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Issue 13

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* Topics marked with * have no entries of their own, but refer readers to relevant abstracts included in other topic areas.

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USSR Space Life Sciences Digest: Number 10 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 or 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)

PLEASE RETURN TO: Dr. Lydia Hooke
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FROM THE EDITORS

This is the thirteenth issue of the USSR Space Life Sciences Digest. We are pleased to report that this issue contains an unprecedented 25 abstracts of works which present and discuss space flight data. These abstracts fall in the areas of Botany, Cardiovascular and Respiratory Systems, Cytology, Developmental Biology, Endocrinology, Habitability and Environmental Effects, Life Support Systems, Immunology, Neurophysiology, Operational Medicine, Perception, Radiobiology, Space Biology, and Space Medicine. We do not produce and thus cannot provide readers with full translations of the materials we abstract. Information concerning availability of English translations of Soviet space life sciences materials is routinely published at the end of each Digest issue. Ordering instructions are also supplied.

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ADAPTATION: See: Biological Rhythms: P560; Cardiovascular and Respiratory Systems: P553, P563, P578; Developmental Biology: P561; Hematology: P569; Space Medicine: P573

BIOLOGICAL RHYTHMS

(See also: Cardiovascular & Respiratory Systems: P563; Space Medicine: M112)

PAPERS:

P560(13/87)* Galichiy VA.
Analysis of biological rhythms in parameters of pulmonary ventilation during tilt tests.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(3): 52-59; 1987.
[15 references; 1 in English]

Biological Rhythms; Cardiovascular & Respiratory Systems, Pulmonary Ventilation
Humans, Males
Tilt Tests; Individual Differences, Orthostatic Intolerance; Adaptation

Abstract: This paper presents data on 5 healthy males, aged 26-40, subjected to a 20-minute tilt test. Over the course of 3 seconds subjects were moved from a horizontal to a head-up position with the body at a 70° angle to the horizontal. Parameters of external respiration were measured initially in the horizontal position and during the 20-minutes spent upright. A "metabolometer" was used to measure respiratory minute volume, respiratory depth and frequency and minute volume of CO_2 exhaled. Concentration of CO_2 in alveolar air was also measured. Alveolar ventilation was computed from exhaled CO_2 minute volume and CO_2 in alveolar air. Respiratory parameters were averaged every 30 seconds while subjects were upright and every 2 minutes in the preceding period. Since the functions measured were cyclical in nature, amplitude-frequency characteristics were analyzed. Amplitude was defined as the difference between the maximum and minimum of each cycle; period was the distance between two adjacent minima; wave level was the mean of the maximum and minimum. Correlations among different parameters were computed for different times during the experimental period. In addition, the ratio of alveolar ventilation to minute volume was computed.

All parameters fluctuated on a cycle of approximately 1 minute. Fluctuations in respiratory depth appeared to occur in stages. The first (minutes 1-3) was characterized by frequent high altitude fluctuations; the second (minutes 4-7) included a single elongated, low-amplitude wave; the third (minutes 7-13) was similar to the first, and the fourth (minutes 14-20) similar to the second. Respiratory frequency curves showed small fluctuations embedded in larger ones. For all parameters studied, during the first 3 minutes in upright position there was an increase above baseline (positive phase) followed by a short period where level dropped below baseline (negative phase). This two-phase response is described as stemming from a phase of sympathetic tonus followed by one of parasympathetic tonus, and may be characteristic of a generalized adaptive response to stress. The authors argue that a prolonged or pronounced negative phase may be evidence of diminished orthostatic tolerance. Beginning at minute 4 in upright position, parameter values again rose above baseline. Alveolar ventilation and respiration rate remained elevated throughout the period, while minute

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volume and respiration depth brieflydropped below baseline at minute 8. The authors argue that because parameter values are generally above baseline, sympathetic-tonic reactions dominated. The mean of minimum and maximum values of a parameter began to increase at minute 4 and reached maximum levels at minutes 13-14, after which minute volume, alveolar ventilation, and respiration frequency leveled, while respiration depth decreased. The authors argue that the instability of parameter values between minutes 1 and 13 indicates that satisfactory adaptation does not occur until then.

During the first 3 minutes in upright position, minute volume was highly correlated with alveolar ventilation, and negatively correlated with respiratory depth and frequency. Between minutes 4 and 7, these correlations were attenuated or even changed sign. During the subsequent period correlations tended to recover. The authors suggest that additional stress during the period of "dissonance" (minutes 4-7) may lead to collapse. It is also pointed out that minute volume and alveolar respiration are more closely related to respiratory depth than to rate.

Table 1: Period and amplitude of fluctuations in parameters of pulmonary ventilation during 20 minutes in upright position in a tilt test

Table 2: Correlation coefficients between depth and rate of respiration, and between minute volume and alveolar ventilation at various periods during a tilt test

Table 3: Correlation coefficients between respiration rate and minute volume and alveolar ventilation at various periods during a tilt test

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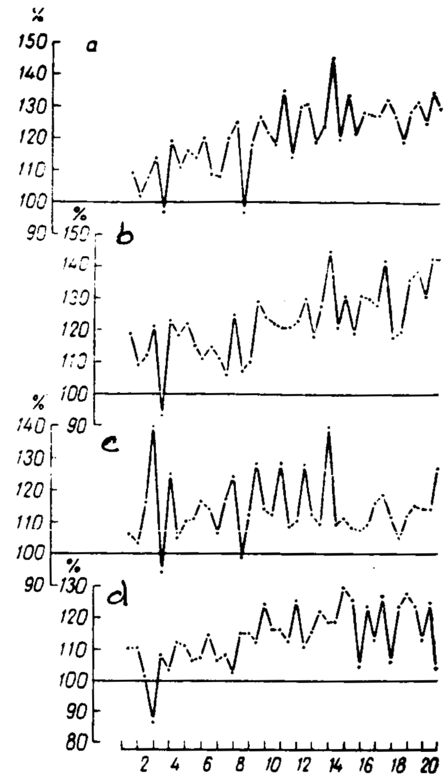

Figure 1: Changes in parameters of pulmonary ventilation in passive upright position (in % of baseline). Here and in Figure 2: abscissa - time in upright position (minutes); ordinate - a, b, c, d -- V_E, V_A, V_T, and f respectively

Figure 2: Changes in level (1) and amplitude (2) of fluctuation in parameters of pulmonary ventilation while in passive upright position. Ordinate - left, level of fluctuation; right, amplitude (in %): a, b, c, d. e -- V_E, V_A, V_T, f (τ = 1.5 min), and f (τ + 3.6 min), respectively

Figure 3: Ratio of alveolar ventilation to respiratory minute volume (V_A/V_A) before and during assumption of passive upright position

BODY FLUIDS

(See also: Space Medicine: P573, P574. M112)

PAPERS

P555(13/87)* Vartbaronov RA, Glod GD, Uglova NN, Rolik IS.
Hypovolemic reactions in humans and animals in response to exposure to $+G_z$ acceleration increasing in intensity.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(3): 35-39; 1987.
[18 references: 10 in English]

Body Fluids, Blood and Plasma Volume, Hypovolemia
Dogs, Humans, Males
Fluid Loading, $+G_z$ Acceleration, Anti-g Suit

Abstract: Subjects in this experiment were 5 mature mongrel dogs, weighing 6-10 kg, and 5 healthy men, aged 20-25. Fluid loading of 3-4% body weight was achieved in dogs by offering them bouillon after they had been deprived of food and water on the previous day; human subjects drank tap water equal in amount to 1% of their weights. Hematocrit was measured in both humans and animals, and hemoglobin concentration in animals alone before fluid consumption and every 15 minutes for the subsequent 1.5 to 2 hours. Subjects were exposed to $+G_z$ acceleration of increasing intensity on a centrifuge until cardiac rhythm was disturbed in dogs, or visual symptoms were noted in humans. The acceleration to which the humans were exposed remained at a given level for 30 seconds before increasing to the next one. Successive acceleration values were 3-, 5-, 6- and 7-g in a condition without an antigravity suit, and 3-, 5-, 6-, 7-, 8- and 9- when the suit was used. Dogs were exposed to acceleration increasing by 1-g per second, with intervals where it decreased to 2-g for 15 seconds. Details of repeated trials are not specified. Dogs too were tested with and without antigravity suits. Hematocrit and hemoglobin were measured in the dogs and hemoglobin concentration in the human subjects 10-15 minutes before acceleration and 2 minutes afterward. Volume of circulating plasma (VCP) and blood (VCB) were estimated with the following formulae:

$$\Delta PV_1 = \frac{100\cdot 100(Hct_0 - Hct_1)}{(100 - Hct_0)\cdot Hct_1}, \qquad (1)$$

$$\Delta PV_2 = 100\,\frac{Hb_0}{Hb_1}\,\frac{1 - 0.01\,Hct_1}{1 - 0{,}01\,Hct_0} - 100, \qquad (2)$$

$$\Delta PB = 100\cdot\frac{Hb_0}{Hb_1} - 100, \qquad (3)$$

where, Hct_0, Hct_1 = hematocrit (in %) before and after acceleration;
Hb_0, Hb_1 = concentration of hemoglobin before and after acceleration;
ΔPV_1, ΔPV_2 = relative change in VCP (in %), estimated from Hct and Hct+Hb, respectively;
ΔPB = relative changes in VCB (in %) estimated from Hb.

Regression and correlation analyses were performed on the data.

After fluid loading, values of Hb and Hct in a given blood sample were highly correlated in animals. This caused the estimates of VCP changes obtained with the two formulae to be very similar. Analogous results were obtained for humans. For this reason, the authors felt it justified to

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estimate VCB on the basis of hematocrit alone, and VCP on the basis of hemoglobin alone. In humans, 1% fluid loading led to significant increases in VCP and VCB, considerably lower than the effect of 3-5% fluid loading in the animals. In both species, increases in VCP were 1.8-2 times greater than in VCB, indicating minimal changes in erythrocytes. After exposure to increasing acceleration, the relative decrease in VCB was less than that in VCP. Use of antigravity suits made no difference to the relative changes in VCP and VCB in animals, but did increase these changes in humans, probably because humans were exposed to higher levels of acceleration while wearing suits. The authors conclude that these results indicate that one possible cause of cumulative effects of repeated acceleration may be a decrease in VCB as plasma moves rapidly into the interstitial spaces.

Table 1: Regressions of hematocrit, hemoglobin concentration and computed values of changes in ΔVCP and VCB in dogs

Table 2: Maximal changes in relative volumes of plasma and blood 30-60 minutes after fluid loading

Table 3: Changes in relative volumes of plasma and blood after exposure to repeated $+G_z$ loading of increasing intensity

Subject	Anti-g suit	Acceleration parameters max. g	durat., min.	Before or after acceler.	HB, %	Hct, %	ΔPV_2, %	ΔPB, %
Dogs	No (10)	14.4	6.8	Before	--	48.1	--	--
				After	--	55.0**	-23.2**	-11.7**
	Yes (4)	14.5	6.9	Before	--	50.1	--	--
				After	--	56.9	-23.6**	-11.2**
Humans	No (7)	7.0	3.3	Before	15.8	--	--	--
				After	16.8	--	-11.1*	- 5.9*
	Yes (11)	9.0	5.7	Before	15.3	--	--	--
				After	17.3**	--	-20.5**	-11.0**

* $p \leq 0.05$; ** $p \leq 0.01$

P557(13/87)* Degtyarev VA, Kaplan MA, Andriyako LYa, Bubeyev YA, Remizov YuI
Blood redistribution in humans in response to lower body negative pressure.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(3): 42-45; 1987.
[13 references; 9 in English]

Body Fluids, Blood Redistribution
Humans, Males
LBNP

Abstract: In this study, 10 healthy males underwent 6 sessions of increasing lower body negative pressure of -10, -20, -30, -40, -50, and -60 mm, with 3 minutes at each pressure level. Negative pressure was created by a vacuum cylinder in which the subject was enclosed in a horizontal position up to the level of the ileum. Sessions were 1-2 days apart. Amount of blood pooling in various parts of the body was determined by labeling erythrocytes with ^{59}Fe, injected intravenously. A collimated radiodetector measured radioactivity in the head, neck, chest, abdomen, pelvis, and legs. LBNP sessions began 14 days after introduction of the label. Regression and correlational analyses were performed. Results indicated that blood redistribution into the lower body depended on amount of decompression and the anatomical and physiological characteristics of individual parts of the body. More than 2/3 of the change occurred in the range of -10 - -30. In this range, amount of blood in the chest decreased by 23%, and in the head by 19%, and increased in the pelvis and legs by 23-26%. No statistically significant changes were noted in the abdomen. Blood entered the lower body during LBNP mainly from the chest, wherein blood volume decreased by an average of 36%. Increase in blood pooling in the lower body reached nearly 50% (note: the text says factor of 2, but this is not confirmed by the figures). The authors conclude that changes in amount of blood in the chest depend on the amount of blood which has entered the area undergoing negative pressure, which, in turn, is related not only to the capacity of the veins in this area, but to venous-arterial reflexes and the effects of negative pressure on tissue hydration.

Figure 1: Change in amount of blood in various portions of the body during LBNP

Figure 2: Redistribution of blood in the body during LBNP

BOTANY

(See also: Life Support Systems: P578; Radiobiology: P579: Space Medicine: M112)

PAPER:

P568(13/87)* Tayrbekov MG.
Investigation of metabolism of biological subjects in weightlessness.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(3): 89-90; 1987.
[1 references; none in English]

Metabolism, Plant and Insect
Botany, Corn, Seeds; Developmental Biology, Flies
Space Flight, Cosmos-1514, -1667

Abstract: This paper describes experiments using the "Biokalorimeter" device on the "Cosmos-1514" (12/83) and "-1667"(7/85) biosatellites. The first experiment used sprouting corn seeds and the second developing drosophila pupae. In both cases the subjects were in the initial stages of development. The experiment began when the material was placed in the biocalorimeter, which in turn was loaded into the biosatellite or ground-based mock-up. Measurements began 14-16 hours after temperatures stabilized within the device. The output signal from the device was measured every 2 hours and immediately before the chamber was cleaned. Total amount of heat produced by all the organisms in the chamber per 1 g initial mass was the parameter measured. Since the seeds were grown in the dark, photosynthesis was precluded and the only process occurring was the transformation of the reserve substances in the endosperm into organ tissues with the biomass remaining relatively constant. In the flies, the observed period of development involved lysis of preliminary organs and tissue, followed by histogenesis associated with morphogenetic movements of the cells, with biomass constant.

Heat production as a function of time for all conditions and both organisms was described by an S-curve, with a rapid development phase, followed by a slower phase and a stationary phase. Thus, weightlessness does not change the basic structure of development. Although heat produced by both organisms was generally lower at any given time in space than it was on Earth, these differences were not statistically significant.

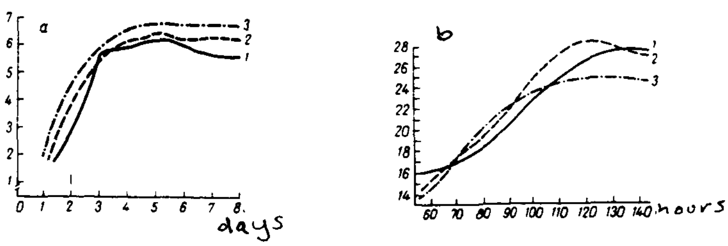

Figure: Heat expended by sprouting corn seeds (a) and developing drosophila pupae (b) in weightlessness.
1 - flight; 2 - synchronous control; 3 - laboratory control

CARDIOVASCULAR AND RESPIRATORY SYSTEMS

(See also: Biological Rhythms; P560; Hematology: P565; Metabolism: P558; Space Biology: M113; Space Medicine: P575, P574, M112)

PAPERS:

P553(13/87)* Bayevskiy RM, Chatterjee PS, Funtova II, Zakatov MD (USSR, India).
Cardiac contractility in weightlessness measured by spatial ballistocardiography.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(3): 26-31; 1987.
[8 references; 1 in English]

Cardiovascular and Respiratory Systems, Cardiac Contractility, Ballistocardiography
Humans, Cosmonauts, Soviet-Indian Crew
Space Flight, Salyut-7; Adaptation

Abstract: Traditional ballistocardiography has been used for measuring changes in cardiac contractility during adaptation to the space environment. Yet, because measurements are made only along the vertical axis of the body, this method cannot provide information on redistribution of the mechanical energy of cardiac contractions due to changes in the position of the heart in the chest cavity and fluid shifts into the upper part of the body. However, the method of "spatial" ballistocardiography which registers body movements associated with cardiac activity along 3 perpendicular axes (see Figure 1) can perform this function. This paper presents the results of a study of the state of the circulatory system of members of the Soviet-Indian visiting crew of Salyut-7, using this technique. Spatial ballistocardiography was performed on the 3 crewmembers, twice during the preflight period, twice during flight (days 3 and 5), and twice postflight (on days 1 and 4 of recovery). Both traditional (amplitude-temporal) and spectral analysis of the resulting ballistocardiograms were performed. For the spectral analysis the signal was recorded for 16 seconds; measurements were made in the frequency range of 0.5-62.4 Hz. Changes in following parameters were analyzed:

E_{max}, frequency of the maximum harmonic of the spectrum;
A_{max}, amplitude of the maximal harmonic of the spectrum;
E_{0-4}, total spectral energy in the frequency range of 0-4 Hz;
E_{4-10}, total spectral energy in the frequency range of 4-10 Hz;
E_{10-20}, total spectral energy in the frequency range of 10-20 Hz.

Three patterns of changes associated with flight were noted in ballistocardiograms. The first involved increase of segments IJ, JK, KL, and MN along the Y axis on day 3 of flight and an increase in segment HI only on day 5. Spectral energy increased in all bands along the Z axis. In the second variant, all segments increased in amplitude, especially along the Y and Z axes. The power of the spectrum increased along the Z axis in all frequency bands. In the third variant, segment HI increased along the Y axis and decreased along the X axis on day 5 of flight. On day 3, segments IJ, JK, and KL increased along the Y and Z axes and decreased along the X axis. Segment MN decreased along the X axis on day 3 and increased along

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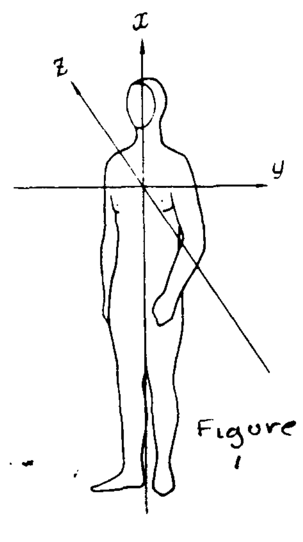
the Z axis in the 0-4 Hz band along axis Z on days 3 and 5 of flight. Spectral energy decreased in the 4-10 Hz frequency band along the X axis and increased in the 10-20 Hz band along the Y and Z axes on day 5. Common factors for all 3 individuals included increases in the frequency of the maximum oscillation along the X axis, increases in the power of oscillation along the Y and Z axes at a frequency of 0-4 Hz, and along all 3 axes in the 10-20 Hz band. The authors interpret this data as indicating that there is an increase in the mechanical work performed by the right ventricle during the acute phase of adaptation to weightlessness, resulting in redistribution of contractile energy between the right and left heart. These changes occur in a different order and at different rates in different individuals.

Table 1: Results of amplitude and spectral analysis of ballistocardiograms with the sensor attached between the shoulder blades (first crewmember)

Table 2: Results of amplitude and spectral analysis of ballistocardiograms with the sensor attached between the shoulder blades (second crewmember)

Table 3: Results of amplitude and spectral analysis of ballistocardiograms with the sensor attached between the shoulder blades (third crewmember)



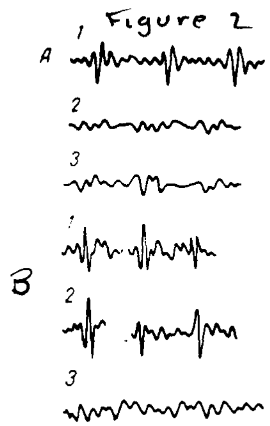


Figure 1: Diagram of the axes used in recording ballistocardiograms.

Figure 2: Sample ballistocardiograms obtained before (A) and during flight (B) along the X (1), Y (2), and Z (3) axes

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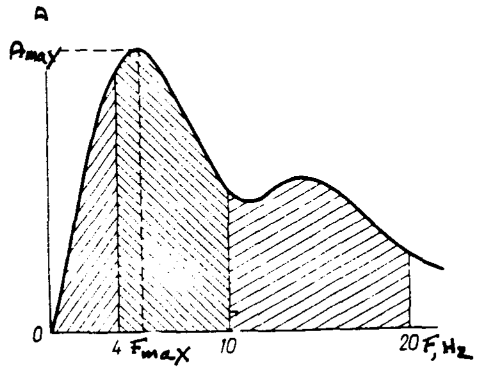

Figure 3: Typical ballistocardiographic spectrum.

