes on higher nervous activity in the cardiovascular system and also by joint work with clinicians to identify the therapeutic qualities of a mountain climate.

N.K. Simeonova (Kiev) spoke about N.N. Sirotinin's work as the chairman of the Department of Physiopathology of the Kiev Medical Institute (1955-1960). His contemporaries were struck by the broad range of his scientific creativity and the practical importance of the research areas in which he worked, such as , space biology and medicine, and man and the environment.

The second session was devoted to discussion of conclusions drawn from study of the hemopoietic function under conditions of hypoxia. A paper by E.V. Gyulling, A.N. Krasnyuk, and A.F. Karac' (Kiev) presented new data on

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the use of the gradual method of adaptation (based on N.N. Sirotinin) for restoring functioning after exposure to irradiation, on the effects of hypoxia on the blood system, redistribution and recovery of cells of the lymphoid organs. The potential for using bone marrow transplantation for decreased immune reactivity at high altitudes was explored.

M.M. Seredenko (Kiev) described the characteristics of anemic hypoxia occurring at high altitudes and cited quantitative data concerning oxygen transport and utilization in animals, and also discussed the morphological changes in the blood-air barrier occurring in various forms of experimental hypoxia. He described the positive influence of preliminary adaptation to moderately high altitudes on the course of experimental anemic hypoxia.

A paper by A.A. Nenasheva and I.M. Tishchenko (Nal'chik) entitled "Structural characteristics of erythrocytes in various hypoxic states" demonstrated the efficiency of a method developed by the authors to determine the mechanical resistance of erythrocytes as a means to evaluate the severity and prognosis of hypoxia in humans. Research on athletes and also patients with heart defects and respiratory insufficiency demonstrated the significance of redistributive and true erythropoiesis in the adaptive response to hypoxia.

V.P. Dudarev (Kiev) presented original data on cellular, subcellular, and molecular mechanisms underlying changes in respiratory functions of blood in hypoxic and anemic hypoxia at high altitudes. The author emphasized the importance of 2,3-diphosphoglycerophosphate in mobilization of compensatory mechanisms of the blood system.

The third session was dedicated to the 50th anniversary of the founding of the A.A. Bogomolets Institute of Physiology of the Ukrainian Academy of Sciences on Mount Elbrus. Covering the period from 1929-1972, P.V. Beloshitskiy (Kiev-Terskol) gave a detailed description of the scientific expeditions to the Caucasus, headed by N.N. Sirotinin, which involved study of such aspects of hypoxia and high altitude physiology as the effects of high altitudes on various systems, high altitude sickness, human and animal reactivity and resistance in onto- and phylogenesis, the comparative physiology of adaptation, therapeutic and prophylactic potential of the mountain climate, and others. A distinguishing trait of N.N. Sirotinin's expeditions was their multidisciplinary nature, involving clinicians with various specialties.

N.A. Agadzhanian (Moscow) in a paper titled "Chronophysiological aspects of physiological adaptation to hypoxia" demonstrated the need to consider ecological, biomedical, economic, and social approaches to the problem of adaptation and proposed 10 criteria for human adaptation to new living conditions which must be considered in the development of a rational schedule of work and rest in a "watch" system.

Evaluation of the adaptive-habituated shifts in the respiratory and circulatory systems and acid-base status in response to physical exertion under conditions of fast-developing exogenous hypoxia were the subjects of a paper by V.P. Nizovtsev and L.V. Zvarich (Kuybyshev). The authors

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demonstrated that the relationship between ventilation and circulation is frequently different in hypoxia than under baseline conditions, and that the level of oxygen consumption is not an adequate indicator of the overall state of the organism.

At the fourth session, A.S. Stypin discussed the mechanisms underlying adaptation to hypoxia in a report entitled "Ultrastructural aspects of adaptation of cells and tissues in aging and hypoxia." This paper described the significant similarities between aging and hypoxia.

A.I. Ivashkevich (Kiev) reported on the significance of the proteolytic blood system in adaptation to hypoxia.

A paper by N.V. Delenyan and A.M. Gerasimov considered participation of enzymes of the antioxidizing system in adaptation to hypoxia. The dual role played by this system -- reconciling supply and demand of oxygen, and supplying extra oxygen to the tissues -- was demonstrated.

In his examination of the mechanisms underlying changes in reactivity under high altitude conditions, V.I. Danileyko (Kiev) argued that the basis for good adaptation to high altitude is an adequate schedule of exercise. Here the primary mechanism for adaptation is realized at the level of peptides with low molecular weight.

The fifth session was devoted to general issues in adaptation to hypoxia. F.Z. Meyerson (Moscow) presented experimental data concerning the role of adaptation to a mountain climate in preventing cardiac arrhythmia and fibrillation. It was shown that preliminary adaptation forestalls the occurrence of fibrillation and extrasystole. An attempt was made to evaluate the role of opioid peptides of various organs in the development of these reactions. The author also demonstrated the possibility of therapy for postinfarction atherosclerosis using adaptation to periodic exposure to hypoxia.

A communication by V.I. Kapel'ko (Moscow), devoted to study of adaptation of the heart to conditions of insufficient energy supply, identified correlations between physiological (cardiac ejection, ejection fraction, end-diastolic pressure in the left ventricle, diastolic elasticity, etc.) and biochemical parameters descriptive of the energy balance of the heart (concentration of adenosine triphosphoric acid, metabolites of Ca^{++} and others). On the basis of this research, he proposed criteria for evaluating acute and chronic insufficient energy supply to the heart.

V. A. Vorontsov's (Orenburg) report, "Some mechanisms underlying adaptation of systems supporting oxygen homeostasis in intermittent hyperbaric hypoxia" was devoted to the systematization of new data showing the heterogeneity, contradictions, and intersubject variability of the initial stages of the adaptation process. The author believes criteria for adaptation can serve as a complex evaluation of a large body of physiological information. Maladaptation, in turn, has its own specific characteristics.

The results of research on the hypothalamus-pituitary system under exposure to hypoxia was the subject of a talk by Yu.N. Orestenko and Yu. M. Kolesnik

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(Zaporozh'ye). Studying the participation of this link in regulation of autonomic functioning, the authors consider adaptation to hypoxia from a new standpoint, as a factor increasing nonspecific resistance.

At the sixth session, aside from general issues relating to adaptation to hypoxia, participants considered the conclusions and prospects for using adaptation to a mountain climate for treating various diseases. V.T. Antonenko (Kiev) in his report on the "Lymphoid system and its role in adaptation and resistance in the norm and pathology" showed that stress stimuli increase the concentration of peptides with low molecular weight in lymphocytes. It was demonstrated that lymphopeptides influence specific and nonspecific resistance of the organism. This raises the possibility of their synthesis and use in clinical practice.

The results of study of the mechanisms responsible for secondary immunodeficiency in response to mixed hypoxia and ways to counteract this state were reported by A.S. Timchenko (Kiev). The author established that in hemorrhagic shock the blood takes on cytolytic properties which destroy lymphocytes. Severe circulatory and tissue hypoxia occurring in lymphoid organs may also be important.

M.N. Yakushenko (Nal'chik) reported on results of work on high altitude treatment of bronchial asthma in children and the mechanisms of its therapeutic effects. The broncholytic effect, evidently, is caused by an increase in the concentration of hydrocortisone in blood, increased sensitivity of adrenoreceptors, and decreased sensitization.

According to data presented by V.G. Kuznetsova (Pyatigorsk), moderately high altitude conditions may differentially affect the insulin-producing apparatus of the pancreas. Animals adapted or not adapted to moderately high altitudes showed significant differences in the timecourse of experimental diabetes. This tends to confirm the theory of N.N. Sirotinin on the possibility of using a mountain climate for the treatment of certain forms of diabetes in humans.

P.V. Beloshitskiy, A.Z. Kolchinskaya, A.P. Andreyeva, et al. (Kiev-Moscow) discussed the treatment of patients with anemia under high altitude conditions. They demonstrated the promise of further work with analogous groups of patients.

BIOLOGICAL RHYTHMS

(See also: Adaptation CR10)

PAPERS:

P875(19/88)* Koreshkov AA, Makarov VI, Abramov IR, Kots AR.
The circadian rhythm of psychomotor response in humans exposed to the combined effects of 18-hour days and elevated concentration of carbon dioxide.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
22(3): 88-91; 1988.

(1 reference; none in English)

Biological Rhythms, Circadian Rhythms, Work-Rest Schedules, Human
Performance, Psychomotor Performance

Humans

Hermetically Sealed Environment, Desynchronosis, Elevated Carbon Dioxide

Abstract: Four individuals spent a total of 30 astronomical days in a two-room hermetically sealed living environment with atmospheric carbon dioxide maintained at an elevated (3%) level. Days were structured to last 18 hours, 6 of work, 6 of leisure, and 6 of sleep. Subjects were not isolated from social indicators of actual time. Work shifts were scheduled for successive temporal intervals: 9:00 to 15:00, 15:00 to 21:00, 21:00 to 3:00, and 3:00 to 9:00 over the course of the experiment. Tests used included a "hatch" test in which a subject must draw as many vertical non-touching lines as possible in a limited space in 30 seconds, and a test of reading (aloud) speed. Both tests are considered indicative of psychomotor reaction time. Subjects were tested 3 times in each work shift.

Subjects complained about the difficulty of adjusting to the compressed diurnal schedule. Drowsiness and sleep disturbances were noted. Individual subjects tended to produce their best and worst performances during a specific time interval (according to Moscow time). Differences in performance between a subject's best and worst intervals were highly significant. Thus, psychomotor reaction time retained its dependence on Moscow time in all subjects, indicating failure to assimilate the newly imposed 18-hour rhythm (desynchronosis). Comparison of results from the initial and final portions of the experimental period demonstrated that stress levels had increased by the end of the period. Performance was most disrupted for the subject whose initial biological rhythms were least well organized. The authors recommend that deviations from a 24-hour schedule be kept at a minimum.

Table 1: Psychomotor reaction time as a function of Moscow time in subjects working on an 18-hour-day schedule

Table 2: Speech rate as a function of Moscow time in subjects working on an 18-hour-day schedule

Table 3: Changes over time in psychomotor reaction time in 4 subjects working on an 18-hour-day schedule

Table 4: Changes over time in speech rate in 4 subjects working on an 18-hour-day schedule

BIOLOGICAL RHYTHMS

P899(19/88) Maksimov AL, Sachanska T, Chernook TB.
Stability of biological rhythms in excretion of salts under exposure to extreme conditions.

Izvestiya Akademii Nauk Kirgizskoy SSR.

1988(1): 50 - 56.

[14 references; 2 in English]

Authors' Affiliations: Institute of Physiology and Experimental Pathology of High Altitudes of the Kirgiz Academy of Sciences; Institute of Industrial Hygiene and Occupational Disease, Bulgarian Academy of Medicine

Biological Rhythms, Body Fluids, Salt Excretion
Humans

Extreme Conditions, Isolation, Stress, Motion Sickness, Hypokinesia

Abstract: Biological rhythms in diuresis and renal excretion of salts are proposed as physiological markers which, at the level of the entire organism, reflect the adverse effects of extreme environmental factors. Six individuals served as subjects in the experiment described. Subjects were first studied under normal conditions, during which diuresis and renal excretion of sodium, potassium, calcium, phosphorus, and chlorides were measured at 4-hour intervals. They were then placed in a lifeboat in the open sea provided with standard emergency rations of water and food and subjected to storm (4-5 marks) conditions, moderate hypokinesia and emotional stress. Two days later the same excretory parameters were measured. Data were statistically analyzed and then a Cosinor?? analysis was performed to reveal 24- and 12- hour component cycles in parameter variation. In addition, spectral analysis of functions was performed.

Excretion of sodium displayed the greatest discrepancy between baseline and experimental conditions, with excretion being considerably curtailed under extreme conditions. No effects of extreme conditions were found for potassium. Chronobiological studies revealed no effects on patterns of excretion of potassium and chloride. The statistically significant 24- and 12-hour rhythms in excretion of calcium and phosphorus that existed under baseline conditions disappeared under extreme conditions. A 24-hour peak occurred in sodium excretion in the norm. Under extreme conditions, an additional 12-hour rhythm was detected. Total diuresis remained relatively constant.

The authors conclude that rhythms of diuresis and potassium excretion remained relatively stable as subjects were exposed to a shipwreck simulation. The most informative parameter was renal excretion of sodium: a sharp decrease in mean level, an increase in fluctuation amplitude, and appearance of an additional 12-hour rhythm attest to greater stress on the subjects. In addition, spectral analysis revealed the presence of additional rhythmic components in excretion of calcium and phosphorus. General evaluation of the stress on the subject, based on changes in biorhythms, shows that several days exposure on the open sea with minimal supplies of water and food, combined with emotional stress and rough seas, do not cause major disruptions that could lead to the development of pronounced irreversible pathological phenomena; instead, the shifts noted appear to be functional disadaptive disturbances.

BIOLOGICAL RHYTHMS

Table 1: Diurnal dynamics of diuresis and renal excretion of salts in subjects at a baseline period and after a simulated shipwreck

Table 2: Cosinor analysis of diurnal rhythms of diuresis and renal excretion of salt in subjects exposed to extreme conditions

Figure: Spectral analysis of rhythms in renal excretion of calcium before and after exposure to extreme conditions

BIOSPHERICS

PAPER:

P894(19/88) Shilov IA.

Biological problems of biospheric homeostasis.

Zhurnal Obshchey Biologii.

XLIX(2): 166-173; 1988.

[10 references; none in English]

Author's Affiliation: Moscow State University; Department of Biology

Biospherics

Theoretical Article

Homeostasis

Abstract: The mechanisms of homeostasis on a biospheric level are based on three general characteristics of life: systematicity, heterogeneity and homeostasis at various organizational levels of living material. On all levels of organization of life, the homeostatic mechanism functions according to a single principle: the organism or biological system adapts to the most generalized and stable environmental parameters; but when the environmental parameters deviate from the mean, typical level, the organism accommodates through labile functional adaptation. These two levels of adaptation operate simultaneously, without merging. Their interaction enables system functions to continually "catch up" with specific environmental conditions, and as a result supports stable functioning of the system under changing environmental conditions.

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CR9(19/88)Buznikov AA, Vedeshin LA.

Review of : **"Space and Ecology Round Table,"** at an international forum marking the 30th anniversary of the launch of the first manmade satellite. Issledovaniye Zemli iz Kosmosa. 1988(2): 119-121.

Key Words: Biospherics, Space, Remote Sensing, Global Ecology, Anthropogenic Impact, International Cooperation, Systems Approaches

"International Collaboration for Peace on Earth," a forum dedicated to the 30th anniversary of the launch of the first manmade satellite, was held in Moscow on October 2 - 5 1987. Topics considered in round table workshops included "Space and Science," "Space and Economics," "Space and Ecology," "Space and Humanity."

The problem of space and ecology is receiving increasing emphasis in contemporary natural sciences. The concept of the transformation of the biosphere into its new evolutionary state -- the noosphere -- under the ever-increasing influence of human activity on the environment, which is particularly urgent and relevant here, was first formulated by the outstanding Soviet naturalist, Academician V.I. Vernadskiy.

The round table discussion included detailed consideration of the following major global ecological problems:

- biogeochemical cycling of matter and energy as the key aspect of global ecology;
- study of the World Ocean and the Earth's climate;
- the dynamics of global systems and possible processes for controlling them;
- interaction of changes in natural resources and the environment in various regions of the globe;
- creation of a space observation system as a means for identifying the dynamics of natural processes in the biosphere and providing information for ecological prediction.

A total of 75 experts from 14 nations participated in this round table, and there were 27 speakers.

In his introductory remarks, round table chairman academician K.Ya. Kondrat'yev dealt with the history of the study of biospherics, the major achievements of science in this area over the last 30 years, and modern international programs and projects using remote sensing data from space.

The co-chairman of the round table, V. Suomi (USA), stated that the potential for studying global changes is linked to the development of Earth Science. He used slides to demonstrate the changes in the Earth's energy balance during the course of a year. V. Suomi believes that problem must be approached by creating an appropriate data base and conducted comprehensive systems analysis studies. Remote sensing devices may be of great help

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in this endeavor, particularly for the construction of systems models for forecasting weather during various times of the year. Professor V. Suomi emphasized that the problem of "space and ecology" is a global one and requires the united efforts of different nations and the peaceful utilization of space.

The chairman of NASA's commission on the problem of global ecological changes, Professor I. Rasool, discussed the global ecological research programs that use remote sensing data from space. He directed the attention of round table participants to the variety of anthropogenic environmental effects and outlined future trends for research by scientists from a variety of nations in the area of global changes in the natural environment. He listed the major parameters measured using space, aircraft, and ground-based devices to enable researchers: to analyze the processes occurring in the atmosphere, biosphere and ocean; investigate the cycles occurring in these processes; and evaluate ecological phenomena and climatic change. In this regard, he noted the importance of implementing international programs and developing coordinated specifications for these measurements. The implementation of these programs will enable long-term forecasting of the state of the geosphere over years, decades, and even longer periods.

In his talk, Professor V. Peters (Denmark), similarly directed the participants' attention to the problem of climatic changes caused by variations in atmospheric components attributable to anthropogenic factors, vulcanization, and release into the atmosphere of fluorine and carbon dioxide compounds and other industrial by-products. He emphasized the need to measure the altitude distribution of suspended matter in the atmosphere and expressed concern with the possibility that these changes will cause major alterations in the biosphere. V. Peters proposed the establishment of international collaboration, including not only space research, but ground-based and other studies.

G.A. Zavorsin, corresponding member of the USSR Academy of Sciences, spoke as a microbiologist on the processes of formation of material cycles in nature realized by plants and animals in continental ecosystems. He proposed that concentrations of nitric oxides be measured across large territories, to enable a better understanding of the dynamics of ecological processes.

Professor R. Moore (USA) considered issues relating to various means of observation from space for the study of the ocean, land, and atmosphere, including combined systems utilizing both active and passive sensing devices, infrared devices and the visual wave band, possibly integrated by computers.

Questions relating to the utilization of space data in oceanology was the topic of a presentation by K.N. Fedorov, corresponding member of the USSR Academy of Science. In particular, he noted that certain oceanographic studies are highly significant for the understanding of the problems of ecology and global changes. In conclusion, he proposed the use of space technology for obtaining information needed to solve problems related to the study of variations in the state of the ocean surface and the construction of models of overall atmospheric and oceanic circulation.

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B. Ney, corresponding member of the Romanian Academy of Sciences, discussed the work conducted in socialist countries within the framework of various "Intercosmos" programs to study the dynamics of geosystems using remote sensing methods. The main goal of this project is the study of the interactions among various components of geosystems, comparison and selection of optimal measurements for remote sensing, taking into account the need for multilevel measurements of the surface-aircraft-satellite surface. Using numerical simulation modeling, project scientists analyzed seasonal and long-range associations among various geosystems. In future years, they plan to move from local and regional studies to a global one.

A paper by L.A. Vedeshin and V.V. Yegorov (USSR) proposed the concept of the biosphere as a complex cybernetic system, the subsystems of which contain a set of direct and backwards associations. This approach would make it possible to study not only the dynamics of the state of the biosphere, but would also point the way toward altering these dynamics to accord with [certain ecological] goals.

Professor A.A. Buznikov (USSR) discussed the development of methods and apparatus for constant tracking of the global distribution of such gaseous elements as water vapor, ozone, nitric oxide, etc.

Professor O.I. Smotkiy (USSR) talked about the creation of a data bank for aerospace information for the North-Western European portion of the Soviet Union in the Leningrad Information Sciences Institute of the USSR Academy of Sciences, and its potential for solving ecological and economic problems.

Candidate in technological sciences N.V. Sazonov (USSR) emphasized the great significance of the closed technological system for gathering and processing aerospace agricultural information developed by the USSR Gosagroprom [State Agricultural Industrial Organization]. This system uses space information from the "Meteor-Priroda" satellites and also information from specially-equipped flying laboratories on Tu-134 aircraft.

In his concluding remarks, the round table chairman, K.Ya. Kondrat'yev stated that the situations currently taking shape requires, first and foremost, analysis of the key problems in research on the geosphere-biosphere system. It is clear that on a time scale of a decade or longer, components of the geosphere constitute a single interrelated system.

Research on the geosphere must be combined with the study of the origin and evolution of the solar system. Here it must be remembered that the geosphere-biosphere system is open, in the sense that it is affected by various space factors.

There is no doubt that complex environmental problems can only be solved through effective international collaboration.

BODY FLUIDS: See Biological Rhythms: P899

BOTANY

(See also: Space Biology and Medicine M134)

PAPER:

P903(19/88) Merkis AI, Laurenvichyus RS, Shvyagzhdene DV.

Study of the growth, development and embryogenesis of plants on board the Salyut-7 space station.

In: Malinin VB, Kosmolinskiy FP, Kuznets YeI (editors).

Perspektivy Razvitiya Kosmicheskoy Biomeditsiny v Svete Idey K.E.

Tsiolkovskogo [**Prospects for the Development of Space Biomedicine in Light of the Ideas of K.E. Tsiolkovskiy**] Proceedings of the XXth and XXIst Lecture Series dedicated to the scientific legacy and development of the ideas of K.E. Tsiolkovskiy., Kaluga 1985, 1988. Section on Problems of Space Medicine and Biology.

Moscow: USSR Academy of Sciences: 1987.

Pages 56-62.

[11 references; 6 in English]

Editor's note: Some of the work described in this paper has been discussed in previous Digest abstracts (Cf., e.g., Botany P281, Digest Issue 7).

Developmental Biology, Development, Embryogenesis

Botany, Lettuce

Space Flight, Salyut-7

The idea of creating a biotechnical system to support the lives of humans in spacecraft, as first expressed by K.E. Tsiolkovskiy, began to be investigated experimentally on the first space flights. Green plants are considered a possible component of this system, which can regenerate the atmosphere of a hermetically sealed cabin and provide vegetables for crew diets. Thus, space experiments on the gravitational physiology of plants are extremely important. First and foremost, experiments must be performed on plants in space in order to determine whether higher plants can undergo an entire developmental cycle in microgravity. At present, we have not succeeded in growing plants from seed to seed in space, although several attempts have been made.

Cultivation of plants in space presents a number of methodological difficulties. In weightlessness, the growth of the axial organs from a sprouting seed depends on the initial position and orientation of these organs within the seeds. Sprouts obtained from seeds that are not correctly oriented will die. The absence of gravity also leads to technical problems related to water supply, dissipation of gases emitted by the leaves and especially the roots, and also heat dissipation. To avoid these difficulties, it may be useful to create artificial gravity for plant cultivation in future space station life support systems. For this reason, it is essential to establish the amount of centrifugal force sufficient to induce normal spatial orientation in plants through the mechanism of gravitropic response, as well as to study botanical systems by examining their orientation under conditions of altered gravity.

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The majority of experiments on plants in space have used an experimental design with two conditions -- a ground-based control and a space-flight condition. They provided information only about the combined effects of such space flight factors as microgravity, altered background ionizing radiation, electromagnetic fields and vibration, and the specific composition of the spacecraft atmosphere. Accurate simulation of many space-flight factors and elimination of the unidirectional effects of gravity have not been possible in the laboratory. Identification of the biological role of gravity requires an experimental design in which artificial gravity is introduced on a spacecraft for one group of plants.

An onboard centrifuge, "Biogravistat-1", which could create centrifugal forces of 0.01-, 0.1-, and 1-g, was used on the Salyut-7 space station. This device made it possible not only to study the effects of the force of gravity on growth processes of lettuce sprouts, but also to determine certain parameters of the gravitropic response.

Lettuce seeds were sprouted inside paper packets, which the cosmonauts attached to the centrifuge and to a stationary block located under a common light-opaque hood. The seeds were oriented in the packets so that their longitudinal axes were perpendicular to the centrifugal vector, and were continuously exposed to the stimulation of gravity. The seed packets were moistened during the space flight. At the experiment's termination, they were fixed using Navashin's method and returned to Earth. Angle of deviation from rectilinear growth was measured in the root and hypocotyl of shoots sprouted in weightlessness and in those centrifuged at 0.01-, 0.1-, and 1-g in space and on Earth. Intracellular location of gravity receptors (amyloplasts) in the cells of the root cap was also recorded for plants in each group.

It is well known that on Earth the root and stem do not grow rectilinearly, but show small angular deviations from the perpendicular. As the experiments showed, the same occurs under space flight conditions, only here the magnitude of the angles of deviation from rectilinear growth are significantly greater than on Earth, as demonstrated by the size of the standard deviation (Table 1). Without Earth's gravity, there is no force to coordinate growth processes in the axial organs of plants.