P559(13/87)* Chinkin AS.
Characteristics of and mechanisms underlying the effects of epinephrine and norepinephrine on cardiac pumping function in hypokinesia.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(3): 49-52; 1987.
[14 references; 5 in English]

Cardiovascular and Respiratory Systems, Cardiac Pumping Function
Rats
Endocrinology, Epinephrine, Norepinephrine; Hypokinesia, Immobilization

Abstract: In this experiment, 9 rats were kept in immobilization cages for 22-23 hours per day for a period of 30 days. To reduce stress, time per day spent in the cages was gradually increased over the 15 days preceding the main experimental period, and animals were allowed 1-2 hours in a communal cage during that period. A control group (n=13) was used. After 30 days animals were anesthetized and injected with atropine, and stroke and heart rate volume determined by impedance plethysmography. Plethysmograms were recorded at the following points:

- before and 10 minutes after intravenous administration of atropine;
- before and 40 seconds after subsequent injection of 0.5 ml/kg epinephrine and norepinephrine (10-12 minutes later);
- before and 8-10 minutes after subcutaneous injection of obzidan (5 mg/kg);
- after a second injection of the same dose of epinephrine;
- before and 5 minutes after intravenous injection of phenylamine (5 mg/kg) and a third injection of epinephrine.

Experimental animals showed a slight (10%) decrease in body weight compared to controls. After hypokinesia, with no drugs administered, experimental animals had a higher heart rate and lower stroke volume than controls, causing cardiac ejection to remain at about the same level. Atropine increased heart rate and decreased stroke volume in control animals, but scarcely affected experimental animals demonstrating attenuated vagal-cholinergic effects. In general, effects of epinephrine on stroke volume were less pronounced for experimental animals and effects of norepinephrine more pronounced. After administration of epinephrine and norepinephrine heart rates of both groups increased. The depressive effect of epinephrine on stroke volume was 2.5 times lower in experimental rats, while the effect of norepinephrine was somewhat greater. After blockade of beta adrenoreceptors by obzidan, heart rate decreased and stroke volume increased in both groups. However, the chronotropic effect was somewhat more pronounced in experimental rats, while effects on stroke volume were 2.5 times greater in controls. The data are interpreted as indicating that beta-adrenergic effects on the heart are more pronounced in animals exposed to hypokinesia. Administration of phenylamine after obzidan decreased heart rate in both groups, suggesting that in the absence of beta-adrenergic effects, heart rate may be regulated by alpha-adrenoreceptors. Effects of phenylamine on stroke volume were less pronounced in experimental animals, indicating that the effect of alpha-adrenoreceptors on stroke volume is less pronounced after hypokinesia.

P563(13/87)* Krotov VP, Sandler H, Badakva AM, Hines J, Magedov VS, Stone H (USSR, USA).
Variation in blood pressure and flow in the common carotid artery of a monkey flown on board the "Cosmos-1514" biosatellite.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(3): 69-74; 1987.
[7 references; none in English]

Cardiovascular and Respiratory Systems, Blood Pressure and Flow, Carotid Artery; Biological Rhythms
Primate, Rhesus Monkey
Space Flight, Cosmos-1514; Adaptation

Abstract: This paper describes results of a study of blood pressure and linear flow velocity in the common carotid artery of a rhesus monkey, "Bion," flown on board the "Cosmos-1514" biosatellite for 5 days. Sensors and transducers were implanted for this purpose preflight. Minute volume was also measured. Parameters were measured for 5-minute periods every 2 hours throughout the flight. Measurements made during a 1.5-day period which the monkey spent in the "Bios-primat" capsule were used for control purposes. No postflight studies were completed, as the monkey died of ileus 69 hours after landing.

On the basis of obtained measurements, it was concluded that the time the animal spent in the rocket on the launching pad was not a significant stressor. Bion's circulatory system showed minimal response to initial absence of gravity: linear blood flow decreased by 10% and blood pressure increased by 4%. However, these parameters changed substantially (BP: +27%, LBF: -28%) during the next few hours, showing a tendency to normalize at the end of day 1 in space. Comparison with control parameters eliminated the possibility that these changes resulted from emotional stress. A result of the early changes in blood pressure and flow was increased resistance to blood flow in the vessels of the carotid basin. These changes are considered a result of a compensatory process serving to normalize cerebral hemodynamics. During the last 4 days of flight, changes in blood pressure corresponded to a diurnal rhythm of increase during the day and decrease during the night. The 2 blood pressure peaks coincided with the animal's failure to perform a task properly, leading to nonreinforcement with juice. The ratio of linear blood flow to minute volume is considered to reflect blood supply to the brain. The lowest mean daily value of this ratio occurred on days 2 and 3, after which it gradually rose to baseline value. Range of fluctuation of this ratio was also lowest on days 2 and 3; fluctuations attained maximum levels on day 5 of the flight. On the basis of this data, the authors suggest that beginning on day 4, the animal had begun to adapt to weightlessness. However, adaptation was by no means complete by day 5. Diurnal rhythms in the parameters measured are considered an adaptive response; damping of these variations, which occurred in Bion on day 2 of flight, is taken as evidence of substantial disruption of cardiovascular regulatory mechanisms. The normalization of these rhythms on days 3-5 is interpreted as further evidence for adaptation to weightlessness.

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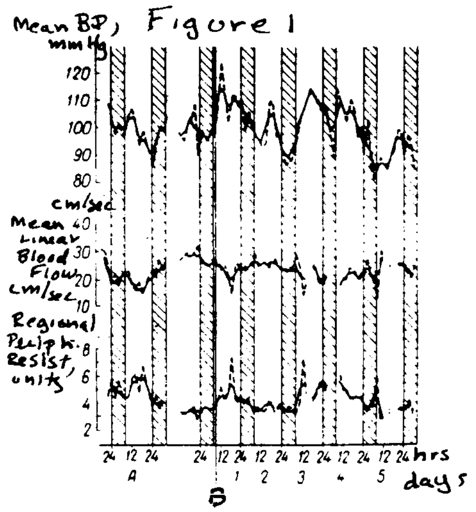

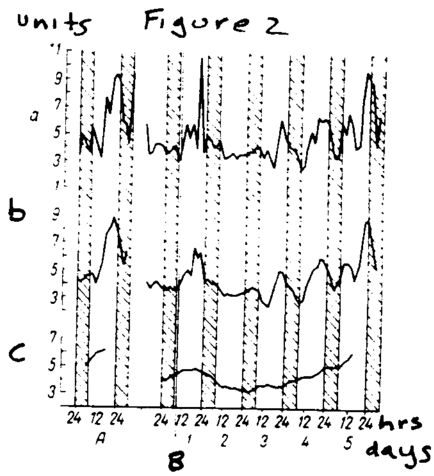

Figure 1: Changes in blood pressure, linear blood flow and regional peripheral resistance in the monkey Bion during space flight
Here and in figure 2 and 3; A - control. B - launch; cross-hatched area corresponds to night. Dotted lines represent data obtained during initial processing of material; solid lines are same data after symmetrical smoothing using 3 points

Figure 2: Changes in ratio of linear blood flow to the head and minute volume in the monkey Bion in the control period and during flight
a, b, and c - data obtained in initial processing, and in symmetrical smoothing using 2 and 12 points, respectively

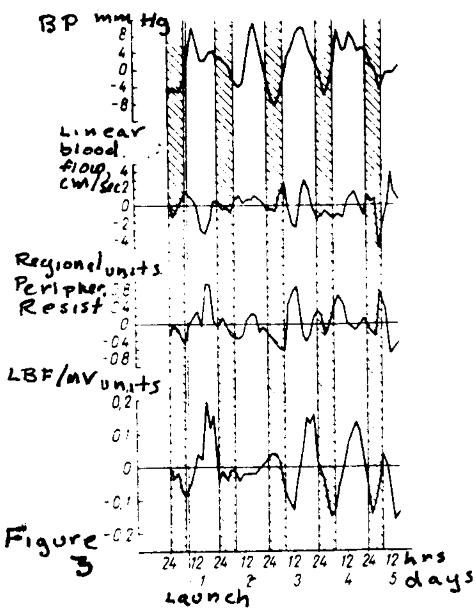

Figure 3: Diurnal rhythms of circulatory parameters in the monkey Bion during space flight

P564(13/87)* Breslav IS, Shmeleva AM, Normatov AT.
Use of biofeedback control of alveolar pCO_2 to avoid hypercapnia in humans exposed to hypoxia.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(3): 74-77; 1987.
(19 references; 3 in English)

Cardiovascular and Respiratory Systems, P_{CO2}, Hypercapnia
Humans, Males
Hypoxia; Psychology, Biofeedback

Abstract: This experiment was performed on 9 healthy men with mean age of 30.6 years. The subjects, seated in a comfortable position, breathed through a mask attached to a spirograph, which controlled the delivery of air automatically and output parameters of pulmonary ventilation to a computer. Parameters measured included pulmonary ventilation (V), respiration frequency (f), respiratory volume (V_I), inhalation duration (T_I), and exhalation duration (T_E). In addition, the maximum speed of increase in negative pressure in the respiratory tract at the beginning of inhalation (dp/dt_I) was used as a noninvasive measure of so-called initial inspiratory activity. The composition of alveolar gas was monitored continuously. After a baseline period during which ordinary air was breathed, subjects breathed a mixture containing 11.1% O_2 in nitrogen, and then breathed normal air. In the first condition, subjects breathed freely. In the second, pCO_2 of alveolar air was stabilized at baseline level using biofeedback. The biofeedback technique involved the presentation of pCO_2 level on an oscilloscope visible to the subject.

Under the free-breathing condition, p_aCO_2 decreased by minute 5 to 2.7 mm Hg (0.36 kPa), while in the biofeedback condition this parameter underwent virtually no change. If p_aCO_2 did not stabilize, hypoxia led to a small increase in ventilation because of slight increases in respiratory volume and frequency, in which inhalation was shortened. Central inspiratory activity increased. In the biofeedback condition, there was only a small increase in ventilation, but a sharp increase in respiratory depth with lengthening of both phases, especially the expiratory phase. Thus, the effort to restrain increase in respiration involuntarily deepened it. Although this tactic was successful in reducing hypocapnia, it also led to significantly less oxygen in alveolar air (hypoxemia). The authors conclude that if hypocapnia (hyperventilation) is considered less desirable than hypoxemia under conditions of reduced oxygen in the environment, biofeedback training may be helpful.

Table: The effect of hypoxia on respiratory parameters under conditions of free breathing and use of biofeedback to stabilize p_ACO_2

Figure 1: Diagram of apparatus for biofeedback on p_ACO_2

Figure 2: Changes in p_ACO_2 during inhalation of a hypoxic mixture under conditions of free breathing and use of biofeedback to stabilize p_ACO_2

P572(13/87) Chinkin AS.

The effect of blockade and stimulation of adrenoreceptors on the pumping function of the heart in animals with or without adaptation to physical exercise.

Fiziologicheskiy Zhurnal SSSR im. I. M. Sechenova
LXXII(3):389-395; 1987.
[18 references; 11 in English]
Author's affiliation: State Pedagogical Institute, Kazan

Cardiovascular and Respiratory Systems, Pumping Function
Rats, Male
Endocrinology, Adrenoreceptors; Adaptation, Physical Exercise

Abstract: Two experiments were performed. In the first, 14 male rats were adapted over a period of 3 months to strenuous swimming for 1 hour 5 times a week. Adaptation was gradual, with no weight attached during the first month, an attached weight 2.5% body weight during the second month, and swimming with a weight of 5% during the third month. Control animals were not compelled to swim during this period. After 3 months, animals were anesthetized, and atropinized. Stroke volume of blood was determined using tetrapolar translocal impedance plethysmography. Baseline data was obtained:

- 10-12 minutes after administration of atropine;
- 30 seconds after intravenous administration of (0.5 mg/kg) epinephrine;
- after an interval of 10-12 minutes, 30 seconds after administration of the same dose of norepinephrine;
- after an interval of 8-10 minutes, after subcutaneous administration of obzidan (a beta-blocker) in a dose of 5 mg/kg;
- and after second administrations of epinephrine and norepinephrine in the same doses and at the same intervals.

In the second experiment, 12 control animals were tested for the effects of catecholamines and the alpha-adrenoagonist mezaton on stroke volume of blood and heart rate before and after blockade of alpha- and beta-adrenoreceptors with phenylamine and obzidan. Because the first experiment showed that catecholamines in a dose of 0.5 ug/kg caused a relatively small increase in stroke volume, dose of catecholamine was determined individually for each animal so as to produce to a systolic effect of 15-50% in the absence of adrenoblockers.

Although baseline values of stroke volume did not differ for experimental and control animals, increase in this parameter in response to catecholamines was 3 times higher in the experimental group. No initial differences in heart rate were noted. Both catecholamines increased heart rate in both groups, but twice as much for control animals. Minute volume increased more for adapted (experimental) rats than for control rats. Thus, adaptation to exercise attenuates the chronotropic effect of catecholamines and enhances their effects on stroke volume. Administration of the beta-blocker, obzidan, increased stroke volume and decreased heart rate in both groups, but stroke volume increased more in adapted animals. Minute volume increased significantly in experimental, but not control, animals. After beta blockade, norepinephrine decreased stroke volume in all control and 57% of experimental animals. However, epinephrine continued to increase stroke volume, even more than before beta blockade. Intergroup differences in this parameter remained. Beta-blockade decreased heart rate and eliminated or

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attenuated the chronotropic effect of exogenous catecholamines. This was true to a greater degree for adapted animals.

The second experiment showed that stroke volume decreased after blockade of alpha-adrenoreceptors. The alpha-agonist, mezaton, increased stroke volume. The effect of norepinephrine on stroke volume was unchanged by selective alpha-blockade and disappeared after blockade of all adrenoreceptors. Increase in stroke volume in response to epinephrine was less pronounced than before blockade. After alpha-blockade heart rate tended to increase, but the effects of epinephrine and norepinephrine on heart rate were attenuated.

The authors conclude that these data indicate that reciprocal changes in the effects of catecholamines on heart rate and stroke volume resulting from prolonged adaptation to physical exercise are caused by a) redistribution of beta-adrenoreceptors in heart structures varying in functional significance, and b) by increased activity of adrenoreceptors in the heart.

Table 1: Changes in heart rate and stroke volume of blood in response to epinephrine and norepinephrine before and after administration of obzidan

Condition	**Stroke volume of blood (ml)**				**Heart rate (bt/min)**			
	Base-	**Change after:**			**Base-**	**Change after:**		
	line	**epin.**	**norep.**	**obzid.**	**line**	**epin.**	**orep.**	**obzid.**
Control, atropine (n=8)	0.41	+5.9	+5.8[1]	+26.7	405.0	+10.2[2]	+10.7[2]	-12.9[2]
Atropine+obzidan	0.49	-6.1[2]	+22.0[2]	--	350.9	+1.6[1]	+ 0.2	--
p	>0.05	<0.001	<0.05		<0.01	<0.001	<0.001	
Adaptation, atropine (n=14)	0.37	15.9[2,4]	+15.8[2,3]	+38.4[2]	400.6	+5.5[2,3]	+5.3[2,3]	-11.2[2]
Atropine+obzidan	0.51	-3.8[1]	+51.7[2,3]	--	359.3	+0.6	+0.2	--
p	<0.02	<0.001	<0.01		<0.01	<0.01	<0.01	

[1] Effect of obzidan or catecholamine significant within the group, $p < 0.05$; [2] $p < 0.01$ or 0.001; [3] differences with corresponding parameter of control significant with $p<0.05$; [4] $p<0.01$

Table 2: Changes in heart rate and stroke volume of blood in response to catecholamines and mezaton before and after administration of phenylamine and obzidan

P576(13/87) Altukhov VG, Grebenik MA, Shapovalov AA.
The effect of elevated concentration of oxygen and carbon dioxide in the atmosphere on the cardiorespiratory system.
Voyenno-meditsinskiy Zhurnal.
1987(4): 39-40.
[Citations not listed.]
Authors' affiliation: Military Medical Corps

Cardiovascular and Respiratory Systems; Life Support Systems
Humans
Hypokinesia, Artificial Atmosphere, Increased O_2 and CO_2, Exercise

Abstract: This experiment tested the effects of long-term (up to 4 months) exposure to an artificial atmosphere with partial oxygen pressure of 160-198 mm Hg (21.3-26.3 kPa) and carbon dioxide pressure of 0.76-3.00 mm Hg (0.1-0.4 kPa) on the state of the human cardiorespiratory system. The other parameters of the atmosphere were similar to those used in spacecraft cabins. Two groups of 20 volunteers participated in the study (sex not specified, age 23-30). One group participated in an exercise program involving 45 minute sessions 3 times a week for the duration of the experiment. Exercises were performed on a treadmill, bicycle ergometer, and rowing machine with mean work of 150 W and mean heart rate of 120-140. The second group followed no such program. Cardiorespiratory parameters measured included heart rate, respiration rate, blood pressure, stroke volume, minute volume of blood, total peripheral vascular resistance, endurance coefficient, and maximum oxygen consumption.

As subjects continued to live in the artificial atmosphere, heart rate, respiration rate, respiration and blood minute volume tended to decrease, while oxygen consumption and output of carbon dioxide, respiratory coefficient and energy consumption at rest decreased. At the same time, the coefficient of oxygen utilization, minimum blood pressure, and peripheral resistance increased somewhat. By the end of the experiment, both groups showed marked predominance of parasympathetic effects on cardiac rhythm. Endurance coefficient remained unchanged in both groups. Changes in electrocardiograms were more pronounced in the non-exercising group. These changes included increases in duration of P-Q interval at rest, duration of actual systole, and in the difference interval Q-T. The non-exercising group showed an decrease in amplitude of the T peak in the second lead starting in month 2. However, the electrocardiographic parameters of both groups were within the norm. Changes in hemodynamic parameters were more pronounced during graded physical exercise. Exercise required more energy expenditure by the non-exercising group, increasing markedly during the third month of exposure to the artificial atmosphere. As exposure to this atmosphere progressed, both groups displayed a decrease in overall peripheral resistance. Maximum oxygen consumption underwent substantial change over the course of the experiment, dropping from levels indicating high and very high work capacity. These drops were more pronounced in the non-exercising group, dropping significantly at the end of the first month and remaining at a low level thereafter. In the exercise group, minimum oxygen consumption reached a minimum at the end of the third month, but then recovered to baseline level. Blood pH fluctuated in both groups. $PaCO_2$ in blood decreased significantly in the non-exercising group, but only showed a trend to decrease in the exercising group. Oxygen pressure was elevated in the blood of both groups throughout the experiment.

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The authors conclude that during long-term exposure to a hyperoxic-hypercapnic atmosphere, the human cardiorespiratory system functions according to the minimal function mode without stressing regulatory mechanisms. The changes observed in the experiment result from the effects of moderate hyperoxia on the body. These changes include an alkaline shift to blood pH and decrease in blood $PaCO_2$, in the blood, which facilitates dissociation of oxyhemoglobin due to a leftward shift in the dissociation curve. This in turn results in decreases in blood and respiratory minute volume, gas exchange and energy expended at rest. Graded physical exercise has a beneficial effect on the functional state of the cardiorespiratory system under conditions of moderate hyperoxia. However, full compensation for the hypokinesia involved in the experiment did not occur; physical work capacity dropped in both groups of subjects, but to a greater extent in those who did not exercise. The authors state that a hyperoxic, hypercapnic atmosphere may be used in hermetically sealed human habitats for up to 4 months without significant ill effects.

CYTOLOGY

(See also: Space Medicine: M112)

CONFERENCE REPORT:

CR6(13/87)* Krasnov IB.
Report of 3rd Soviet-French Symposium on Space Cytology.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(3): 92-95; 1987.

KEY WORDS: Cytology, Weightlessness, Spaceflight, Cosmos-1514, -1667, Hypergravity, Hypokinesia; Neurophysiology; Developmental Biology, Embryology; Genetics; Immunology, Lymphocytes; Musculoskeletal System, Osteoclasts, Osteoblasts; Hematology, Erythrocytes; Mathematical Modeling; Equipment and Instrumentation; Metabolism

Report translation: The third Soviet-French Symposium on Space Cytology took place between 4 and 11 May 1986 in Rheims, France, as part of a program of collaboration in medicine and medical technology, jointly sponsored by the USSR Ministry of Health and the French National Institute of Public Health and Medical Research. The first Soviet-French symposium on space cytology took place in Paris in 1983; the second in Moscow, 1984.

Space cytology is a discipline which studies the effects of space flight factors (weightlessness, high energy particles, etc.) on the structure, function, and metabolism of cells of pro- and eucaryotes (bacteria, plants and animals). Because of the rapid conquest of space and increasing duration of manned space station flights, research in the area of space cytology is becoming more and more important for the solution of practical, as well as theoretical problems in space biology and medicine. As a result of experiments performed on biosatellites, spacecraft, and orbital stations, the field of space cytology has acquired the basic information needed to begin to understand the effects of space flight on the cell. At the same time, the further development of methods of quantitative cytochemistry, immunocytochemistry, and electron microscopic stereology has provided new ways to study bacterial, plant, and animal cells which have been exposed to space.

The symposium consisted of 7 sessions: session 1 was plenary; session 2 was entitled "The nerve cell;" session 3 was devoted to "Lymphocytes and cells of tissue cultures;" session 4 was called "Bone tissue;" session 5 dealt with "The erythrocyte"; session 6 discussed "Analytical methods;" and 7 described "Biological models." A total of 22 papers were presented.