Comparison of the angles of inflection of the root and hypocotyl when they are stimulated by centrifugal forces of different magnitudes provides some idea of the threshold level of artificial gravity required to stimulate the geotropic reaction characteristic of the response to the Earth's gravity. The data in Table 1 show that the hypocotyl and the root bend in response to a centrifugal force as low as 0.1-g [sic., misprint for 0.01g]; however, at this level the angle of inflection is significantly smaller than that occurring under exposure to 1-g. When centrifugal force equals 0.1-g, the angles of the roots are equal to, and those of the hypocotyls less than those occurring at 1-g. However, this response is sufficient to allow the axial organs to be correctly oriented with respect to the surface of the nutrient substrate.

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Use of a centrifuge in space creates the necessary methodological prerequisites for determining the quantitative relationship between the magnitude of centrifugal force and such processes as geotropic bending of the axial organs. Computation of the correlation coefficient for the data cited in Table 1 (assuming a linear association), gave the following results: correlations between the magnitude of centrifugal force and the angle of inflection of the root, hypocotyl, and width of the band containing amyloplasts were 0.5, 0.75, and -0.67, respectively. These results are persuasive, although indirect, proof that statoliths participate in the gravitotropic response of plants. It should be noted that a linear regression equation adequately approximated the empirical mean response of the hypocotyl; extrapolation of this equation to zero produced a threshold stimulation value of $2.9 \cdot 10^{-8}$ -g. (Figure 1). In ground-based experiments involving clinostatting of oat sprouts, the corresponding value for the coleoptile was $1.4 \cdot 10^{-3}$ -g. If mean values of the angle of deviation from rectilinear growth obtained for the hypocotyl in different experiments in space without centrifugation are included in the linear regression equation (Figure 1), then the estimated level of gravity on the space station during performance of our experiments was $5 \cdot 10^{-3}$ -g. This level exceeds the proposed threshold of gravity sensitivity not only for roots, but for hypocotyls, as was established experimentally.

An experiment to study the complete developmental cycle of arabis plants was performed in space using the "Fiton-3" miniature greenhouse. The "Fiton-3" consists of 5 reservoirs with nutrient medium, a device for sowing seeds under space flight conditions, and a light source. The plants were grown under conditions of 24-hour illumination. During the flight, the cosmonauts sowed the seed, turned on the light source, and observed the growth and development of the plants. Duration of the experiment was 69 days. When the "Fiton-3" was returned to Earth, 7 mature plants were found within it. Five plants developed 22 normal pods, while the remaining 2 developed only 11 sterile, seedless pods. In all, 200 mature seeds generated during flight were collected. Eight arabis plants cultivated in the same device on the ground bore 34 normal pods. No explanation was found for differences in the morphological characteristics of plants grown under space flight conditions and those of the control group (Table 2). These differences may have been induced by indirect effects of space flight factors, primarily weightlessness, on the physiological processes of the plants or by mediated changes in parameters of such physiological processes of the plants as heat and gas metabolism in the absence of convection.

Higher plants show a rather broad spectrum of phenotype variability in response to alteration in environmental factors, but this is not accompanied by loss of reproductive capacity. For this reason the deviations noted in plant growth and rate of development are not that important from the standpoint of the general biological significance of space flight factors. A fundamental result of this experiment was that seeds of higher plants exposed to space flight conditions sprouted and underwent the growth processes in the formation of asexual and generative organs and, judging by the final results, successfully underwent fertilization, embryogenesis, and seed maturation.

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These results can appropriately be compared to data from other experiments studying the separate phases of generative development of plants in space. Arabidopsis plants cultivated on Earth until the stage of flowering and then placed on a biosatellite formed seeds, but the percentage concentration of fertile seeds was lower, while sterile seed buds and embryo death were more common than in control plants. In other experiments, when the arabidopsis was cultivated in space from the cotyledon leaf to the flowering phase, fertile seeds did not form. This comparison shows that the experiment described here succeeded in proving that a new generation of higher plants can be grown under space flight conditions, which opens up extensive possibilities for their use in space greenhouses.

Table 1: Deviation of axial organs of lettuce from rectilinear growth and localization of amyloplasts under conditions of altered gravity

Growth Condition	Deviation, °				Width of amyloplasts, % cell length
	hypo-cotyl	standard deviation	root	standard deviation	
Flight					
0-g	-5.8	23.1	8.1	35.3	77.5
0.01-g	-11.9	20.8	50.7	27.7	76.2
0.1-g	-47.1	17.3	76.5	10.9	67.1
1-g	-67.7	16.8	78.3	10.1	51.2
Control					
Horizontal	-77.8	8.8	77.5	8.3	—
Stationary	0.7	10.5	1.2	9.5	48.8

Table 2: Morphological parameters of plants and seeds of arabidopsis cultivated on the ground and on board Salyut-7 in the "Fiton-3" device

Parameters	Control	Experiment
Number of sprouting plants	8	7
Number of leaves per rosette	7.50	5.80
Height of the plant, cm	17.50	9.60
Length of mature pods, mm	7.51	5.20
Biologically viable seeds, %	67.6	42.0

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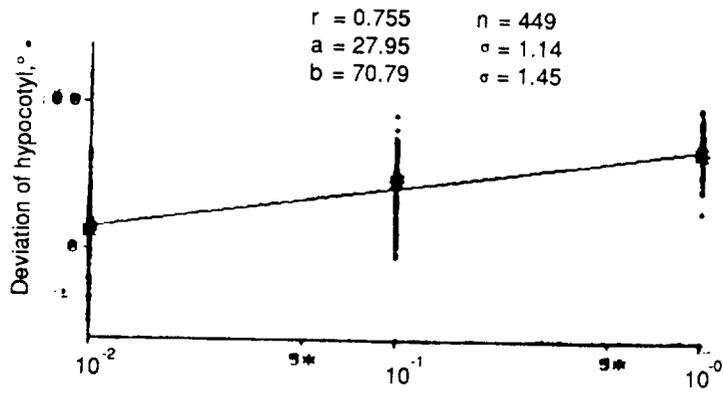


Figure 1: Angle of deviation of hypocotyl and magnitude of centrifugal force under space-flight conditions. Crosses indicate mean angle of deviation.

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(See also: Adaptation CR10; Human Performance P863;
Operational Medicine P872; Space Biology and Medicine M134, BR14)

PAPERS:

P861(19/88)* Artamanova NP, Turbasov VD, Georgiyevskiy VS, Golubchikova ZA, Lyamin VR, Potapova MG, Tolmacheva MYa, Nechayeva EI, Zakharova TS.

The effect of long-term hypokinesia on bioelectric cardiac activity in healthy men.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

22(3): 31-37; 1988.

(38 references; 4 in English)

Cardiovascular and Respiratory Systems, Cardiac Bioelectric Activity
Humans, Men
Hypokinesia, Long-Term, Physical Exercise, Pharmacological Countermeasures,
Metabolism, Mineral, Lipid; Nutrition, Vitamin D

Abstract: These 2 experiments utilized as subjects a total of 39 healthy males aged 25 to 45 (3 over 40). In the first, 18 subjects were exposed to hypokinesia with head-down tilt (-4.5°) for 182 days. The first group of subjects engaged in an exercise program and had their muscles stimulated electrically. Group 2 underwent an abbreviated (in time and strenuousness) exercise program. No prophylactic countermeasures were used on the third xgroup. In the second experiment, 21 men underwent a 120-day period of hypokinesia with head-down tilt (-4.5°). The first group served as a control, with no countermeasures used. Group 2 participated in an exercise program, while group 3, in addition to exercise received drugs to correct mineral and lipid metabolism (ksidifon /hydroxyethylidene biphosphonic acid/, glaumak /chemical name unknown/), functions of the pancreas (solizim /a lipolytic substance obtained from cultures of Penicillium solitum/, F-99,) and to simulate hemopoiesis (folicobalamine). Group 4 was treated like group 3 program and additionally received Korinfar (2,6-Dimethyl-4-(2'nitrophenyl)-1,4-dihydropyridin-3,5-dicarboxylic acid dimethyl ester), an antianginal drug, on days 50-64 of hypokinesia. In addition, subjects in groups 2 and 3 underwent a series of ultraviolet treatments to increase vitamin D transport. EKGs were registered using the 12 standard leads and 3 bipolar chest leads. EKGs were recorded in the morning on an empty stomach twice during a baseline period, on days 1, 7, and 15 and subsequently every 2 weeks until treatment termination; and on days 1, 7, 15, 30, 45, and 60 of a recovery period.

In the first experiment, 9 of the subjects displaying normal heart rates at baseline showed decreases in this parameter; 1 individual with a tendency toward bradycardia under normal conditions showed an increase during the initial period of the treatment. Although heart rates fluctuated during the subsequent treatment period, there was a general tendency toward increased heart rate, which was less marked in exercising subjects. Respiratory arrhythmia, noted in all subjects before treatment, decreased or disappeared in the majority during hypokinesia. These results are interpreted as suggesting a decrease in parasympathetic and an increase in sympathetic influence on cardiac activity. This interpretation was confirmed by a parallel study of blood catecholamines. Heart rate returned to normal 30

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days after treatment termination for the exercising groups and 50-60 days for the control groups. Despite the increase in heart rate, atrioventricular (A-V) conduction time increased (nonsignificantly) in all but one subject. Intraventricular conduction and duration of electric systole were unchanged. No changes occurred in the magnitude of ventricular biopotentials during the depolarization phase, while the greatest changes occurred in the ventricular repolarization phase. In particular, the T-wave became lower, broader and flatter. T-wave effects occurred first in the control group (day 60), and are described as similar to mild hypocalcemia. T-wave effects were retained into the recovery period by some subjects in each group.

Results of the second experiment, were similar to those of the first. In both experiments, effects on A-V conduction time and T-waves developed during the first few weeks of exposure leveled off for 1.5 to 2 months and then underwent fluctuation. Exercise programs performed during hypokinesia decreased levels of T-wave suppression (by a factor of 1.5 to 2) and accelerated recovery after treatment. Korinfar proved effective in decreasing or preventing cardiac changes associated with hypokinesia. Because they disappeared during the 2-month recovery period, EKG changes associated with hypokinesia are considered functional and reversible by the authors.

Table 1: Changes in EKG parameters in healthy men during a 182-day period of hypokinesia with head-down tilt

Table 2: Changes in EKG parameters in healthy men during a 120-day period of hypokinesia with head-down tilt

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P864(19/88)* Fatenkov VN.

New information on cardiac biomechanics.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

22(3): 45-55 ; 1988.

(21 references; 10 in English)

Cardiovascular and Respiratory Systems, Cardiac Biomechanics

Dogs

Contraction, Myocardial Layers, Interactions

Abstract: The author studied functional interactions among myocardial layers, which operate the ventricles through deformation of their walls. One long-term and three short-term experiments were performed on outbred dogs. In all four, animals were anesthetized and pulmonary ventilation was performed artificially. In the first experiment (26 subjects), EKGs were recorded; tension was recorded in the subepicardial and circular layers; intraventricular pressure in the left ventricle and pressure in the aorta were also measured. In the second experiment (5 subjects) paper labels were placed at specific points on the surface of the myocardium, so that the lines connecting them lay along the lines of the 6 fibers of the subepicardial and subendocardial layers. Displacement of the labels was recorded with a movie camera and EKG was also recorded. Still photographs were made from the movie film and displacement of the lines measured for systole and diastole. In the third experiment (7 subjects) electromyograms of the muscle layers of ventricle walls were recorded, with two electrodes implanted in each layer. In experiment four (4 subjects) sterile X-ray contrast steel labels were implanted in the myocardium at various levels. After the general condition of the animals stabilized, a series of X-rays were taken of the heart, systolic and diastolic X-rays were identified, and the distance between the labels measured.

It was discovered that the various layers of the myocardium do not contract at the same time. The subendocardial and subepicardial layers and papillary muscles contract first. This changes the shape of the ventricle from elliptical to spherical, and, inside the ventricle, moves the stroke volume of blood into the arterial cone. After 0.03-0.04 seconds the powerful circular layer begins to contract, leading to straightening of the outflow path, rapid increase in intraventricular pressure, closing of the bi- and tricuspid valves, and elongation of the other two contracting layers. The contractile power of all three layers combines. The contracting papillary muscles, a component of the subendocardial layer, prevents the valve cusps in the auricle from slipping. The first portion of blood composing the stroke volume is pushed from the ventricle by this muscle interaction, but decrease in size of the cavity causes all three layers to shorten (contract). This occurs in the maximal ejection phase. Toward the end of this phase (EKG T wave), the circular layer stops contracting, its muscle fibers relax and begin to elongate in the phase of reduced ejection as a result of the continued longitudinal contraction of the subendocardial and subepicardial layers. While the circular layer is elongating, intramural pressure (which determines intraventricular) pressure decreases. Thus, contraction of the subendocardial and subepicardial layers smoothly decreases intraventricular pressure and actively alters the configuration of the ventricles. These processes occur in the phases of reduced ejection, isovolemic decrease in intraventricular pressure, and rapid filling. The contraction of these layers leads to opening of the mitral and tricuspid

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valves, continues the decrease in intraventricular pressure, and creates ventricular suction in the rapid filling phase. Contraction of the subendocardial and subepicardial layers terminates at the end of the rapid filling phase (EKG U wave), their muscle fibers relax and grow longer along with circular fibers in the slow filling phase and auricular systole, in which blood enters because of contraction of the auricle. Thus it is contraction of the subendocardial and subepicardial layers which initiate diastolic phases.

Table: Changes in the distance between points on the exterior surface of the left ventricle during the cardiac cycle

Figure 1: Structure of the myocardium of the left ventricle

Figure 2: Mechanocardiogram with simultaneous recording of EKG

Figure 3: Synchronous recording of tensogram of the circular and subepicardial layers, pressure in the aorta and intraventricular pressure

Figure 4: An electromyogram of the layers of the myocardium

Figure 5: X-ray of the heart of dogs with implanted labels

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P866(19/88)* Barinyan SB, Oganesyanyan SS, Eloyan MA.

The effect of neutral muscle proteases on contractile parameters of isolated strips of the myocardia of white rats during exposure to acceleration and during a subsequent recovery period.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

22(3): 58-60 ; 1988.

(19 references; 14 in English)

Cardiovascular and Respiratory Systems, Contractile Parameters

Rats

Acceleration, Enzymology, Musculoskeletal System, Muscle, Protease

Abstract: White male rats were divided into three groups: a vivarium control (N=9), an adapted group (N=8), and a 30-day readapted group (N=7). The animals in groups 2 and 3 were rotated on a centrifuge with diameter of 3.2 meters and exposed to +5 G_z for 25 minutes per day for 15 days. The animals were sacrificed and a strip cut from the left cardiac ventricle 4-5 mm long and 1 mm wide. Contractile parameters were recorded on a mechanographic device. The strip was perfused with an unspecified solution. Preparations of Ca²⁺-activated neutral proteases were obtained from the skeletal muscles of white rats. Maximum activity of the enzyme was observed in the presence of 2·10⁻³ M and Ca²⁺. Maximum amplitude of contraction, and rate of development of maximum tension and relaxation of the strip were computed by an unspecified method.

In the control group, after the myocardial strip was processed with protease, contractile amplitude and rate of relaxation decreased significantly, and rate of development of tension decreased to a lesser extent. The effect of protease on these parameters may be explained by a decreased number of binding sites for Ca ions due to proteolysis of the appropriate protein components. In animals of groups 2 and 3, the effects of neutral proteases increased significantly, while there was a more marked decrease in all the biomechanical parameters studied. Decrease in rate of tension development reached 25%. One can conclude that the proteolytic capability of the protein apparatus in the myofibrils increased. This could be due either to morphostructural changes in myocardial fibers making the contractile apparatus more susceptible to the effects of the enzyme, or to the appearance of isoforms of myofibril proteins with altered affinity for proteases. Computations showed that an increase in the concentration of Ca²⁺ in the medium from 2·10⁻³ to 3·10⁻³ M increased the amplitude of contraction by 30%, while after processing with protease this parameter increased by only 13%. Similar results were obtained with adrenalin and corglycon??. It may be concluded that neutral proteases modulated the Ca²⁺-regulability functions of myofibrils. These changes are evidently not readily reversible since 30 minutes of perfusion of the myocardial strip with solution not containing protease did not restore the parameters to their baseline values. The authors argue that the increased proteolytic capability of the contractile apparatus noted during adaptation to hypergravity cannot be considered solely pathological in nature. However, activation of Ca²⁺-dependent neutral proteases in the cytosol of muscle cells in the presence of slight fluctuations of free Ca²⁺ suggests their participation in adaptive and destructive processes in the early stages of response, when the first changes in the permeability of membranes to ions occur.

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Table: The effects of neutral protease from skeletal muscles in intact rats (60 ug/ml) on contractions of isolated myocardial strips from control and experimental animals

Figure: The effect of cardiogenic compounds on the contractile force of isolated myocardial strips before and after processing with preparations of neutral proteases

CARDIOVASCULAR AND RESPIRATORY SYSTEMS

P868(19/88)* Goncharov IB, Ivanov AP, Savina VP, Repenkova LG, Yakovleva, MYe, Nikitin YeI.

Evaluation of the effects of enterosorption in humans exposed to an altered gas medium.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

22(3): 64-66; 1988.

(10 references; 9 in English)

Cardiovascular and Respiratory Systems, Central Circulation

Humans

Habitability and Environment Effects, Hermetically Sealed Environment, CO₂, CO;
Operational Medicine, Prophylactic Detoxification Enterosorbent

Abstract: Subjects in this experiment were 18 apparently healthy men, aged 25-45, who spent 7 days in a hermetically sealed chamber with an elevated concentration of CO₂ (2.9-3.1%) in the atmosphere. Eight hours before the end of their confinement, 40 mg/m³ CO was introduced into the living quarters. Beginning on day 1 of the experiment, subjects in the experimental group (n=12) received the enterosorbent SNI in a dose of 0.75 g per 1 kg body weight 3 times per day. The 6 members of the control group received no enterosorbent. Material (blood, exhaled air) for study was removed from the chamber through a special airlock. Cardiography and impedance plethysmography were performed. The paramecium method (comparison of survival time of paramecia in blood plasma of subjects to that of normal individuals) was used to test toxicity. Exhaled air was analyzed using gas chromatography. Acid-base homeostasis and concentration of carboxyhemoglobin were also measured.

The altered atmosphere had a significant effect on a number of parameters of central circulation in both groups. Minute blood volume was unaltered in the control, and increased by 7.7% in the experimental group after exposure to CO₂ alone. After CO was introduced, minute volume was virtually unchanged in the experimental group, but reduced by 42.4% in the control. Peripheral resistance to blood flow decreased slightly in both groups after CO₂ breathing; after CO was introduced, this parameter increased by 4.2% for the experimental and 39.4% for the control group. No significant effects on heart rate were noted. The paramecium test showed that the greatest increase in toxicity occurred after introduction of CO; toxicity increase was significantly greater for the control group. Significant changes were observed in concentrations of a variety of carbohydrates after exposure to CO₂+CO, but the magnitude and direction of these effects differed for the two groups. CO₂ alone had no significant effect on carboxyhemoglobin in blood; however, addition of CO led to significant increases which were higher in the control (183.7%) than in the experimental group (62%). No significant changes were found in acid-base balance. The authors conclude that enterosorption shows promise for use in prophylactic detoxification to protect individuals from the stress of extreme environmental factors.

Table: Mean parameters of minute blood volume, total peripheral vascular resistance to blood flow and heart rate in experimental subjects

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P885(19/88) Kovalev OA, Parfenova MA.

Regional vascular effects of decreasing adrenergic activity in animals at rest and immobilized.

Fiziologicheskiy Zhurnal SSSR im I.M. Sechenova.

74(4): 510-516; 1988.

[8 references; 2 in English]

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Cardiovascular and Respiratory Systems, Regional Vascular Effects

Rats

Endocrinology, Adrenergic Effects; Immobilization

Abstract: This research was performed on outbred male rats. Four days before the beginning of the experiment a catheter was implanted in the right auricle and aortic arch. In some animals a thermister was placed in an arterial catheter. The venous catheter were flushed twice daily to familiarize the animals with the experimental procedure. On the day of the experiment, radioactive indicators were introduced into the catheter, and then an intravenous injection of 0.7 ml of a saturated solution of potassium chloride was used to stop the heart. In the control group, this procedure was performed on animals at rest, while in the experimental conditions it was performed 2 hours after introduction of adrenergic receptor blockers and sympatholytic substances, the alpha-blocker Pyrroxan (6-[Beta-(3'Phenylpyrrolidyl-1')propionyl]-benzodioxan-1,4 hydrochloride) in a dose of 10 mg/kg, the beta-blocker Obzidan (propranolol hydrochloride) in a dose of 5 mg/kg, and the sympatholytic agent Ornid (o-Bromobenzyl ethyl dimethylammonium bromide). The same drugs in the same doses were used in a control condition and in an experimental group in which animals were immobilized on a special stand. In two conditions (control and experimental), regional redistribution of cardiac minute volume, with the exception of its coronary fraction, was measured using macroaggregates of albumins of iodine-131 introduced into the aortic arch. In two other experimental conditions regional redistribution of chloride rubidia-86, introduced intravenously 60 seconds before stopping the heart, was recorded. In the next two conditions regional redistribution of volume of circulating blood was studied using erythrocytes-chromium-51 and microaggregates of albumin iod-131. Redistribution in the volume of circulating blood was compared to redistribution of cardiac ejection and rubidium-86 to evaluate the capacitance of regional vascular response. Systemic hemodynamic parameters were recorded for the same animals before and after decrease in adrenergic activity. There were 14 rats in each of the six conditions in which regional hemodynamics were studied and 10 rats in the two conditions in which systemic hemodynamics were measured.

Decrease in adrenergic activity led to hypotension, bradycardia, and decreases in cardiac minute and stroke volumes in animals at rest. In immobilized control and experimental animals, this treatment was associated with unchanged pressure in the carotid artery and minute circulatory volume, while stroke volume increased. Pyrroxan, Obzidan, and Ornid administered to animals at rest induced only insignificant redistribution of blood flow. In immobilized rats these same drugs induced significant regional redistribution of cardiac ejection volume, with the fraction in the skin, stomach, pancreas, intestine, and kidneys increasing, while the fraction in the bronchial tract, hepatic artery, and spleen decreased.

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Decreased adrenergic activity in animals at rest decreased the content of rubidium-86 in the myocardia, lungs, adrenals, and skin of the chest and lower extremities and increased it in the muscles and bone tissues of the head. In immobilized rats, decreased adrenergic activity led to decrease in rubidium-86 in all muscles and bone tissues, skin of the abdomen and groin and increased it in all visceral organs except the liver and heart and also in the skin of the front legs. Pyrroxan, Obzidan, and Ornid administered to rats at rest increased blood perfusion in the major portion of the skin, muscles, bone tissues and kidneys, but decreased blood in the pancreas, spleen, myocardia, and lungs. When animals were immobilized, changes in many parts of the skin, muscles, and bone were analogous; however, blood in the myocardium, intestine, spleen, kidneys, skin of the front legs and abdomen showed different effects. Comparison of regional changes of blood volume distribution with changes in blood flow and range of rubidium-86 suggests that decreased adrenergic activity causes redistribution of circulatory blood volume by changing absorption through the lumens of accumulating vessels.

Table 1: Systemic changes in circulation in response to decreased level of adrenergic activity in rats

Table 2: Regional redistribution of blood flow in response to decreased adrenergic activity in rats

Table 3: Regional redistribution of rubidia-86 chloride in response to decreased adrenergic activity in rats

Table 4: Regional redistribution of circulatory blood volume in response to decreased adrenergic activity in rats

CARDIOVASCULAR AND RESPIRATORY SYSTEMS

P889(19/88) Korzh SV, Polonskiy VV, Morozov LA, Nosov VN.

Evaluating physical work capacity under conditions of hypokinesia.

Voyenno-meditsinskiy Zhurnal.

1988(4): 50-51.

[No references.]

Authors' Affiliations: Military Medical Corps

Cardiovascular and Respiratory Systems, Orthostatic Reflex, Deconditioning
Human Performance, Work Capacity

Humans, Men

Hypokinesia, Limited Living Environment, Exercise

Abstract: This article is concerned with the use of the orthostatic cardinal reflex (increased heart rate upon assumption of an upright position) as an estimate of the effects of hypokinesia on work capacity. The orthostatic reflex is tested by recording EKGs for subjects in prone position and sitting erect. The magnitude of the reflex is obtained by measuring the difference between the mean duration of five cardiac cycles in each position. The time for the reflex to develop is also considered. To ensure that the full effect is recorded, the EKG is measured for 15 seconds after sitting up. The capacity of this test to predict work capacity after exposure to hypokinesia was investigated under four conditions. In each, a group of 10 healthy young men lived in a very limited space. In two relatively short-term experiments (lasting 20 days each) there were only 1.6 m² per man in the living quarters. A pedometer indicated that each subject took 300-600 steps a day. In the first condition, no measures were taken to combat the effects of hypokinesia, while in the second, subjects engaged in 50 minutes of daily exercise (90-110 W) on a bicycle ergometer, and worked out with springs and weights. In the last two conditions, subjects spent several months in a space of 10-20 m² per person. Each subject took an average of 2000-4000 steps per day. In the first of these conditions no measures were taken to increase activity, while in the second subjects used a bicycle ergometer, treadmill, and other exercise equipment 5 times per week for 45 minutes per day. Throughout each experiment, a number of techniques were employed to evaluate the state of the cardiovascular system and directly measure physical work capacity.