At the plenary session, a paper by M. Bouteille (Institute of Biomedical Research, Pierre and Marie Curie University, Paris), entitled "Contemporary problems in cellular biology applied to the study of the effects of space conditions," was devoted to the general problems facing space cytology. It reviewed experiments on cellular biology performed by French scientists on board spacecraft, as part of the European Space Agency (ESA) program. A review paper by I.B. Krasnov (Institute of Biomedical Problems, Moscow), "The accomplishments of Soviet space cytology," presented the results of a cytological investigation performed by the Soviet Union to study the effects of weightlessness on the metabolism, structure, and function of cells of fungi, tissue cultures, and various organs and tissues from rats exposed to space flight on the "Cosmos" biosatellites.

A number of papers reflected the real need which has been felt recently to extend the neuromorphological study of animals exposed to weightlessness. I.B. Krasnov's (Institute of Biomedical Problems, Moscow) paper, "Quantitative cytochemical analysis and its potential use in space cytology," described

the methods the author has developed for quantitative cyto- and histochemical analysis of enzyme activity in individual isolated nerve cells and brain structures, and also the results of the use of these methods for study of the brains of rats exposed to space on "Cosmos" biosatellites. These methods revealed changes in the vestibular structures of the brain, induced by effects Earth's of gravity on the otolith system after the animals had lived under conditions of weightlessness.

Adaptation to weightlessness, as a demonstrated in a paper by L.N. D'yachkova (Institute of Evolutionary Morphology and Ecology, USSR Academy of Sciences, Moscow), "Ultrastructural bases for adaptive processes in the brain of animals exposed to altered gravity," is accompanied by a reorganization of the system of interneural contacts in the cerebral cortex. The complex synaptic complexes in various layers of the sensorimotor, visual, and olfactory cortex of the brain of rats exposed to a 7-day space flight on the "Cosmos-1667" satellite not only displayed destructive changes in some of the axo-dendrite synapses, indicating loss of functional activity, but also showed signs of the appearance of growth cones and new synapses at various stages of development, testifying to the continuing formation of new synaptic units.

A paper presented by G. Geraud, C. Masson, A.-M. Dupuy-Coin, M. Bouteille, (Institute of Biomedical Research, Pierre and Marie Curie University, Paris), entitled "Experiment Purkinje-3: Preliminary results of a morphometric analysis," cited data obtained by the authors in a Soviet-French experiment "Purkinje-3" using rats flown on the "Cosmos-1667" biosatellite. The results of morphometric analysis of glomerules in the cortex of the central lobule of the vermis of rats flown in space for 7 days confirmed the enlargement of the glomerules in that same structure discovered earlier by the authors in the "Purkinje-1" experiment, which was part of an embryological experiment with rats on the "Cosmos-1514" biosatellite. Enlargement of glomerules, the termini of the mossy fibers which carry the proprioceptive impulse from muscle proprioceptors, cartilage, and interarticular surfaces of the hind limbs, evidently testifies to an increase in the flow of impulses from the proprioceptors of rats experiencing normal gravity after exposure to weightlessness.

A. Privat (Biological Institute, Montpelier), in a paper entitled "Purkinje-2 experiment: Culture of the cerebellum of rat embryos," presented along with I.V. Viktorov (Brain Institute, All-union Science Center for Psychological Health, USSR Academy of Medicine) and J. Drian, described the results of a joint Soviet-French experiment, "Purkinje-2," performed as part of the embryological study with rats flown on "Cosmos-1514." An electron microscope analysis was performed on nerve cells of postflight cultures of the cerebellum of rat embryos developing in space, from day 13 to 18 of prenatal ontogenesis. This analysis did not show any changes in the ultrastructure of neurons and, in the authors' opinion, indicated the absence of any effects of weightlessness on the genetically determined capacity of cells of the cerebellum to regulate the process of growth and differentiation.

Parallels between the state of the ultrastructure of lymphocytes -- normal killer cells and the decrease in their functional activity were established in humans exposed to long-term space flight. As I.V. Konstantinova (Institute of Biomedical Problems, Moscow) showed in a paper entitled "Ultrastructure and function of antiviral lymphocytes in weightlessness and hypokinesia," presented in the "Lymphocyte and cells of tissue cultures" session, the decrease in the cytotoxic activity of normal killer cells, found using the immunological method in humans after a 75-day space flight, was accompanied by the loss of the capacity of these cells to adsorb and engulf the target cells. In the cytoplasm of such normal killers the numbers of microtubules and microfilaments decrease, and the intracellular orientation of the Golgi complex is altered in the secretor granules. In research performed in accordance with the Soviet-French "Cytotox" program, decrease in the cytotoxic activity of normal killer cells and alteration of their ultrastructure was also observed in humans after a 120-day period of hypokinesia with head-down tilt.

C. Beaure d'Augeres, J. Bureau, J, Arnoult, A.-M. Dupuy-Coin, M. Bouteille (Institute of Biomedical Research, P. and M. Curie University, Paris) presented a paper entitled "The 'Plasmatic Cell' experiment: Preliminary Results," in which they detailed the results of an experiment performed on board a spacecraft in 1985 as part of the ESA program. The authors studied the effects of weightlessness on the viability of cells of an AM-2 hybridoma, their production of antibodies, ultrastructure and spatial arrangement of cells, rate of RNA biosynthesis (radioautographic analysis of semifine cross-sections, and rate of ^{3}H-uridine inclusion) and secretion of amino acids in an incubation medium. During the flight, a portion of the cultures were rotated on a centrifuge at 1-g. Cultures maintained on the ground at 1- and 1.4-g served as controls. After the flight it was found that number of cells surviving in space flight conditions decreased to a moderate extent; however, cells exposed to hypergravity (1.4-g) showed an even greater decrease. RNA synthesis was the parameter most affected (decreased) by weightlessness.

A paper, "A technique for identifying monoclonal antibodies in a hybridoma culture," by C. Boucheix described a method for obtaining antibody-producing hybridoma AM-2 cells by hybridizing cells of myeloma cells and splenocytes of mice and immunizing them with a retinal antibody, a technique used by French scientists in the "Plasmatic Cell" experiment in space. The author described the method for identifying and measuring monoclonal antibodies in supernatant cultures of the AM-2 hybridoma.

At the "Bone Tissue" session, the paper presented by A.T. Lesnik (Institute of Biomedical Problems, Moscow), "Interaction of the osteoclast-activating factor and osteoclasts in space flight simulation," demonstrated that the period during which production of the osteoclast-activating factor of immunocompetent cells is elevated in humans undergoing a 120-day period of

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hypokinesia with head-down tilt coincides with the period during which the resorption activity of osteoclasts increases (as disclosed by biopsy of iliac bone). The author argues that this suggests that the immune system plays a role in activating the process of resorption in bone tissue. Supporting evidence for this hypothesis is provided by the increase in production of osteoclast-activating factor by rat splenocytes after 40 days of hypokinesia with head-down tilt. Lesnik advances a hypothesis that immunological regulation of bone resorption is activated in weightlessness. J.-R. Nefussis (University VII, Paris) in a paper entitled "A model of the formation of bonds _in vitro_," was devoted to the author's _in vitro_ model of bone formation using osteoblasts of the flat bones of the skull from mouse embryos. This model enables cytological analysis of bone tissue formation and mineralization, investigation of the effects of various factors and pharmacological agents regulating this process, and study of the effects of weightlessness on bone tissue formation and mineralization. Bone tissue begins to be formed in the culture on day 7-8 of culturing. He cites evidence that the samples of bone tissue mineralization in the culture are analogous to the bone tissue of animals. The maximum period that growth of the culture was observed was 21 days.

Mechanisms underlying the interaction of proteins and crystals of hydroxyapatite during bone tissue mineralization were examined in a report by G. Daculsi (Department of Odontology, INSERM, Nantes), "Interaction of proteins and crystals during the formation and growth of crystals in the phases of mineralization of calcified tissues and calcification." A model of the interaction of protein and mineral components was offered. According to this model, the protein of bone tissue has definite components required to initiate the mineralization process. Proteins further determine the direction of mineralization, the dimensions and structure of minerals, and the process of mineralization itself. This paper discussed the properties of various bone tissue proteins (collagen, enameline, fibronectine, osteocalcine) and their role in various stages of the mineralization process. The possibility of using electron microscopy to analyze the protein and mineral components of bone tissue after space flight was stressed.

A paper by P. Birembaut and J.J. Adnet (Maison Blanche Hospital, Rheims), "Morphology of the extracellular matrix," cited the results of an immunohistochemical study of the proteins of the interstitial substance of bone tissue, in particular fibronectine, which is of considerable interest because of its participation in the response of immune system cells to pathological processes.

In the session devoted to erythrocytes, considerable attention was devoted to discussion of the function, metabolism, and structure of erythrocytes of humans and animals subjected to long-term hypokinesia with head-down tilt, which to some degree reproduces the hemocirculatory and hematological phenomena of weightlessness. A paper by V.I. Lobachik, A.S. Ushakov, and S.M. Ivanovna (Institute of Biomedical Problems, Moscow) entitled "Study of the functioning, structure and metabolism of erythrocytes in humans and animals exposed to hypokinesia," demonstrated the presence of phases (cyclical changes) in the volume of blood, plasma, erythrocyte mass, hemoglobin, rate of glycolytic processes, and erythrocyte resistance during

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120- and 182-day periods of hypokinesia with head-down tilt in humans. Rats undergoing a 60-day period of hypokinesia displayed decreases in titre of erythropoietin in blood plasma and depression of biosynthetic processes in bone marrow cells. A number of papers heard at the session concerned methodological aspects of the study of erythrocytes. The use of study of the lifespan of erythrocytes using ^{51}Cr, the use of ^{59}Fe in low background chambers for investigating erythropoiesis, and also attempts to apply mathematical modeling of blood circulation were demonstrated in a paper by J. Valeyre (Anticancer Center Hospital, Rheims), "Problems in the study of blood mass and erythrocytes." G. Potron (Debres Hospital), in a paper on "Rheological investigations in hematology" presented an extensive analysis of methods for studying the structure of erythrocytes, and also hematocrit and such rheological properties of blood as viscosity and fluidity. To evaluate the state of erythrocyte structure, the author suggests using water solutions varying in osmolarity and passing the erythrocytes through the pores (up to 5 u in diameter) of a metal or teflon filter. Human blood has optimal rheological properties when hematocrit equals 35.9; however, this conclusion applies only to bed rest.

At the session devoted to analytical methods, J. Bisonte's (Biocom Society) paper demonstrated the capabilities of a new apparatus microvideophotography of tissue culture cells. The apparatus is compact in size and weight, is automatic, and records the image of culture cells on magnetic tape in the form of a digital record. It can be modified for use on a space station, to study the effects of weightlessness on tissue cultures.

The results of a search for optimal conditions for studying biological subjects with electron microscopes were presented by P. Bonhomme (University of Rheims) in his report on the "Newest methods of electron microscopy." He proposes that electron beams, exposure time, and width of the sections all be reduced in order to improve the storage characteristics of cellular structures in ultrafine cross-sections of tissue undergoing electron microscopy. He also proposes to place the section on a slide without backing and to cool the samples being studied.

The method for reconstructing the ultrastructural organization of cells using computer processing of electron microscope generated images proposed by Y. Epelboin (P. and M. Curie University, Paris), in a paper entitled "Three-dimensional reconstruction of biological subjects," is very promising for the analysis of intercellular interactions. Using examples drawn from the analysis of various biological subjects, he described the results of a search for ways to increase the method's accuracy and information content. Epelboin demonstrated the possibility of using 3-dimensional interactions between cytoplasmic lymphocytes and target cells under conditions of altered gravitational force.

The session devoted to "Biological models" included two papers, "Sensitivity of marine animals to gravity" by J. Soyer (P. and M. Curie University, Paris) and "A living model for studying the sensitivity of cells to gravitation" by C. Delettrex, P. Duie, M. Bouteille (MATRA Society) which demonstrate that sea worms (Convoluta Roskofensia), native to Brittany, can be used as subjects in the study of the effects of weightlessness. The advantage of these creatures are their small size (less than 4 mm), their symbiosis with seaweed which allows oxygen to be regenerated in the medium when the aquarium is illuminated, the worms' reaction to changes in gravitational force by changing the position of its body in space, and the possibility of rapidly fixing the worm for electron microscopic cytochemical study of the statocyst, statolith, and neurons fed by the statocyst. A paper by J. Bureau, G. Geraud, and M. Bouteille (Institute of Biomedical Research, P. and M. Curie University, Paris), presented jointly with W. Briegleb (Institute of Aviation Medicine, Koln, FRG), "A cellular model of hypergravity and simulation of microgravity," described an attempt to clarify the relationship between proliferation rate and level of gravity, and gave rise to a lively discussion. According to the authors' data, the cells of the AM-2 hybridoma proliferated 3.5 times more slowly under the influence of gravity of 2-, 4-, 6-, and 8-g, than under Earth's normal gravity. At the same time, the effect of reduced gravitational force caused by clinostatting also reduced the growth of the cells.

The high scientific level and good organization of the symposium are worthy of note. The results of the experimental research presented represent significant contributions to the development of our ideas about gravity, and particularly weightlessness, on the structure, metabolism and functioning of human, and animal cells.

The symposium demonstrated the successful development of Soviet-French cooperation in space cytology and the productivity of joint research, the results of which are of great significance for the solution of theoretical and practical problems facing space biology and medicine.

COSMONAUT TRAINING

MONOGRAPH:

M114(13/87) Korchemnyy PA.
Psikhologiya Letnogo Obucheniya
[**Psychology of Flight Training**].
Moscow: Voyennoye Izdatel'stvo; 1986.
[136 pages; 5 tables; 5 figures; no references]

KEY WORDS: Cosmonaut Training, Flight Training, Pilots, Psychology, Human Performance

Annotation: This book discusses the most important issues related to initial training of student pilots, and provides the knowledge of aviation psychology necessary to the pilot trainer and flight crew involved in job training. Particular emphasis is given to understanding the student's personality and to ways of helping him master flight skills and develop the most desirable moral, political, and psychological qualities. This book is intended for flight and classroom pilot instructors, students in military flight schools, and aviation personnel in the Air Force.

CONTENTS

(Numbers in parentheses refer to page numbers in the original.)

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DEVELOPMENTAL BIOLOGY

(See also: Botany: P568; Cytology: CR6)

PAPERS:

P561(13/87)* Serova LV.
The mother-fetus system in the study of the mechanisms underlying the physiological effects of weightlessness.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(3): 63-66; 1987.
[29 references; 10 in English]

Developmental Biology, Fetal Development; Reproductive Biology
Rats, Female, Pregnant
Space Flight, Cosmos 1514; Adaptation; Genetics

Abstract: This theoretical article discusses the objectives and findings of experiments exposing pregnant mammals (in this case, rats) to space flight conditions. At one level, the stress placed on the mother by pregnancy is seen as a kind of ultimate provocative test providing information on the (possibly hidden) price exacted by adaptation to weightlessness. Pregnancy is viewed as necessitating the mobilization of reserves and stressing all regulatory systems, while at the same time making additional demands on individual organs and systems (e.g., bone tissue, hemopoietic system) which have been shown to be adversely, but reversibly, affected by space flights. Experiments related to the flight of 5 pregnant rats onboard the "Cosmos-1514" biosatellite are described. On the basis of the overall results of these experiments researchers concluded that animals exposed to weightlessness are able to activate compensatory-adaptive processes and mobilize resources to provide the necessary conditions for fetal development. Although some general parameters of the mothers were markedly affected by space flight, virtually no changes were noted in the reproductive function, and only minor and reversible developmental delays occurred in offspring. Although these studies demonstrated that normal fetal development in mammals is possible when mothers are exposed to space flight during pregnancy, the possibility of serious adverse effects arising in individuals has also been demonstrated. These individual changes are attributed to cumulative genetic effects. The author concludes that identification of methods for preflight prediction of individual differences in reactions to weightlessness is an important area for future research.

P562(13/87)* Komolova GS, Makeyeva VF, Yegorov IA, Serova LV.

Nucleic acids in spleen lymphocytes of pregnant rats flown in space and their offspring.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(3): 66-69; 1987.
[7 references; none in English]

Developmental Biology; Hematology, Spleen Lymphocytes
Rats, Female, Pregnant; Neonates
Space Flight, Cosmos 1514

Abstract: This paper describes studies of the spleen lymphocytes of 10 female rats flown in space for 5 days during the third trimester of pregnancy. Vivarium and synchronous controls were used. Half of the rats were sacrificed immediately on landing (on day 18 of pregnancy) while the others were allowed to deliver at full term. The offspring of the latter group were studied on days 30 and 100 of their lives. Rate of synthesis of nucleic acids in spleen lymphocytes was estimated on the basis of inclusion of radioactive precursors in DNA (5-methyl-^{3}H-thymidine), and RNA (5-^{14}C-uridine). Radioactivity of nucleic acids was computed using DNA, while their concentration was determined using spectrophotometry.

Synthesis of DNA in spleen lymphocytes was reduced in flight animals by a factor of almost 2 compared to the vivarium control, while the synchronous control did not differ significantly from the latter. Comparison of present results with those from non-pregnant rats exposed to weightlessness or hypokinesia led the authors to conclude that pregnancy does not materially affect the stress reaction to space flight conditions on the part of the DNA synthesis system. Offspring of experimental rats did not show depressed DNA synthesis at either period studied. RNA synthesis was elevated in flight rats compared to both control groups. RNA/DNA ratio in the cells studied increased by more than a factor of 2. Offspring aged 30 days showed normal RNA synthesis, while RNA synthesis in 100-day-old offspring was depressed by 28% relative to the vivarium control. However, RNA was also depressed in the synchronous control group and thus the flight results can possibly be attributed to generalized stress on the mother. The authors conclude that heightened RNA synthesis in spleen lymphocytes of pregnant rats in response to space flight has the effect of maintaining flexible homeostasis in the fetus.

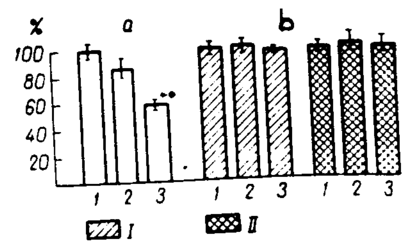

Figure 1: Inclusion of ^{3}-thymidine in DNA of spleen lymphocytes of rats (1) and their offspring (2).
Here and in figure 2: I and II - offspring aged 30 and 100 days, respectively; 1 - vivarium control, 2 - synchronous control, 3 - flight group. Stars and circles indicate statistically significant differences from vivarium and synchronous control groups, respectively.

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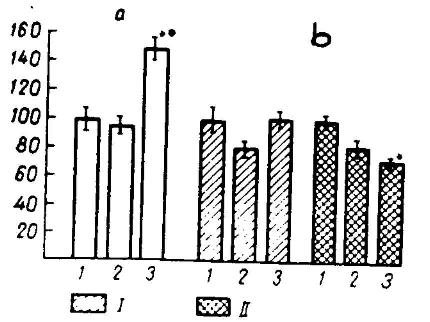

Figure 2: Inclusion of ^{14}C-uridine in RNA of spleen lymphocytes of mother rats (1) and their offspring (2).

ENDOCRINOLOGY

(See also: Cardiovascular and Respiratory Systems: P559; P578; Space Medicine: P574, M112)

PAPERS:

P554(13/87)* Tigranyan RA, Kalita NF, Kiseleva TA, Ivanov VM, Kolchina YeV, Afonin BV.
Hormonal responses of cosmonauts to short-term space flights.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(3): 32-35; 1987.
[10 references; 4 in English]

Endocrinology, Hormones; Psychology, Stress
Subjects, Cosmonauts
Space Flight, Soyuz, Soyuz-T

Abstract: Subjects for this experiment were 17 cosmonauts who had participated in 7-day space flights on the Soyuz and Soyuz-T spacecraft. Venous blood and daily urine were analyzed pre- and postflight. Blood was taken 30-40 days preflight and 1 and 7 days postflight. Urine was collected on days 30, 29, 28, 5, 4, and 3 preflight and immediately after landing and during the first 5 days postflight. Blood was analyzed using RIA for concentration of: ACTH, aldosterone, thyrotropin (TSH), thyroxin (T_4), triiodothyronine (T_3), testosterone, adenosine cyclic phosphate (cAMP), cyclic guanosine monophosphate (cGMP), prostaglandins (PG), pressor (PG F_2-α) and depressor (PG A+E) groups, as well as activity of renin in plasma. In addition, parameters providing information about activity of kallikrein-kinin (initial arginine-esterase activity, concentration of prekallikrein, and activity of its inhibitor), coagulation (concentration of prothrombin and activity of its inhibitor), and fibrinolytic (concentration of plasminogen and activity of its inhibitor) systems were measured 1 day postflight. Concentration of aldosterone in urine was measured by RIA, while excretion of total 17-hydroxycorticosteroids (17-OHCS) was determined on the basis of reactions with phenylhydrase.

Changes in the ratio of pressor and depressor prostaglandins, and elevated ACTH in blood, which is indicative of emotional stress, occurred preflight, Renal excretion of 17-OHCS was also elevated. On days 1 and 7 postflight, the only sign of activation of the pituitary-adrenal cortex system was an increase of blood hydrocortisone. However, ACTH concentration and excretion of 17-OHCS, while not above preflight levels, exceeded the norm. On day 1 postflight, signs of activation of the renin angiotensin-aldosterone system were noted (increased renin activity in plasma, increased aldosterone in blood and urine). Increased insulin in the blood postflight testified to stimulation of the β- cells in the pancreas. A significant increase in cAMP in the blood during the first day of readaptation was also noted. The ratio of pressor to depressor prostaglandins was elevated on day 1 postflight, due to a decrease in the latter. Decreased prekallikrein and increased arginine-esterase activity demonstrated increased activity of the kallikrein-kinin system postflight. All other parameters measured did not differ significantly from preflight levels. The authors attribute the effects of space flight to a moderate stress reaction, engendered by the need to maintain homeostasis in weightlessness. No indications of major changes in regulatory systems were observed immediately postflight.

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Table 1: Concentrations of hormones and biologically active substances in the blood of cosmonauts

Parameter	Day 30 preflight	Day postflight 1	7
ACTH, pg/ml	50.48	60.53	71.90
Hydrocortisone, ug%	12.39	20.39*	20.85*
Renin, ng/ml·hr	2.25	4.30*	2.26
Aldosterone, pg/ml	46.8	80.0*	57.7
Insulin, uunits/ml	11.46	15.17*	20.09*
TSH, uunits/ml	1.60	1.56	1.24
T_4, ug %	7.18	8.65	8.41
T_3, ug %	148.5	161.2	122.3
Somatotropin, ng/ml	1.81	2.08	2.76
Testosterone, ng %	579.6	563.3	516.6
cAMP, pmole/ml	14.7	31.1*	13.2
cGMP, pmole/ml	4.2	6.7	4.5
PG A+E, ng/ml	2.37	1.34*	2.14
PG $F_2 - \alpha$, ng/ml	1.95	0.62	0.82

* Here and in tables 2 and 3, indicates differences significant compared to preflight levels

Table 2: Renal excretion of steroid hormones in cosmonauts

Parameter	Days preflight 30	3-5	On Landing	Days postflight 1	2	3	4	5
Total 17-OX, mg/day	7.44	6.99	5.24	8.13	6.94	7.29	5.99	6.41
Aldosterone, ug/day	12.6	16.6	14.4	20.8*	18.7*	24.3*	20.3	14.2

Table 3: Activity of kallikrein-kinin, fibrolitic and coagulation systems in the blood of cosmonauts

Parameter	Day 30 preflight	Day 1 postflight
Initial arginine-esterase activity, mmole/ml·hr	3.86	5.44*
Prekallikrein, umole/ml· hr	62.3	49.1*
Kallikrein inhibitor, units	0.9	0.8*
Plasminogen, umole/ml·hr	66.7	63.6
Plasmin inhibitor, units	0.18	0.24
Prothrombin, umole/ml·hr	63.9	58.6
Thrombin inhibitor, units	1.08	1.02

ENZYMOLOGY: See Metabolism: P570; Musculoskeletal System: P572; Space Medicine: P574
EQUIPMENT AND INSTRUMENTATION: See Cytology: CR6; Neurophysiology: P567; Operational Medicine: P580; Space Biology: M113; Space Medicine: P573, M112
GASTROINTESTINAL SYSTEM: See Space Medicine: M112
GENETICS: See Cytology: CR6; Developmental Biology: P561

HABITABILITY AND ENVIRONMENTAL EFFECTS

(See also: Life Support Systems: P589: Neurophysiology: P556, P561; Space Biology: M113; Space Medicine: M112

PAPERS:

P571(13/87)* Pak ZP, Lobacheva GV.
Physiological and biochemical aspects of the toxic effects on humans of environmental (air, water) oxidants.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(3): 16-23; 1987.
[111 references; 59 in English]

Habitability and Environment Effects, Toxicity
Humans
Life Support Systems, Environmental Oxidants

Abstract: The use of chemical products containing oxidants is increasing both in ordinary terrestrial environments and in life support systems. The toxic effects of oxidants have been well documented. The major mechanisms through which these toxic effects occur is the stimulation of free radical processes -- interaction of oxidants with the majority of the biochemical components of cells, leading to degradation of molecules necessary for vital processes. Some of the toxic agents discussed are the superoxide radical (O_2); its byproduct, hydrogen peroxide; the hydroxyl radical, a product of reactions of the previous two compounds; and lipid peroxide radicals, products of the action of free radicals on unsaturated fatty acids in the presence of oxygen. Free radical processes lead to destruction of the membrane structures of cells, damage to thiolic compounds and protein structures, and inactivation of enzymes. Oxidant effects on the body include damage to blood cells, disruption of blood coagulation, changes in immune response and the histochemical structures of organs and tissues, and damage to the genetic apparatus of cells. Free radicals formed in the process of oxidation can accelerate the aging process. The number and variety of molecular and cellular structures sensitive to the effects of oxidants indicate that there are a large variety of natural and synthetic substances which have antioxidant properties. These include: ascorbic acid, sulfhydryl compound, tocopherols (especially, alpha-tocopherol), ubiquinone, certain steroid hormones, polyamines (spermidine, spermine), thiourea, arginine, -guanodinobutyric acid, GABA, EDTA, selenium, hydroquinone, ionol, naphthol, chlorpromazine, and caffeine. The mechanisms through which all these substances counteract oxidants' toxicity are not sufficiently clear. Because it is difficult to chemically identify microquantities of oxidants and their byproducts in the environment, the authors recommend testing of biological subjects for oxidant effects in the development of new means of protection against these effects.

P586(13/87) Zaloguyev SN.
Human habitability conditions on the space station: Major goals of the sanitary and hygienic studies; Microclimate and atmosphere of the cabin.
In: Gurovskiy NN, editor.
Rezultaty Meditsinskikh Issledovaniy Vypolnennykh na Orbital'nom Nauchno-issledovatel'skom Komplekse "Salyut-6"-"Soyuz"
[Results of Medical Research Performed on the "Salyut-6"-"Soyuz" Space Station Complex.]
Moscow: Nauka; 1986. Abstract: Space Medicine: M112, this Digest Issue.
Pages: 36-39; [42 references; 3 in English (whole chapter)]

Habitability and Environmental Effects, Microclimate, Cabin Atmosphere; Life Support Systems, Thermal Regulation
Humans
Space Flight, Salyut-6

Abstract: The polymer materials used to build the "Salyut-6" space station were subjected to rigorous tests for flammability, toxicity, resistance to the effects of biological agents, and propensity to produce dust. During factory assembly and installation, a great number of measures were taken to prevent accumulation of dust and probable infectious agents. Particular stress was placed on germicidal and sanitary/hygienic measures during the last stage of preparation. Analogous measures were taken when the "Soyuz" and "Progress" spacecraft were being prepared. At the time the space station entered orbit, work on sanitary-hygienic measures for manned space stations had reached the phase of developing standards for acceptable levels of adverse factors under hermetic living conditions. Many problems were solved by laboratory studies using space station simulations. This allowed researchers to develop and recommend a wide range of sanitary, hygienic, germicidal, and housekeeping measures before the space station was manned. Prior to "Salyut-6," evaluation of sanitary and hygienic conditions was based solely on cosmonaut automicroflora and environmental microflora. However, for the "Salyut-6" this research was supplemented by studies of atmospheric parameters, accumulation of harmful chemical contaminants derived from metabolic products, polymer materials in the cabin's interior, and equipment. Studies were made of the development of microbial associations on various types of polymer materials in the cabin. A system was developed to provide the ground with information derived from continuous monitoring of atmospheric and microclimate parameters. Specifications were developed for the water provided to the cosmonauts, both onboard supplies carried from Earth and water regenerated by purifying atmospheric condensate. "Salyut-6" implemented the first set of set of sanitary and housekeeping measures developed specially for a space station. These included new measures for personal hygiene (this was the first time cosmonauts could shower in space), a broad range of devices for periodic cleaning of the cabin, and new technological devices for increasing the efficiency of the life support system.

Living conditions on a space station must be equivalent to the microclimate and atmospheric parameters of the Earth's atmosphere. To support the conditioning of the human thermal regulation system and decrease the time required for readaptation, it was considered desirable to create a variable microclimate with artificially created variations in temperature within acceptable limits.

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Comparative analysis of data gathered during the flights of the five prime crews showed that the diurnal differential in overall atmospheric pressure did not exceed the acceptable limits for a spacecraft cabin. Partial pressure of oxygen and carbon dioxide fell within physiologically acceptable levels (22-24 kPa and 0.133-0.320 kPa, respectively).

Mean microclimate parameters, for the 5 flights, as shown in Table 1, were virtually the same. Cosmonauts rated as "cold" or "cool" temperatures below 19°C with relative humidity above 70%. This suggests a considerable strain on the thermoregulation system, which the author attributes to changes in metabolism, external respiration, blood perfusion, and vascular tonus. As is predictable from the physiological effects of space flight, cosmonauts complained particularly of cold feet even when air temperature was optimal (20-22°C). The temperature cosmonauts rated as comfortable was 22-24° which is described as characteristic of preferences of people with low physical activity, those experiencing emotional stress, or in a state of hypokinesia. Studies conducted with a Czechoslovakian catathermometer showed that cosmonauts' perception of temperature differed from that of people on Earth. The heating panels were sources of atmospheric pollution with volatile products of incomplete combustion of the dust which had settled on them, and also, when the panels were made of polymers, of products of the gases they emitted. Increase in air temperature also increased gas emission from polymers used in the cabin interior. It was found that cabin temperature increased by 2 or 3° when cosmonauts were working with equipment or visiting crews were present. However, cosmonauts did not remark on this difference.

Table 1: Atmospheric parameters on the "Salyut-6" space station

Prime crew number	Flight duration, days	Temperature, °C	Relative humidity, %	Total pressure (P), kPa (mm Hg)
1	96	21.6	50-63	104 (790)
2	140	20.5	50-75	100 (760)
3	175	20.5	50-80	104 (790)
4	186	20.5	51-92	99 (753)
5	76	20.3	57-83	102.7 (780)

P586(13/87) Savina VP, Solomin GI, Mikos KN.
Human habitability conditions on the space station: Toxicological and hygienic description of the environment.
In: Gurovskiy NN, editor.
Rezultaty Meditsinskikh Issledovaniy Vypolnennykh na Orbital'nom Nauchno-issledovatel'skom Komplekse "Salyut-6"-"Soyuz"
[**Results of Medical Research Performed on the "Salyut-6"-"Soyuz" Space Station Complex.**]
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Pages: 39-43; [42 references; 3 in English (whole chapter)]

Habitability and Environment Effects, Atmospheric Toxins, Polymers, Metabolites; Life Support System
Humans, Cosmonauts
Space Flight, Salyut-6

Abstract: The first toxicological and hygienic task to be performed was to monitor the concentration of harmful contaminants using specially developed apparatus (with follow-up analysis of samples returned to Earth). In addition, the efficacy of the life support system had to be evaluated in order to maintain the atmosphere within limits necessary for ensuring maximum cosmonaut productivity.

Before construction of the space station a list of toxicologically safe polymers recommended for use was prepared, and a toxicological and hygienic evaluation of the apparatus for biological and technological experiments was made. Development of a technique for sampling and analyzing cabin air allowed analysis of the gas components of spacecraft atmospheres starting with "Soyuz-22." Much ground-based work was completed to develop techniques for sorption and desorption of harmful contaminants, in order to create a system of adsorbents to take in and concentrate volatile organic substances from the atmosphere of the inhabited cabin during various periods of flight. The space station carries a set of adsorbents containing the sorbent "Tenaks" and a small bellows hand pump. [In a test] 0.5 l of air was pumped through the adsorbent. This was sufficient to increase the set of contaminants by a factor of 15-25. The proportion of individual substances removed was previously established using artificial gas mixtures on Earth. Analysis of the samples was performed using gas chromatography in the laboratory. Substances were separated and identified with three chromatographic columns differing in polarity.

Since the various spacecraft systems and scientific equipment was not distributed uniformly throughout the station and a large number of experiments were performed during the flight, it was likely that air pollution varied throughout the work module. For this reason, air samples were taken at 3 points: in the area of the cosmonaut work stations (post # 1), near the exercise trainer, and in the transfer module. Based on the results obtained, recommendations were made for future flights to sample air in the region of post 1 and the trainer, and in some cases in the sleeping quarters and sanitary facility. Samples were taken approximately every 3 weeks. A total of 52 samples were taken throughout the station's operation.

Analysis of the material obtained by gas chromatography identified 30 organic substances, gases emitted by polymers and volatile metabolites, in the station atmosphere. However, the level of microcontaminant pollution

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of the station atmosphere during the tenure of the first prime crew (near post 1) substantially exceeded concentrations found in ground-based simulations using mock-ups. Major components of atmospheric pollution in the station included acetone, acetaldehyde, methanol, ethanol, n-butanol, isobutanol, ethyl acetate, toluyl, and m- and n-xylylol. Aside from these, the station atmosphere contained aliphatic hydrocarbons and sometimes n-propanol, isopropanol, propyl acetate, butyl acetate, ethyl benzol and others. Methylethylketone and diethylether were found only rarely and in insignificant quantities.

Data indicated that, first of all, air pollution levels differed at different locations on the space station and, second, that concentrations of harmful contaminants were higher in the early months of the flight. (See Figure 1) The latter result suggests that the outgas rate from nonmetallic materials decreases over time and that the atmospheric purification equipment was working well. The level of volatile metabolites in the space station atmosphere remained relatively stable. Near the exercise machine, which was also close to the working area, there was no tendency for the concentration of acetone to decrease. This concentration fluctuated between 3.0 and 7.7 mg/m^3. In general, although pollution tended to decrease, there was substantial variation. Certain organically generated toxins, (e.g., acetone and ethanol) increased over the flight. Thus, during the flight of the fourth visiting crew, the concentration of acetone near the trainer rose on day 32 from 0.9 to 14.0 mg/m^3, and of ethanol from 1.8 to 14.0 mg/m^3. On day 88 acetone rose from 3.6 to 18.4 and ethanol from 3.0 to 12.4 mg/m^3. These changes were associated with installation of equipment brought by "Progress." Ground experiments have established that human emission of acetone in respiration is associated with physical exertion. The fact that the equipment brought on "Progress" was made of "fresh" polymer also contributed to the high levels of acetone and ethanol. Two weeks after "Progress" returned to Earth, acetone and ethanol had decreased in the atmosphere. Levels of air contaminants found on "Salyut-6" are similar to "Skylab" results. Recommendations about the operating schedule of the filter system were made on the basis of the studies performed.

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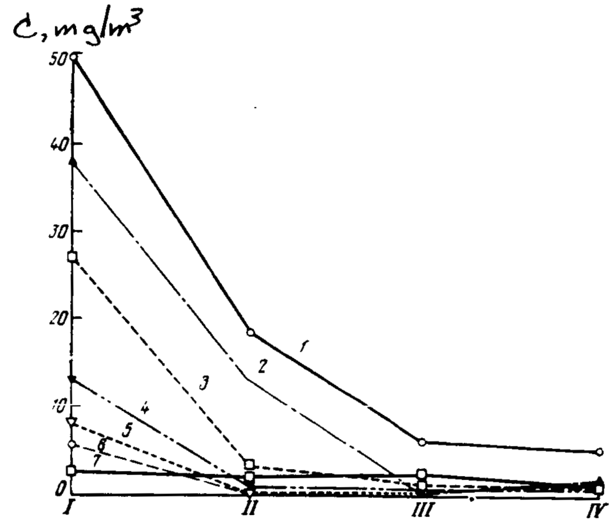

Figure 1: Concentration of harmful contaminants (C) in space station (near post # 1) atmosphere during occupation by prime crews (I, II, III, and IV) 1 - acetone; 2 - ethylacetate; 3 - n-butanol; 4 - methanol; 5 - toluyl; 6 - xylene; 7 - acetaldehyde.

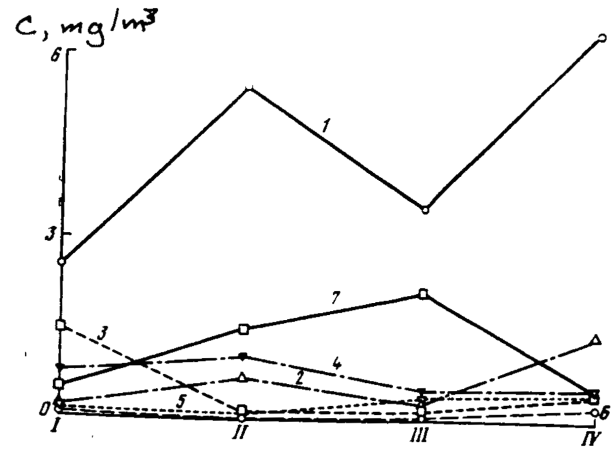

Figure 2: Concentration of harmful contaminants in the space station atmosphere during the tenure of the 4 prime crews. Key as in Figure 1.

P588(13/87) Zaloguyev SN, Viktorov AN, Gorshkov VP, Novikova ND.
Human habitability conditions on the space station: Sanitary/Microbiological description of the environment.
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Rezultaty Meditsinskikh Issledovaniy Vypolnennykh na Orbital'nom Nauchno-issledovatel'skom Komplekse "Salyut-6"-"Soyuz"
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Pages: 43-46; [42 references; 3 in English (whole chapter)]

Habitability and Environmental Effects, Sanitation; Microbiology; Life Support Systems
Humans, Cosmonauts; Microbiology, Microflora, Bacteria, Fungi
Space Flight, Salyut-6

Abstract: Germicidal and sanitary measures taken on the space station were based on the results of a substantial amount of research on the microbial environmental in hermetic quarters inhabited by humans. Preflight measures were taken to preclude infectious diseases and foster hygienic conditions, including preventing dust from gathering in the quarters. Just before launch the interior surfaces of the space station were disinfected. During its flight the station interior was periodically cleaned with disinfectants. This, in addition to the continuous operation of the air filtration system, ensured epidemiological safety throughout the flights of all crews.

The flight of "Salyut-6" represented an increase in the duration of manned space flight and, during visits of the international crews, and an increase in the number of individuals present on a station. Therefore, it was considered appropriate to study the amount and species of microflora in the station atmosphere and interior surfaces, and also in the cosmonauts' noses and mouths and on their skin, as well as the nature of exchange of microorganisms among members of the prime and visiting crews.

One of the new types of studies performed on this flight involved identification of the conditions under which microorganisms accumulated on various polymer materials. Human automicroflora may survive and even multiply on the surface of polymers. The basic experimental apparatus used to study the quantitative and species distribution of microflora were the "air sample collector" and the "test-tube case." The validity of the data obtained with this apparatus had been confirmed in previous ground-based studies. Pre- and postflight studies of microflora on the mucous membranes of the nose, mouth, and fauces and the skin of crew members were performed using multiple sampling.

Changes in composition of automicroflora of the upper respiratory tract during flight mainly involved the appearance of microorganisms on the mucous membrane which are not normally present in healthy individuals. These microorganisms belonged to the conditionally pathogenic species -- Staph. aureus, beta-hemolytic Streptococcus, Enterobacter-Kelibsiella sp., and Pr. Mirabilis, which are capable of causing infectious diseases in humans. In some cases staphyloccus bacteria were passed among crewmembers, who became temporary carriers of these bacteria in their respiratory tracts. A diagram of this process is presented below. These results show that prime crewmembers can easily be infected as a result of contact with visiting

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crewmembers who are healthy carriers of pathogenic microflora. This must be considered when measures are taken to prevent infectious diseases on space stations.

Diagram 1: Appearance and spread of pathogenic staphylococci (III phagogroup, phagotype 6/47, toxicity 1:1280) among the members of visiting crews (VC) 1 and 4 and prime crew (PC)

Commander VC-1
---Pre- and postflight in upper respiratory tract ---
(10^3-10^4 cells)

Flight engineer PC
On day 54 and post flight ------>

Commander PC
On day 169 and postflight
(10^3 cells) (10^3-10^4 cells)

Payload specialist VC-4
-------> On day of landing and day 3 postflight <-----
(10^6-10^4 cells)

The microflora found on nonmetallic materials was mainly composed of constant inhabitants of the human upper respiratory tract and skin and also nonpathogenic Neisseria and conditionally pathogenic bacteria:

Bacteria	Fungi
Staphylococcus	Aspergillus
Corynebacterium	Penicillium
Neisseria	Fusarium
Bacillus	Mucor
Enterobacter	Cladosporium
Klebisiella	Rhodotorula
Moraxella	Rhizopus
Pseudomonas	
Proteus	
Aeromonas.	

In addition, gram-negative bacteria of the families *Aeromonas, Acinetobacter, Moraxella*, and gram positive spore-forming organisms of the family *Bacillus* were found periodically.

Substantial numbers of fungi spores were found growing on nonmetallic surfaces, particularly where moisture could accumulate. Of the species listed above *Penicillium* and *Aspergillus* were the most common. Conditionally pathogenic species (*Rhizopus oryzae, A. niger, A. oryzae, P. lanosum*) were also found. These species could cause disease in humans with depressed immunological defenses. The majority of fungi found are active producers of enzymes and organic acids, which can cause damage to polymer materials.