When subjects were exposed to hypokinesia and no countermeasures were employed, the changes occurring in the cardiovascular system suggested a shift to a lower level of functioning. Heart rate decreased by 10-12 beats/minute and EKG intervals and cardiac cycle phases increased. The magnitude of the orthostatic reflex increased from 0.18-0.23 seconds to 0.26-0.36 seconds, demonstrating cardiovascular deconditioning. Direct measures of work capacity in subjects not undergoing conditioning exercise decreased by 20% after 20 days and 30% after hypokinesia lasting a number of months. For most parameters, in the short term, severely limited motion condition, effects reached a maximum by day 5; in the longer term, less severe condition, the comparable period was 15 days.

Most parameters stabilized after reaching maximum. The one parameter which continued to deteriorate was time required for the orthostatic reflex to develop. When motion was severely restricted, the time required for the orthostatic reflex was prolonged. In short-term hypokinesia, reflex development time increased from 1.98 seconds to 4.02 seconds on day 18 of treatment. In the long-term condition, this parameter reached 4 seconds on

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day 45, and 4.7 at the end of the experiment.

When subjects engaged in exercise, all parameters measured showed less deterioration, and this was particularly true of the orthostatic reflex. During the first 10 days of hypokinesia, this reflex showed a tendency to increase by 0.5-1 second, but subsequently stabilized at 2.4-3 seconds. The direct association of this parameter with cardiovascular deconditioning and its sensitivity to hypokinesia severity and duration make it a good candidate for use as a simple method for diagnosing effects of hypokinesia on work capacity. The authors' experiments showed that when the time to develop the orthostatic reflex reaches 3 seconds (140-150% baseline value) physical work capacity is only insignificantly decreased. When this parameter increases to 4 seconds, work capacity is decreased by 20%, and when the former reaches 5 seconds, the latter is decremented by 30%.

Figure: Results of orthostatic test in subjects with or without exercise

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P895(19/88) Kovalev OA, Korovin KF, Radchenko YeR, Parfenova MA.
**Characteristics of changes in circulation and adrenergic activation
in rats confined in immobilization cages or restrained on a board.**
Patologicheskaya Fiziologiya i Eksperimental'naya Terapiya.
1988(1): 29-32.

[11 references; 1 in English]

Cardiovascular and Respiratory Systems, Circulation; Endocrinology,
Adrenergic Activity
Rats, Male
Immobilization, Cages, Restraint

Abstract: This experiment tested the hypothesis that placing animals in immobilization cages and rigidly restraining their limbs and head represent moderate and severe forms of the same process. Subjects in the experiment were outbred white male rats previously habituated to experimental conditions and catheterized in the right auricle through the external jugular vein, and the arc of the aorta through the common carotid artery. Four days later, one group of animals was placed in an immobilization cage for 1 hour (group 1), another group was tightly restrained on their backs so that no movement was possible (group 2) for 1 hour, while a third (control) group was maintained under normal laboratory conditions. Heart rate, blood pressure in the carotid artery, minute circulatory volume, cardiac stroke volume, and mean peripheral vascular resistance were measured in 10 animals in each group. Concentrations of norepinephrine (NE) and epinephrine (E) in plasma and tissues were measured in samples obtained directly after decapitation in 12 rats in each group. Regional redistribution of blood flow was recorded in 10 rats in each group by introducing albumins into the aortic catheter. Systemic hemodynamic parameters, parameters of adrenergic activation, and or regional redistribution of blood flow were all determined before and 1 hour after immobilization.

Group 1 rats showed moderate hypotension; group 2 evidenced more pronounced hypotension, bradycardia, decreased circulatory minute volume, and increased peripheral resistance. These symptoms are characteristic responses to hypokinesia. In addition, signs of emotional stress (catecholamine decreases in the adrenal glands and increase in blood) were observed. Again, these were more pronounced in group 2. In spite of increased plasma norepinephrine, tissue norepinephrine remained stable or increased (in the liver) for both groups, especially group 2. Increases in epinephrine were parallel in blood and tissues for group 1. In group 2, epinephrine increased sharply in blood, but only moderately in tissues. The authors conclude that both immobilization procedures are associated with accelerated elimination of norepinephrine from tissues into the blood, or metabolic transformation of norepinephrine in tissues, with the more extreme effect in the restraint condition. In condition 1, there is evidence for attenuation of the capture of epinephrine from the blood by the tissues or its metabolic transformation in the tissues. Thus, exposure of 1 hour to both types of immobilization was associated with signs of emotional stress, more pronounced in rigid restraint on the board. At the same time, there were qualitative differences in responses to the two paradigms, which may be associated with characteristics of alpha- and beta-adrenergic activation in the tissues.

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Table 1: Changes in parameters of systemic hemodynamics and adrenergic activation in immobilized rats

Parameter	Control	Group 1	Group 2
BP, mm Hg	120	110**	--
	121	--	108*
Heart rate, beats/min	524	544	--
	497	--	420**
Circulatory minute volume, ml/min/ 100g	29.5	30.6	--
	25.1	--	15.3**
Stroke volume, ml/100g	0.0231	0.0230	--
	0.0172	--	0.0194
Peripheral resistance $H \cdot c \cdot m^{-5} / 100 \text{ g} \cdot 10^{-2}$	3.25	2.97	--
	3.85	--	5.64
Concentration E and NE in adrenals, nmole/g			
NE	0.66	0.58*	0.51
E	1.72	1.59	1.37*
in blood plasma, nmole/g			
NE	20.3	26.4*	29.3*
E	13.1	15.4	28.8*
in myocardium, umole/g			
NE	1.63	1.75	1.64
E	0.15	0.20*	0.22*
in liver, nmole/g			
NE	105	86.5*	76.5*
E	8.74	14.1*	12.9
in diaphragm, nmole/g			
NE	569	515	492*
E	67.3	83.3*	97.6*
in pectoral muscle, nmole/g			
NE	197	185	188
E	12.7	19.1*	18.6
in the adductor muscle of the femur, nmole/g			
NE	165	151	150
E	11.2	13.8	13.3*

* $p < 0.05$ (t-test); ** $p < 0.05$ (chi square test)

Table 2: Regional changes in blood flow in immobilized rats.

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P896(19/88)* Muravov IB.

The effects of therapeutic exercise on patients undergoing long periods of hypokinesia (bed rest).

Voprosy Kurortologii Fizioterapii i Lechebnoy Fizichesko Kul'turu.
1988(2): 25-29.

[11 references; 1 in English]

Author's Affiliation: Institute of Physical Culture, Kiev

Cardiovascular and Respiratory Systems, Heart Rate, Blood Pressure
Humans, Patients, Heart Disease; Healthy
Hypokinesia, Bed Rest; Exercise

Abstract: The author argues that physical exercise may extend beneficial (therapeutic and prophylactic) effects, in addition to training effects, to patients suffering from various diseases requiring bed rest and healthy individuals undergoing hypokinesia. This argument is based on the results of studies which showed that patients undergoing bed rest (for arteriosclerosis, ischemic heart disease, high and low blood pressure) respond to exercise in a way diametrically opposed to that of normal subjects. Healthy middle-aged subjects respond to exercise by increased heart rate during and immediately after exercise, while patients undergoing bed rest show decreased heart rate, with hyperkinetic patients also displaying decreased blood pressure during and after an exercise period. The functional state manifested by these patients (as revealed by EKG data) improved during performance of the exercise. The author argues that this paradoxical reaction is not associated so much with the pathological process, but with hypokinesia itself, since it occurs in patients with a variety of diseases and is also noted in healthy individuals subjected to long-term (10 to 30 days) experimental hypokinesia. He states that the data suggest that, given conditions of hypokinesia, even low levels of physical exercise can have a therapeutic effect without any necessary increase in physical work capacity (cardiovascular training effects). The mechanism of this effect is compensation for motor insufficiency by triggering reflexes from the muscles (motor-visceral reflexes) which, under conditions of long-term or severe hypokinesia, facilitate restoration of normal regulation of vital functions. The magnitude of this compensatory effect is heightened by increased sensitivity to motor stimulation associated with hypokinesia. Immediate beneficial effects can be realized with relatively mild exercise, insufficient to increase conditioning, when more intense exercise would be dangerous to the patient.

Table 1: Effects of standard therapeutic exercises on heart rate in patients undergoing long periods of bed rest and in healthy individuals the same age with normal motor activity

Group	At rest	During Exercise			Recovery Period	
		after 1st ex.	after 2nd ex.	at end of session	after 1 minute	after 5 minutes
Patients (n=42)	87.4	81.6	74.4*	72.6**	70.7***	72.3**
Healthy (n=36)	71.5	77.8	80.5	79.4	75.2	73.5

* differs from at rest value, $p < 0.05$; ** $p < 0.02$; *** $p < 0.01$

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Table 2: Effects of standard therapeutic exercises on EKG parameters in patients undergoing long periods of bed rest and healthy individuals with normal motor activity

Group	Change for Better		No Change		Change for Worse	
	End of session	20 minutes later	End of session	20 minutes later	End of session	20 minutes later
Patients	27	8	3	9	0	13
Healthy	3	23	5	7	22	0

Table 3: Effects of standard therapeutic exercises on duration of breath-holding on exhalation in patients undergoing long periods of bed rest and in healthy individuals the same age with normal motor activity

Group	At rest	During Session		Recovery Period	
		Middle	End	After 1 minute	After 5 minutes
Patients (n=42)	6.3	7.0	7.9*	7.6	7.4
Healthy (n=36)	14.2	12.9	12.2*	13.3	14.6

* difference with at rest value significant, $p < 0.05$

CYTOLOGY: See Adaptation M133

DEVELOPMENTAL BIOLOGY

(See also: Botany P903)

PAPERS:

P886(19/88)* Parfenov GP, Oygenblik EA.

The effects of hypergravity on embryonic development and survival in amphibians.

Izvestiya Akademii Nauk SSR: Seriya Biologicheskaya.
1988(3): 346-351.

[20 references; 10 in English]

Authors' affiliation: Institute of Biomedical Problems; USSR Ministry of Health, Moscow.

Developmental Biology, Embryonic Development, Survival
Amphibian, Grass Frog
Gravitational Biology, Hypergravity, Centrifugation

Abstract: In this experiment, the authors studied the effects of prolonged exposure to hypergravity ranging from 2- to 30-G during early embryogenesis in amphibians. Ova of the grass frog Rana temporaria were collected from the field 30-40 minutes after fertilization. Thus, all experiments started with the gray crescent stage. Ova were exposed to acceleration varying in duration and G-load. In the first experiment, exposure continued up to the period of increased sensitivity, i.e., before cleavage III, or up to blastulation, gastrulation, neurulation, or the tail-bud stage. Accelerations of 2, 3, 5, 7, 10, 17, 25, and 30-G were used. Six egg masses per condition were centrifuged at the first three accelerations and four masses for the remaining acceleration levels. The egg mass of this species contains 1115-4005 ova. Samples of 150-350 ova per egg mass were studied. Thus, at each level there were 800-1500 ova in the experimental and control conditions. After centrifugation terminated, the ova were placed in a dish and allowed to hatch. Number of embryos dying in embryogenesis and number of larvae were counted. Tadpoles were classified as normal living, anomalous living, or anomalous dead.

The experiment showed that 2-G acceleration terminating before cleavage III has virtually no effect on frog larva. When centrifugation continued up to blastulation, the number of normal, living larva decreased and anomalous larva began to appear; when it continued up to gastrulation the number of larva dying in embryonic development and the number of dead anomalous larva increased significantly. Acceleration at 3-G for all durations decreased the number of normal living larva and increased the number of anomalous living larva. Centrifugation up to gastrulation and neurulation also significantly increased the number of anomalous tadpoles that died. Acceleration of 5-G terminating at cleavage III increased death during embryogenesis and decreased the number of normal living larva. When continued until blastulation, this G-load worsened the state of tadpoles in all groups, and, when it continued until the tail-bud stage, all larvae died.

In a second experiment intended to reveal sensitivity to hypergravity of frog embryos at various stages of development, ova from the same egg mass were accelerated from the grey crescent to cleavage III stage, from cleavage III to blastulation, from blastulation to gastrulation, or from

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gastrulation to neurulation. Centrifugation rates were 2- and 5-G. Acceleration of 2-G at all stages somewhat increased the number of dead anomalous tadpoles, but had no other effects. When acceleration was increased to 5-G, the number of anomalous living and dead larvae increased significantly at virtually all stages. No reliable correlation was found between sensitivity and stage of development during which centrifugation occurred. There was a reliable increase in death during embryogenesis when centrifugation occurred between 0 and cleavage III or between gastrulation and neurulation. Evidently, when centrifugation occurred between the grey crescent and later stages of development it affected the primary organization of the egg and the transition to meroblast cleavage. This resulted in differential disarray of the embryo, with the two most common types of anomaly being failure of the yolk plug to grow and many double monsters. These anomalies were frequently present simultaneously. Typically, death of anomalous larvae occurred because the nonfractionating yolk began to decompose.

A third experiment investigated effects of acceleration ranging from 2- to 30-G on frog embryos during the period between the grey crescent and eight blastomere stage. Acceleration of 2-G had no effect on the embryos. Acceleration of 5-G significantly increased the number of anomalies and embryo deaths. The number of anomalous embryos was virtually identical at 7 and 10-G; at 17-G anomalies had increased by a factor of two; at 25-G almost no anomalous larvae hatched because of embryo deaths, and percentage hatching was 8%. After 30-G, all embryos died. The authors computed the 50% lethal acceleration at 14-15-G.

Table: Results of 2- and 5-G centrifugation of ova from a single egg mass at various stages of development

(1 = normal living, %; 2 = anomalous living, %; 3 = anomalous dead, %; 4 = death during embryonic stages, %)

Acceleration	2-G				5-G			
	1	2	3	4	1	2	3	4
Grey crescent- 8 blastomeres	97.5	0	1.10+	1.39	92.61+	0.40	0.24*	6.85+
8 blastomeres- blastula	96.17	0	0.37*	3.46	94.41 ^o	1.81+	1.30+	2.37
Blastula-gastrula	96.24	0	0.44+	3.31	93.40+	1.71+	1.24+	3.63
Gastrula neurula	95.82	0	0.94+	3.23	93.25+	0.99+	1.75+	4.93
Control	97.18	0.31	0	2.50				

* p < 0.05; ^o p < 0.01; + p < 0.001 [Note: not stated what differences are being tested; presumably control values]

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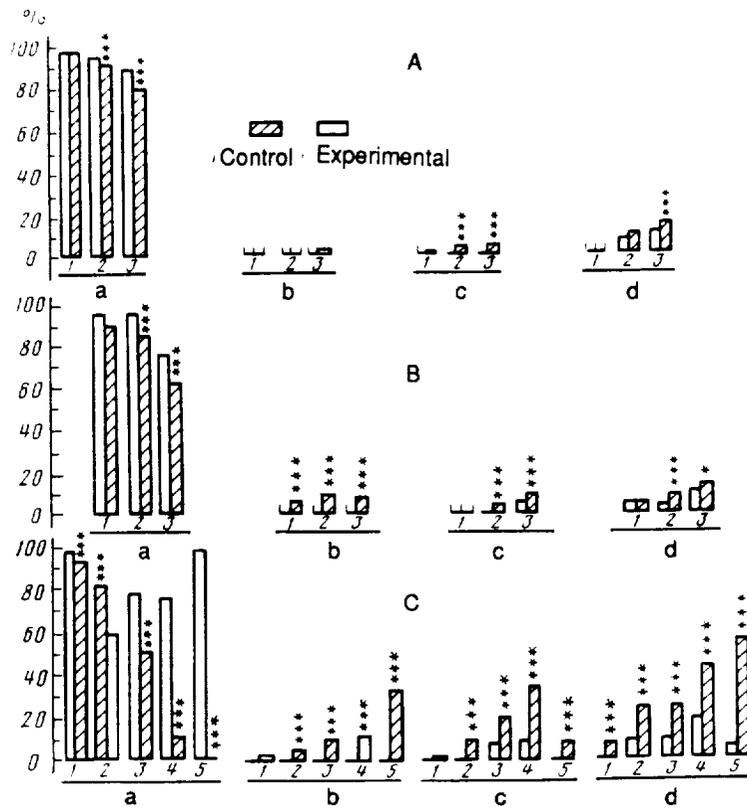


Figure 1: The effects of centrifugation on frog embryos. Acceleration: a - 2-G; b - 3-G; c - 5-G, up until stage: 1-III cleavage; 2 - blastula; 3 - gastrula; 4 - neurula; 5 - tail bud; A - normal living larva; B - anomalous dying larvae; C - embryo deaths; Significance of difference between experimental and control conditions: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

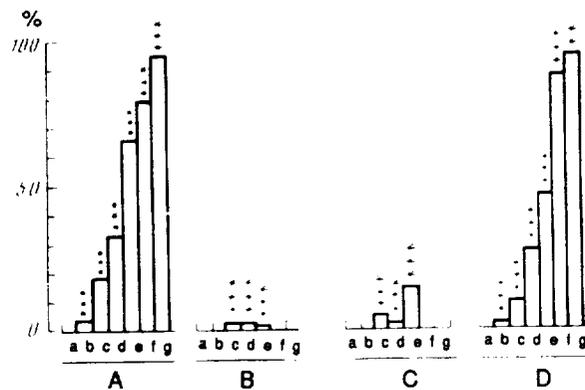


Figure 2: Effect of centrifugation during development from grey crescent -- 8 blastomeres. Histograms show the difference between experimental and control conditions. Acceleration: a - 2-G; b - 5-G; c - 7-G; d - 17-G; e - 25-G; f - 30-G; A - decrease in number of normal living larvae; B - increase in number of anomalous living larvae; C - increase in death during embryonic stage. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

DEVELOPMENTAL BIOLOGY

P893(19/88)Serova LV, Kvetnyanski R, Vigash M, Knopp Ya, Makho L.
The effects of weightlessness on the development of the endocrine system in mammals.

In: Polenov A.L., editor.

Endokrinnaya Sistema Organizma i Vrednyye Faktory Vneshney SREDY: III Vsesoyuznaya Konferentsia (8-10 Sentyabrya 1987) [**The Endocrine System and Adverse Environmental Factors**: IIIrd All-Union Conferences (8-10 September 1987) [Paper Abstracts].

Leningrad: 1987. Page 205.

Affiliation (book): USSR Academy of Sciences, Scientific Council on Visceral Systems, I.P. Pavlov Institute of Physiology, I.M. Sechenov Institute of Evolutionary Physiology and Biochemistry, Leningrad Research Institute on Industrial Hygiene and Occupational Diseases, Samarkand Medical Institute
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Developmental Biology, Endocrinology
Rats, Female, Pregnant
Space Flight, COSMOS-1514

Abstract: Space flight conditions offer a unique opportunity to study the biological effects caused by a number of extreme factors, and also investigate the role played by gravity in growth and development of terrestrial organisms. The COSMOS-1514 biosatellite contained an embryological experiment in which the first attempt was made to solve fundamental questions regarding the development of mammalian fetuses and various physiological functions when the mother is exposed to weightlessness.

Female Wistar rats were exposed to weightlessness for 5 days (days 13-18 of pregnancy). The state of mother and fetus was evaluated on the day of reentry. Another group of rats was allowed to give birth naturally. After offspring were born, they were observed for several months, with a portion being sacrificed on days 1, 15, 20, and 100 of their lives to study the structure of their visceral organs and metabolic processes.

Exposure to space was accompanied by serious changes in the bodies of the pregnant females (decreased weight gain, involution of the thymus, decreased concentration of adrenalin in the adrenal glands, increased thyroxine hydroxylase, and other changes). At the same time, the major parameters of reproductive function were unaltered.

When animals which developed under weightlessness during the fetal period were studied at various stages of postnatal ontogenesis up to sexual maturity, no significant differences were observed between the experimental and control groups in adrenal weight, concentration of adrenalin, noradrenalin and enzyme activity, synthesis and degeneration in the adrenal glands, concentration of thyroxin and triiodothyronine in the thyroid, or in blood corticosterone, somatotropic hormone, prolactin or insulin.

The effect of weightlessness in the antenatal period during the stage when visceral organs and the mechanisms regulating their activity develop did not affect the rate of growth of the organs or their metabolic level in any stage of postnatal ontogenesis.

ENDOCRINOLOGY

(See also: Adaptation CR10; Gastrointestinal System P878; Cardiovascular and Respiratory Systems P885, P895; Neurophysiology P887; Developmental Biology P893)

PAPERS:

P867(19/88)* Mamalyga LM.

Neurochemical and morphological studies of hypothalamic structures in stress.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
22(3): 61-64 ; 1988.

(20 references; 3 in English)

Endocrinology, Hypothalamus; Neurophysiology, Neurochemicals
Rats, Male
Psychology, Stress

Abstract: This experiment involved cyto- and karyometric investigations of neurons in the supraoptical and paraventricular nuclei of the hypothalamus after exposure to immobilization stress. Concentrations of RNA and total protein were also measured. Research has shown that these two structures play a key role in integration of endocrine regulation and coordination in response to stress. The functional metabolic state of the neurons in these structures is an indicator of the body's adaptive capacity. In this experiment, male Wistar rats (N not specified) were subjected to hypokinesia in immobilization cages for 14 hours or 1, 5, 10, or 20 days. A control group was used for each condition. After treatment, animals were sacrificed at the same time of day. The hypothalamus was removed and fixed; after standard histological processing, serial cross sections 6-7 um thick, were prepared. RNA and total protein concentrations were measured spectrophotometrically after appropriate staining. A total of 45-50 neurons were studied in each animal. Cyto- and karyometry were also performed.

No significant changes were found in the size of cell nuclei of the supraoptical nucleus at any hypokinesia duration; cytoplasm decreased significantly only on days 5 and 22. The neurocyte nuclei in the paraventricular nucleus were diminished in size for all hypokinesia durations; cytoplasm was reduced for all durations except 5 days. Possible causes for decrease in size of secretor neurons include increase in anabolic processes, decomposition of intracellular chemical components, and intensified secretion. During the early hypokinesia period (14 hours and 1 day) no changes occurred in RNA or protein in the supraoptical nucleus, while these substances decreased markedly in the paraventricular nucleus. After 5 days of hypokinesia, protein and RNA decreased in the supraoptical nucleus while protein increased in the paraventricular nucleus. After 10 days results in the two structures also differed. Only at 20 days were both substances depressed in both structures. The authors conclude that changes in RNA and protein in the structures studied result from a general stress response and not from limited motor activity per se. They further state that participation of the paraventricular and supraoptical nuclei in stress response to immobilization does not follow the same temporal pattern.

Figure 1: Volume of nuclei and cytoplasm of neurons of the supraoptical and paraventricular nuclei after hypokinesia of different durations

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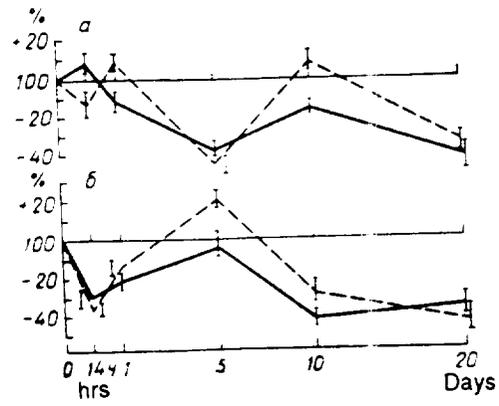


Figure 2: Change in concentration of RNA and total protein at various periods during hypokinesia

P890 (19/88) Zagorskaya YeA.

Functional state of the adrenal cortex of rats exposed to hypokinesia: Results of morphological and biochemical analysis.

In: Polenov AL, editor.

Endokrinnaya Sistema Organizma i Vrednyye Faktory Vneshney Sredy: III Vsesoyuznaya Konferentsia (8-10 Sentyabrya 1987) [**The Endocrine System and Adverse Environmental Factors**: IIIrd All-Union Conferences (8-10 September 1987) [Paper Abstracts].