P589(13/87) Zaloguyev SN, Viktorov AN, Shumilina GA, Kondrashova VN.
Human habitability conditions on the space station: Sanitation and housekeeping.
In: Gurovskiy NN, editor.
Rezultaty Meditsinskikh Issledovaniy Vypolnennykh na Orbital'nom Nauchno-issledovatel'skom Komplekse "Salyut-6"-"Soyuz"
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Pages: 46-50; [42 references; 3 in English (whole chapter)]

Habitability and Environmental Effects, Personal Hygiene, Cabin Maintenance; Life Support Systems
Humans, Cosmonauts
Space Flight, Salyut-6

Abstract: Sanitation and housekeeping for long-term space flights can be defined as a set of measures designed to facilitate cosmonaut personal hygiene and to support optimal living conditions, including the disposal and subsequent preservation or processing of wastes, periodic cleaning of living quarters, regular removal of dust and microorganisms, etc., from the air. In the first generation of personal hygiene systems used on the "Vostok," "Voskhod" and "Soyuz" and also on US "Mercury," "Gemini," and "Apollo" flights, only dry and wet wipes were used for personal hygiene. The second generation system, used on "Skylab," had no limits on weight, size, and power, such as those imposed on previous systems. However, the basic means of hygiene remained the moistened wipe. A shower was available but astronauts used it only occasionally because of its inconvenience. Water used for personal hygiene was not regenerated. A 10% solution of hydrogen peroxide was used for cleaning the cabin interior. A special air purification system was used.

On "Salyut-6" cosmonauts maintained personal hygiene by use of moist wipes and moist and dry towels (made of antimicrobial gauze and tricot). A portion of these were moistened with a special hygienic lotion. The wet and dry wipes were used every day for the hands and face. The wet and dry towels could be used once a week for cleaning the whole body before changing underwear. However, the cosmonauts preferred to use the wet towels daily, especially after physical exercise. Along with the tricot towels, the transport craft brought the prime crew two moist towels made of an antimicrobial honeycomb fabric. The crew were asked to compare the two towels and select the most acceptable. Laboratory tests of the absorbency of various fabrics (linen, terry cloth, honeycomb) showed that terry cloth was the best. The third prime crew was given terry cloth towels in addition to the types described above.

Ground tests showed the shower procedures developed for the space stations to be highly effective. These procedures involved the use of a cleansing agent made of a combination of catamin?? AB and amine oxide. Examination of the skin for microorganisms, lipid concentration and rate of secretion, showed no adverse changes after showering either in hermetically sealed living quarters or under normal conditions. System development involved selecting water and air temperature, mean expenditure of water per shower, etc. Medical and engineering tests of the system showed that it was fully satisfactory for the parameters selected and used no more than 10 liters of

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water. Cosmonauts who had tried the system on Earth stated that its use in weightlessness had its own peculiarities associated with the distribution of water in the shower stall and on the body. A honeycomb weave towel was used for drying after a shower. Cosmonauts of the fourth prime crew could shampoo their hair in a special device brought to the station.

Microbial studies performed during the station's flight, showed no increase in total number of microbes on the cosmonauts' skin, nor in species distribution, demonstrating the utility and efficiency of the hygienic measures used.

For oral hygiene, cosmonauts used: 1) toothbrushes; 2) wipes of viscous tricot for the mouth, massage of the gums, and cleaning of the toothbrush after use; 3) chewing gum, intended to clean the mouth after eating and strengthen the gums; 4) toothpicks. The most beneficial measure was use of toothbrushes with paste or liquid, but this procedure was not always used because of the difficulty of disposing of used toothpaste. This created the need for the chewing gum combined with the moist wipes, which were recommended along with toothpicks and floss. Hair care was accomplished with metal comb and massage brush. Razors were equipped with a device to vacuum up the hair.

The majority of effective available disinfectants are inappropriate for manned spacecraft because of potential harm to the body or incompatibility with the life support system. It was established preflight period that good antimicrobial effect (bactericidal and fungicidal) could be achieved with chemical prophylactic disinfection using a water solution of hydrogen peroxide and of catamin AB.

A set of mechanical and chemical techniques for disinfecting the cabin were used. These include diffused ultraviolet radiation and washing the interior surfaces with a water solution of catamin AB. These measures are said to be highly effective.

The cabin is dusted with a vacuum and wiped with special sanitizing wipes containing disinfectant. Wastes are placed in specially designed containers for disposal.

Additional research must be done to improve means of personal hygiene and water supply. Emphasis should be given to selecting the best fabrics for wipes and towels and also detergents and disinfectants. Small quantities of the substance selected should provide long-term antimicrobial effects that prevent multiplication of microorganisms when water is stored for long periods before input into the regeneration system.

HEMATOLOGY

(See also: Cytology: CR6; Developmental Biology: P562; Space Medicine: P574)

PAPERS:

P565(13/87)* Ivanov KP, Chuykin AYe, Samsonov GV, Kuznetsova NP.
The role of hemoglobin's affinity for oxygen in [determining] the efficiency the respiratory function of the blood.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(3): 77-79; 1987.
[5 references; 1 in English]

Cardiovascular and Respiratory Systems, Respiratory Efficiency
Rats
Hematology, Hemoglobin, Oxygen Affinity

Abstract: Experiments were performed on 18 anesthetized male rats. Gradual (staged) isovolemic replacement of the animal's blood with one of two artificial oxygen-carrying blood substitutes was performed by peristaltic pumping. The first solution had an enhanced affinity of hemoglobin to oxygen P_{50} =12.5 mm Hg and concentration of hemoglobin 8.0 g $\pm$ 0.7 g per 100 g blood substitute. The second showed low affinity -- P_{50} = 21.0$\pm$0.5 mm Hg, 4.4$\pm$ 0.6 g per 100 ml. Rate of replacement during each stage was 0.3 ml/min. Measurements of oxygen consumption, minute volume of blood, concentration of oxygen in arterial and mixed venous blood, difference between concentration of oxygen in arterial and venous blood, and oxygen pressure in mixed venous blood were made during a baseline period and 20 minutes after each stage (45%, 74%, 90%, 97%) of replacement. In addition, curves of dissociation of oxyhemoglobin in whole blood and the 2 solutions were plotted before and after replacement. Each session lasted 3 hours; 8 rats received solution 1 (group 1) and 10 solution 2 (group 2).

After 90% replacement with the high affinity solution, overall consumption of oxygen decreased by approximately 30%. After 97% replacement 6 animals died, but the 2 remaining showed a 50% decrease in oxygen consumption. Minute volume in these animals increased by 44% after 45% replacement, and then decreased. In the second group, replacement of blood did not change oxygen consumption; however, minute volume increased up to 204% at 97% replacement. At all stages of replacement, oxygen concentration was higher in the blood of group 1 animals than in group 2 animals. Thus, the first solution led to more efficient respiratory function of the lungs. However, low P_{50} causes pO_2 to decrease and oxygen to diffuse from the blood into the tissues, thus worsening blood supply to the latter. Solution 2 had half the oxygen capacity of solution 1, but this was completely compensated by a shift in the oxyhemoglobin dissociation curve to the right. The first solution shifted the dissociation curve to the left, worsening supply of oxygen to the tissues, particularly the myocardium. Decrease in the strength of the myocardium and minute volume of blood further worsened oxygen supply to the tissues, decreasing oxygen consumption and leading to a sharp decrease in pO_2 in venous blood.

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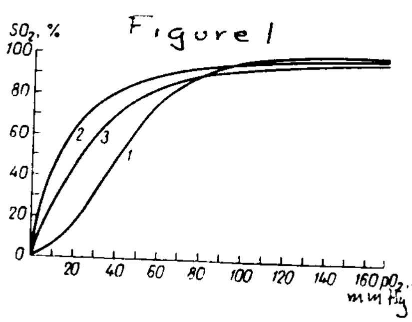
Table: Parameters of overall gas exchanges and oxygen transport in rats undergoing isovolemic replacement of the blood by two solutions of modified hemoglobin

Parameter	Gp	Baseline	% replacement of blood 45%	74%	90%	97%
Oxygen consumption, ml/100 g/min	1	1.31	1.57	1.48	1.15	0.7*
	2	1.44	1.59	1.50	1.44	1.40
Minute volume ml/100 g/min	1	25.9	37.4	35.2	28.3	16.8*
	2	32.7	38.5	52.6	60.7	67.0
% O_2 in arterial blood	1	15.3	12.6	8.7	7.3	6.4*
	2	15.8	11.6	7.8	5.4	5.0
% O_2 in mixed venous blood	1	10.0	8.4	5.2	3.9	2.7*
	2	11.2	7.4	5.0	3.1	2.9
Difference in % O_2 between arterial and venous blood	1	5.3	4.2	3.5	3.4	3.8*
	2	4.6	3.9	2.8	2.3	2.1
pO_2 in mixed venous blood, mm Hg	1	45.4	38.5	27.2	15.2	9.3*
	2	46.3	38.3	38.7	28.6	24.3

* n = 2



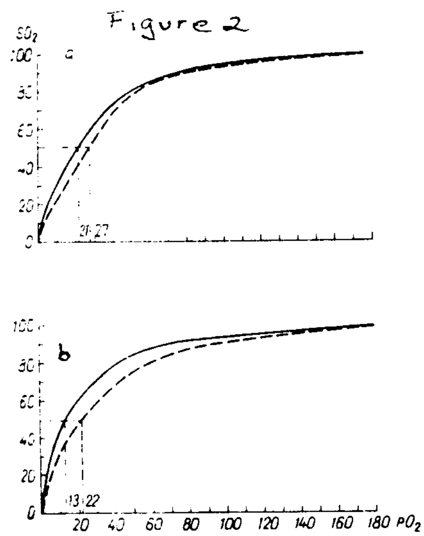


Figure 1: Dissociation curves of oxyhemoglobin in whole blood (1) of rats and solutions of modified hemoglobin with high (2) and low (3) O_2 affinity

Figure 2: Dissociation curves of oxyhemoglobin in a mixture of blood and modified hemoglobin after partial isovolemic replacement of blood in rats. a - after 74% replacement; b - after 90% replacement; solid lines - solution 1, dotted lines - solution 2.

P569(13/87)* Andreyeva OI, Pukhov VV, Daniyarov SB.
Differentiation of stem hemopoietic cells during adaptation to high altitudes.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(3): 90-91; 1987.
[5 references; 3 in English]

Hematology, Stem Hemopoietic Cells, Differentiation
Mice
Adaptation, High Altitude

Abstract: Experiments were performed on 156 mice. Differentiation of stem hemopoietic cells were studied by the method of splenic exocolonies. Donors were mice sacrificed on days 3, 7, 14, and 30 of adaptation to high altitude (3200 m). After sacrifice, bone marrow was removed from the femurs, put into a suspension and injected into the tail vein of the subject mice. Immediately before injection these mice had been given a lethal dose of gamma radiation (^{137}CS, 10.0 Gy). Each subject received the marrow of 5 donors. On day 8 after injection subjects were sacrificed, their spleens fixed and cross-sections 4 um thick prepared and stained. Differentiation of stem hemopoietic cells was estimated by counting hemopoietic microcolonies of various types in 3 samples from each spleen. There were 8-10 subjects for each period of adaptation. Number or erythrocytes and leukocytes had been counted in the donors at various stages of adaptation. A control group of donors was used.

In mice receiving marrow from donors at sea level, stem hemopoietic cells predominantly differentiated into cells of the granulocytic series. There were fewer erythroid and megakaryocytic colonies and still fewer mixed colonies. Adaptation to high altitude for 3 days decreased the number of erythroid and megakaryocytic colonies and increased the number of mixed colonies by a factor of nearly 5. Number of colonies on the surface of the spleen decreased when donors underwent adaptation to high altitude.
Blood of high altitude donors contained more erythroid cells than that of low altitude donors. The authors attribute this finding to the action of erythropoietin not on the stem hemopoietic cells, but on differentiated precursor cells. The decrease in megakaryocytic colonies is considered a consequence of decreased demand for platelets because of hypocoagulative shifts during high altitude adaptation.

Table: Differentiation of stem hemopoietic cells in the spleens of irradiated recipients (mice) and changes over time in blood elements of mice adapting to high altitude

HUMAN PERFORMANCE: See: Cosmonaut Training: M114; Neurophysiology: P561; Space Biology: M113; Space Medicine: P573, P574, M112; Perception: P582, P583; Psychology: P581

IMMUNOLOGY

(See also: Cytology: CR6; Space Biology: M113; Space Medicine, P574)

PAPERS:

P575(13/87) Kut'kova ON, Kuznets YeI, Yakovleva EV, Shal'nova GA, Bobrov AF, Yastrebov PT, Nevinnaya AD, Utekhin BA.
Changes in immunological protection factors in humans undergoing simulated weightlessness.
In: Trudy XVIII-XIX chtenii, posvyashchennykh razrabotke nauchnogo nasledii i razvitiyu idei K.E. Tsiolkovskoga, Kaluga: 1983, 1984.
[Papers from the XVII and XIXth lectures dedicated to the development of the scientific heritage and further advancement of the ideas of K.E. Tsiolkovskiy, Kaluga: 1983-1984].
Space Biology: M113; this Digest issue.
Pages: 40-45.
[7 references; none in English]

Immunology, Cellular and Humoral Immunity Parameters
Humans
Hypokinesia, Head-down Tilt; High Temperatures

Abstract: The objectives of this experiment were study of shifts in the immunological system during exposure to hypokinesia and head-down tilt and high temperatures, and to select sensitive immunological methods for evaluating thermal tolerance of humans exposed to hypokinesia. In the first part of the experiment, unclothed individuals were exposed to a temperature of 50°C until their rectal temperature had risen by 1°. After a period of 1-3 days the same individuals were placed in a head-down tilt position (-8°) for 1 to 7 days. They were again subjected to the thermal procedure while remaining in head-down position. After this, subjects were returned to normal conditions and observed for 7 days. Three types of immunological parameters were studied during this period: 1) cellular immunity parameters - phagocyte activity of neutrophils (PAN); level of spontaneous agglutination of leukocytes (SAL) and number of T- and B-lymphocytes; 2) humoral immunity parameters - lysosome titer in saliva (LTS), activity of beta-lysines, bactericidal activity of blood serum (BABS), titer of A, M, and G immuno globulin; 3) destructive changes - reactions to C-reactive proteins (CRP).

Hypokinesia with head-down tilt lasting 1 or 2 days combined with heat had no effect on immunological parameters. Exposure to heat affected (not specified how) LTS, PAN, and SAL both immediately after the exposure and on the next morning. Hypokinesia with head-down tilt decreased PAN and LTS. The longer the hypokinesia period (3, 5, or 7 days) the more depressed were these parameters. Recovery occurred in the 7-day observation period only when hypokinesia lasted no more than 3 days. After 5 and 7 days of hypokinesia SAL increased, and increased further after the second exposure to heat. The authors state that this is not related to activation of cellular mechanisms as in the first exposure, but to development of autoimmune processes. This hypothesis is supported by the presence of

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destructive changes (positive reaction to CRP). After 5 and 7 days of hypokinesia the precipitation column grew to 2 cm. Level of beta-lysines, an indicator of adaptive restructuring, was elevated after 5 and 7 days of hypokinesia. T-lymphocytes were reduced from a baseline of 61.4% to 17.4% and 41.7% after heat exposure subsequent to 5 and 7 days of hypokinesia, respectively. Quantity of B-lymphocytes, immuno globulin titer, and BABS were not affected by any of the treatment conditions.

The authors conclude that the combined effects of 3-7 days of hypokinesia with head-down tilt and exposure to high temperatures depress immunological defense mechanisms. The longer the period of hypokinesia, the more profound the immunological shifts and the longer the period before recovery. The following factors are considered useful in evaluating the course of shifts in the immunological defense system under the influence of the independent variables studied: for cellular immunity, PAN, SAL, T-lymphocytes; for humoral immunity, TLS, and Beta-lysine activity; for destructive changes, response to CRP.

LIFE SUPPORT SYSTEMS

(See also: Cardiovascular and Respiratory Systems: P576; Habitability and Environmental Effects: P571, P586, P587, P588; Space Biology: M113; Space Medicine: M112)

PAPERS:

P591(13/87) Author not cited
Quails in space.
Translation of excerpts from article in Journal SELSKAYA ZHIZN' (Rural Life), 1987(3), pp. 127-128.

Life Support Systems; Nutrition, Eggs
Quails
CELSS

Scientists have estimated that quail eggs, smoke-grey with multicolored speckles, are richer in Vitamins A (150%), B_1 (280%), and B_2 (220%) than chicken eggs, and have four times the amounts of iron and potassium. They contain an ideal combination of amino acids and other nutrients, and also trace elements and biologically active compounds. Quail eggs are invaluable, for example, in child nutrition: they have no allergenic tendency.

It is not inappropriate to mention another characteristic of these remarkable birds. Unlike all the other members of the extensive feathered kingdom, the quail produces eggs which are absolutely sterile. Nature has completely protected the newly hatched grey chicks from bacterial, viral, and other diseases.

....

The productivity of quails is truly phenomenal. Each laying hen produces 270-280 eggs a year. Experts are hoping to increase this figure to 300. If we compare the weight of all the eggs laid by a quail in the year to her own weight, we find that the former exceeds the latter by a factor of 30! The chicken would have a long way to go to match this figure: the weight of the eggs she lays in a year is only five to six times her own weight. And here is yet another interesting fact about quail eggs. No matter how long they are kept they never spoil.

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Every year quail farmers raise four generations from every healthy, mature bird. This easily surpasses the records achieved by farmers working with such champion reproducers as chickens and rabbits. The quail begins to lay when she is 50 days old, "broiler" quails are ready to be eaten when they are 35 days old. The quail produces more meat for its feed than either the duck or the rabbit.

And here are yet more interesting facts of another type. Speaking metaphorically, the quail has already flown beyond the confines of the Earth. [Because of their sterility] her eggs have been used to determine the toxicity of lunar soil and in other space experiments. The meat is used in food products for cosmonauts. In the near future the cosmonauts will carry a mini-farm with them into space: these birds will furnish them with the freshest possible source of protein --- eggs.

P566(13/87)* Shikina MI, Sinyak YuYe, Chizhov SV, Kolesina NB.
An investigation of the effects of silver compounds on the microflora of water regenerated from atmospheric condensate in a hermetically sealed environment.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(3): 80-82; 1987.
[6 references; none in English]

Life Support Systems, Regenerated Water, Hermetically Sealed Environment
Microbiology, Microflora
Silver Compounds

Abstract: In an experiment where humans lived in a hermetically sealed environment, studies were performed on 1-day cultures of microorganisms extracted from atmospheric condensate and regenerated water from a sorption water supply system . Microorganisms included _Alcaligenes faecalis, Aeromonas hydrophylla, Staphylococcus epidermitus, Citrobacter freundii, Bact. E. coli_ and _Streptococcus faecalis_ were studied for comparative purposes. In one condition, each strain was cultured separately. Initial concentration was 10^4-10^5 microbes per ml, corresponding to their concentration in samples of water and condensate. In another condition actual regenerated water and condensate were used. Effects of various silver compounds (solutions of ionic silver, silver sulphate, and silver nitrate varying in concentration from 0.1 to 10 mg/l on the growth and development of microflora was investigated. The study lasted 4 days.

After 4 days, control cultures to which silver compounds had not been added showed no significant changes in microflora. All concentrations of silver sulphate led to virtually complete suppression of the growth of the bacteria in the samples with isolated bacteria. Rate at which this suppression occurred depended on strain of microorganism and concentration of silver compound, with silver ions being the most efficient. However, when samples containing atmospheric condensate were used, a dose of 0.1 mg/l of silver ions was not sufficient to fully suppress microbial growth. All doses over 0.5 mg/l of all compounds were sufficient to completely suppress growth; however, only doses over 1 mg/l were capable of preventing reactivation of growth within 3 days. Microflora in the water regeneration system were highly resistant to the silver compounds. The authors state that this results from the physical/chemical and bacterial composition of the treated products.

P578(13/87) Meleshko GI, Shepelev VA, Kordyum VA (USSR); Setlik I, Doukha (Czechoslovakia).

The effects of weightlessness on microorganisms and plants: One-celled algae.