Leningrad: 1987. Page 78.

Affiliation (book): USSR Academy of Sciences, Scientific Council on Visceral Systems, I.P. Pavlov Institute of Physiology, I.M. Sechenov Institute of Evolutionary Physiology and Biochemistry, Leningrad Research Institute on Industrial Hygiene and Occupational Diseases, Samarkand Medical Institute
 Author's Affiliation: Institute of Biomedical Problems

Endocrinology, Adrenal Cortex

Rats, Male

Hypokinesia, Immobilization Cages, Psychology, Immobilization Stress, Restraint

Abstract: Functional state, reserve capacities, and structural changes were studied in the adrenal cortex of 250 male rats exposed to long-term hypokinesia (7, 14, 30, 60, and 90 days) created by housing them in immobilization cages. Reserve capacities were evaluated on the basis of response to acute stress (5-hour fixation of the animals in a prone spread-eagle position). Histological analysis was performed on the adrenal glands and the serum concentration of corticosterone in blood was determined using modified radioimmune assay.

Histological study of the adrenal gland showed hypertrophic alteration in the steroid-producing tissue and increase in the number of functionally active cells after hypokinesia at all durations studied. On days 7 and 14 delipidization of the cortical substance was also noted. On day 30, lipid accumulation was noted and on days 60 and 90 lipid concentration was similar to that of a control group.

Serum corticosterone increased compared to control levels by 47% on day 7, returning to normal on day 14, and decreasing on days 60 and 90 by 31% and 39%, respectively. The effect of 5 hours of acute stress induced more pronounced increases in serum corticosterone in rats previously exposed to hypokinesia than in control rats. However, there was no evidence of structural reorganization or delipidization in the cortical substance. Thus, long-term hypokinesia in rats is characterized by dissociation between hypertrophy of steroid-producing tissue of the adrenal glands and decreased serum corticosterone. Exhaustion of the adrenal gland is not noted in response to long-term hypokinesia; the reserve capacities of the adrenal cortex are maintained. At the same time, increased sensitivity of steroid-producing tissue in the adrenal cortex to the additional effects of acute stress after exposure to long-term hypokinesia suggests the possibility of disruption of regulatory mechanisms.

P891(19/88) Prodan NG.

Investigation of the medullary substance of the adrenal glands of rats in an experiment on the "COSMOS-1667" biosatellite.

In: Polenov AL, editor.

Endokrinnaya Sistema Organizma i Vrednyye Faktory Vneshney Sredy: III Vsesoyuznaya Konferentsia (8-10 Sentyabrya 1987) [**The Endocrine System and Adverse Environmental Factors**: IIIrd All-Union Conferences (8-10 September 1987) [Paper Abstracts].

Leningrad: 1987. Page 190.

Affiliation (book): USSR Academy of Sciences, Scientific Council on Visceral Systems, I.P. Pavlov Institute of Physiology, I.M. Sechenov Institute of Evolutionary Physiology and Biochemistry, Leningrad Research Institute on Industrial Hygiene and Occupational Diseases, Samarkand Medical Institute

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Endocrinology, Adrenal Glands, Medullary Substance

Rats

Space Flight, COSMOS-1667

Abstract: A histologic and morphometric study was performed on the medullary substance of the adrenal glands of rats 4-8 hours after a 7-day space flight. This study involved: identification of adrenocytes (A-cells) and noradrenocytes (N-cells) using Wood's method; measurement of the area occupied by medullary substance, A- and N- cells; and cell nucleus area.

It was established that the area occupied by N-cells decreased. Cytoplasm vacuolization occurred in both types of cell, increasing in magnitude with duration of reexposure to normal gravity.

Evidently, decreased area of N-cells may be attributed to weightlessness, while increased excretion of catecholamines (as demonstrated by vacuolization of cytoplasm) is a consequence of acute gravitational stress which develops in response to return to Earth's gravity after exposure to weightlessness. The absence of morphological signs of hypertrophy of the medullary substance and its cells indicates that, even during the initial stage of flight, weightlessness does not stimulate this component of the sympathetic adrenal system. On the contrary, for the first time data has been obtained suggesting the possibility of decreased secretion of noradrenaline in rats exposed to weightlessness in connection with reduction of noradrenocytes.

ENZYMولوجY: See Adaptation CR10; Musculoskeletal System P865;
Cardiovascular and Respiratory Systems: P866

EXOBIولوجY

PAPER:

P883(19/88) Kuzicheva YeA, Tsupkina NV, Potapova NG.
The effects of individual flight factors on the abiogenic synthesis of nucleotides.

Zhurnal Evolutsionnoy Biokhimii i Fiziologii.
24(1): 3-7; 1988.

[15 references; 5 in English]

Authors' affiliation: Institute of Cytology, USSR Academy of Sciences,
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Exobiology, Abiogenic Synthesis
Nucleotides
Space Flight, Salyut-7; Thermal Energy

Abstract: The goal of this work, performed on Salyut-7, was experimental confirmation that thermal energy plays a dominant role in the abiogenic synthesis of nucleotides. Materials used were the nucleosides deoxyadenosine and cytidine. These substances underwent phosphorylation in the solid phase in a vacuum in the presence of inorganic phosphate, i.e., simulation of the conditions in the lithosphere of primeval Earth or of planets similar to Earth. Experimental samples contained a mixture of Na_2HPO_4 , urea, ammonium chloride (phosphorylating mixture), and the nucleoside in a molar ratio of 1:10:10:1. Chromatography was performed on pure preparations of deoxyadenosine, deoxyadenosine-5'-monophosphate (5'dAMP), cytidine, cytidine-5'-monophosphate (5'CMP), Na_2HPO_4 , urea, and ammonium chloride. Water content of these preparations did not exceed 10%. Unrefined snake venom (*Agkistrodon halys*) and alkaline phosphatase from the intestines of chicks were used for enzymatic hydrolysis. Flight experiments were performed in a special cassette device housing quartz ampoules, allowing penetration by UV radiation with wavelengths greater than 220 nm, which contained the samples to be studied. Two experiments were performed. In the first, experimental samples were subjected to the joint effects of temperature differentials and UV-radiation. In the second, they were only exposed to temperature differential. Temperature differential at the bottom of the cassette device ranged from -50 to 65°C . Exposure duration was 13 months. Ground control samples were housed in a vacuum with temperatures of 20 , 45 , and 65°C for 8 days to 6 1/2 months. No nucleotides were found at temperatures below 65°C . Initial purification of synthesized products was performed using DEAE-sephadex A-25. Fractions with elution volume equal to elution volume of 5'dAMP and 5'CMP, were vaporized and purified a second time on sephadex G-10. Gel filtration was also used to compute the molecular mass of the substances formed. Descending paper chromatography was performed on Whatman paper 3 MM in a solvent consisting of 95% ethanol (I), and also a solution of 1 M ammonium acetate and $2 \cdot 10^{-3}$ M EDTA, brought to a pH of 5.0 with acetic acid (II). The I:II volume ratio was 7:3. Absorption spectra of the purified products were examined at various pH values: 1.0, 8.0, 10.0. The output of products formed was measured with respect to the initial quantity of nucleoside. The ratio of 3'- and 5'-monophosphates in the mixture of deoxyadenosine monophosphates and the ratio of 2'(3')- and 5'-monophosphates in the mixture of cytidine monophosphates were measured in

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two stages. In the first stage, monophosphates were processed with unpurified snake venom, specifically hydrolyzing nucleoside-5'-phosphates, followed by chromatography on Whatman paper. In the second stage, nucleotides not separated out the first time were incubated with alkaline phosphatase followed by separation of the products formed on Sephadex G-10.

In the flight experiments, exposure to UV radiation and temperature differentials did not lead to the formation of nucleotides in the presence of a phosphorylating mixture of nucleosides. Thermal phosphorylation of deoxyadenosine and cytidine in space led to the formation of a single new product in each case: deoxyadenosine phosphate (dAP₁) and cytidine phosphate (CP₁), which were identified in the first purification of the mixtures on DEAE-Sephadex A-25. Analogous results were obtained in the ground experiment, producing dAP₂ and CP₂. After the second purification of the synthesized products on Sephadex G-10 it was found that the molecular weights of the nucleotides dAP₁ and dAP₂, and CP₁ and CP₂ completely corresponded to the molecular weights of 5'dAMP and 5'CMP, respectively. All the compounds separated were homogeneous and their R_f values were identical to R_f 5'dAMP and 5'CMP. No anomalies were noted in the absorption spectra of the compounds obtained. The maxima of the absorption spectra of these substances corresponded to those of the standard nucleotides. Analogous results were obtained in the ground condition. In space, the output of cytidine monophosphates (0.30%) exceeded that of deoxyadenosine monophosphate (0.16%). This was also the case for the ground condition. The maximum output of CP₂ was 4.5% and of dAP₂ 0.5% for exposure of 2 months. After enzymatic hydrolysis, the concentration of 5'-bonds exceeded that of 2'- and 3'- bonds. Analogous results were obtained earlier in the phosphorylation of uridine on Salyut-7. This may be the result of the 5'-hydroxyl group occupying a more advantageous position in the carbon residue.

The major conclusion of this study is that abiogenic synthesis of native nucleotides occurs in space, as it does on Earth, with thermal energy acting as the energy source. Thus, in spite of the fact that the most powerful source of energy in space at present and in the prebiological era of Earth is and was short-wave UV rays from the sun, in our experiments native nucleotides formed only under the influence of thermal energy.

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Table 1: Characteristics of products synthesized through phosphorylation of deoxyadenosine and cytidine under exposure to thermal energy in space and in ground experiments

Condition	Initial nucleo- side	Synth. product	Molec. mass	Rf	Max out- put, % 3MM	Concent. of various bonds, %		
						5'bond	2'(3)bond	3'bond
Flight: temp.range -50 - 65°C	Deoxy- adenosine	dAP ₁	331	0.63	0.16	42	—	34
	Cytidine	CP ₁	360	0.67	0.30	48	39	--
Ground: temp. 65°C	Deoxy- adenosine	dAP ₂	331	0.63	0.51	27	—	31
	Cytidine	CP ₂	360	0.67	4.5	61	29	--
Control:								
	5'dAMP		331	0.63	—	100	--	--
	5' CMP		360	0.67	—	100	--	--

Table 2: Optical characteristics of nucleotides synthesized through phosphorylation of nucleosides in space and on the ground

Condition	Initial nucleoside	Synthesis product	Spectral characteristics for various pH					
			1.0		8.0		10.0	
			max	min	max	min	max	min
Flight: temp. range -50 - 65°C	Deoxy- adenosine	dAP ₁	261	234	262	236	262	240
	Cytidine	CP ₁	281	243	270	252	273	256
Ground: temperature 65°C	Deoxy- adenosine	dAP ₂	261	233	261	232	262	233
	Cytidine	CP ₂	280	242	271	253	272	254
Control:								
	5'dAMP		262	229	262	229	262	233
	5'CMP		280	243	272	253	273	255

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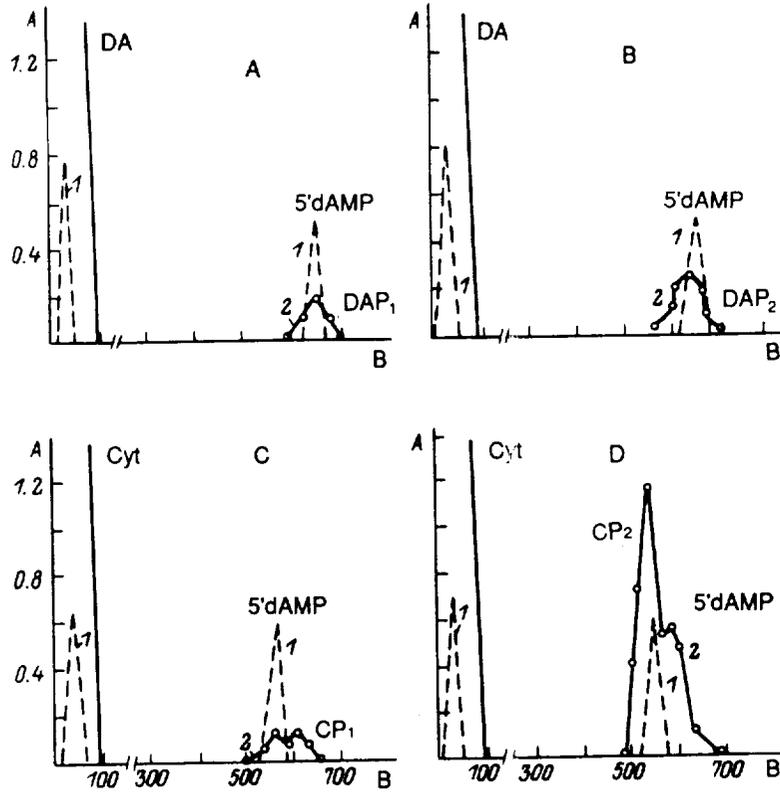


Figure 1: Separation of nucleotides synthesized under exposure to thermal energy in space and in ground experiments, on DEAE-Sephadex A-25
 A- D_{260} , B - elution volume (ml). a - phosphorylation of deoxyadenosine (DA) in space (temperature from $-50 - 65^{\circ}\text{C}$, exposure 13 months); b - phosphorylation of cytidine; c - phosphorylation of deoxyadenosine under laboratory conditions (temperature 65°C , exposure 60 days); d - phosphorylation of cytidine under laboratory conditions; 1 - control, 2 - experiment

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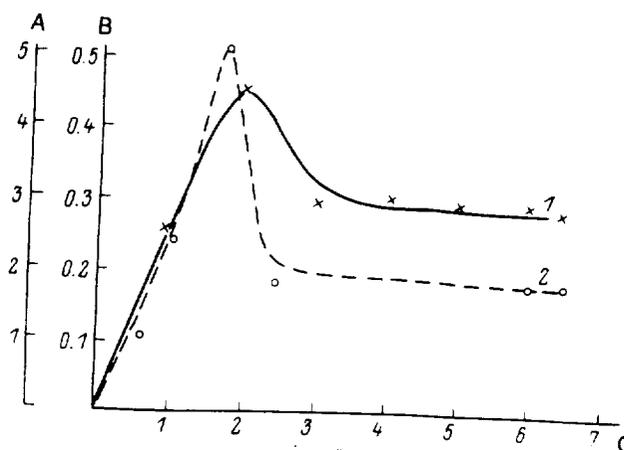


Figure 2: Output of nucleoside monophosphates as a function of duration of heating under ground-based experimental conditions (temperature 65°C)

A - output of CP₂ (%); B - output of dAMP₂ (%), C - heating duration (months). 1 - Cp₂; 2 - dAMP₂

GASTROINTESTINAL SYSTEM

PAPER:

P878 (19/88)* Bernkhardt Kh, Knopke M (GDR).

The effect of stress on gastrointestinal microflora.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

22(3): 94-95; 1988.

(No references)

Gastrointestinal System, Dysbacteriosis
Microbiology, Intestinal Microflora: Humans
Endocrinology, Endocrine Stress

Abstract: The most likely cause for the dysbacteriosis observed in cosmonauts after flight is emotional stress. This experiment modeled the effects of stress on intestinal bacteria by creating artificial endocrine stress. Triiodothyronine, corticotropin, and somatotropin were injected in 18 medical students, after which the microflora in their duodenal contents and feces were observed for 3 weeks [It is not clear whether there was one or daily injections]. Quantitative and qualitative analyses were made of aerobic microorganisms on six media and anaerobic microorganisms on seven media. After stress, there was a significant increase in the anaerobic organisms, predominantly bacterioids and fusobacteria, as well as eubacteria and propriobacteria in duodenal contents. Under stress the total amount of aerobes and facultative anaerobes decreased, while the total number of obligate anaerobes increased in feces. In some cases the number of streptococci increased, while yeast decreased. The total number of coliform bacilli decreased, while the form resistant to antibiotics increased. No changes were noted in staphylococcus. Gram-positive asporous bacilli decreased in quantity and variety, while quantity of clostridia increased in feces. These changes were analogous to those found in individuals suffering from dysbiosis or intestinal contamination, and in many suffering from gastrointestinal diseases, as well as cosmonauts after space flights.

Table 1: Gastrointestinal microflora of duodenal contents during a 3-week period of endocrine stress

Table 2: Gastrointestinal microflora of feces during a 3-week period of endocrine stress

GENETICS

PAPERS:

P873(19/88)* Delone NL, Antipov VV.
Genetic amplification as a model for the study of the biological effects of weightlessness.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
 22(3): 84-86 ; 1988.

(6 references; 1 in English)

Genetics, Amplification, RNA, rDNA
 Tortoises

Space Flight, COSMOS-690

Abstract: Genetic amplification, the replication of individual genes and their subsequent disengagement from the chromosome into separate functional units, is suggested by the authors as a model for investigating the biological effects of weightlessness at a genetic level. Amplification of ribosomal RNA (rRNA) genes is well understood. The authors describe an experiment performed on COSMOS-690 with steppe tortoises (Testudo horsfieldi Grey) whose liver cells were studied after reentry. Microspectrometers were used to study the concentration of RNA in the cytoplasm and nucleoli. These studies were performed in the winter, when liver cells of tortoises do not undergo mitosis and cellular activity is at a minimum. Compared to controls, liver cells of flight tortoises contained none of the smallest or largest classes of nuclei, while the number of medium cells increased. There were no grains of brown pigment in the cytoplasm of cells of flight animals. In control animals, all small cells contained pigment grains. The greatest differences were observed in the number and especially the size of the nucleoli, which were significantly larger in control than in flight animals. Cytochemical analysis revealed significant increases in RNA in the flight group. The authors believe that the growth stimulation sometimes noted in animals exposed to space results from the stimulating effect of space flight factors on expression of rDNA genes. They conclude that analysis of existing data provides a basis for using amplification of genes as an approach likely to cast light on molecular mechanisms of biological adaptation to space-flight factors, particularly weightlessness. The most suitable oocytes for stimulating amplification of rDNA genes come from fish, amphibians, reptiles and insects.

Table 1: Number of nucleoli in the oocytes of groundlings after exposure to PABA

Table 2: Characteristics of the nuclei of hepatocytes in tortoises

Group	No. of nuclei in visual field	Number of nuclei of various diameters, um				
		3.8	5.0	6.3	7.5	8.7
Flight	5.8	—	73.0	27.0	—	—
Control	11.1	5.7	69.0	19.0	5.0	1.3

GENETICS

P879(19/88)* Delone NL, Antipov VV.

Problems of variability in weightlessness.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

22(3): 4-15; 1988.

(58 references; 15 in English)

Genetics, Variability, Mutation
Theoretical Articles, Research Program
Space Flight

Abstract: The authors review what is known about genetic variability. Early space research was directed at determining whether weightlessness in itself is a strong mutagenic factor. The answer to this question appears to be negative. The next question to be answered involved the presence and nature of possible effects of weightlessness at the chromosomal and cellular levels. Small but statistically significant effects were found in Tradescantia paludosa and Drosophila melanogaster. The authors argue that the third stage of genetic space research should study the problem of variability as a whole, including research at the level of genes, chromosomes, cell nuclei, whole cells, and so forth up to the level of the population. The following program is outlined.

1. **Gene amplification.** Research should study the effect of space flight conditions, and weightlessness in particular, on gene amplification and rRNA. This process has been extensively studied during oogenesis in fish, amphibians, reptiles, and insects using genes 28S and 18S of rDNA. Amplification is a process which may be controlled. Thus, addition of small doses of the chemical mutagen DMSO and modifier PABA to the water in which groundlings live increased amplification in oocytes. It has also been found that space flight factors stimulate rDNA genes. Oocytes of fish, reptiles, amphibians, and insects are proposed as subjects for this research.

2. **Extra chromosomes.** Extra chromosomes continue to receive little attention in work interpreting the effects of extreme factors on the cell. The authors' work on effects of cold on extra chromosomes in a Tradescantia clone has convinced them that this is an excellent model, since counting chromosomes in the metaphase offers a relatively simple way to gain understanding of complex events occurring in the interphase in regulation of genetic blocks. They propose to use Tradescantia clones with extra chromosomes for this line of research.

3. **Crossing over.** Crossing over, one of the mechanisms of genetic recombination, has already been studied in Drosophila exposed to space. The authors recommend repeating the studies with a larger number of marker genes and computing the percentage of coincidences so as to exclude the possible effects of interference.

4. **Chromosome conjugation.** The effect of weightlessness on mitosis, particularly chromosome segregation, has been demonstrated in Tradescantia, in which 3% of the microspore cells studied showed mitotic changes. The prophase of meiosis warrants particular study. Eukaryote chromosomes have other functions besides carrying information, reproduction, and transcription. They segregate, conjugate, and undergo the karyokinesis cycle in mitosis and meiosis. All these processes deserve careful study. The

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prophase of meiosis may be studied in any species, but it is especially appropriate to use plants and insects.

5. **Differentially-stained chromosomes.** The technique of staining metaphasic chromosomes to reveal the sites of heterochromatic segments is of special interest. These sites are called "C-disks." Heterochromatin is very labile and thus the size of C-disks is highly variable. However, comparison of C-disk size in individuals living under optimum and extreme conditions yields clear differences. At the same time, heterochromatization of chromosome segments and the subsequent decrease in heterochromatin blocks are indicators of adaptation at the chromosome level. When a block of heterochromatized genes decreases in size, the potential for transcription is increased. This is especially true of tandem multiple genes adjacent to the heterochromatin segments. It is recommended that the method of differential staining be used on human and mammalian peripheral blood.

6. **Interphase nucleus.** The authors propose that the cytogenetic method be used to study interphase nuclei. The arrangement of heterochromatin segments in metaphase chromosomes provides limited evidence about the place occupied by chromatin in the structure of the interphase nucleus and the quantity of chromatin. The interphase nucleus is important because at this phase, transcription occurs. Metaphase chromosomes only echo the events occurring during the interphase. The extent of chromatin condensation in the interphase nucleus can be studied using an electron microscope and other molecular-genetic methods. Interphase nuclei may be studied in any tissues. The authors suggest renal cells of rats.

7. **The effect of gene position.** A gene can change its expression as a function of its position in the chromosome. When chromosome restructurings occur, such as inversion or translocation, genes may change places, and this frequently affects the traits of the organism. Interest has recently been rekindled in the effects of gene position, which were studied intensively in the 1940s. It has been suggested that the chromosome field, i.e., the place occupied by genes in relation to the telomere and centromere, is particularly important here. The authors hypothesize that the effect depends on gene's position in the nucleus. The position of the chromatin condensation zone in the nucleus is very important. Thus, if, before inversion, the gene is located in an area of decondensed chromatin and hence cannot be transcribed, when it is relocated by inversion in the condensed segment transcription can occur. The interphase nucleus is critical here. Established models that demonstrate the gene position effect, principally the white gene in the J-chromosome of Drosophila or the pink gene model in Tradescantia could be used.

8. **The nucleus position effect.** The nucleus always occupies a particular position in any differentiated cell. Changing the position of the nucleus in the cell causes changes in cell homeostasis. The cell cytoskeleton, cellular and nuclear membranes, and energy redistribution are very important in cell volume and operation of the genome. Many researchers have discovered that different cell shapes in weightlessness lead to changes in the position of the nucleus within the cell, which in turn affects its differentiation. In a case studied by the authors, where the spindle was displaced by 90° in Tradescantia microspores, differentiation of

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daughter nuclei was altered. The increased water content of cells in weightlessness, which changes its size, also leads to position changes by the nucleus, thus altering interactions within the heterochromatin-membrane complex. Thus the effect of nucleus position is an extremely critical problem for space research. Mouse cells are suggested for use here.

9. Cell competition within a tissue. Tissue consists of a number of different cells. Normal tissue structure and function depend on a particular quantitative relationship among these cells. Disruption of exact quantitative relationships among various groups of cells leads to disruption of tissue function. It is notable that under such circumstances each individual cell may still remain completely normal over a long period, without undergoing any alteration of homeostasis. Of importance are regulators at a higher level, e.g., within the neurohumoral and immune systems. Tissues can be profoundly affected if these regulators alter the quantity of one type of cell contained within that tissue. We must understand this process better in order to counteract it. It is suggested that cartilage and bone tissue be used for experimentation on this phenomena.

10. Genetic reaction norms. The route from gene to trait (phenotype) is rather complex. A trait is influenced both by heredity and environment. One of the most important concepts in classical genetics is that of "norm of reaction" (i.e., the range of traits which may develop from a given gene). Some genes may have a narrower norm of reaction, while others have a broader one. There also exists the so-called "alternative norm of reaction," when extreme factors lead to the appearance of the opposite value of a trait -- white hair instead of black on the pelt of the Himalayan rabbit, white flowers instead of red in the primrose, etc. The appearance of new traits with respect to the norm of reaction may be expected in space flight. This phenomenon must be studied, because it may reveal potential tendencies and predispositions for the appearance of new traits different from those found on Earth. The authors propose to study the phenomenon of alternative norm of reaction with plants, Tradescantia clones, which have blue flowers under optimal conditions, but cream-colored flowers when exposed to the cold.

11. Populations. The processes of population formation and dynamics are types of microevolution. Populations form due to variability and selection. Selection is based on inherited traits and their modification. In weightlessness, both variability and selection may be different from that on Earth. Adaptation is partially caused by environmental factors, but is primarily determined by genetic ones. Polymer genes, which mainly participate in the creation of quantitative traits, create broad potential for polymorphism. Only those individuals can survive and reproduce whose genotypes give them an advantage. The dominant genotype in a population is the one that best fits the requirements of the specific environment. The size of the population plays a critical role here. In small populations, genetic-automatic processes with random drift of genes operate, which must be reckoned with when the number of individuals in the population is computed. The authors propose to repeat experiments by F. G. Dobzhanskiy and B. Spasskiy in space. In these, experiments overcrowding was created in cultures, leading to strong selection effects. Such experiments would be

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the first step, although a small one, in the direction of studying constrained populations and the formation of ecotypes in space.

The authors conclude by emphasizing that the time has come for an integrated and comprehensive program for studying the role of genetic cellular factors in adaptation to weightlessness, so as to better control and facilitate this process. In addition, such a program would provide data to broaden and deepen understanding of the role of gravity in the evolution of life on our planet.

Figure 1: Causes of variability

Figure 2: Types of mutations

Figure 2: Types of modification

Figure 4: Types of selection in populations

GRAVITATIONAL BIOLOGY: See Developmental Biology P886
GROUP DYNAMICS: Human Performance M132; Man-Machine Systems M135

HABITABILITY AND ENVIRONMENT EFFECTS

(See also: Cardiovascular and Respiratory Systems: P868)

PAPERS:

P869(19/88)* Nefedov YuG, Novikova ND, Surovezhin IN.
Products of biodegradation of polymers as a factor in the possible pollution of the air of hermetically sealed environments with toxic substances.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
22(3): 67-71 ; 1988.
(10 references; 3 in English)

Habitability and Environment Effects, Air Pollution, Toxic Effects
Microbiology
Hermetically Sealed Environments, Polymers, Biodegradation

Abstract: This experiment sought to provide information relevant to the following questions: Can the biodegradation of polymers result in formation of volatile toxins? Will this occur for all polymers or will the qualitative and quantitative characteristics of the products of biodegradation depend on the composition of the polymer itself? What significance do environmental conditions and the species composition of the microbial association play in this process? In the first stage of this experiment microorganisms were grown either using a "short-cut" method in which mineral pollution of a polymer was modeled using an agarized Chapek-Dochs medium with or without sugar, or using a simulation of atmospheric condensate. Materials tested were polymers used in hermetically sealed living environments for structural or decorative purposes. Test cultures were obtained from the surface of polymers in hermetically sealed environments and included mold fungi Penicillium chrysogenum, Aspergillus niger, Aspergillus flavus, Aspergillus fumigatus, Rhizopus oryzae, and Pseudomonas aeruginosa bacteria. During the second stage of the experiment samples of polymers were placed in hermetically sealed environments, fitted with membrane sample collectors, and left for 10 days at a temperature of 40°C. Presence of trace contaminants in the air was determined using gas-liquid chromatography.

Results confirmed that when microorganisms develop on the surface of certain polymers, new substances not present in the original material are formed. For example, when mold fungi were grown on polyurethane foam, ethanol and acetaldehyde were formed. Isooctanol (2-ethyl hexanol) was formed on polyvinylchloride(PVC), particularly on PVC tubing. Such substances did not form on control (nonbiodegraded) samples. New substances did not form on polyamide, aramide, polyethyleneterephthalate, polyisoprene, polyethylene, or cellulose. Growth of mold fungi was similar on all polymer samples. As the growth of mold fungi increased, the products of biodegradation increased geometrically. Because results of the first stage of the experiment showed that development of microorganisms was greater on PVC-tubing, the second part of the experiment looked at formation of isooctanol on this polymer in a simulated hermetically sealed environment with simulated environmental moisture. Isooctanol was not contained in the condensate nor

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could it be formed by biodegradation of the condensate components. Isooctanol was formed by the action of mold fungi on PVC-tubing. Quantity of isooctanol increased with time. Rate of formation was higher between days 20 and 60 than between days 1 and 20, evidently due to increased biomass of the mold. Increasing humidity and temperature increased rate of biodegradation. Pseudomonas aeruginosae also produced isooctanol from reactions with PVC-tubing. Increased temperature increased the rate of this effect.

The authors conclude that when microorganisms develop on the surface of polymer materials they may produce volatile toxic substances as biodegradation by-products that negatively affect the sanitary and chemical properties of the polymer and pollute the air of a hermetically sealed environment. The components of the polymer are critical in determining the number and nature of the volatile products formed. High humidity, organic contaminants, and increased temperatures (up to the level optimal for microorganism growth) increase biodegradation activity and thus the rate of formation of biodegradation by-products. The species composition of the associations does not have critical significance in determining the number and nature of toxic substances formed.

Table: Concentration of isooctanol in hermetically sealed environments with biodegraded samples of polyvinylchloride materials

Figure 1: Chromatogram of air samples from hermetically sealed environments with control and biodegraded sample of polyvinyl chloride tubes

Figure 2: Growth of fungi on PVC-tubing and formation of isooctanol using the second group of methods

HABITABILITY AND ENVIRONMENT EFFECTS

P870(19/88)* Mikos KN, Polovnikin AA, Savina VP.

Interaction of chemicals polluting the air of hermetically sealed environments.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

22(3): 72-75; 1988.

(17 references; 6 in English)

Habitability and Environment Effects, Chemical Interactions, Air Pollution
Ammonia, Carbon Dioxide
Hermetically Sealed Environments

Abstract: This study investigated the interaction of ammonia and carbon dioxide in an airtight chamber. Gaseous ammonia (110 mg per 1 m³) was introduced into a 200 liter chamber filled with nitrogen. This procedure was repeated every day for 5 days. On day 6, 3 hours after introduction of ammonia 5 liters of carbon dioxide was introduced to create a concentration of 2.5%. Rate of interaction was determined by measuring changes in the concentration of ammonia over time.

After introduction, the concentration of gaseous ammonia in the chamber atmosphere decreased exponentially due to adsorption of ammonia on the metal walls of the chamber. Introduction of additional ammonia on successive days led to decreased rates of adsorption by the walls; the quantity of ammonia remaining in the air increased. After the introduction of carbon dioxide the volume of the gaseous phase increased, somewhat lowering the concentration of ammonia. Data indicated that after CO₂ was introduced, the rate of adsorption of ammonia increased somewhat. The experiment showed that when ammonia concentration is approximately 100 mg/m³, carbon dioxide is 2.5% and relative humidity is 40-50%, the reaction producing carbamate ammonia compounds proceeds very slowly due to the formation of solid products on the walls of the chamber. During a 1-day period, no more than 13-15% of the gaseous ammonia is involved in this reaction. Under actual conditions, where standards for permissible concentrations of harmful substances are observed, it is likely that virtually no ammonia carbonate and carbamate would be formed.

Figure 1: Curves of saturation of ammonia in the atmosphere of a hermetically sealed chamber

Figure 2: Rate of ammonia saturation increase in the atmosphere of a hermetically sealed chamber

HEMATOLOGY

(See also: Adaptation CR10)

PAPERS:

P862(19/88)* Vorob'yev VYe, Ivchenko VF, Stazhadze LL.
Catabolic metabolism in human erythrocytes under conditions of hypokinesia with head-down tilt.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
22(3): 39-41 ; 1988.

(11 references; 3 in English)

Hematology, Erythrocytes; Metabolism, Catabolic
Humans, Males
Hypokinesia With Head-Down Tilt; Oxygen Breathing

Abstract: Two experiments were conducted, in which erythrocytes from the veins of 18 apparently healthy men subjected to a 14-day period of hypokinesia with head-down tilt were examined for 2,3-DPG, ATP, ADP, AMP, and inorganic phosphate. Blood pH was also measured. Ten subjects breathed pure oxygen for 35-minute periods during the baseline period and on day 6 of hypokinesia.

During hypokinesia, concentrations of 2,3-DPG, ATP, ADP and inorganic phosphate increased in erythrocytes, probably due to increased glycolysis. This is described as an adaptive response serving to increase rate of oxygen transport in tissues without requiring changes in cardiac activity. ADP:ATP ratio increased, suggesting that increased glycolysis rate could not be attributed to increased utilization of glucose through the Embden-Meyerhof pathway. When pure oxygen was administered during hypokinesia, further increases were noted in all the parameters cited, as well as in the ADP:ATP ratio. When oxygen was administered during the baseline period, 2,3-DPG had decreased rather than increased. Oxygen was associated with a lowered blood pH during the baseline period and an increased pH in hypokinesia. The authors conclude that glucose metabolism during hypokinesia with head-down tilt is enhanced by increased interaction between the glycolytic and pentose-phosphate pathways.

Table 1: Changes in concentration of metabolic parameters in erythrocytes and inorganic phosphate in human plasma before and during hypokinesia with head-down tilt

Table 2: Changes in concentration of metabolic parameters in erythrocytes and inorganic phosphate in plasma in humans when oxygen concentration increases

HEMATOLOGY

P874(19/88)* Sominskiy VN, Sokovnik VM, Okun' KV.

Kinetic parameters of the interaction of propranolol with the erythrocyte membrane in individuals varying in their antihemolytic response to this drug.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

22(3): 86-88; 1988.

(6 references; 1 in English)

Hematology, Erythrocyte Membrane, Antihemolytic Response
Humans, Individual Differences
Propranolol

Abstract: This experiment used erythrocytes from the veins of 19 healthy male donors aged 20 to 42. The subjects were divided into three groups on the basis of their previous response to propranolol (propranolol hydrochloride, inderal). The first group reacted weakly, the second moderately, and the third strongly. The interaction of propranolol with the erythrocyte membrane was evaluated using Hill's equations for changes in the level of hypotonic hemolysis of erythrocytes in response to certain increasing concentrations of a drug. The following parameters were identified: Hill coefficient, dissociation constant, minimal dose for which the relative effect was approximately 0.09, maximal dose for which the relative effect was approximately 0.91, and cooperative coefficient (ratio of 0.09 dose to 0.91 dose). It was found that heightened response to propranolol was associated with decreased dissociation constant, and increased Hill coefficient and cooperation parameters. The authors argue that their data suggest that erythrocyte membranes of individuals with strong response to beta-blockers is caused by higher affinity of binding sites to this drug and its increased specific binding and cooperation. It is suggested that the prognostic and diagnostic utility of an antihemolytic test using propranolol be validated.

Table: Parameters of interaction of propranolol with the erythrocyte membrane of three groups of healthy individuals

Figure: Graphic representation of Hill model

HEMATOLOGY

P880(19/88)* Fedulova GA.

Characteristics of the hemostasis system in aviation personnel.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

22(3): 15-21 ; 1988.

(62 references; 13 in English)

Hematology, Hemostasis

Humans, Pilots

Flight Conditions, Psychology, Stress

Abstract: The author argues that since the aviation professions are associated with significant levels of emotional tension, as well exposure to a number of extreme factors (hypoxia, acceleration, meteorological or climatic conditions) causing physiological stress, the adaptive systems of its members, including the hemostasis system, are likely to be under higher levels of stress than those of the population at large. Specific problems associated with stress are disseminated intravascular coagulation, traumatic thrombosis, and increased possibility of clots due to elevated catecholamine secretion. Low motor activity associated with flight professions is also associated with disruption of the regulatory-adaptive mechanisms and normal interrelationships in the hemocoagulation system, as well as the risk factor of disorders of lipid metabolism, and dehydration. The author concludes that the study of hemostasis in aviation and space medicine is in the formative stage and needs the accumulation of hard data, and the development of normative criteria for flight personnel.

HUMAN PERFORMANCE

(See also: Adaptation M136, CR10; Biological Rhythms P875; Cardiovascular and Respiratory Systems P889, P895; Man-Machine Systems M135; Radiobiology P906; Space Biology and Medicine M134)

PAPERS:

P863(19/88)* Pavlov AS, Moloshtan VS.

The role of increased body temperature in increasing work capacity.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

22(3): 42-45; 1988.

(9 references; 3 in English)

Human Performance, Work Capacity, Physical and Mental; Cardiovascular and Respiratory Systems

Humans, Athletes, Pilot Trainees

Physical Exercise, Hyperthermia

Abstract: Subjects in this experiment were 49 students at technical schools, 27 students in flight school, and 49 athletes, all having an age range of 18-24. Body temperature was increased through graded physical exercises, selected so as not to fatigue any particular group of muscles. Variables were measured before, during, and immediately after exercise and during a 10-minute recovery period. Body temperature was measured rectally. Physical work capacity was measured in accordance with international standards for determining physical fitness. Mental work capacity was assessed on the basis of psychomotor, memory, attention, and cognitive functions.

All subjects maintained a normal body temperature during the first 3-7 minutes of exercise, after which rectal temperature climbed slowly to $38.74 \pm 0.01^{\circ}\text{C}$. This plateau was maintained for a relatively long period. Some subjects ceased exercising while at this temperature plateau. In those who continued, the plateau temperature suddenly "broke" and began to increase rapidly. A short time thereafter these subjects were compelled to stop exercising. Results showed that neither physical nor mental work capacity was at its maximum during the period of normal temperature, but while rectal temperature was $38.7-39.2^{\circ}\text{C}$. Work capacity increased by a mean of 28.1% with 1.5° of hyperthermia. When athletes (jumpers, discus throwers) were studied under conditions of "normal" competition, it was found that mean body temperature remained at 39.0° throughout a 2-3 hour meet and athletes achieved optimal results. To evaluate the physiological cost of increased hyperthermia-induced work capacity, the authors performed a mathematical analysis of cardiac rhythm. It was found that all subjects showed the same pattern of response to the initial phases of exercise hyperthermia in the sphere of autonomic regulation of cardiac rhythm, indicating increased functional stress in the circulatory system. However, for the fittest groups (athletes and pilot trainees) further increase in exercise hyperthermia (from 1.0 to 1.5°C) was marked by stabilization of the stress indicators. Analogous results were obtained with spiographic data. Response to exercise hyperthermia serves not so much to return the body to normal conditions, as to reach a higher level of functioning optimal for the trained body.

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Table 1: Changes in parameters of mental work capacity in subjects during increasing exercise hyperthermia

Table 2: Maximal physical work capacity in subjects with rectal temperature of 38.7°C

Table 3: Changes in parameters of special work capacity in pilot trainees during increasing exercise hyperthermia

Figure 1: Changes in rectal temperature while performing physical work under thermally neutral conditions

Figure 2: Changes in parameters of cardiac rhythm regulation in individuals in physically fit and less fit groups under conditions of exercise hyperthermia

Figure 3: Changes in respiratory parameters in physically fit and less fit subjects under conditions of exercise hyperthermia

HUMAN PERFORMANCE

P881(19/88) Tsibulevskiy IYe.

Engineering psychological problems related to the effectiveness of displays depicting the spatial position of an aircraft. (Review of research)

Vestnik Moskovskogo Universiteta. Seriya 14. Psikhologiya.

1988(1): 3-23.

[21 references; 18 in English]

Human Performance, Display Effectiveness

Pilots

Aircraft Position

Abstract: This detailed review, which covers primarily work originally published in English, arrives at the following conclusions.

1. Currently two types of artificial horizons are used to display to a pilot the spatial position of his aircraft. Either the aircraft element moves or the horizon element moves. Experimental research on the relative effectiveness of these displays has demonstrated the unquestionable superiority of horizon displays in which the aircraft element moves. This type of artificial horizon is associated with lower frequency of errors in which the pilot increases bank when he really wants to eliminate it; faster assessment of the spatial position of the aircraft; higher target tracking accuracy when the display is used for air warfare; and shorter time to master the use of the display. Both novice and experienced pilots prefer this type of display.
2. The accuracy of tracking an airborne target for either type of aircraft spatial position display does not depend on the coordinate system (spatial or in relation to the aircraft) depicting the angular coordinates of the target on the display.
3. In laboratory studies of display effectiveness, motion of the cabin of the training simulator is an important factor determining the modality and amount of information the subject perceives. When the cabin is motionless, the subject controls the aircraft using only visual information. Cabin motion adds kinesthetic information. Change from a motionless cabin to one that moves in order to simulate angle of pitch and bank or angular velocities, may affect the relative effectiveness of the various displays. Absence of linear acceleration on a simulator reproducing angles of pitch and bank causes the subject to rely more on kinesthetic information than visual in determining the direction and magnitude of cabin tilt. As a result, a training simulator with a motionless cabin creates conditions closer to those of an actual aircraft than a trainer with a cabin that moves.
4. In a new experimental type of bank indicator, the kinalog, the aircraft element tilts in the direction of the bank in the initial stage of a turn, and subsequently in the opposite direction, and both elements gradually rotate into the position they would take on the standard display with a moving horizon. Research has demonstrated the effectiveness of the kinalog to be low, and it will not be used in aviation.
5. Another new experimental type of bank indicator differs from the standard display with a moveable horizon; its aircraft element rotates, by an angle proportionate to that of the angle of incidence of the ailerons, in the direction of the changes in aircraft bank induced by this deflection. When

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this display was tested in aircraft and training simulators, it produced superior accuracy in compensatory tracking of a continuous random signal displayed on the bank indicator. Since it will not hinder the pilot's use of the standard display with moving horizon and since its installation involves minimal expense, its use can be recommended for improving displays with moving horizons.

6. Two variants of the fundamental guiding principle for the development of aircraft displays and other means for depicting flight information are proposed. These are the principle of pictorial realism and the principle of congruence with the flight image. In accordance with the first principle, the aircraft display must reproduce the environment visible to the pilot during visual flight as fully and accurately as possible. This principle cannot be considered universal, since it is not applicable to displays of the spatial position of the aircraft. In accordance with the second principle, the display must optimally correspond to the pilot's psychological image of the flight, which is formed and controlled by his operations in guiding the aircraft. Aviation psychology and highly expert pilots have convincingly confirmed the importance of the flight image.

Table 1. Number of errors committed by pilots

Table 2: Number of erroneous movements performed by pilots

Table 3: Frequency of erroneous responses and response latencies

Table 4: Time to distinguish direction and time to detect movement as a function of angular acceleration

Table 5: Limit values of displacement, velocity, and acceleration on the training simulator

Table 6: Decimal logarithms of mean quadratic error

Table 7: Number of reverse controlling movements by pilots per 10 trials

Table 8: Number of reverse controlling movements by pilots per 10 trials

Figure 1. Samples of displays studied

Figure 2. Relative time on target averaged for five consecutive trials

Figure 3. Displays studied by D. Bauerschmidt and Roscoe

Figure 4. Horizontally and vertically averaged absolute aiming errors

Figure 5: Movement of aircraft element and horizon on the kinalog

Figure 6. Types of displays studied by R. Jacobs, R. Williges, and S. Roscoe

P888(19/88) Shenderova IS.

Local heat removal as a means for improving alertness of a human operator performing monotonous work.

Fiziologiya Cheloveka.

14(3): 428-433; 1988.

[20 references; none in English]

Author's affiliation: Institute of Industrial Hygiene and Occupational Disease

Human Performance, Alertness

Humans, Operators, Drivers

Monotony, Chilling, Local

Abstract: This study observed the stimulating effects of local heat removal (i.e., chilling) on operator performance under conditions of monotony. Chilling was accomplished by thermoelectric cooling of a 5.3 cm² area on the skin of the forehead. The difference in temperature between the skin and cooling plate was 5°C, a level which corresponded to the maximum tonic activity of cold receptors and did not have detrimental effects. Subjects in the experiment were seven individuals previously found to be susceptible to monotony, by demonstrating clear symptoms after 20-25 minutes of exposure to monotony. Subjects were pretrained on a discrimination in which stimuli were eight combinations of flashing lights differing in color and location. Six combinations were positive stimuli and two were negative, response was pushing a button. During the first part of the experiments, subjects first performed the discrimination task for 7 minutes. Then they were exposed to only regular flashes of white light flashes, although they still believed themselves to be performing the original task. After 30 minutes, the discriminant stimuli were again presented for a period of 5.5 minutes. The second part of the experiment was identical, except that the forehead was chilled at the start of the monotony period until the end of the second task performance session. EEG, EKG, and task performance parameters were recorded, and afterwards subjects completed a questionnaire on their subjective sensations.

In all subjects performance showed less decrement after monotony when cold was applied. Performance improvement under these conditions averaged 7%. Local chilling was also associated with increases in self-rated alertness and more stable reaction times (in six of seven subjects). EEG data were consistent with performance data. Local chilling was also tested with vehicle drivers driving under monotonous conditions and was found to have a positive effect in 65.2% of the cases; the greatest benefit occurred in subjects susceptible to monotony and prone to doze at the wheel. The author recommends this technique for increasing alertness in human operators.

Table 1: Number and frequency of missed signals in various subjects

Table 2: Changes in ratios of alpha and beta EEG rhythms during the experiment

Figure 1: Experimental procedure

Figure 2: Characteristic changes in "Alertness" scale

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Figure 3: Changes in reaction time and frequency of missed signals in subject P

Figure 4: Change in parasympathetic index of subject S

P902(19/88) Leonova AB.

Psychological self-regulation and prevention of adverse functional states.

Psikhologicheskiy Zhurnal.

9(2): 43-52; 1988.

[22 references; 4 in English]

Author's affiliation: Lomonosov State University of Moscow

Human Performance, Work Capacity, Well-Being

Humans, Women, Workers

Psychology, Fatigue, Self-Regulation, Autogenic Training, Relaxation

Abstract: In this work, the author investigated the effect of a relaxation training program on cardiovascular parameters and self-ratings of functional state. The program was developed on the basis of exercises that induce complete relaxation and develop voluntary control of autonomic and psychological processes. The subjects started with exercises to produce neuromuscular relaxation (NMR), and then underwent autogenic training (AT) [described in detail in Issue 9], in which voluntary (progressive) muscle relaxation is combined with appropriate mental imagery and verbal autosuggestion. The organization of the training program is described below.

Stage I (1.5-2 weeks)

Basic method for self-regulation: NMR: cycle of exercises for relaxing muscle groups

Goal: Familiarization with the subjective phenomenology of relaxation

Session duration: 20 minutes

Auxiliary procedures: Breathing exercise (start of session - 2 minutes)

General calisthenics (end of session - 2 minutes)

Stage II (1-1.5 weeks)

Basic method for self-regulation: Imagery and sensorimotor training: mental representation of the effects of relaxation using imagery

Goal: Shift to voluntary relaxation of muscles, formation of individualized system of images

Session duration: 18 minutes

Auxiliary procedures: Breathing exercises (start and end of session - 2

minutes); General calisthenics (end of session - 3 minutes); background music (start and end of session)

Stage III (1-1.5 weeks)

Basic method for self-regulation: Autogenic Training: combination of autosuggestion formulae with imagery

Goal: Mastery of the autosuggestion formulae with support from an image system

Session duration: 15 minutes

Auxiliary procedures: Breathing exercises (start and end of session - 2

minutes); slide program and background music (start and

end): general and postural calisthenics (end of session - 3 minutes)

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Stage IV (1 week)

Basic method for self-regulation: Autogenic Training: use of autosuggestion formulae with elements of voluntary alteration of state

Goal: Acquisition of skills of voluntary regulation of state and mood

Session duration: 15 minutes

Auxiliary procedures: Same as above, but increased calisthenic time to 5 minutes

Stage V (1-2 weeks)

Basic method for self-regulation: Set of techniques for self-regulation based on AT; alternation of relaxation and activation, use of "goal formulae"

Goal: Acquisition of skills for directed activation of state, formation of optimal state for work

Session duration: 10 minutes

Auxiliary procedures: Same as above

Stage VI: (4 weeks)

Consolidation of the acquired skills with expanded use of the whole set of recovery procedures

The study used three groups of 18 women aged 20-42 working in assembly of microinstruments, aged 20 - 42. Data on physiological parameters and self-ratings were obtained on all subjects. Evaluation of work capacity during a shift were obtained from some women. According to their self-ratings after a session, the women felt that their general well-being improved by 13% to the top of the rating scale and reported symptoms of acute fatigue decreased by 32%. Cardiovascular parameters did not alter in a regular way from start to finish of session. Throughout the entire program, there was a significant tendency for blood pressure to normalize (all subjects showed unsatisfactory blood pressure parameters in the baseline measurement). Heart rate parameters normalized to a statistically significant extent. From the start to the finish of the program, general self-rated well-being increased by 12% and reported fatigue symptoms decreased by 9% for acute and 11% for chronic fatigue. Measurements of various psychomotor skills throughout a working day showed clear improvements from start to finish of program. Effects of the program are described as involving increased stability at a relatively high level of in various performance parameters.