In: Gurovskiy NN, editor.
Rezultaty Meditsinskikh Issledovaniy Vypolnennykh na Orbital'nom Nauchno-issledovatel'skom Komplekse "Salyut-6"-"Soyuz"
[**Results of Medical Research Performed on the "Salyut-6"-"Soyuz" Space Station Complex.**]
Moscow: Nauka; 1986. Abstract: Space Medicine: M112, this Digest Issue.
Pages 370-380. [41 references; 15 in English]

Life Support Systems, CELSS, Photoautotrophic Component, Growth Conditions, Interaction
Microbiology, Botany, Chlorella, Scenedesmus, Active and Inactive Cultures
Space Flight, Salyut-6

Abstract: This chapter describes experiments performed on one-celled algae on board one or more (not specified) of the international flights of "Salyut-6-Soyuz." The general conditions of the experiment are described as follows: simultaneous exposure of actively growing algae cultures and cultures in an inactive state; placing the seeded cultures in orbit while in an inactive state; monitoring the conduct of the experiment on board; delivery of both live material and material fixed at the landing site to the laboratory; simultaneous analysis of active and inactive cultures. The objective of this research was to study the initial effects of weightlessness on fundamental biological processes (growth, development, reproduction] in algae cells, and also the interactions of organisms within a culture. These basic research issues are related to the question of whether it is possible to create a biological life support system in space. In these experiments, Chlorella vulgaris strain LARG-1 was exposed in a monoculture, while Chlorella pyrenoidosa Q-11 (colorless mutant), Chlorella Kessler, Nebas (A-2) and Scenedesmus obiquus (A-16) were cultured together. Cultures were grown for 2 weeks before the experiment. Six experiments were performed lasting from 6 to 15 days. On the spacecraft the algae were maintained in heterotrophic conditions. Four ampoules with cultures and nutritive media were placed in the "IFS-2" device, consisting of a container with hermetically sealed chambers of acrylic plastic with a hydrophilic coating. The cultures were seeded in the medium onboard the station using a special apparatus which did not break the hermetic seal. Additional ampoules were left sealed with the cultures in an inactive state. After landing, some active cultures were fixed on site, and others were delivered at a temperature of $0^{o}C$ to the laboratory, along with the inactive cultures. Synchronous and vivarium controls were used. After the initial experiment, it was determined that use of the IFS-2 apparatus for the ground control groups was not comparable to its use in space, because in space the algae could grow on all internal surfaces of the apparatus, while on the ground growth was limited by gravity to the bottom surface. For this reason, subsequent experiments used the "Kyuveta" device in which the bottom surface was equal to the sum of all surfaces in the IFS-2. Parameters studied included: rate of growth (increase of number of cells, and dry matter, number of new cells); reproduction and development (proportion of mother cells in the population and autospores in the cells, cell dimensions); state of the population (relative number of dead cells and cell with reduced viability and also cells of various physiological ages). Algae cultures

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containing 10^5-10^8 kl/ml were studied. These cultures can be considered to be closed populations, so effects of weightlessness at the population level, as well as the cellular level can be considered.

In all experiments, cell growth was rapid in space, as shown in Table 57. In the longer experiments maximum number of generations was limited by the supply of oxygen in the apparatus. This can be seen in the curve of terminal density of suspended algae for experiments of different durations (Figure 40). Cell growth parameters were greater for the space-flown cultures than for the ground "IFS-2" cultures. But when the more comparable "Kyuveta" container was used on the ground, no significant differences were obtained. The difference in results with the two containers demonstrates that research at the cellular level of biological organization does not preclude erroneous conclusions concerning the role of gravity, which may be influencing the organism indirectly through cultivation conditions. Reproduction of the cells in space was normal, as demonstrated by the fact that the proportions of mother cells and autospores within cells were comparable to those in the control conditions. Distribution of cells by size (Figure 41), proportion of dead cells, and cells with decreased viability were all comparable to control conditions.

When the space culture was considered from the standpoint of population variables, it was found that the age structure of the population was comparable to that of the controls. Proportions of photosynthetically active and mother cells were also identical to those for ground cultures. Thus, no effects of weightlessness on algae cells was found over the course of 5 successive generations either at the cellular or at the population level.

When a mixed culture was studied, it was found that the flight culture had been contaminated with fungus, which is known to depress algae growth under the conditions used. Thus, growth was significantly below that of the uncontaminated ground culture. Relationships among the different cultures in the suspensions, were comparable for flight and ground cultures.

No effects of weightlessness were found on inactive cultures (Table 61). When cultures fixed at the landing site were compared to those transported to the laboratory at 0°C, it was found that growth continued under the latter condition. No effects of weightlessness were apparent in the characteristics of cell growth subsequent to landing.

The authors conclude that the use of one-celled algae as the photoautotrophic component of a biological life support system is promising. However, they caution that in spite of these results, the possibility remains of the accumulation of results not evident in a few generations of rapidly growing cultures.

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Table 57: Growth characteristics of algae in weightlessness (I) and ground conditions in the "IFS" (II) and "Kyuveta" (III) apparatus

Duration, days	Condition	Density, mln. kl/ml init.	Density, mln. kl/ml term.	Increase in no. of cells, %	Increase in dry subst. g/l	Increase in dry subst. %	Product. per day g/l	Product. per day mln. kl/ml	Number of generations
4	I	7.0	82.0	146	2.2	131	0.55	20.5	2.0
	II	7.0	56.0		1.7		0.42	14.0	1.5
6	I	1.4	89.0	247	3.2	228	0.53	15.0	3.0
	II	1.2	36.0		1.4		0.23	6.0	2.5
6	I	1.4	89.0	85	3.2	90	0.53	14.6	3.0
	III	1.2	105.0		3.6		0.59	17.3	3.2
9	I	1.7	103.0	117	3.7	123	0.42	11.3	3.0
	III	1.7	88.4		3.0		0.34	9.6	3.0
18	I	1.9	140.0	92	4.0	111	0.22	7.8	3.0
	III	1.9	152.0		3.6		0.20	8.4	3.2
15	I	7.5	184.0	92	4.5	110	0.30	11.8	2.4
	III	7.5	200.0		3.8		0.25	12.8	2.4
15	I	0.2	201.0	110	4.3	122	0.29	13.4	5.0
	III	0.2	183.0		3.5		0.23	12.2	4.9

Table 58: State of cultures in flight (I) and control (II) experiments

Duration, days	Condition	Number of Cells Dead, %	Number of Cells Viability Reduced, %	Cell size, um Mean	Cell size, um Range
6	I	0	8.5	5.71	2-12
	II	0	11.8	5.87	2-12
4	I	0	2.0	4.73	2-12
	II	0	2.5	5.17	2-12
9	I	0	2.0	5.11	2- 9
	II	0	3.0	4.80	2-12
18	I	0	3.0	5.32	2-10
	II	0	5.2	5.08	2-10
15	I	1.0	2.0	4.21	2- 9
	II	0.5	2.0	4.37	2-11
15	I	1.0	2.0	4.01	2- 9
	II	0	2.0	4.74	2-12

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Table 59: Age structure of algae population in flight (I) and control (II) conditions

Duration, days	Condition	Age Structure, % Autospores	Cells Mother	Photosyn. active
6	I	23.0	7.0	70.0
	II	14.0	6.5	79.5
4	I	24.0	8.0	68.0
	II	23.0	12.0	65.0
9	I	17.5	1.0	81.5
	II	33.8	2.0	64.2
18	I	23.0	5.0	72.0
	II	25.2	4.5	70.3
15	I	34.0	2.0	64.0
	II	35.5	2.0	62.5
15	I	37.0	2.0	61.0
	II	42.0	2.0	56.0

Table 60: Number and proportion of various types of algae in a mixed culture grown in weightlessness (I) and on Earth (II)

Condition	Duration, days	Density, mln. kl/ml	Number of duplications	Proportion of Types A-2	Q-11-1	A-16
I*	0	1.65		25.0	25.0	50.0
	6	10.80	2.7	39.0	36.0	25.0
II	0	1.50		25.0	25.0	50.0
	6	60.00	5.3	58.3	20.2	21.5

* contaminated with fungus

Table 61: Major characteristics of algae exposed to space in an inactive state (I), or in transport (II) and laboratory (III) ground control groups

Condition	No. cells mln/ml	State of the culture: Mean Size, um	Size Range, um	Dead* %	Age structure of population,% Autospores	Cells Photosyn. active	Mother
I	89.6	4.33	2-10	12	26	73	1
II	80.6	4.57	2-10	7	20	79	1
III	90.0	4.42	2-10	11	27	72	1

* as indicated by staining

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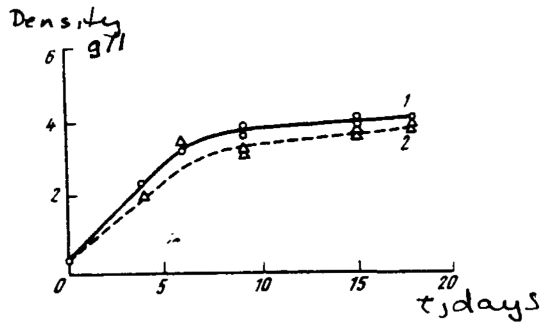

Figure 40: Terminal density of algae suspension in dry substance, after various exposure duration. 1 - flight; 2 - control

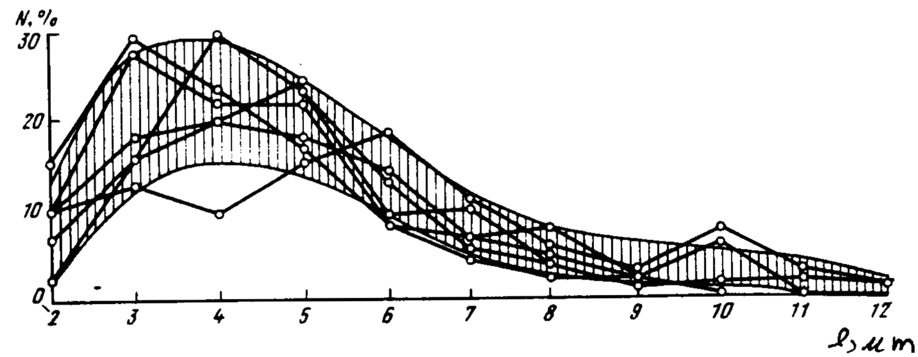

Figure 41: Distribution of algae cells (N) in size in flight and ground control cultures

Cross-hatched area is distribution of cells in control cultures

P589(13/87) Pak ZP, Sinyak YuYe, Chizhov SV.
Human habitability conditions on the space station: Water supply.
In: Gurovskiy NN, editor.
Rezultaty Meditsinskikh Issledovaniy Vypolnennykh na Orbital'nom Nauchno-issledovatel'skom Komplekse "Salyut-6"-"Soyuz"
[Results of Medical Research Performed on the "Salyut-6"-"Soyuz" Space Station Complex.]
Moscow: Nauka; 1986. Abstract: Space Medicine: M112, this Digest Issue.
Pages: 50-52.
[42 references; 3 in English; (whole chapter)]

Life Support Systems, Water Supply; Habitability and Environmental Effects
Humans, Cosmonauts
Space Flight, Salyut-6-Soyuz

Abstract: Before development of a water supply system for "Salyut-6" the following had to be developed:

- water consumption norms for long-term spaceflight;
- long-term storage techniques for drinking water supply which ensure stabilization of physical, chemical and bacteriological parameters by means of preservatives;
- recommendations of modern building materials which are safe for use in the water supply system involving long-term contact with preserved drinking water;
- technology for regenerating drinking water from condensed atmospheric moisture which produces water meeting rigid standards for chemical and toxicological parameters.

Water consumption norms took into account: flight duration, level of physical exertion by the cosmonauts; degree of energy expended, nature, caloric value, and water content of cosmonaut rations. Study of the nature of fluid-electrolyte metabolism was studied under simulated spaceflight factors in order to develop these norms. Recommendations were made for a daily consumption of 2900 ml of fluid, including 1700 ml of free drinking water, 800 ml of water in the diet, and 400 ml of drinking water. This amount of fluid is needed to ensure full equilibrium with a daily caloric intake of 2800-3000 calories and mean daily energy expenditure equivalent to 2500-3000 calories.

A preservative agent had to be found which would maintain water potability for 1 year, have reliable, prolonged antimicrobial properties, and be non-toxic. Experiments with simulations of the type of water supply system designed for the space station showed that solutions of electrolytic silver in concentrations of 0.2 mg/l provided reliable storage of drinking water for more than 6 months. A new system was developed on the basis of these experiments. This system, "Rodnik," was designed for repeated use by refilling it with water brought by the transport spacecraft. The system designed for use on long-term space stations and transport ships provides for the delivery, storage, transfer, and distribution of 410 l of potable water (it consists of two tanks, which are located in the non-hermetic portion of the space station and spacecraft.)

The "Rodnik" system was first approved for use of the fourth prime crew and was used to supply cold water for the tank within the inhabited module. In addition the crew could obtain hot water from the water regeneration system.

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The regeneration of water from atmospheric condensate depended on a process which involved: separation of the gas-liquid mixture, removing harmful impurities, disinfection, enriching with mineral additives, preservation with silver ions and heating. The water is regenerated from atmospheric condensate by sorption purification on ion exchange resin (cation and anion) and activated charcoal. The former is necessary to remove inorganic impurities and the latter to get rid of organic substances. No correlation was found between the body weights of crewmembers and their water consumption. As Table 2 shows, water consumption also is subject to considerable individual variation.

The cosmonauts praised the sensory characteristics of the water after long storage. The operation of the regeneration system confirmed the utility of using such systems to reduce starting weight. During the entire flight of the space station this system supplied the cosmonauts with hot potable water and also warm water for washing. After the flight of each crew samples of water regenerated from atmospheric condensate were returned to Earth for analysis. The water obtained from the system met the standards for potable water and was evaluated highly by crew members. Cosmonauts preferred hot drinks made from regenerated water to the cold preserved drinking water. Consumption of hot drinks was 1.50, 1.22, 1.14, 2.04 l/day for crew 2-5 respectively; while consumption of cold water was 0.63, 0.57, 0.66, and 0.61 l/day.

Table 2: Comparative data on changes in body weight and mean water consumption

Crew #	**Changes in body weight, kg**	**Water consumption, l/day**
1	-3.8	1.1
2	-4.2	2.1
3	-2.6	1.8
4	-2.05	1.8
5	-2.4	1.6

Table 3: Quality of regenerated water after completion of the flights of five crews

Parameter	**Standard**	**Crew #**				
		1	2	3	4	5
pH	6.5-9.6	7.5	7.0	7.8	7.5	7.1
Transparency, cm	30	30	30	30	30	30
Odor, rated	2	0	1	0	0	0
Taste, rated	2	0	1	0	0	0
Total hardness, mg-equiv/l	7	1.6	2.1	5.2	2.8	1.6
Nitrogen (ammonia), mg/l	2.0	0.27	0.35	0.45	0.26	0.2
Oxygen (bichromate oxidizability), mg/l	100	30.0	21.0	22.0	25.6	30.0

MATHEMATICAL MODELING: See Cytology: CR6

METABOLISM

(See also: Botany: P568; Cytology: CR6; Musculoskeletal System: P570: Space Biology: M113; Space Medicine: P574: Space Medicine: M112)

PAPERS:

P558*(13/87) Vorob'yev VYe, Kovachevich IV, Stazhadze LL, Ivchenko VF, Abdrakhmanov VR, Kal'yanova VN, Voronina SG, Repenkova LG.
Metabolism and peripheral circulation in humans exposed to hypokinesia with head-down tilt.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(3): 46-49; 1987.
[11 references; 2 in English]

Metabolism; Cardiovascular and Respiratory Systems, Peripheral Circulation
Humans, Males
Hypokinesia, Head-down Tilt, Short- and Long-Term

Abstract: This paper describes 4 experiments in which 32 healthy males underwent 14- and 120-day periods of hypokinesia with head-down tilt. Apparently tilt was -8° in the short-term and -4° in the long-term study. Venous and arterial blood were taken and their gaseous composition and acid-base balance determined. Parameters measured included: oxygen concentration, difference in oxygen concentrations in arteries and veins, utilization of oxygen by tissues, concentration of 2,3-diphosphoglycerate (2,3 DPG) in venous erythrocytes, concentration of inorganic phosphorus (IP) and lactate in venous plasma. At the same time, impedance plethysmography was performed on the hand and the following parameters measured: α/T, indicative of the elasticity of large and medium-sized arteries, dicrotic and diastolic indices, and rate of pulsed blood perfusion. Measurements were made during a baseline period with subjects in a horizontal position, and during head-down tilt. Measurements were apparently made on days 3, 7, and 14 of the short-term study and days 30, 49, 55 and 90 of the long-term study.

In the short-term study, oxygen pressure in arterial blood had already decreased markedly by day 7, although oxygen consumption by tissues had not decreased, since the oxygen utilization parameter and the difference between arterial and venous blood both increased. During this period there was also an increase in blood perfusion in the hands, which could not be attributed to decrease in arterial tonus. By day 30, arterial pressure was essentially the same as on day 10, but oxygen consumption by the tissues had dropped. Venous hyperoxia indicates that the reason for this was decreased capacity to utilize oxygen. On days 55 and 90 of head-down tilt there was a gradual improvement of oxygen consumption by tissues (increased oxygen utilization and difference between oxygen in arterial and venous blood). The authors consider whether the decrease in oxidative processes observed on day 30 results from the diminished capacity of the tissues to utilize oxygen, or from decrease in the amount of oxygen the tissues receive. They argue for the latter explanation because oxygen concentration in arterial blood is depressed on day 30, while concentration of inorganic phosphorus and lactate peaks during this period, as does concentration of 2,3-DPG in erythrocytes. Another possible explanation for decreased oxygen

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ruled out because long-term hypokinesia with head-down tilt did not decrease blood perfusion in the hands. The authors argue that the decrease in oxidative processes during hypokinesia with head-down tilt may result not merely from decreased need of the tissues for oxygen due to decreased physical activity, but also possibly from reduction in supply of required oxygen. This is confirmed by the occurrences of symptoms of metabolic acidosis (base deficit rose from baseline level of -2.3 mmoles/l to -3.3 mmole/l, most pronounced on day 30 of head-down tilt). In addition, increased levels of 2,3-DPG on day 30, testifying to decreased affinity of hemoglobin for oxygen, provide indirect evidence of diminished affinity of tissues for oxygen, a symptom of tissue hypoxia.

Table 1: Changes in metabolic parameters under exposure to hypokinesia with head-down tilt

Time	N	pO_2, mm Hg art.	pO_2, mm Hg vein	O_2, % art.	O_2, % vein	BE, mmole/l	2,3-DPG, umole/ml	IP, umole/ml	O_2 util %	A-V,+ % O_2
Baseline	19	96.1	34.5	15.1	5.7	-2.3	3.23	4.37	63.3	9.4
Hypokinesia day:										
3(-8°)	11	87.7	25.0*	14.1	4.0**	-0.6	3.67	5.12	71.2	10.1
7(-8°)	20	87.0**	25.1**	13.9*	4.0**	+0.4	3.49	4.75	71.2*	9.9
14(-8°)	20	92.9	30.6	14.7	5.0	-2.2	3.54	4.68	65.8	9.7
30(-4°)	12	86.2*	41.9*	13.8*	6.7	-3.3	4.15*	5.20**	51.8*	7.1*
55(-4°)	12	85.3	29.6	14.5	5.8	-2.8	1.21**	5.35*	59.9	8.6
90(-4°)	12	93.9	33.1	15.0	5.3	+0.1	1.38**	4.82*	64.9	9.7

+ A-V = difference between oxygen concentration in arteries and veins
* differs from baseline, $p < 0.05$
** differs from baseline, $p < 0.01$

Table 2: Changes in plethysmographic parameters in the hands

P570(13/87)* Nasolodin VV, Rusin VYa.
Trace element metabolism in humans and animals under hypoxic conditions varying in etiology.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(3): 10-16; 1987.
[75 references: 16 in English]

Metabolism; Nutrition, Trace Elements; Enzymology
Humans, Review Article
Hypoxia; Musculoskeletal System, Physical Exercise

Abstract: This paper reviews the data on trace element metabolism under hypoxic conditions. It has been established that the activity of metaloenzymes in blood and tissues increases under various types of hypoxia, which in turn may lead to an increase in level of trace elements, since these are either components of the enzymes or nonspecific activators of them. The trace elements which are most important in this respect are iron, copper, and manganese. The effects of muscle activity on trace elements in the blood and tissue are considered examples of hypoxic effects. Increases in trace element levels in response to hypoxia of various origins are seen as part of an adaptive response to increase oxygen transport. Long-term exposure to intense hypoxia (or exercise) may lead to depletion of trace element reserves of the body and thus to decrease in their levels. The relationship between trace elements and the functioning of the sympathetic adrenal system is discussed and consequences of deficits of iron, copper, manganese, and zinc are listed. The authors conclude that since it has been established that oxygen deficiency increases rate of trace element utilization for synthesis of metal-protein compounds, which in turn leads to a decrease in the body's trace element reserves, trace element levels of individuals likely to undergo hypoxia of any origin should be ensured. Data is cited indicating that administration of copper, cobalt, iron, manganese, and other trace elements increases tolerance to hypoxia.