Figure 1: The effect of a relaxation training program on cardiovascular parameters and subjective evaluation of state

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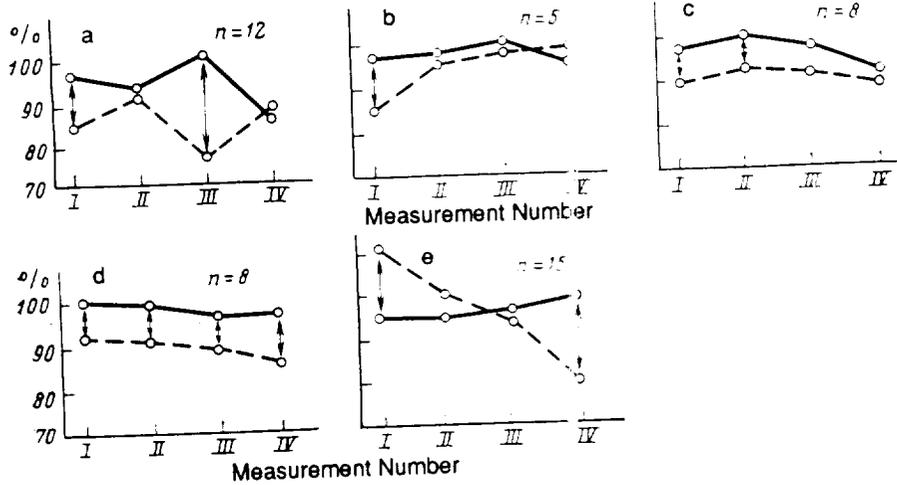


Figure 2: Change in shift dynamics of work capacity as revealed by a set of behavioral and psychometric parameters under the influence of a relaxation training program. Parameters are: productivity of work (a); complex reaction time (b); tapping test (c); KChSM (???) (d); level of reactive anxiety (e); solid line — baseline condition; dashed line -- experimental condition; arrows indicate statistically significant differences; n - number of sessions.

MRAPH:

M132(19/88)* Dikaya LG, Zankovskiy AN, Sukhodoyev VV.
Metodiki Issledovaniya i Diagnostiki FS i Rabotosposobnosti Cheloveka-
Operatora v Ekstremal'nykh Usloviyakh: Sbornik Nauchnykh Trudov
[**Methodology for Studying and Diagnosing Functional State and Work
Capacity of a Human Operator Under Extreme Conditions**].
Moscow: Psychological Institute USSR Academy of Sciences; 1987.
[290 pages]
Affiliation: Psychological Institute, USSR Academy of Sciences

KEY WORDS: Human Performance, Functional State, Work Capacity, Human
Operators, Extreme Conditions, Group Dynamics, Sleep Deprivation, Tracking,
Signal Detection

Annotation: This collection is devoted to methodological problems related to
the study and diagnosis of functional state and work capacity in a human-
operator working under extreme conditions. It considers the principles
underlying diagnostic and experimental methodologies, and presents the major
approaches to assessing functional states. It describes new partial and
modified experimental procedures, and cites the results of research
conducted using original methodological instruments.

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MONOGRAPH:

M135(19/88)* Fedosov YeA.

Voprosy Kibernetiki: Modelirovaniye Protsessov Upravleniya v Cheloveko-Mashinnykh Sistemakh [**Issues in Cybernetics: Modeling in Man-Machine Systems**]

Moscow: 1988.

[130 pages]

Affiliation: Scientific Council of the USSR Academy of Sciences on the Multidisciplinary Problem of Cybernetics

KEY WORDS: Man-Machine Systems, Cybernetics; Mathematical Modeling; Group Dynamics; Human Performance, Aviation, Air Traffic Control

Annotation: This collection examines issues in the analysis and synthesis of aviation man-machine cybernetic systems using the methods of mathematical, physiological, and seminatural?? modeling. The collection is intended for specialists working in the study, development, and utilization of aircraft cybernetic systems.

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MATHEMATICAL MODELING: See Man-Machine Systems: M135

METABOLISM

(See also: Cardiovascular and Respiratory Systems P861; Hematology P862; Musculoskeletal System P865)

PAPER:

P860(19/88)* Olfer'yev AM, Kudinova AO, Zaykin YeV, Dvorkin VI, Gel'man BL, Perova NV.

Blood lipoprotein spectra in pilots in civil aviation.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
22(3): 27-31 ; 1988.

(26 references; 8 in English)

Metabolism, Lipoproteins
Humans, Pilots
Flight Conditions, Psychology, Stress

Abstract: A total of 560 apparently healthy pilots, aged 30-59, were examined. Blood was taken from the ulnar vein after a 12-14 hour fast. Serum was extracted and examined for total cholesterol, triglycerides, and high density lipoproteins. Ratio of high to low density lipoproteins was computed. Analogous data on the entire male population of Moscow was used for comparative purposes.

Mean concentrations of cholesterol and triglycerides were higher for pilots in all age groups. No pattern of age-related changes in these parameters was observed in the pilot sample. Pilots showed elevated low and very low density lipoproteins and depressed high density lipoproteins compared to the population at large, so that the low to high density ratio was significantly elevated in this population. A total of 53.5% of the pilots showed normal levels of cholesterol, triglycerides and high density lipoproteins. Abnormally low levels of high density lipoproteins were noted in 25.6% of the pilots overall. The authors conclude that pilots have a higher risk of cardiovascular disease than the population at large and recommend yearly testing of cholesterol, triglycerides, and high density lipoproteins.

Table: Lipoprotein spectra parameters in the blood of flight personnel and a sample of the male population of Moscow as a function of age

Figure 1: 10% and 90% boundaries of "normal" parameters of the distribution of cholesterol, triglycerides, and high density lipoproteins in civil aviation flight personnel and the male population of Moscow

Figure 2: Frequency of hyperlipidemia in civil aviation flight personnel as a function of level of high density lipoproteins and age

Figure 3: Distribution of hypercholesterolemia, hypertriglyceridemia, and low levels of high density lipoproteins in civil aviation flight personnel compared to the male population of Moscow

MICROBIOLOGY: See Gastrointestinal System P878: Habitability and Environment Effects P869

MUSCULOSKELETAL SYSTEM

(See also: Adaptation M133; Cardiovascular and Respiratory Systems P866)

PAPERS:

P865(19/88)* Maylyan ES, Chabdarova RN, Korzun YeI.
Energy reactions in the skeletal muscles of rats after a short-term space flight on the COSMOS-1514 biosatellite.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
22(3): 55-58; 1988.
(6 references; 1 in English)

Musculoskeletal System, Muscle Bioenergetics; Enzymology; Metabolism
Rats, Female, Pregnant
Space Flight, COSMOS-1514, Short-term; Psychology, Stress

Abstract: Muscle bioenergetics was studied in 3 groups of 5 pregnant female rats, a flight, synchronous control and a vivarium control group. The flight (duration = 5 days) animals were sacrificed 10 hours after reentry, their posterior femur muscles removed and preserved. The mitochondria were isolated and a polarographic analysis of oxidative phosphorylation performed. Rate of tissue respiration was estimated on the basis of rate of mitochondrial respiration in various metabolic states: substrate respiration (V_{4p}), ADP-dependent respiration (V_3) and respiration in adjusted state?? (V_{40}). Phosphorylating functions of skeletal muscles were studied using phosphorylation time (Δt) to calculate parameters of the energy function of the respiratory process: Landry (RC_L) and Chance (RC_C) controls??, ADP:O coefficient and rate of phosphorylation ($ADP:\Delta t$). Respiratory control for glutamate was obtained by performing a test revealing inhibition of succinate dehydrogenase by oxalacetate. Activity of malate dehydrogenase, isocitrate dehydrogenase, and total lactate dehydrogenase was measured in cytoplasmic and mitochondrial fractions. Enzyme activity and proteins were also measured.

Animals of the flight group did not differ from those of the control in rate of respiration in the mitochondria in various metabolic states. The derived parameters of respiratory energy efficiency postflight were also analogous, although there was a tendency for phosphorylation time to increase and metabolism in state V_{40} to be accelerated. The only significant difference between these two groups was in concentration of mitochondrial protein, which was depressed by 30% in the flight group. In contrast, rats in the synchronous group showed increased respiration and signs of divergence from oxidative phosphorylation: significant decrease in the ADP:O ratio and rate of phosphorylation. Changes noted in the synchronous group can be attributed to a stress reaction. Because accumulated oxalacetate in tissues could result from mobilization of lipids in response to stress, this parameter was measured in order to identify possible stress responses at the beginning of space flight. This substance was tested by comparing inhibition of succinate dehydrogenase and succinate dehydrogenase + glutamate. Signs of a stress response were noted only in the synchronous, but not the flight, group.

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These data were confirmed by results of study of enzyme activity. Flight group animals showed no significant changes in the activity of malate dehydrogenase, isocitrate dehydrogenase, or lactate dehydrogenase in either mitochondria or cytoplasm. Synchronous animals showed a (nonsignificant) tendency for the activity of these enzymes to increase. The author notes that because the animals used in this study were pregnant females the results may not be generalizable. The authors conclude that inhibited oxidative metabolism and glycolysis demonstrated after 20-days of space flight does not occur during the initial 5 days of flight.

Table 1: Characteristics of oxidative phosphorylation in mitochondria of skeletal muscles in rats during a 1-day readaptation period after space flight (oxidation substrate 5 mM succinate)

Parameter	Flight Group	Synchronous Control	Vivarium Control
V _{4p}	5.81 (10)	6.85 (10)	6.34 (10)
V ₃	8.78 (10)	11.55 (10)	9.69 (10)
V ₄₀	8.04 (6)	6.42 (9)	7.60 (7)
RC ₁	1.50 (10)	1.68 (10)	1.55 (10)
RC _C	1.11 (6)	1.86* (9)	1.11 (7)
Δt, min	4.75 (6)	5.73* (9)	3.89 (7)
ADP:O	0.44 (6)	0.28* (9)	0.36 (7)
ADP:Δt	20.53 (6)	18.48* (9)	28.19 (7)

Notes: Respiration rate is given in nanomoles O₂/min per 1 mg protein.

* indicates a significant (p<0.05) difference from the vivarium control. Numbers in parentheses indicate number of observations.

Table 2: Activity of dehydrogenase in skeletal muscle of rates on day 1 of readaptation after space flight (in mE per 1 mg protein)

Fraction	Enzyme	Flight Group	Synchronous Control	Vivarium Control
Mitochondrial	Isocitrate Dehydrogenase	0.55 (5)	0.60 (5)	0.55 (5)
	Malate Dehydrogenase	2.93 (5)	3.06 (5)	2.91 (5)
	Lactate Dehydrogenase	30.25 (5)	22.46 (5)	23.97 (5)
Cytoplasmic	Isocitrate Dehydrogenase	1.21 (5)	1.53 (5)	1.36 (5)
	Malate Dehydrogenase	14.22 (5)	15.88 (5)	14.80 (5)
	Lactate Dehydrogenase	30.25 (5)	22.46 (5)	23.97 (5)

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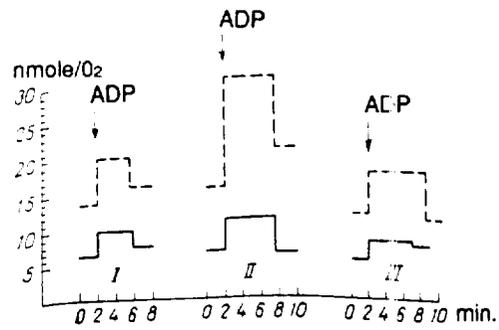


Figure: Rate of mitochondrial respiration in metabolic states 4p, 3 and 4o in animals of the vivarium (I), synchronous (II), and flight (III) groups in oxidation of 5 mM succinate (solid line) and 5 mM succinate + 43 mM glutamate (dotted line)

NEUROPHYSIOLOGY

(See also: Adaptation: CR10; Endocrinology P867; Metabolism P860)

PAPERS:

P876(19/88)* Bodo G, Elkan K, Bentse G. (Hungary)

The effect of sound on certain vestibular/autonomic reactions during motion sickness.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

22(3): 91-92; 1988.

(4 references; 2 in English)

Neurophysiology, Motion Sickness, Vestibular, Autonomic Responses
Humans, Males; Individual Differences, Tolerance
Sound

Abstract: A total of 100 apparently healthy males were studied. Motion sickness was induced using a vestibular Coriolis test. Twelve subjects of the total group were examined again after exposure to sound (white noise, 70 DB) for 3 minutes with 8-second breaks every 30 seconds. The following autonomic parameters were measured: heart rate, systolic blood pressure, time from beginning of Coriolis test to heart rate change of +10 per minute and to onset of nausea. In 53 of 100 men, heart rate changed within the first 2 minutes of the test; these were considered the low tolerance group. Ten men displayed changes in heart rate only after 10 minutes and were considered the high tolerance group. The remaining men were considered to have moderate tolerance. Twelve men (from the 3 different groups) were analyzed further and it was found that heart rate and systolic pressure changed in the direction of greater sympathetic dominance (increases) in response to the Coriolis test, while skin resistance changed toward parasympathetic predominance (decreases). Preliminary exposure to sound had no effects on changes in heart rate and systolic blood pressure; however, skin resistance changed in the opposite direction (i.e., toward sympathetic dominance). The authors conclude that skin resistance is especially sensitive to changes in autonomic tonus.

Figure: Changes in endurance time for a vestibular Coriolis test, heart rate, systolic blood pressure, and skin resistance in individuals with varying susceptibility to motion sickness before and after exposure to noise

NEUROPHYSIOLOGY

P887(19/88)* Orlova EKh, Pshennikova MG, Dmitriyev AD, Meyerson FZ.
Increased concentration of immunoreactive opioid peptides in the brain and adrenals of rats adapted to physical exercise.

Byulleten' Eksperimental'nyy Biologii i Meditsiny.
CV(2): 145-148; 1988.

[16 references; 7 in English]

Authors' affiliation: Scientific Research Institute for Pathological Physiology, Moscow All-Union Research Center for Mental Health, USSR Academy of Medicine

Neurophysiology, Brain; Endocrinology, Adrenal; Opioid Peptides
Rats
Adaptation, Physical Exercise

Abstract: Experiments were performed on male Wistar rats divided into two groups, a control (group 1) and rats adapted to physical exercise (group 2). Adaptation was induced by compelling the animals to swim 5 times a week for 7 weeks. Duration of daily swimming was increased gradually over a 3-day period until rats were able to swim for 1 hour per day. Concentrations of endorphins and enkephalins (met- and lev-enkephalin and beta-, alpha-, and gamma-endorphins) were determined using radioimmunoassay in the cerebral cortex, cerebellum, striatum, hypothalamus, pituitary, and adrenals.

Results indicated that adaptation to physical exercise was associated with increased concentration of the majority of opioid peptides measured in a significant number of the brain structures studied. Thus, lev- and met-enkephalin and beta-endorphin increased in the cerebral hemispheres by 120, 232, and 93%, respectively, compared to control; these same peptides increased by 30, 76, and 83% in the cerebellum. In the striatum, lev-enkephalin increased by 53%, and beta-enkephalin by more than a factor of 2; alpha-endorphin showed a tendency to increase. In the hypothalamus, beta-endorphin increased by 59% and the other endorphins showed tendencies to increase. In the adrenals, lev-enkephalin and beta-endorphin increased by 169 and 71%, respectively. The mechanisms through which these changes occurred in response to adaptation to exercise are not clear. Increases in opioid peptides may play an important part in the stress-limiting protective effect of adaptation to exercise.

Table 1: The effects of adaptation to physical exercise on concentration of enkephalins in the brain and adrenals of rats

Table 2: The effects of adaptation to physical exercise on concentration of endorphins in the brain and adrenals of rats

NEUROPHYSIOLOGY

P892(19/88) Vavakin YuN, Zhekov IP, Zavadovskiy AF.

The effects of various schedules of special tolerance-building exercises on increasing tolerance of head-down tilt.

Teoriya i Praktika Fizicheskoy Kultury.

1988(3): 20-23.

[13 references; none in English]

Authors Affiliation: Institute of Biomedical Problems

Neurophysiology, Tolerance, Antiorthostatic
Humans, Males

Physical Exercise, Special

Abstract: In this experiment, a total of 12 apparently healthy young men, aged 29-40, exercised 3 times a week for 2 hours over the course of 2 months in an exercise program including special exercises performed in head-down position. These included standing on the head and hands, and hanging by the knees. One group of 6 subjects performed these exercises in the middle of the exercise session for 20 minutes with only momentary breaks (continuous schedule). The other group performed the same exercises at various times during the session with breaks of 5-10 minutes (discrete schedule). Effectiveness of the exercises was estimated on the basis of changes in blood flow in the vessels of the head during a 20-minute tilt test with angle of -30° . The test utilized impedance plethysmography and was conducted every 2 weeks. Before and after the experiment the latency of sensorimotor response to a light was measured while the subject was hanging head down by his knees. Static and dynamic muscular endurance were also assessed.

For both groups of exercising subjects, rate of increased blood flow in the head in response to head-down position decreased until week 6 of training (when it reached 2%) and then leveled off. Increases in visual motor reaction time attributable to head-down position amounted to 23% before training and afterward decreased to 5.5% for both groups. The exercise program increased static and dynamic endurance by 41-48% and 32-34%, respectively. Subjects rated the discrete schedule as easier to tolerate. Since both schedules created analogous improvements in tolerance for head-down tilt, the subjectively preferred discrete schedule is recommended for use in training cosmonauts and pilots.

Table: Changes in dynamic and static endurance in subjects performing special exercises in head-down position before and after the experiment

Figure 1: Changes in total blood in vessels of the head in minute 20 of a tilt test during various experimental periods

Figure 2: Changes in sensorimotor reaction time of subjects hanging upside down by their knees before and after experimental treatment

Figure 3: Subjective evaluation by subjects of the tolerability of special head-down exercises

NEUROPHYSIOLOGY

P897(19/88) Mantsev EI, Gavrilin VK, Yakovleva IYa.

Use of parallel swings to evaluate paired activity of the otolith system in healthy humans.

Vestnik Otolaringologii.

1988(2): 28-33.

[17 references; 5 in English]

Authors' Affiliation: Institute of Biomedical Problems, USSR Ministry of Health

Neurophysiology, Otolith, Paired Activity, Asymmetry
Humans, Males
Parallel Swings

Abstract: Research using parallel swings was performed on 51 apparently healthy men aged 24-41. A subject was positioned on a platform so that the long axis of the body corresponded to the plane of oscillation of a parallel swing. The subject was swung lying on his back and right and left sides, sequentially. The amplitude of displacement of the swing was 37 cm, corresponding to maximum acceleration at the lowest point of the trajectory of 0.153G (superthreshold stimulus). Compensatory eye movements were recorded while the subject was wearing a light-tight mask with his eyes open. An electronystagmograph was used to record monocular vertical and binocular electrooculograms. Nonpolarizing silver chloride electrodes 12 mm in diameter were affixed above and below both eyes along the line of the pupil, and at the external angle of each eye; a seventh indifferent electrode was attached in the middle of the forehead. Eye movements were recorded concurrently with swing movements. The subject was swung for 1-2 minutes in each position so that no fewer than 15-20 cycles of eye movement were recorded. Maximum displacement amplitude was measured for each compensatory eye movement and the mean amplitude of 15 eye movements was computed. Magnitude of asymmetry was computed in degrees as the difference between the compensatory downward movements when the subject was lying on his right and left sides and coefficient of asymmetry was computed in percent as the ratio of this difference to the sum of the movement amplitudes for the two positions.

Most subjects showed vertical compensatory eye movements in the direction of rectilinear acceleration, while 4 subjects showed atypical movements perpendicular to the acceleration direction. Amplitude of compensatory movements of the left eye while subject lay on his left side and back were more pronounced than those of the right eye. Mean amplitudes of movements of the right and left eyes were always significantly different. Eye movement amplitudes with eyes directed upward while subjects lay on the right and left sides were significantly smaller on the average than those with eyes directed downward. Difference between compensatory movements while subject lay on the right and left side averaged 7.21° (coefficient = 26.2%). Differences between amplitudes of compensatory movements on the right and left sides exceeding 7° were considered to indicate otolith asymmetry. Of 50 subjects, 19 (38%) fell into the otolith asymmetry category, while 31 displayed relative symmetry. Mean amplitude of compensatory movements of the right eye when subject lay on his right side was 9.69° , while that of the left eye on the left side was 14.32° . In some cases compensatory movement occurred not immediately, but after a delay of 3-4 minutes.

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Table: Norms of compensatory eye movement amplitudes

Figure 1: Compensatory eye movements of subject T during experiment on parallel swings. Compensatory eye movements in all positions. Otolith symmetry.

Figure 2: Compensatory eye movements of subject Kh during experiment on parallel swings. Otolith symmetry.

Figure 3: Compensatory eye movements of subject K during experiment on parallel swings. Compensatory movements show hyperreflexia. Otolith asymmetry. Amplitude of left eye movements always greater than that of right eye movements.

Figure 4: Compensatory eye movements of subject M during experiment on parallel swings. Otolith asymmetry. Amplitude of right eye movements always greater than that of left eye movements.

P898(19/88) Bronshteyn YuL, Raytses VS.

Dynamics of vestibular nystagmus in neurogenic stress.

Fiziologicheskii Zhurnal.

34(3): 59-63; 1988.

[15 references; 1 in English]

Authors' Affiliation: Ivano-Frankovsk Medical Institute, Ukrainian Ministry of Health

Neurophysiology, Nystagmus

Rabbits

Psychology, Stress

Abstract: The goal of this experiment was to study the dynamics of vestibular response to experimentally induced stress. Subjects in the experiment were 18 rabbits. Stress was modeled by subjecting the animals to random light, noise, and shock. Subjects were exposed for 2-4 hours at a time, either once or daily for 10 days. Before and after the session rotational and postrotational nystagmus were recorded and electrocardiography was performed.

After 2 hours of stress, rotational nystagmus significantly increased in frequency, and the amplitude of the slow phase increased by 44.6%. Duration of postrotational nystagmus increased by 16.5% and amplitude increased by 31.6%. After 4 hours of stress, frequency of rotational nystagmus decreased by 6.7% and amplitude increased by 29.3%; postrotational nystagmus duration and amplitude increased by 19.4 and 33%, respectively. Frequency of rotational nystagmus decreased by 18% on day 5 of repeated 2-hour stress exposure, and by 12% on day 10; while amplitude increased by 23% on day 5 and 34% on day 10. Changes in duration and frequency of postrotational nystagmus were not statistically significant. Amplitude of the slow phase in postrotational nystagmus increased on day 5 by 25% and on day 10 by 37%. Thus both short-term and repeated exposure to stress tended to attenuate the nystagmic response. Heart rate increase in response to rotation was enhanced by stress, as were effects on depth and rate of respiration. The authors conclude that changes in vestibular reactions after exposure to nervous stress result from disruption of systemic central and peripheral mechanisms for regulating the vestibular system. Such effects can potentially lead to changes in the movements involved in job tasks and present a potential danger for individuals who must do their jobs during vestibular stimulation, e.g., pilots.

Table: Dynamics of vestibular nystagmus in rabbits exposed to stress

Figure 1: Effects of nervous stress on vestibular nystagmus in rabbits

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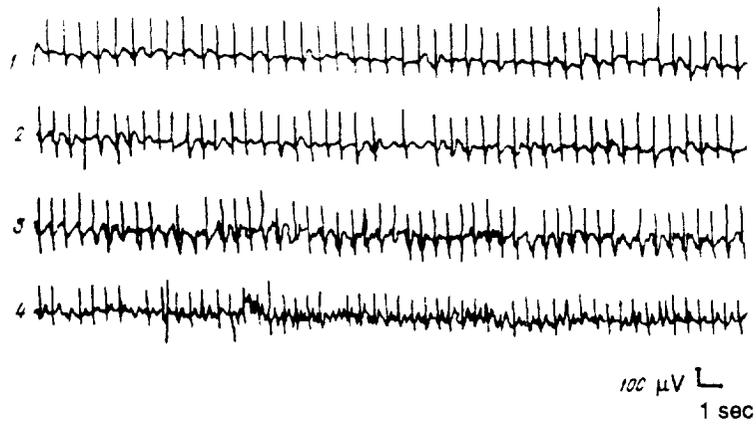


Figure 2: Electrocardiographic changes in a rabbit in response to rotation before and after exposure to stress

NUTRITION: See Cardiovascular and Respiratory System P861

OPERATIONAL MEDICINE

(See also: Adaptation CR10; Cardiovascular and Respiratory Systems P868;
Space Biology and Medicine: M134, BR14)

PAPERS:

P871(19/88)* Iseyev LR, Polyakov VN, Chadov VI.