MICROBIOLOGY: See: Habitability and Environmental Effects: P588; Life Support Systems: P566; Space Medicine: P578; M112

MUSCULOSKELETAL SYSTEM

(See also: Cytology: CR6; Metabolism: P570; Space Biology: M113; Space Medicine: P573, P574, M114

PAPERS:

P577(13/87) Kuznetsov SL, Goryachina VL, Lebedeva NB.
Response of striated fibers in human skeletal muscles to hypokinesia combined with exercise.
Arkhiv Gistologii i Embriologii.
XCII(2): 32-35; 1987.
[8 references; 4 in English]
Authors' affiliation: Department of Histology, Cytology, and Embryology, I.M. Sechenov First Medical Institute, Moscow

Musculoskeletal System, Striated Fibers; Metabolism; Enzymology
Humans, Males
Hypokinesia, Head-down Tilt; Physical Exercise

Abstract: Measurements were performed on biopsied samples of skeletal muscle tissues of 12 men who had just undergone 30 days of bed rest with head-down tilt (-8^{o}). Starting on day 3-4 of hypokinesia, 6 subjects exercised daily on a treadmill (moderate loading) with their legs while maintaining a horizontal position. Exercise sessions lasted 60 minutes until the last 6 days of hypokinesia, when their duration was increased to 120 minutes. A needle biopsy was performed on the gastrocnemius muscle before and after hypokinesia. The samples were frozen in liquid nitrogen and 10 um cross-sections were prepared. A portion of the material was prepared for electron microscopy. Activity of calcium-dependent ATPase myosin was determined and used to identify fast- and slow-twitch fibers. Cross sectional areas of muscle fibers were measured. Concentration of RNA, glycogen and total protein were determined. Activity of NADH-tetrazole reductase (NADH-TR), succinate dehydrogenase (SDH), malate dehydrogenase (MDH), hydroxybutyrate dehydrogenase (HBDH), lactate dehydrogenase (LDH), glutamine dehyrogenase (GDH), and glycerophosphate dehydrogenase (GPDH) was determined. Measurements were expressed in percentage of baseline.

Neither control nor exercise protocols led to significant changes in the relationship between the two types of muscle fiber. Both protocols led to changes in enzyme activity, fiber dimensions, and concentration of RNA, protein, and glycogen, which were more pronounced for type II (fast-twitch) than for type I (slow-twitch) fibers. Exercise did not prevent atrophic changes; indeed, fast twitch fibers were more diminished in size after exercise. Exercise also led to slight decreases in RNA, but increases in protein in slow-twitch fibers. Enzyme activity was diminished by hypokinesia in one or both types of fibers in all cases except GDH and LDH. This is interpreted as demonstrating decreased metabolism. Increase in GDH and LDH suggest atypical metabolic paths, with amino acids used to produce energy. Exercise increased activity in one or both fiber types for all enzymes except GDH and LDH. Exercise normalized GDH and LDH levels, suggesting normalized metabolism. Although exercise led to accumulation of glycogen in the muscle, which is characteristic of physical conditioning, the failure of GPDH activity to increase suggests that fatty acids were not

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sufficiently metabolized. Electron microscopy showed that after hypokinesia the mitochondria matrix was lightened, the number of cristae reduced, the normal structure of myofibrils disrupted, and there were sites of destruction filled with homogeneous granular substance. When physical exercise was combined with hypokinesia, the mitochondria retained their normal structure; while myofibrils were attenuated, they too were normal in structure, but the number of glycogen granules was elevated.

The authors conclude that 30 days of hypokinesia with head-down tilt evokes atrophic changes and decreased metabolism of both types of fibers in humans. Exercise does not prevent atrophy. However, it improves the condition of mitochondria and myofibrils, increases metabolism, and induces greater changes in fast-twitch fibers. Although the effects associated with physical exercise are similar to those occurring after exercise under normal conditions, they do not compensate completely for the effects of hypokinesia.

Table: Percent changes in slow- and fast-twitch muscle fibers in humans after exposure to hypokinesia and head-down tilt with and without exercise

Parameter	**Condition**			
	Hypokinesia		**Hypokinesia + Exercise**	
	Slow	**Fast**	**Slow**	**Fast**
Cross-sectional area	84	87	83	60
RNA concentration	110	107	91	100
Total protein concentration	87	84	103	100
ATPase-myosin activity	100	71	100	148
NADH-TR activity	91	83	113	142
SDH activity	100	100	165	171
MDH activity	100	83	100	107
GPDH activity	78	100	125	100
HBDH activity	90	61	90	100
GDH activity	100	111	100	83
LDH activity	133	144	100	100
Concentration glycogen	100	162	157	150

Values expressed in percent of baseline.

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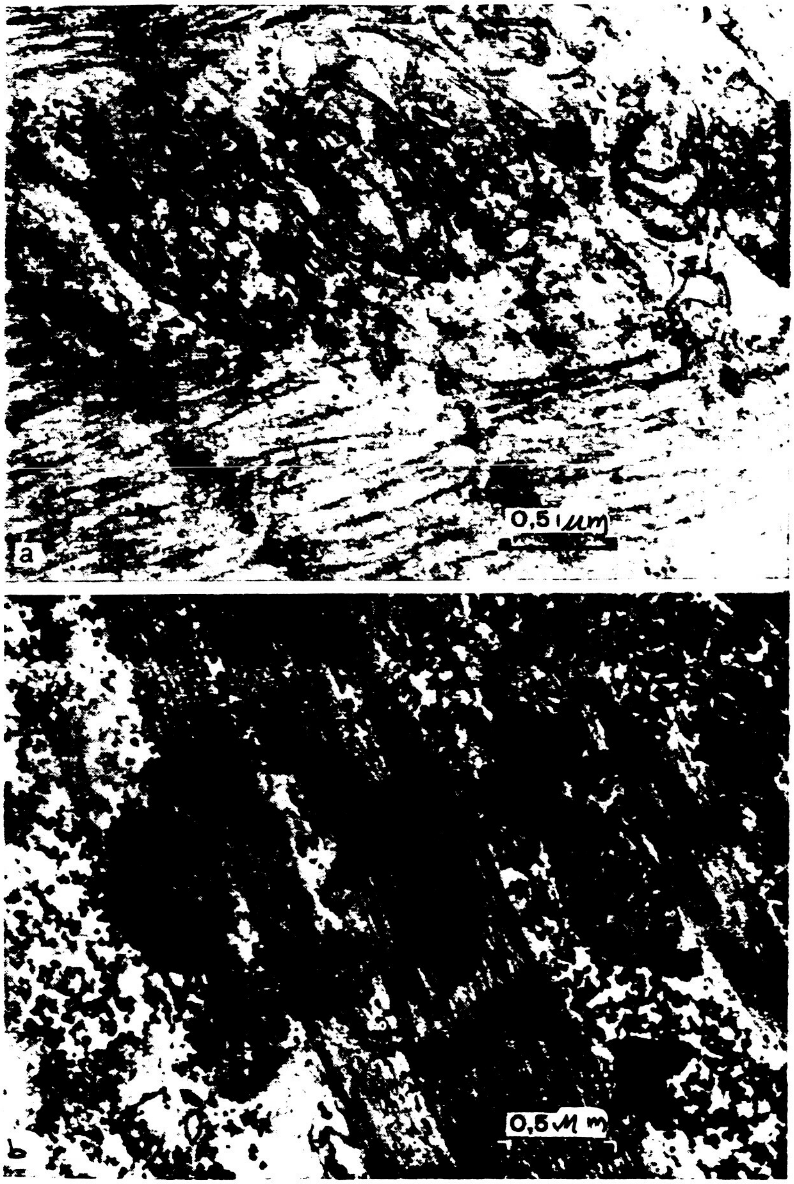

Figure: Section of human skeletal motor fiber after 30 days of hypokinesia with head-down tilt
a - no exercise; b - exercise.

NEUROPHYSIOLOGY

(See also: Cytology: CR6; Space Medicine: SM112)

PAPERS:

P556(13/87)* Fedorov VP, Ushakov IB.
Karyometric estimation of the reactions of neurons of the cerebral cortex to the combined effects of ionizing radiation, longitudinal acceleration, and vibration.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(3): 39-42; 1987.
[11 references: 3 in English]

Neurophysiology, Sensorimotor Cortex, Neurons
Rats
Radiobiology, Gamma-Radiation; Habitability and Environment Effects, Vibration, Acceleration, $+G_z$

Abstract: In this experiment, Wistar rats were exposed to gamma-irradiation in a dose of 10, 50, or 200 Gy with dose rate of 12 cGy/sec. Before or immediately after irradiation the animals were exposed to longitudinal $+G_z$ acceleration of 5-g for 2.5 minutes, and also vibration with acceleration of 8 m/sec^2 and frequency of 80 Hz. Control animals were placed in the apparatus but not exposed to the conditions. Each experimental group contained 6 animals. Animals were sacrificed 1.7 hours after irradiation and samples of the sensorimotor cortex removed and fixed for study. The diameters of the nuclei of layers III and IV of the sensorimotor cortex were measured in cross sections 6 um thick using an ocular micrometer, and volume was computed using the ellipsoid rotation formula. Cells from each animal were classified on the basis of the logarithm of their volume and distribution curves were constructed for each group.

No effects attributable solely to longitudinal acceleration were observed. Irradiation decreased the volume of nuclei, increasing the number of very small nuclei and decreasing the number of large ones. Acceleration before irradiation attenuated these effects, so that data for experimental animals did not differ significantly from those for controls. If acceleration occurred after irradiation, while the mean volume of nuclei remained unchanged, the number of neurons with small nuclei increased while those with large nuclei decreased relative to control. Vibration of 80 Hz shrank the nuclei of the neurons compared to control level. Relatively low irradiation levels (10 Gy) induced no changes in nuclei size. However, when this dose was followed by vibration, the neuronal nuclei decreased in size. When vibration preceded this dose of radiation, no effects were noted. When radiation dose was increased to 50 Gy, the functional activity of the nuclei of nerve cells of the cortex increased, leading to a displacement of the distribution curve to the right, although no significant changes in mean nucleus volume were noted. When vibration followed the 50 Gy dose of radiation, nuclei size decreased sharply. If vibration preceded this dose of radiation, nuclei size decreased to an even greater extent. Irradiation in a dose of 200 Gy combined with vibration decreased the size of cell nuclei. This effect was more marked when vibration followed irradiation.

Figure 1: Distribution of nuclei of neurocytes in the sensorimotor cortex of rats after irradiation of the head at a dose rate of 50 Gy combined with longitudinal $+G_z$ acceleration

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Figure 2: Distribution of nuclei of neurocytes in the sensorimotor cortex of rats after irradiation of the head at a dose rate of 10 Gy combined with vibration

Figure 3: Distribution of nuclei of neurocytes in the sensorimotor cortex of rats after irradiation of the head at a dose rate of 50 Gy combined with vibration

Figure 4: Distribution of nuclei of neurocytes in the sensorimotor cortex of rats after irradiation of the head at a dose rate of 200 Gy combined with vibration

P561(13/87)* Nalimova TA.
Characteristics of nystagmus in individuals with regular occupational exposure to vibration.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(3): 59-62; 1987.
[14 references; 1 in English]

Neurophysiology, Nystagmus
Humans, Workers
Habitability and Environmental Effects, Vibration, Long-term; Human Performance, Occupational Exposure

Abstract: Twelve workers exposed to vibration (16-1000 Hz) regularly in their jobs for no fewer than 10 years served as subjects in this experiment. Each subject was tested for nystagmus, once in the morning before his shift, and once in the afternoon after it. A classic caloric irrigation procedure was used. Atypical features of the electronystagmogram of caloric nystagmus were recorded. In addition, optokinetic nystagmus was induced with a stimulus moving at 20^{o}/sec. Cortical and subcortical optokinetic nystagmus (not further described) were studied.

Atypical caloric nystagmus was very common in these workers, particularly before the beginning of their shifts, giving rise to a hypothesis of nystagmus normalization during the course of the working day. Difference between morning and evening atypicality was statistically significant. Subjects for whom it was possible to evaluate labyrinth asymmetry showed a change in the direction of asymmetry from morning to evening. Atypicality and asymmetry were also elevated in optokinetic nystagmus and again tended to normalize after the work shift.

Table: Comparison of results of "morning" and "afternoon" tests

Figure 1: Fragments of electronystagmograms with signs of atypicality: pauses, tonicity, frequent reversal of reaction

Figure 2: Fragments of electronystagmograms recorded during caloric irrigation

Figure 3: Asymmetry of cortical and subcortical optokinetic reaction in "morning" and "afternoon" tests

P567(13/87)* Matveyev AD.
A history of development of methods for studying space motion sickness.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(3): 83-88; 1987.
[59 references; 16 in English]

Neurophysiology, Space Motion Sickness
Humans, Cosmonauts
Review Article, Methods; Equipment and Instrumentation; Space Flight,
Soyuz-8, -9, Soyuz-T-7, Soyuz-T-3, Soyuz-37, -38, -39, Salyut-6, -7

Abstract: This paper outlines 20 years of experience in developing methods of studying space motion sickness. These methods were based on the theory of sensory conflict, fluid shifts, and disruption of fluid homeostasis, and the author's theory that space motion sickness results in part from the development of circulatory congestive venous ischemia and cerebral hypoxia. The first set of methods were used to study vestibular sensory function in space. On board "Soyuz-8" in 1969, tests of "vertical writing" and visual tracking of an image were used to test vestibulosensory reaction when the head was moved. This study disclosed a more than tenfold increase in the vestibulotonic reflex compared to ground data. In 1971 on "Soyuz-9," cosmonauts were asked to visually and tacto-kinetically identify the vertical and horizontal in a blank field. Results of this study demonstrated that in weightlessness, the otolith gravity receptors do not play a major role in the formation of visual spatial orientation. In space, tactile and proprioceptive cues become more important to compensate for the loss of gravity receptor information. After landing, cosmonauts were shown to make significant errors in determining spatial coordinates. These results suggested that body position illusions occurring in weightlessness are related to otolith function.

A questionnaire concerning space motion sickness and vestibular tolerance on Earth was given to 6 space crews (international and Soviet) pre-, in-, and postflight. No precise description of information gained from responses is given. In 1982 on the flight of "Soyuz T-7," eye movements were monitored during the acute phase of adaptation to weightlessness in order to further elucidate the role of the vestibular system in the development of space motion sickness. The study involved provocative tests with head movements in the frontal plane and recording of eye movements using an onboard apparatus. Analysis of electrooculograms recorded during the first 4 days in space showed disappearance of the compensatory otolith response to ocular counterrolling and the appearance of a nystagmoid response. This suggests suppression of the gravity receptor function of the otolith and enhancement of its sensitivity to inertial stimuli when the head is moved. A specially-developed apparatus allows determination of the threshhold for electrostimulation of the vestibular system. When the system is stimulated with bipolar current, vestibulomotor and sensory responses are attenuated or suppressed, suggesting that electrostimulation might be useful in eliminating undesirable vestibular responses. New provocative tests were developed to study the reactivity of the vestibular system: "otolith cupolometry" involving rotation in a central and eccentric position of the head; and "otolith reactions while doing knee-bends." Laboratory use of these tests produced data showing that otolith response could be enhanced or attenuated as a function of stimulation of the cupoloendolymphatic system. A special stand was developed for studying patients with disorders of

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vestibular functioning. A device for producing caloric stimulation with air streams directed into the ears was also created. This method is recommended as more comfortable and no less accurate than traditional caloric irrigation.

Various methods and devices to prevent and treat space motion sickness were developed on the basis of research results. The first of these is a device providing graded and regulated tension on the occipital and cervical group of antigravity muscles; and simulated weight on the cervical region of the spine, exerting symmetrical tension in the two areas and also decreasing stimulation of the vestibular apparatus by angular acceleration by limiting head movement. This device is illustrated in Figure 3. It was intended to be worn during working hours for the first 3 or 4 days in space, with tensions to be determined on an individual basis. This device was used on the "Soyuz T-3," "Soyuz-39," "Soyuz-40," "Soyuz-T-7," spacecraft, and "Salyut-6" and "Salyut-7" stations. Cosmonauts considered this device effective in preventing dizziness, illusions, discomfort, and nausea and claimed it did not interfere with their work. No undesirable side effects were noted. The effectiveness of this device is based on normalization of the vestibulocervical reflex system, which supports vestibulovisual stabilization of the visual field when the head is moved, as well as of the vestibulocervical mechanism regulating orientation of the head in space. A second method used to prevent motion sickness involves subthreshhold multichannel electrical stimulation of the anterior antigravity group of cervical muscles. This stimulation produces no discomfort or side effects. Laboratory tests support the promise of this method for combatting motion sickness.

The author's own research implicates cerebral hypoxia as a causal factor in space motion sickness. He has developed a set of methods to combat motion sickness, involving periodic breathing of hyperoxic and hypercapnic atmospheres combined with administration of drugs. This methodology has been tested under laboratory conditions, but has not been used in space.

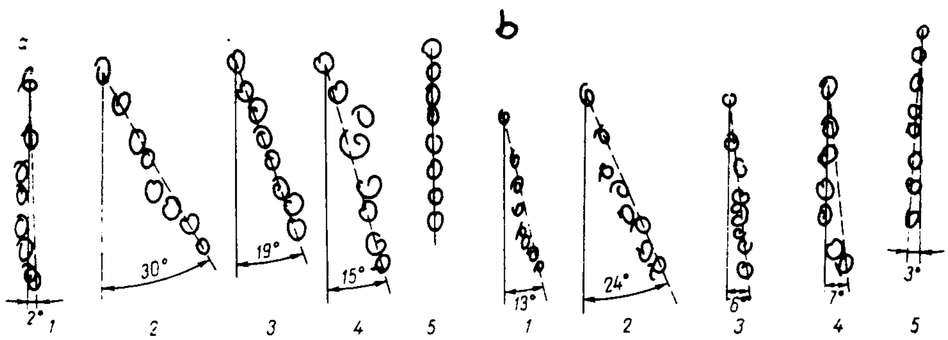

Figure 1: "Vertical writing" by spacecraft commander (a) and flight engineer (b). 1 -3 - tilt to the left, right and forward, respectively; 4 - eyes closed; 5 - eyes open.

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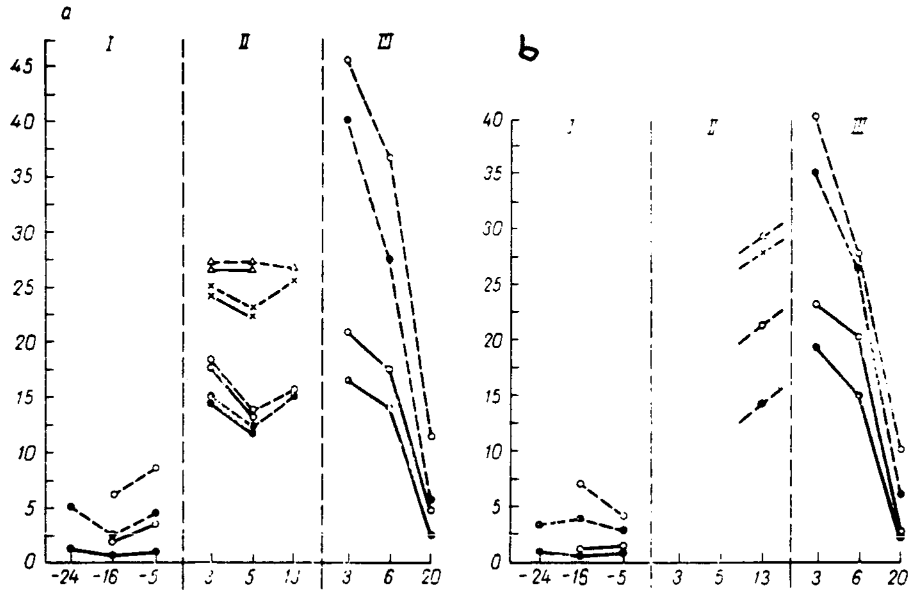

Figure 2: Setting of the "vertical" by spacecraft commander (a) and flight engineer (b) by visual (solid line) and tactile-kinetic (dotted line) means. Abscissa - time of test, days; ordinate - magnitude of deviation, degrees; I - preflight, II - inflight, III - postflight. Dot - vertical standing, circle - vertical lying, cross and triangle - the same without fixation of legs.

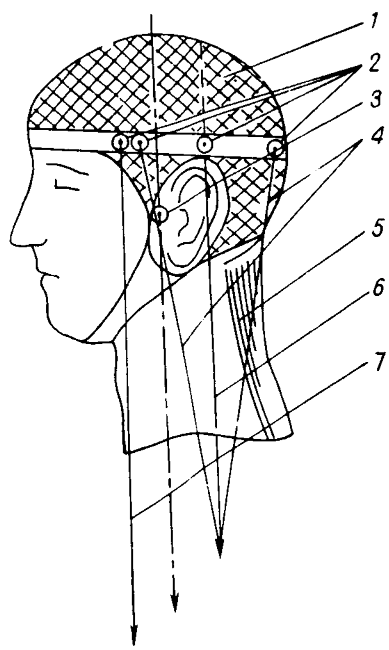

Figure 3: Diagram of tension applied using a device to prevent and eliminate space motion sickness in flight.
1 - weight of head, 2 - points at which pressure is applied, 3 - center of gravity of head, 4 - force vector limiting head movement; 5 - occipital-cervical antigravity muscles, 6 - force vector of tension on cervical region of spine, 7 - force vector on the occipital-cervical antigravity muscles.