Comparative study of decompression-induced gas bubble formation and occurrence of high altitude decompression sickness.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
22(3): 75-82; 1988.

(18 references; 11 in English)

Operational Medicine, Decompression Sickness, Gas Bubbles
Humans, Males
Barochamber Decompression, Head-Down Tilt, Exercise

Abstract: The goal of this research was to establish for tissues the nitrogen-saturation thresholds at which gas bubbles form in venous blood and the first clinical symptoms of high altitude decompression sickness appear, as well as to determine the relationship between gas bubbles and symptoms in humans undergoing various schedules of decompression. Contributing effects of head-down tilt and exercise were also investigated. Barochamber studies were performed with a total of 40 men, aged 23-45. No subject was exposed to decompression more than once a week. Rate of ascent was always 25 m/sec. Duration of exposure to the ascent height was 6 hours. Actual height to which subjects ascended was determined each time on the basis of the saturation coefficient to be achieved and the initial atmospheric pressure. Altitude was increased each week to produce a saturation coefficient increase of .1, until gas bubbles appeared. Subjects began to breath oxygen at 5000 m. Doppler ultrasound was used to identify the presence of gas bubbles in venous blood. Subjects were trained to use this apparatus on their own pulmonary arteries. Ultrasound readings were made on a subset of subjects (n=16) either sitting or in a head-down tilt (-15°) position; in the latter position subjects, were either at rest or exercising with their arms at a rate of 4-5 cal/min for 5 minutes. Ultrasound localization of gas bubbles was performed every 10-15 minutes while subjects were at the ascent height and during descent. Bubbles were rated on a scale of 0-4.

Threshold saturation coefficient ranged between 1.7 and 2.4 and corresponded to heights ranging from 6530-9100 m. Bubbles began to occur between 5-260 minutes after exposure to threshold altitude and disappeared between minutes 25-360. Head-down tilt position led to either increase or decrease in the threshold saturation level. Decreases in threshold occurred exclusively in subjects who already had low thresholds. Mean differences in the two positions did not reach statistical significance. In some subjects threshold was measured over a period as long as 24 months. Although the amount of data is small, results indicated considerable variability over time in bubble formation threshold for a given individual. As the saturation threshold for bubble formation increased, there was a tendency for bubbles to form earlier in exposure to threshold altitude, and the duration and severity of the bubbles tended to increase. When bubbles were assigned a

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rating of 1-2 (on a scale of 0-4) probability of decompression sickness symptoms was 10-16%. When severity was 3-4, probability was 50-75.9%.

Table 1: Experimental conditions

Table 2: Threshold and characteristics of decompression-induced formation of gas bubbles in seated position at rest in various subjects

Table 3: Comparative magnitude of threshold for decompression-induced formation of gas bubbles in certain subjects at rest, in head-down tilt position, and in head-down tilt position while exercising

Table 4: Threshold for occurrence of symptoms of decompression sickness and zone of "mute" bubbles in various subjects

Table 5: Severity of decompression-induced formation of bubbles and frequency of occurrence of decompression sickness symptoms

OPERATIONAL MEDICINE

P872(19/88)* Novotny I, Shul'ts I (Czechoslovakia).

Acute cerebrovascular diseases in pilots.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

22(3): 82-84; 1988.

(6 references; 4 in English)

Operational Medicine, Cardiovascular and Respiratory Systems,

Cerebrovascular Disease

Humans, Pilots

Disease Incidence

Abstract: A total of 15 Czechoslovak pilots with acute cerebral hemorrhage and/or malacia were studied over the course of 10 years. In all cases but one, onset of the disease did not occur during flight. It is concluded that it is possible, if very unlikely, that exposure to acceleration and other flight factors may trigger acute cerebrovascular symptoms in susceptible individuals.

OPERATIONAL MEDICINE

P877(19/88)* Draguzya MD, Lustin SI.

The effect of Diphenin on tolerance of animals to acute hypoxic hypoxia.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

22(3): 92-94 ; 1988.

(4 references; 4 in English)

Operational Medicine, Tolerance

Rats, Male

Hypoxia, Countermeasures, Dilantin

Abstract: Experiments were performed on 570 white outbred male rats. The experimental group of subjects were injected with a saline solution of Diphenin (Dilantin) intraperitoneally. The control group was injected with saline. The amount of liquid injected never exceeded 1.7 ml. Both groups of rats were placed in a barochamber and raised to a "height" of 12000 m at the rate of 70 m/sec. The antihypoxic effects of Diphenin were assessed on the basis of survival of animals at the ascent height, i.e., the time interval between attaining 12000 m and the animals' death. After 2 hours the ascent was terminated. In the first experiment doses of 10, 20, 40, 80, and 160 mg/kg of Diphenin were used and the ascent occurred 1 hour after the injection. Results showed that the most effective antihypoxic doses were 40 and 80 mg/kg. All unprotected animals died within 2-5 minutes. After a dose of 40 mg/kg, mean survival time was 47 minutes; after a dose of 80 mg/kg, mean survival time was 86.6 minutes. In the second experiment, the optimal time interval between injection with diphenin and hypoxia exposure was investigated. Intervals of 0.5, 1, 2, 3, 4, 5, 6, 24, and 48 hours were examined. It was found that 2 hours was the optimal interval, at which animals lived 75.1 minutes after a dose of 40 mg/kg and 72.3 minutes after a dose of 80 mg/kg. No inference is drawn concerning the possible mechanism underlying the antioxidant effect of Diphenin.

OPERATIONAL MEDICINE

P882(19/88) Bodrov VA, Kol'tsov AN, Sergeev VA.

Methods and criteria for assessing exhaustion in flight personnel.

Voyenno-Meditsinskiy Zhurnal.

1988(2): 61-64.

[No references]

Authors' affiliation: USSR Medical Corps

Operational Medicine, Exhaustion, Chronic Fatigue: Psychology, Neurosis
Humans, Pilots
Assessment Techniques

Abstract: The purpose of this research was to determine qualitative and quantitative indicators of chronic fatigue and exhaustion, and to distinguish the latter from neurosis. Research was performed in the laboratory (where conditions conducive to acute fatigue were modeled), and flight personnel with diagnosed chronic fatigue and exhaustion were also studied. Acute fatigue was created in the laboratory by requiring subjects to perform operator tasks at an accelerated rate without interruption for 3-24 hours. These conditions created a reliable worsening in subjectively evaluated state and in a number of psychophysical functions. A total of 25 apparently healthy subjects, aged 23-34, participated in a total of 105 experimental sessions. To evaluate fatigue, the experimenters used a self-rating test, a static muscle loading test, evaluation of reaction time for a simple motor response, electroacupuncture diagnosis, electrocardiography and impedance plethysmography of the head, and questionnaires. The most reliable means for diagnosing symptoms of acute fatigue were skin conductivity at biologically active points, the subjective assessment test, measurement of coordination, critical flicker fusion frequency, heart rate during static muscle loading, orthostatic intolerance, and the step test. Methods involving voluntary activity were insufficiently informative.

Pilots working under high stress/high workload conditions were also studied. A control group of pilots working under ordinary conditions was also used. The physiological parameter most affected was orthostatic intolerance, a parameter derived from impedance plethysmography of the head, indicated decreased blood flow in the brain during acute fatigue. Other parameters associated with flight fatigue and exhaustion are presented in the table below. Exhaustion was associated with decreased work capacity and in some subjects decreased visual acuity toward the end of the shift. When pilots diagnosed as exhausted were compared to neurotic subjects, they were found to differ in the level of mucoprotein in urine, which was elevated in exhausted subjects while neurotic subjects displayed average or subnormal levels. As stated above, fatigue was associated with decreased conductivity in biologically active (acupuncture) points; exhaustion was further associated with right-left asymmetry in these points.

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Table: Parameters and criteria of fatigue and exhaustion in flight personnel

Parameter	Chronic Fatigue	Exhaustion
Subjective state, decrease on 7-point scale	3	>4
Increase in reaction time, simple motor response, %	20-25	26-30
Finger tremor, increase, %	30-39	40-50
CFFF, decrease, %	8-10	11-15
Manual (grip) strength, decrease, %	20-25	26-30
Muscle endurance, decrease, %	15-20	21-30
Breath holding time on inhalation, decrease, %	25-30	>30
Mucoproteins in urine, mg/l	>175	>375
Deviation in step test:		
angle, degree	60-89	>90
linear, m	1.5-1.9	>2
Orthostatic index, increase, %	30-40	>40
Cardiac activity parameter, points	6-7.9	>8
Pulsed pressure, decrease, %	15-20	>20
Skin conductivity at acupuncture points, decrease, %	20-29	>30

OPERATIONAL MEDICINE

P904(19/88)* Morozova LV, Nikiforov VI, Titova LA.

The effect of space-flight factors on the tissues and organs of the oral cavity in cosmonauts.

In: Malinin VB, Kosmolinskiy FP, Kuznets YeI (editors).

Perspektivy Razvitiya Kosmicheskoy Biomeditsiny v Svete Idey K.E.

Tsiolkovskogo [**Prospects for the Development of Space Biomedicine in Light of the Ideas of K.E. Tsiolkovskiy**] Proceedings of the XXth and XXIst Lecture Series dedicated to the scientific legacy and development of the ideas of K.E. Tsiolkovskiy., Kaluga 1985, 1988. Section on Problems of Space Medicine and Biology.

Moscow: USSR Academy of Sciences: 1987.

Pages 131-137.

[11 references; 3 in English]

Operational Medicine, Oral Cavity, Stomatological Parameters
Humans, Cosmonauts
Space Flight Factors

The performance of theoretical and applied research in the area of space medicine has made it possible to develop effective human life support systems for long-term space flight. To achieve this most important goal of space medicine, the range of investigations being performed has grown steadily broader, including studies in specialized medical areas such as stomatology.

When Soviet and foreign information were surveyed about biomedical problems in space research, only a few studies were found to be devoted to stomatological problems. In the United States the main focus in stomatological research has been the development of devices for oral hygiene and extraneous stomatological intervention in weightlessness. The USSR has also sought the most effective devices and methods for oral hygiene for spacecraft crews; however, this question has not yet been resolved.

There are only a few studies of the state of the tissues and organs of the oral cavity in humans undergoing space flight or ground-based simulations in the Soviet and foreign literature.

On the basis of current ideas about the pathogenesis of stomatological diseases, and considering the main rules underlying the influence of space flight factors on various human physiological systems, and also the characteristics of the course of pathological processes in the oral cavity in simulation experiments, the authors assembled a set of methods for a clinical-laboratory stomatological examination of cosmonauts in the prelaunch and postflight periods.

Investigation of stomatological status was performed using special clinical mathematical indices; X-ray, immunological, and microbial methods, and also methods involving assessment of hemodynamic disruption in the mucous membrane of the oral cavity.

Scientists at the Central Stomatological Scientific Research Institute examined the oral cavities of subjects and candidate cosmonauts. Examination of data from the first study indicated significant variability in the state of tissues and organs of the oral cavity, stomatological hygiene, resistance of hard dental tissues to weak acid solutions, local

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antibacterial defense factors and microbial density in the tissues of mucous membranes and enamel surface of the teeth.

Use of special prophylactic techniques, oral hygiene, and therapeutic measures facilitated attenuation of variability for some indices and parameters (oral hygiene index, periodontal tissue status index, index of dental resistance to acid, parameters of total microbial density in the oral cavity).

As a rule, clinical and laboratory examination of stomatological status was performed on cosmonauts during space-flight training, in the prelaunch period, and 1-2 days after reentry. Stomatological parameters were studied in a total of 30 spacecraft crews, including 8 international crews.

During the space flight training period, flight and stand-by crews underwent a rigorous cleaning of the oral cavity, using specially-developed outpatient hygienic and dental and periodontal prophylactic measures. Orthodontal treatment was performed as indicated. Studies of cosmonauts' oral hygiene during the preflight periods showed that the tooth enamel and gingival space were very clean, corresponding to an oral hygiene index no greater than 1.

During the postflight period the state of oral hygiene, as a rule, was rated 2-3, indicating inadequate compliance with the hygienic recommendations for spacecraft crewmembers. The value of this parameter was not a function of duration of space flight.

The presence of inflammation in the area of the mucous membrane of the gums was indicated with the periodontal index widely used at the present time. The parameters reflected in this index correlated with duration of space flight. On the average, postflight parameters were 0.1 - 1.0 and 1.5, indicating the presence of the initial signs of inflammation in the tissues of the marginal gingiva, which was diagnosed as gingivitis.

Resistance of tooth enamel to acid was evaluated using the TsRT?? test. During the preflight period after prophylactic fluoride treatment the TsRT test indicated high resistance (70-75"). After long-term space flight this index decreased to 45-40," indicating a decrease in resistance of tooth enamel to dental deposits containing products of cavity-causing microorganisms. Members of international and other visiting crews of manned space laboratories, who spent no more than 7 days in space, did not display such sharp decreases in the TsRT test.

The program of stomatological studies of cosmonauts included special microbiological studies which made it possible to evaluate the quantitative and qualitative parameters of the microbe population of various tissues and organs of the oral cavity (dental deposits, contents of the gingival sulcus, the mucous membrane of the tongue and fauces). In addition, total microbial density of the oral cavity was determined.

As a result of these differentiated microbial studies, it was established that on days 1-2 postflight there is an increase in total microbial density of the oral cavity. After long-term space flight (63 days and longer) shifts in the microbial picture suggest a so-called "cariogenic situation."

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In particular, there is an increase in the density of bacillary forms of lactobacteria and cariogenic streptococcus (Str. mutans).

Individual cosmonauts displayed increased titers and altered associations of yeastlike *Candida* fungi; staphylococci with pathogenic features and Gr-bacilli were noted in the oral cavity and fauces. As a rule, these indicators were correlated with inadequate hygienic status of the oral cavity.

After long-term flight, a large number of cosmonauts displayed an increase in total microbial density due to asporous anaerobic microorganisms (bacteroids, fusobacteria, veillonellae), sometimes without relationship to state of oral hygiene. On the whole, in evaluating the microbial status of the oral cavity of cosmonauts pre- and postflight, it should be noted that there are various changes in the microbial picture, which can be considered as a dysbacterial situation of a cariogenic or periodontogenic nature. The authors consider certain changes in the oral microflora to indicate dysbacterial shifts with ratings of I and II in severity. No signs of severe dysbacteriosis were noted in the cosmonauts studied.

Evaluation of the antibacterial protection factors in the oral cavity by measuring parameters of lysozymal activity of saliva, functional activity of the cellular composition of the oral cavity, and microbial levels in various regions of the skin integument attests to a significant decrease in the natural resistance in this portion of the body.

Judging from the data obtained in this study, there is real justification for predicting possible stomatological disease under conditions of long-term human exposure to space.

The results of the study were used to generate recommendations concerning stomatological support of space flights, and develop a program of self- and mutual aid in performing essential stomatological procedures (interventions).

A set of therapeutic and prophylactic stomatological measures which can be individually prescribed on the basis of baseline stomatological parameters were recommended.

PERCEPTION

(See also: Space Biology and Medicine: M134)

PAPER:

P905(19/88) Moseyeva II.

On the perception of time under extreme conditions.

In: Malinin VB, Kosmolinskiy FP, Kuznets YeI (editors).

Perspektivy Razvitiya Kosmicheskoy Biomeditsiny v Svete Idey K.E.

Tsiolkovskogo [**Prospects for the Development of Space Biomedicine in Light of the Ideas of K.E. Tsiolkovskiy**] Proceedings of the XXth and XXIst Lecture

Series dedicated to the scientific legacy and development of the ideas of

K.E. Tsiolkovskiy. Kaluga 1985, 1988. Section on Problems of Space

Medicine and Biology.

Moscow: USSR Academy of Sciences: 1987.

Pages 72-76.

[9 references; 0 in English]

Perception, Time Perception, Human Performance

Humans, Athletes, Hang Glider Pilots

Extreme Conditions, Psychology, Stress; Biological Rhythms, Rhythm Types

K.E. Tsiolkovskiy was concerned with an extremely wide range of issues related to man's conquest of space, including the issue of what qualities are desirable for people selected to establish extraterrestrial colonies. It is characteristic that the first qualities he considered were character traits (adaptability, gentleness, resourcefulness, diligence) and only then did he talk about physical endurance. In addition, he hoped that people could even be conditioned to prevent immediate death in the absence of oxygen. Focusing on man's encounter with weightlessness (and developing techniques for locomotion under such circumstances) he also considered the possibility of changes in perception of space and time. But no matter how the passage of time is altered in space, it must be adapted to. And just as people capable of tolerating weightlessness and "short-term absence of oxygen" must be selected, it is likely that cosmonaut selection would include consideration of how candidate individuals perceive time under extreme conditions, (if for no other reason than because the need to make responsible decisions under time pressure is a stress factor which in some people leads to increased signal detection latency). When crewmembers must estimate the duration of a time interval during aircraft flights, estimates tend to increase during relatively calm periods and decrease as emotional stress increases. V.I. Lebedev et al. identified a tendency in cosmonauts to alter their estimates of time intervals as a function of general well-being. The most highly trained cosmonauts (e.g., Yuriy Gagarin) were the most accurate in their estimates of time interval duration.

Before jumping, parachutists erroneously perceive time intervals as shorter, and there is actually a relatively long-duration decrease in pulse, even when full motor activity is maintained. The author observed the same phenomena at the start and finish of motorcycle races and immediately after landing of hang-glider pilots. The athletes who were most successful at covering the distance had the longest "subjective minutes."

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The present work considered the results of an examination of 17 hang-glider pilots who were members of a club in the city of Kyzyl (12 rated athletes and 5 novices), before and after 76 flights. The duration of a "subjective minute" was studied, as were heart and respiration rate before leaving the clubhouse, in the hangar during assembly of equipment, on the launch pad (when the athletes were strapped to the trapeze), and 30 seconds - 5 minutes after landing. Each flight was timed, and the athletes were asked to assess the duration of their own flights. The quality of each flight was assessed, taking account of the pilot's athletic qualifications, weather conditions, and the difficulty of the route. In addition, the athletes were asked to respond to the Osberg survey (which divides the population into "owls," "larks," and "arrhythmics" on the basis of rhythms in work capacity) and to fill out a "semantic differential analysis" that provided information about the emotional and cognitive components of time perception.

The data obtained were analyzed. A clear correspondence was found between flight quality and duration of subjective minutes, which averaged 65.4 seconds before a successful flight, 51.7 seconds before a satisfactory flight, and 31.0 seconds before an unsuccessful one. After such flights subjective minutes lasted 66.6, 51.1, and 30.6 seconds, respectively.

Study of the frequency of change in the duration of a subjective minute and evaluation of flight duration showed that flight quality was clearly associated with the direction of these changes, as Table 1 shows.

Investigation of the association between the direction of changes in duration of a subjective minute and evaluation of flight duration in each specific flight showed that for successful and satisfactory flights, these changes were in different directions in 60-63% of the cases, while for unsatisfactory flights changes were in the same direction 60% of the time. Evidently in more successful flights the pilot uses two separate mechanisms for evaluating time scale -- a mechanism for changing the duration of a subjective minute and a mechanism for changing the duration of the flight.

As Table 2 shows, it was further found that successful flights were more frequently performed by "larks" (55% successful flight) than by "arrhythmics" (32%). (There were no "owls" in the sample.) As the tables show, "larks" have two options for eliminating shortage of time -- increasing the subjective duration of a minute or of the performance period.

Study of the emotional and cognitive components of time perception through factor analysis of the results of the "semantic differential" instrument with more than 300 "larks" and "arrhythmics" showed that "larks" perceive time as "active," "large" and "bright." Positive emotional characteristics are assigned to the present, past, and future. "Arrhythmics" perceive the fast flow of time, and the activity factor is secondary. They assign positive features only to the past and future and not to the present.

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Thus, "larks" tend to be optimistic and active, while "arrhythmics" perceive time as existing primarily in the future. It is precisely this principle that is reflected in the greater flight success of "larks," as well as in their greater capacity to "stretch out" time to complete tasks in the period allotted. The effects of this "stretching" were observed in actual flight activity by N.D. Zavalova.

Table 1: Success of flights as a function of direction and frequency of changes in the duration of a subjective minute and of changes in the estimation of flight duration (in % of number studied)

Parameter	Direction of change	Flights		
		Successful	Satisfactory	Unsatisfactory
Duration of subjective minute	Increase	67	26	12.5
	No change	--	17	50
	Decrease	33	57	37.5
Assessment of flight duration	Overestimate	22.5	14	--
	Accurate	12.5	14	37.5
	Underestimate	65	72	62.5

Table 2: Mean duration of a subjective minute before and after flights and the nature of changes in temporal evaluations in "larks" and "arrhythmics"

Parameter	Period	Flight	Subject Group	
			Larks	Arrhythmics
Duration of subjective minute	Preflight	Success.	57.7	66.7
		Average	57.25	55.75
		Unsuccess.	40.66	32.2
	Postflight	Success	62.45	62.33
		Average	56.33	53.6
		Unsuccess.	57.0	28.25
Change in duration of subjective minute	Increase		53%	30%
	No Change		11%	30%
	Decrease		36%	40%
Assessment of flight duration	Overestimated		26.5%	8%
	Accurate		15%	15%
	Underestimated		58.5%	77%

PERSONNEL SELECTION: See Adaptation M135; Space Biology and Medicine BR14

PSYCHOLOGY: See Adaptation P901; Endocrinology P867, P890; Hematology P880; Neurophysiology P898; Operational Medicine P882; Radiobiology P906; Space Biology and Medicine M134; Human Factors: All Entries

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(See also: Adpatation CR10; Space Biology and Medicine: M134)

PAPERS:

P900(19/88) Akopova AB, Dudkin VYe, Karpov ON, Melkumyan LV, Potapov YuV, Rshtuni ShB.

Determination of the characteristics of cosmic radiation on Salyut-7 space station.

Kosmicheskiye Issledovaniya.

XXVI(1): 162-165; 1988.

[14 references; 4 in English]

Radiobiology, Cosmic Radiation
Dosimetry
Space Flight, Salyut-7

Abstract: The goal of this work was to determine the spectra of LET and absorbed dose rate of radiation on board Salyut-7 over the course of many months using a nuclear emulsion which could be controlled on the basis of features registered. Control was achieved through a threshold phenomenon in which, for a broad range of linear energy transmission (LET) values, the duration of the induction period increases due to increased concentration of citric acid and KBr induced in the amidol developer. The emulsion layers were calibrated with protons, alpha-particles, and ions of O^{16} to establish the relationship between pH of the developer and the value of the development threshold. The threshold was determined either from the point in time when the particle of a particular charge disappeared, or from the curtailment of the residual path length of a particle on the basis of the well-known function relating residual path length to particle energy.

Flight parameters of Salyut-7 and COSMOS-1443, used in computations were as follows: angle of incidence of the orbit to the plane of the equator 52° , altitude of apogee 360 km, perigee 330 km, exposure duration of the emulsion 265 days for 1983, i.e., between the phases of minimum and maximum solar activity.

Figure 1 shows the calibration curve relating the development threshold of the emulsion to dE/dx of the developer composition. This curve was used to measure planar fluence of the particles for eight threshold values. Accuracy was computed at +15%. The integral LET spectrum in the nuclear emulsion thus obtained was converted into an LET spectrum in biological tissue, as shown in Figure 2, using values of LET spectra in the Salyut-7 orbit. Within the wave band the values of the LET spectrum were primarily determined by heavy nuclei of galactic cosmic radiation and secondary radiation arising in the materials of the spacecraft.

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Particle fluence behind a screen of thickness x with LET greater than a given number $N(>L_0)$ was computed with the following equation:

$$N(>L_0) = \sum_i \int_{L_i(L_{max})}^{L_i(L_0)} dE \Phi_i(x, E),$$

where $\Phi_i(x, E)$ is the spatial energy distribution for the i th charged group of nuclei, and L_0 is the LET of particles in a biological tissue.

The following system of equations was used to find the distribution function $\Phi_i(x, E)$:

$$\frac{\partial \Phi_i(x, E)}{\partial x} + \frac{1}{\lambda_i} \Phi_i(x, E) - \frac{\partial}{\partial E} [S_i(E) \cdot \Phi_i(x, E)] = \sum_{j>i} \frac{P_{ij}}{\lambda_i} \Phi_j(x, E) + \Phi_{i0}(E),$$

where $\Phi_{i0}(E)$ is the energy spectrum of the i th group of nuclei of galactic cosmic radiation (GCR) falling on the screen; $S_i(E)$ is the energy transmission dE/dx in the shield material for nuclei of the i th group. Values for λ_i and P_{ij} are taken from the literature. In performing this computation, it was assumed that fragments of primary nuclei move in the same direction and at the same velocity as the primary nucleus itself, and that the free path length to nuclear interaction λ_i and fragmentation parameters P_{ij} do not depend on energy. $N(>L_0)$ was evaluated by solving the above equation system by the method of statistical testing.

Because the detector was carried on both the satellite and the space station, screening thickness varied. Analysis showed that the mean width of screening for emulsion detectors did not exceed $1-2 \text{ g/cm}^2$. A value of 1 g/cm^2 was used in the computations. Values for energy spectra of all the charge groups of GCR were computed using a method which considered the magnetic field of the Earth and used vertical cut-off rigidities.

Agreement between computational and experimental data appeared satisfactory in light of the number of indeterminate factors in the calculation. (For example, thickness of screen on COSMOS-1443 had to be estimated.) The density of nuclei stopped in the emulsion layers for a number of threshold values in the aforementioned range of dE/dx were determined. These data are of interest for evaluating the level of radiation exposure for humans, since they were obtained under conditions analogous to those of manned flights occurring at the present time.

Figure 3 presents the integral spectrum (n_z) of the charge distribution of stopped nuclei with charge $z > 5$, which can be explained by the track loading of layers making it impossible to perform microscopic measurements with low values of development thresholds, while traces of particles with charge < 5 could be detected in the layer. Figure 3 juxtaposes Apollo-11 and -14 data with those from Salyut-7. Differences in the shape of the distribution spectra are attributed to the effects of the Earth's magnetic field. The absolute values of stopping nuclei are close, as were the values for the Soyuz-Apollo flight.

Figure 2 also shows computed estimate of multicharged particles ($Z=2-8$) from

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demonstrate that the fragments and nuclei from stars in the emulsion are comparable in magnitude of fluence to traces of all multicharged particles.

The dose rate in biological tissue was computed from the LET spectra obtained in the range of $3.8 \cdot 10^4$ MeV/cm. The value obtained for absorbed dose was 3.5 mrad/day on the Salyut-7-COSMOS-1443 complex.

Thus, this method made it possible to measure the LET spectrum during a long period of exposure and made it possible to record rare events of particles with large LET ($>10^4$ MeV/cm) hitting the detector.

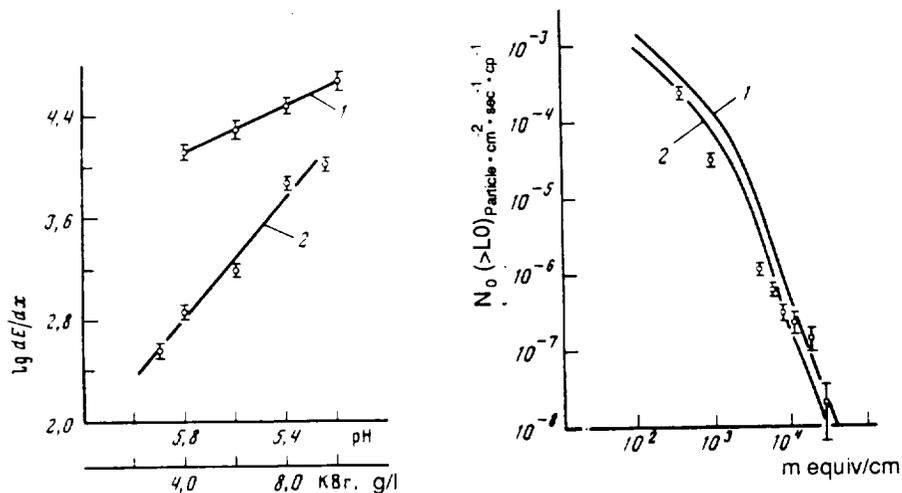


Figure 1: Calibration curve of the relationship between the magnitude of the development threshold of an emulsion on the basis of dE/dx and composition of the developer

1 - as a function of concentration of KBr with pH = 5.3, 2 - as a function of pH with KBr concentration of 3 g/l

Figure 2: Integral LET spectra

1 - computation (minimum solar activity), 2 - computation (maximum solar activity), circles - experimental data, threshold development

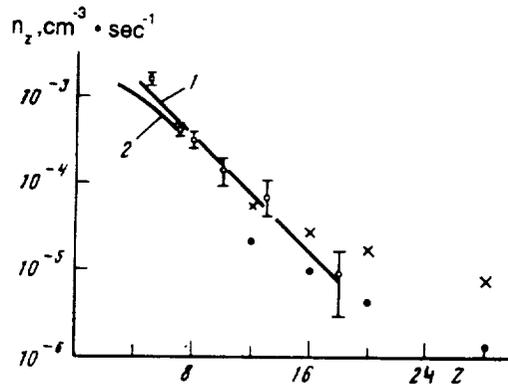


Figure 3: Integral spectrum of charge distribution of stopped nuclei
 1 - experimental data; 2 - computation (stopped multicharged particles
 from stars; dots - experimental data from Apollo-11; x - Apollo 14

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P906(19/88) Davydov BI, Antipov VV, Ushakov IB.

Some issues in radiation psychophysiology as applied to space flight practices.

In: Malinin VB, Kosmolinskiy FP, Kuznets YeI (editors).

Perspektivy Razvitiya Kosmicheskoy Biomeditsiny v Svete Idey K.E.

Tsiolkovskogo [**Prospects for the Development of Space Biomedicine in Light of the Ideas of K.E. Tsiolkovskiy**] Proceedings of the XXth and XXIst Lecture Series dedicated to the scientific legacy and development of the ideas of K.E. Tsiolkovskiy., Kaluga 1985, 1988. Section on Problems of Space Medicine and Biology.

Moscow: USSR Academy of Sciences: 1987.

Pages 28-31.

[8 references; none in English]

Psychology, Radiobiology, Radiation Psychophysiology, Human Performance
Theoretical Paper, Paradigm Evaluation
Space Flight

The authors consider the ways information can be obtained and used in the area of radiation psychophysiology in space biology and medicine.

It is evident that human performance in a "cosmonaut-spacecraft" system is evaluated on the basis of work capacity. The reliability and quality of the work attributed to the whole system is, to a significant extent, dependent on this performance. In his works, K.E. Tsiolkovskiy paid considerable attention the question of maintaining high work capacity and physiological tolerance to the effects of adverse factors associated with long-term space flight.

One of the factors that can substantially disrupt the functioning of a spacecraft operator during space flight is ionizing radiation. Prediction of the possible disturbances in humans associated with radiation is based on clinical and experimental material. Systematic changes in response to ionizing radiation in cosmonauts have been thoroughly discussed in print. But effects of radiation on operator performance have not received enough attention.

To a significant extent, operator work capacity is defined as a function of four interrelated factors: the physical state of the operator, his psychological status, the complexity of the task to be performed, and the conditions under which it is performed. The quantitative evaluation of work capacity in response to ionizing radiation is stochastic in nature. With this in mind, the authors analyzed 186 sources in the literature relevant to three major research areas.

1. Indirect evaluation of work capacity based on clinical data. This method of evaluation is used because direct data on the work capacity of an irradiated person is very limited. Clinical studies of irradiated individuals present a variegated picture of symptoms which undoubtedly are directly related to human physical and psychological work capacity. These data provide some idea of the time of occurrence, duration, severity, and frequency of primary reactive symptoms. The most interesting data from the point of view of cosmonaut work capacity involve the early somatic effects of acute irradiation: general debility, fatigue, apathy, dizziness, headache, paresthesia of the extremities, sleep disorders, nausea, vomiting,

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and diarrhea. Under conditions of weightlessness, these symptoms may be particularly important.

Without a doubt, somatic effects have "behavioral importance." However, it has not previously been possible to predict unequivocally the effects of these somatic and psychosomatic effects on cosmonaut performance because their high levels of training and motivation allow them to perform complex control tasks under a variety of extreme conditions.

2. Psychophysiological studies of people undergoing radiation therapy. It is essential to stress that prediction of human work capacity is still based primarily on individual predictions for various types of performance. Some studies place greater significance on physiological parameters of sensory systems, others on psychological personality traits, and still others on motor skills. Through modeling, radiation psychophysiology studies the individual parameters of sensory, integrative, and effector system functioning and their interactions.

Expert evaluation or extrapolation of data obtained in the first two research directions is associated with a number of problems: the significant differences between patients undergoing radiation therapy and cosmonauts, the limited significance of the evaluation methods used, and the great heterogeneity of irradiation conditions.

3. Experimental psychophysiological research on animals. The obvious and natural shortcomings of the data obtained from the study of irradiated humans, may and must be compensated for by an extensive program of research on animals. Extrapolation from this work to humans has been frequently questioned.

Without a doubt, a human being, as a social entity, operates at a significantly higher level than animals. His psyche is qualitatively different from theirs. However, radiation psychophysiological research on animals identifies the source of many human psychological functions, and evaluates principles underlying changes occurring in animals in response to a particular extreme factor, and thus is very valuable.

The majority of authors have identified the following categories of behavior as being affected by radiation, especially in primates: learning and retention of discriminations, transfer of skills to a new situation, delayed responses, attention, locomotor acts, object manipulations, solution of various mechanical problems by "intellect" or "insight," and conditioned avoidance response with elements of operator activity.

After analysis of the work in this area the following must be noted:

-From a theoretical viewpoint, each irradiation event leading to a marked shift in the normal physiological state of the organism should be considered behaviorally significant for cosmonaut performance since it places some limit on the functioning of a system that must be used by the organism to adapt to environmental conditions.

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- Animals perform a behavioral task with a high degree of accuracy after irradiation in a broad range of doses, despite severe somatic effects. Duration and accuracy of task performance is greater when motivation is higher.

-Directly after irradiation of animals within the limits of the mean lethal dose there is a decrease in general activity and number of locomotor movements, especially "exploratory" behavior, and decrease in capacity to solve mechanical problems requiring "insight."

-Changes in emotions and motivations in the postirradiation period are associated with the appearance of symptoms of radiation sickness and lead to a marked constriction of the "psychophysiological space."

Thus, researchers in the area of radiation psychophysiology are confronted with the complex problem of selecting a model of radiation-induced changes in operator performance. Review of the research lead to the conclusion that, from the standpoint of the potential for obtaining reliable quantitative data, varying the experimental situation, and using multifactor designs, psychophysiological research on animals is the most justified and expedient paradigm.

Without a doubt, even though possibility of a radiation event occurring in space is remote, this does not give radiobiologists the right to ignore this eventuality. It is important to remember that that nonradiation flight factors, the high emotional tension, and unjustified exaggeration of radiation damage may create unforeseen "radiation-psychological" situations in flight. It is completely obvious that without solving many problems in radiation psychophysiology, it is not possible predict the psychophysiological effects of irradiation, nor to develop scientific norms for acceptable levels of exposure to radiation during space flight.

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PAPER:

P859(19/88)* Talavrinov VA, Anashkin OD, Bagramov KhG, Volgin VA, Luk'yanchikov VI, Lyamin VR, Sergeyev AV, Turbasov VD, Chirkov AA.
Anthropometric studies of the prime crews on Salyut-6 and -7 space stations.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
22(3): 22-27; 1988.
(17 references; 3 in English)

Space Medicine, Anthropometric Parameters
Humans, Cosmonauts
Space Flight, Salyut-6 and -7

Abstract: Body weights of Salyut-6 and -7 prime crewmembers (total of 21) were measured in flight using a special device based on the principle that a body's period of oscillation is a function of its weight. Calf perimeter was measured at eight points using tapes placed at 3 cm. intervals. Volume was computed under the assumption that each calf segment was a conical cross section. During the initial period of the flight, measurements were made every 2-3 days, and subsequently every 2-3 weeks. Flight results were compared with preflight values.

It was found that changes in body weight during flight varied in magnitude and even direction. On Salyut-6, 2 cosmonauts out of 8 displayed substantial weight loss for a short period and 2 others for a long period, 2 (in the same crew) showed a noticeable increase, and only 2 showed no appreciable change. On Salyut-7, 7 of 13 cosmonauts showed consistent weight loss in space and 2 others weight loss with the exception of short periods. Only 1 individual consistently showed weight gain. On the average, early in the flight, weight was 0.7 kg greater than preflight weights. Subsequently weight was 0.3-2.5 kg lower than preflight. Greatest weight deficits occurred between days 51-70. During the initial flight period, calf volume decreased in all subjects; however, there were significant individual differences, with decreases ranging from 3-5 to 14-16%. Progressive decreases in calf volume continued into the flight. Some degree of recovery was noted only in 3 cosmonauts out of the total number of 21. Typically, calf volume decreased by 16-16.5% by the end of month 3 and remained at that level until the flight terminated. Decreases were most rapid during the early flight period. The authors attribute some of the changes in body weight to divergence from the recommended diet. The authors argue that initial calf volume loss is associated with changes in fluid balance; however, later effects cannot be so attributed, because calf size continues to decline after balance is stabilized. Exercise was associated with less extreme calf volume effects.

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Table 1: Changes in body weight (in + or - kg from preflight levels) in crewmembers of Salyut-6 prime crews

Crew-member	Pre-flight	Days of flight						
		4-10	11-30	31-60	61-90	91-120	121-150	151-185
1	84.5	-0.7	-0.5	-2.9	-1.3	-1.3	-1.0	--
2	75.5	-0.6	-2.1	-3.6	-4.2	-4.6	-4.3	--
3	81.7	-1.1	-0.4	-1.2	-2.4	-3.7	-4.1	-4.5
4	84.0	+0.4	-0.1	+0.1	+0.6	+0.1	+1.2	+1.2
5	70.2	+0.6	+0.9	+1.1	+1.2	+1.2	+2.5	+1.8
6	86.5	+0.9	+1.1	+1.2	+2.6	+2.7	+3.2	+4.5
7	83.0	+0.9	-0.2	-1.1	--	--	--	--
8	73.2	-2.3	-4.1	-2.7	--	--	--	--

Table 2: Changes in body weight (+ or - kg from preflight levels) in crewmembers of Salyut-7 prime crews

Crew-member	Pre-flight	Days of flight								
		4-10	11-30	31-60	61-90	91-120	121-150	151-180	181-210	211-224
1	66.0	--	-1.8	-2.2	-2.9	-1.9	-1.8	-1.4	-2.0	--
2	78.0	--	-1.5	-2.6	-6.2	-3.8	-3.9	-4.1	-4.5	--
3	79.0	+2.2	+3.1	+1.7	+0.6	-1.0	-1.4	--	--	--
4	72.0	+1.7	+0.7	-0.8	-1.5	-1.3	-1.7	--	--	--
5	73.5	+1.5	+1.2	+2.5	+3.6	+1.8	+1.8	+1.8	+1.8	+1.8
6	76.5	+0.8	+0.2	+1.0	-4.3	-0.4	-0.2	-0.3	-0.2	-0.3
7	72.0	-0.1	-2.1	-3.2	-4.6	-4.4	-4.5	-4.2	-4.2	-4.2
8	79.8	--	-4.0	-2.0	-2.2	--	--	--	--	--
9	74.2	--	-6.3	-4.5	-3.5	-3.2	-3.2	--	--	--
10	70.0	-2.2	-1.6	-1.7	--	--	--	--	--	--
11	74.0	-2.2	-2.1	-2.3	--	--	--	--	--	--
12	75.0	--	-0.7	-0.6	+4.5	+1.5	--	--	--	--
13	76.1	--	+0.3	-1.3	+0.9	-1.3	--	--	--	--

Table 3: Changes in calf volume (in % less than preflight) in members of Salyut-6 prime crews

Crew-member	Pre-flight*	Day of flight							
		3-5	6-10	11-30	31-60	61-90	91-120	121-150	151-185
1	2449	8.6	12.6	14.1	17.4	23.0	21.1	--	--
2	2063	8.1	7.9	10.6	14.9	18.5	18.4	--	--
3	2141	12.7	12.5	14.2	14.4	16.2	16.6	17.7	16.7
4	2210	14.3	16.3	19.0	21.2	22.1	20.1	21.1	22.1
5	2109	6.7	8.3	8.7	8.7	13.8	12.4	10.8	6.7
6	2205	7.8	8.7	11.1	13.2	14.9	15.6	14.6	13.7
7	2342	--	7.6	13.6	13.8	--	--	--	--
8	2045	--	7.4	13.6	14.8	--	--	--	--

* in cm³

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Table 4: Changes in calf volume (in % less than preflight) in members of Salyut-7 prime crews

Crew- member	Pre- flight	Day of flight									
		3-5	6-10	11-30	31-60	61-90	91-120	121-150	151-180	181-210	211- 224
1	1885	3.7	5.4	8.1	13.5	14.3	13.1	12.4	13.4	13.0	--
2	2456	6.8	10.1	22.7	23.2	25.1	24.1	23.5	23.1	27.0	--
3	2004	--	5.1	4.1	5.7	7.3	7.7	10.4	--	--	--
4	2022	--	5.6	8.3	10.6	13.2	11.4	11.9	--	--	--
5	1923	5.0	--	8.0	6.5	8.1	11.3	14.2	11.5	12.8	12.9
6	1947	7.5	--	5.7	12.7	15.1	15.0	16.4	16.3	17.3	14.8
7	1885	3.6	--	10.8	7.3	11.5	12.4	13.5	14.0	17.8	20.2
8	2263	--	--	7.3	7.2	8.3	--	--	--	--	--
9	2081	--	--	14.8	14.1	16.5	19.9	19.0	18.9	--	--
10	1737	--	10.9	12.9	14.0	--	--	--	--	--	--
11	2014	--	4.6	6.0	6.7	--	--	--	--	--	--
12	1997	12.6	13.7	20.5	16.9	11.9	--	--	--	--	--
13	1974	15.2	17.0	14.2	13.9	18.9	--	--	--	--	--

MONOGRAPH:

M134(19/88) Malinin VB, Kosmolinskiy FP, Kuznets YeI (editors).
 Perspektivy Razvitiya Kosmicheskoy Biomeditsiny v Svete Idey K.E.
 Tsiolkovskogo [**Prospects for the Development of Space Biomedicine in Light
 of the Ideas of K.E. Tsiolkovsiy**] Proceedings of the XXth and XXIst Lecture
 Series dedicated to the scientific legacy and development of the ideas of
 K.E. Tsiolkovskiy, Kaluga 1985, 1988. Section on Problems of Space
 Medicine and Biology.

Moscow: USSR Academy of Sciences: 1987.

[139 pages]

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 Scientific Heritage of K.E. Tsiolkovskiy, K.E. Tsiolkovskiy State Museum on
 the History of Cosmonautics.

KEY WORDS: Space Biology and Medicine, Human Performance, Psychology,
 Radiobiology, Botany, Life Support Systems, Operational Medicine,
 Perception, Metabolism, Cardiovascular and Respiratory Systems, Immunology,

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*Translated in this Digest issue.

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Review of: Fiziologiya cheloveka v usloviyakh vysokogor'ya [**Human physiology under high altitude conditions**]; OG Gazenko, editor, Moscow: Nauka; 1987. Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina. 22(3): 95-96 ; 1988.

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Our era has witnessed active utilization of high altitude areas. In such regions, we mine mineral resources, conduct scientific observations, protect state borders, engage in sports and athletic competitions, and treat certain illnesses. Because of this, the book "Human physiology under high altitude conditions," just released by the Nauka publishing house, is of great scientific and practical interest. Its significance and timeliness is confirmed by many clear examples from the history of man's penetration of the high altitude regions of the Earth. These attest to the major, sometimes adverse, effects of the environmental conditions at high altitudes on the body. Thus, there exist 16th century records of high altitude sickness and loss of fertility from long-term exposure to altitudes on the order of 4000 m. Particularly severe symptoms were experienced by people (including professional mountain climbers) in the Himalayas, the site of the highest (8000 m) mountain peaks. Let us not forget, for example, the eloquent description by the mountain climber R. Messner of his state when he reached the peak of Everest, which he and his companion had been the first to scale without recourse to oxygen: "I was no longer in possession of my identity nor my vision, but had become nothing but a straining and choking lung floating above the fog and the peaks..." This is but a single example of the profoundly detrimental effects of high altitude on the human body, making it essential to select participants in high altitude expeditions carefully and to solve the problems of protection and prevention.

The main value of this book is its original synthesis of a vast amount of material from clinical physiological and laboratory research, resulting in one of the fullest reviews in the Soviet literature of the physiological effects of high altitude climates on the human organism. It is well illustrated, includes the results of a large number of foreign and Soviet studies in the mountains and is highly scientific, yet quite accessible. Everyone with an interest in high altitude sport, mountain tourism, and high altitude physiology and medicine can obtain information about the effects of high altitudes on the human body.

A significant portion of the book is devoted to issues of biomedical support of the first Soviet Everest expedition. From this standpoint, the theoretical ideas and opinions presented in the first two chapters are given a practical slant. It should be noted that Everest's altitude (8848 m with barometric pressure of only 253 mm Hg) represents the approximate upper limit which can be attained without supplementary oxygen, and then only by a few highly acclimated and trained mountain climbing athletes. Rapid ascent to such an altitude by someone not adapted (for example, in a nonpressurized cabin of a flight vehicle or a barochamber) would lead to the development of severe hypoxia, resulting in loss of consciousness and possible death if treatment is not given in time.

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The authors' research team has succeeded in solving a number of important problems such as selection of candidates for climbing in the Himalayas, oxygen and biomedical support of the expedition (including means of personal hygiene), prevention of infectious diseases, and provision of medical treatment during the climb.

Issues related to selecting candidates were solved using the results of a set of clinical physiological examinations with broad reliance on functional diagnostics. Aside from the many traditional provocative tests used, new tests were developed and used successfully, for example, a test combining breathing of an oxygen-poor gas mixture and performance of graded physical exercise on a bicycle ergometer. This problem was solved by a group of physicians and physiologists with experience in the area of aerospace medicine. It should not be forgotten that more than 70 individuals have died in the course of Everest expeditions. Those in charge of the Soviet expedition accepted a heavy responsibility -- ascent to the top of the world by a new and singularly difficult route.

Problems arose at the very beginning, since 16 expedition members had to be selected from 28 candidates. The examinations performed by specialists made it possible to identify and exclude those who suffered from various chronic diseases (including occult forms). It is important to note that limited medical observation performed during the expedition by its physician, candidate of medical sciences S.P. Orlovskiy, generally confirmed the prognostic conclusions made during selection.

Much attention was devoted to providing the expedition with supplementary oxygen. Even before the climb began, the participants were able to familiarize themselves with the oxygen apparatus and test it at training camps in the Pamir mountains. Light masks of an improved design, combined with a regulator for supplying oxygen and relatively lightweight tanks, proved to be highly effective and reliable. There were no instances of failure, and, in the opinion of Soviet and foreign climbers, this Soviet oxygen apparatus is superior to any foreign model.

It should be noted that the expedition members, as distinct from physicians and physiologists, were not in unanimous agreement concerning the need to use supplemental oxygen in the ascent. Some thought that it should be used very rarely and sparingly. However, after the expedition, team captain V. Ivanov said that without oxygen they would have had no business in the Himalayas. And indeed the use of oxygen actually saved the life of the first pair who found themselves in an emergency situation on descent from the peak. Expeditions of this type rarely avoid accidents and some did occur on this one. However, the expert physician-climber S.P. Orlovskiy provided timely treatment for illness (severe cardiovascular insufficiency, frostbite, and trauma). This expedition also included some shortcomings: some climbers used only half the oxygen recommended by physicians and physiologists (3-4 l/min) for storming Everest. This, undoubtedly, slowed the ascent and decreased work capacity. At the same time, other climbers (for example, S. Bershov and M. Turkevich), who were highly qualified rock climbers but with less experience at very-high-altitude ascents and comparatively less endurance for oxygen deficit during the selection tests preferred to follow the recommendations and use oxygen in the suggested

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amounts. They were able to aid their comrades and to complete a night ascent of Everest at a good rate. Some shortcomings were also found in the rations, which will require further consideration for the future.

This book is the product of unique experience in providing biomedical support for an extremely difficult and responsible expedition. The book is particularly timely in light of the preparations for the next Soviet expedition to climb the third highest peak in the world, Kanchendzhangy, in 1989. In the projected expedition, participants will spend long periods of time at extremely high altitudes and experience a high degree of oxygen deficiency (hypoxia). The book is a useful, practical handbook for specialists — not only those responsible for training amateur, scientific, and other expedition forces for great heights, but also those who select people for jobs involving working at high altitudes for long periods of time.



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