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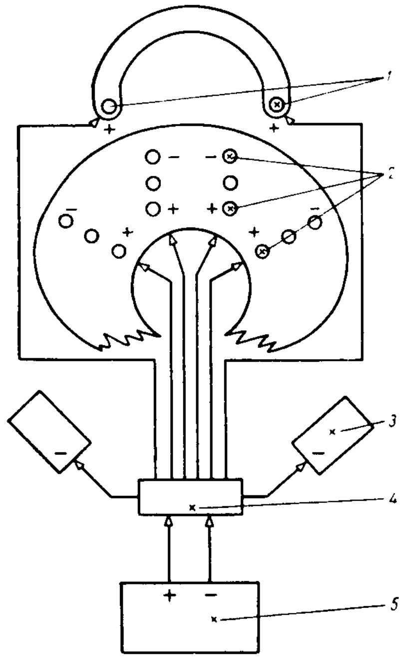

Figure 4: Diagram of the position of electrodes for electrostimulation of the antigravity muscles

1 - labyrinth electrodes; 2 - cervical electrodes; 3 - passive electrodes; 4 - commutative pack; 5 - current source,

P585(13/87) Bryanov II, Gorgiladze FI, Kornilova LN, Tarasov IK, Yakovleva IYa.
Sensory systems [of prime crews on "Salyut-6" flights]: Vestibular function.
In: Gurovskiy NN, editor.
Rezultaty Meditsinskikh Issledovaniy Vypolnennykh na Orbital'nom Nauchno-issledovatel'skom Komplekse "Salyut-6"-"Soyuz"
[Results of Medical Research Performed on the "Salyut-6"-"Soyuz" Space Station Complex.]
Moscow: Nauka; 1986. Abstract: Space Medicine: M112, this Digest Issue.
Pages: 169-185 [58 references; 8 in English (whole chapter)]

Neurophysiology, Vestibular Function
Humans, Cosmonauts
Space Flight, Salyut-6, Soyuz

Abstract: The goal of the vestibular studies performed on "Salyut-6" prime crew cosmonauts was study of the phenomenology of illusions and autonomic reactions, and the efffects of long-term exposure to weightlessness on the functioning of the vestibular system. Methods used pre- and postflight included: spontaneous and positional nystagmus studied using electrooculography in sitting and supine positions with the head held straight, tilted back or to one side; study of otolith reflex on the bases of ocular counterrolling measured using indirect otolithometry; determination of the sensitivity threshhold of the horizontal semicircular canals to angular acceleration on the basis of nystagmic response and illusions; study of the reactivity of the horizontal semicircular canals to the effects of increasing stop-stimuli measured using cupolometry; investigation of canal-otolith interactions using the OR (otolith reaction) test, including nystagmus, ocular counterrolling, magnitude of autonomic response and cardiorespiratory parameters; eye movements studied during foveal and retinal stimulation; accuracy of perception of spatial coordinates measured with the portable "Vertikal'" device; resistance to motion sickness evaluated during "Coriolis-precessional" acceleration, and prolonged retinal optokinetic stimulation. Preflight tests were made 3 to 6 times. Postflight measurements were made at the landing site, many additional times during the first 2 weeks postflight, and 1 month postflight. Members of the first 5 "Salyut-6" prime crews were studied (75-, 96-, 140-, 175-, and 185-day flights). Previously 112 healthy men aged 25 - 40 had been subjected to these same tests to determine norms.

Preflight, no cosmonauts showed spontaneous or positional nystagmus. Otolith reflexes were within physiological norms. Six cosmonauts showed symmetrical responses while lying on their sides; 3 showed asymmetry. Six cosmonauts showed equal degrees of nystagmus and illusion on the left and on the right; 2 showed asymmetry. All but 1 cosmonaut showed a decrease in canal reaction when the body was straightened. All but 1 cosmonaut were within normal limits in determining the vertical. All cosmonauts displayed eye movement in response to optokinetic stimulation; parameters of this response were within the norm. Six cosmonauts showed "average" tolerance for Coriolis acceleration; and 2 showed "satisfactory" tolerance. Two cosmonauts showed high tolerance of optokinetic stimulation, while 4 showed average tolerance.

Survey responses indicated that all cosmonauts experienced symptoms of motion sickness in flight; while all but 1 experienced some illusions of

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body position or body rotation. These reactions typically occurred upon onset of weightlessness. Duration and magnitude of illusion varied widely. In some cosmonauts, illusions lasted only a few minutes, in others for 4 hours, and in still others they recurred throughout the flight. Recurrence was associated with increased physical activity or optokinetic stimulation. Marked motion sickness symptoms were experienced by half the cosmonauts, while the other half felt only discomfort. Symptoms varied in duration from several hours to 2 weeks. All cosmonauts noted sensations of blood rushing to the head and heaviness of the head, and some also headache. There were also symptoms of stuffiness of the nose and gradual increase in puffiness of the face. Motor activity increased autonomic discomfort. Most cosmonauts stated that following the panorama outside the window increased discomfort. Those who experienced motion sickness tried to limit movement and hold their heads rigid, which helped to reduce discomfort and even banish illusions. Some experienced the sensation of their visceral organs being displaced upward and had difficulty fixing their gaze. Motion sickness symptoms developed gradually and typically disappeared gradually; however, in some instances they disappeared suddenly. Usually symptoms did not recur. Motion sickness symptoms were also noted in some cosmonauts postflight. A symptom where the eyes involuntarily rolled up or to one side was also noticed. Such symptoms persisted as long as 3 days.

Return to Earth was accompanied by recurrence of sensory and autonomic disturbances, especially in cosmonauts who developed motion sickness in flight. Wandering of the eyes, and problems with regulating position and spatial perception occurred. Transitory increases in reactivity of the otolith as well as the cupular portions of the vestibular system were noted postflight. In some cosmonauts, direction of the otolith reflex was reversed, and spontaneous and positional nystagmus was observed. Some changes in visual tracking of optokinetic stimuli were noted. During the initial postflight period asymmetry was found in virtually all reactions tested, but particularly the otolith reaction. There was a high correlation between the frequency of motion sickness and otolith asymmetry. Such asymmetry was found in all cosmonauts experiencing overt symptoms of motion sickness after long-term space flights. It was also found that those who had completed multiple orbital flights were less prone to motion sickness.

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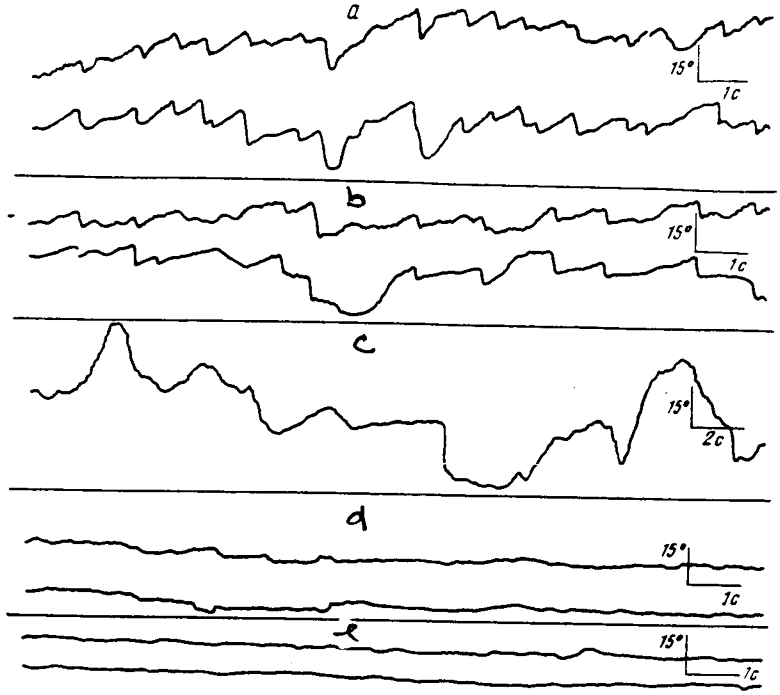

Figure 25: Ocular nystagmus in space station flight engineer in sitting position with head held straight and opaque glasses

a - with eyes open; b - with eyes shut; c - floating movements of the eyes when they are focussed 1 hour after completion of a 75-day orbital flight; d - on day 56 postflight, absence of nystagmus with eyes open in opaque glasses

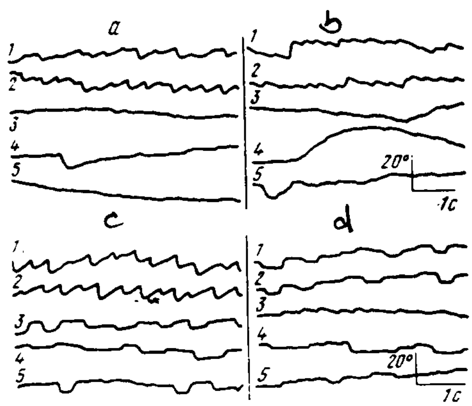

Figure 26: Optokinetic nystagmus in space station commander (a, b) and flight engineer (c, d) in response to displacement of black and white stripes to the left (a, c) and to the right (b, d) at a rate of 40 (1), 60 (2), 80 (3), 100 (4), and 120 (5) stripes per minute, 50 minutes after completion of a 75-day flight.

NUTRITION: See Life Support Systems: 591; Metabolism: P576; Space Medicine: M112

OPERATIONAL MEDICINE

(See also: Space Biology: M113; Space Medicine: M112)

PAPER:

P580(13/87) Gazenko OG, Grigor'yev AI, Ilyin YeA, Kholin SF.
Medilab - Design for a medical laboratory in space.
Paper delivered at the 1987 NASA Space Life Sciences Symposium.
Washington DC, June 21-26.

Operational Medicine, Medilab
Equipment and Instrumentation
Space Flight, Mir

Synopsis: Medilab is the name given by the Soviets to a dedicated module for biomedical investigations which will become part of the Mir space station complex. The first module of this type was the astrophysics module "Quantum," which docked with Mir in April 1987. Medilab is currently in the development process. It will be transported to Mir on board existing or redesigned transport vehicles. Medilab is designed to expand the number, complexity, and quality of the biomedical investigations which can be performed in flight. Medilab will contain additional scientific research apparatus, and computers to allow inflight processing of data. Medilab will be used by two types of specially trained scientists -- physicians and biologists -- well versed in all areas of space biology and medicine. Medilab will be used to monitor and maintain the health of space station personnel, to perform emergency medical and diagnostic procedures, and to perform noninvasive studies on cosmonauts and a variety of biological experiments on animals, tissues and cells. Because Medilab will have data processing and analysis facilities, research protocols can be modified in space to better meet scientific needs.

Biomedical investigations using Medilab will be conducted according to a 3-month cycle. When each cycle is completed, the scientists will be replaced, some of the biological subjects and samples will be returned to Earth for further processing and analysis, and new subjects and equipment will be transported to Medilab. Although additional information processing will be performed on Earth, the bulk of information will be processed by Medilab's computers. The subjects to be used in the first Medilab research cycle will be placed on board the module prior to launch. Before docking, physiological data will be recorded and processed automatically. Medilab scientists will be housed in the Mir crew module and will begin their research activities immediately after docking.

Medilab will be cylindrical in shape and will contain the following components: lock and hygiene module, research module, experimental surgical module, and module for housing biological subjects. All these modules will be separated by partitions, with doors leading to the adjacent module. The lock and hygiene module, which will connect Medilab with the rest of the station, will be used by the scientists to wash and change clothes before and after performing the experiments. The research module will be used for

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medical and physiological examinations of station personnel and will contain almost all the scientific apparatus and computers, which will be configured modularly and arranged around the periphery of the module. Physiological data generated by medical instruments will be collected by a commutation-distribution unit and input to amplifying and recording devices and computers. The experimental surgical module will be used for gaining experience in performing surgery in space and for experimenting with animals. The module will contain a surgery table, anesthesiology equipment, and apparatus for use in the animal experiments. The animal module will contain cages for housing unrestrained and restrained primates and rats, as well as containers for cell biology and population genetics studies.

PERCEPTION

(See also: Space Medicine: M112)

PAPERS:

P582(13/87) Plyasova-Bakunina IA, Portnov VD.
Sensory systems [of prime crews on "Salyut-6" flights]: Vision.
In: Gurovskiy NN, editor.
Rezultaty Meditsinskikh Issledovaniy Vypolnennykh na Orbital'nom Nauchno-issledovatel'skom Komplekse "Salyut-6"-"Soyuz"
[Results of Medical Research Performed on the "Salyut-6"-"Soyuz" Space Station Complex.]
Moscow: Nauka; 1986. Abstract: Space Medicine: M112, this Digest Issue.
Pages: 163-165. [58 references; 8 in English (whole chapter)]

Perception, Vision; Human Performance
Humans, Cosmonauts
Space Flight, Salyut-6

Abstract: Questionnaires and interviews were used to collect subjective information about the vision of members of "Salyut-6" prime crews. Visual acuity, refraction, muscle balance of the external muscles of the eye, sensitivity to light, intraocular pressure, and diastolic pressure in the central retinal artery were studied. The lacertus, anterior compartments, refractive medium, and ocular membrane were examined by traditional techniques. According to cosmonauts' reports, visual acuity at a distance did not change during long-term flights. However, they did experience difficulty working inside the station. Slight reddening and tearing of the eyes were noted, and a sensation of pressure and pain in the eyes, lasting 2-3 days, was reported. When cosmonauts avoided eye strain these symptoms disappeared. The cosmonauts believed that these problems resulted from poor illumination of work stations, and effects of blinding sunlight. Almost all crewmembers experienced light flashes, mainly while they were falling asleep and had their eyes closed. The frequency, duration, and form of these flashes varied widely from individual to individual.

During their first few days on the station, almost all crewmembers noted slight edema of the eyelids, and moderate hyperemia of the eyeball. These symptoms fluctuated over the course of the flight. After landing, the majority of cosmonauts showed slight or moderate hyperemia of the conjunctiva and sclera, and some exhibited pastiness of the eyelid as well. All these symptoms disappeared without treatment in 3 or 4 days. Almost all cosmonauts showed moderate dilation of retinal veins, congestive in nature, 6-8 hours after landing and continuing for 7 days. There were no noticeable changes in the arteries. Peripapillar edema of the retina was observed in one or, more frequently, both eyes, which gradually disappeared by day 7 postflight. Absolute light sensitivity, time for vision to recover, close vision, and resistance to being blinded (by a flash of light) were studied in members of the te{wo prime crews. There was some tendency for absolute dark adaptation to be delated , while time for vision to recover was lessened slightly. No evidence of disruption of regional ocular dynamics was found. There was a tendency for conjunctive microflora to change in composition during long-term flight.

P583(13/87) Yakovleva IYa, Nefedova MF.
Sensory systems [of prime crews on "Salyut-6" flights]: Hearing.
In: Gurovskiy NN, editor.
Rezultaty Meditsinskikh Issledovaniy Vypolnennykh na Orbital'nom Nauchno-issledovatel'skom Komplekse "Salyut-6"-"Soyuz"
[Results of Medical Research Performed on the "Salyut-6"-"Soyuz" Space Station Complex.]
Moscow: Nauka; 1986. Abstract: Space Medicine: M112, this Digest Issue.
Pages: 165-168. [58 references; 8 in English (whole chapter)]

Perception, Hearing; Human Performance
Humans, Cosmonauts
Space Flight, Salyut-6

Abstract: The hearing of "Salyut-6" cosmonauts was studied during 2 periods. Preflight studies included: ortholaryngological case history, otoscopy, determination of audibility threshholds for sound transmitted through air at frequencies of 125-8000 Hz, and determination of the range of discomfort for loudness at varying frequencies. During the flight the level and spectral characteristics of noise in the area where audiometry was performed were determined, and auditory threshhold for sounds transmitted through air with background noise were studied. Preflight, all cosmonauts demonstrated normal hearing with the discomfort range varying from individual to individual. Noise inside the "Salyut-6" was wideband, and of moderate intensity, and described as equivalent to noise levels measured in other Soviet and U.S. flights. Cosmonauts reported no change in the unpleasant sensation associated with background cabin noise throughout the flight. After approximately 60 days in space, cosmonauts reported some increase in auditory acuity, along with congestion of the ears. They could readily apprehend and locate any change in apparatus noise in the station. Moderate changes were noted in masked hearing threshholds during the flight. Threshholds increased by 5-15 dB. The greatest increases occurred during the first month. By day 102 the threshhold had decreased, and by day 155 it had increased to the level of day 26. During the first 2 days postflight, threshholds remained elevated by 10-45 dB. Greatest threshhold increases were noted at high frequencies (4000 Hz and above). Hearing in the speech range remained within the normal range. Auditory threshhold returned to normal by day 6-10 postflight. Postflight all cosmonauts showed decreased discomfort threshholds. Changes in discomfort threshholds were greater and more persistent than changes in auditory threshholds. Some cosmonauts displayed decreased tolerance for loud noises 7 months postflight.

P584(13/87) Nefedova MF, Yakovleva IYa.
Sensory systems [of prime crews on "Salyut-6" flights]: Taste.
In: Gurovskiy NN, editor.
Rezultaty Meditsinskikh Issledovaniy Vypolnennykh na Orbital'nom Nauchno-issledovatel'skom Komplekse "Salyut-6"-"Soyuz"
[Results of Medical Research Performed on the "Salyut-6"-"Soyuz" Space Station Complex.]
Moscow: Nauka; 1986. Abstract: Space Medicine: M112, this Digest Issue.
Pages: 168-169 [58 references; 8 in English (whole chapter)]

Perception, Taste
Humans, Cosmonauts
Space Flight, Salyut-6

Abstract: Taste was studied in the "Salyut-6" cosmonauts with the "Electrogustometr-1" apparatus (Romania). The sensitivity threshhold of taste receptors was determined by delivering a gradually increasing current to the tongue. The threshhold was identified with the weakest current associated with a sensation of acidity or tingling. Threshholds were determined on the right and left sides of the tongue on an empty stomach and 10-15 minutes after eating. Difference in the two threshholds measured was attributed to the gastrolingual reflex. This study was performed in space on the members of the second prime crew. One cosmonaut was studied on days 31, 54, 105, and 132; and the other on days 105, 115, and 132. Results were compared with norms. Taste threshold on an empty stomach fluctuated during the flight but remained within normal limits. Asymmetry (presumably difference between left and right sides of tongue) exceeded normal limits at one measurement point for each cosmonaut. The threshhold of taste sensitivity decreased after eating for one cosmonaut, which is opposite to the normal situation. The second cosmonaut showed a normal gastrolingual reflex during flight, but this reflex increased considerably toward the end of the flight, when it was accompanied by asymmetry of taste receptor threshhold. The authors consider that asymmetry may be the result of emotional stress.

PERSONNEL SELECTION

(See also: Space Medicine: M112)

PAPER:

P552(13/87)* Yevdokimov VI, Parkhomenko PP.
(Some aspects of) Social and psychological selection of flight school applicants.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(3): 23-26; 1987.
[9 references; none in English]

Personnel Selection, Flight School; Human Performance
Humans, Pilots
Psychology, Social and Psychological Traits

Abstract: Subjects in this study were 159 successful applicants to flight school, who had passed the medical and written entrance exams. Aside from the traditional paper and pencil and performance tests, subjects were given the following personality and attitude tests: 1) 16 factor Cattell survey, form A; 2) survey for determining personality type, consisting of 176 questions of which 50 related to an extroversion-introversion dimension, 50 to neurosis, 50 to neurasthenia, and 26 to vocational preference and general health; 3) the flight thematic apperception test (FTAT: described in abstracts: Psychology: P526, P547; Digest Issue 12). In addition, the subjects were given a biographical survey, which solicited information on such factors as personality traits in childhood and adolescence, relations between parents, family attitude to alcohol; age when subject began to smoke and drink; and social attitudes. The relationship of students' progress in their first year of flight school and their responses to the above tests was investigated. A factor analysis was performed on all data.

It was found that students who were evaluated as having a troubled childhood on the basis of biographical survey results were less likely to succeed in flight school. Such individuals had, for example, a drop-out rate twice that of other students. Comparison of results of the projective test and biographical interview indicated that in a number of individual cases, psychologically important events in the past were predictive of an applicant's attitude to discipline and use of alcohol. Factor analysis revealed 3 factors. The first, called general development, showed high positive loadings for flight school performance, score in the certification process, and score on the entrance test. Loadings of extroversion score, Cattell moodiness and intellectualism scores, and decisiveness score on the FTAT approached statistical significance. The second factor had high loadings on certain selection tests, and psychological stability rated by flight school instructors. Loadings on training flight simulator work, and age when started smoking (negative loading) approached statistical significance. The third factor had high loadings on neurosis, and neurasthenia scores, and answers to biographical questions concerning parents' attitude toward alcohol, frequency of alcohol consumption, and occurrence of childhood traumas.

PSYCHOLOGY

(See also: Cardiovascular and Respiratory Systems: P564; Cosmonaut Training: M114; Endocrinology: P554; Space Biology: M113; Space Medicine: P573, P574, M112)

PAPERS:

P581(13/87) Simonov PV.
Monitoring man's work capacity in aviation and space flight.
Paper delivered at the NASA Space Life Sciences Symposium.
Washington DC, June 21-26, 1987.
Author's affiliation: Institute of Higher Nervous Activity and Physiology, USSR Academy of Sciences.

Human Performance, Work Capacity, Functional State
Humans, Pilots, Cosmonauts
Psychology, Motivations, Emotion, Stress, Uncertainty, Fatigue, Vigilance

Synopsis: This paper discusses the effect of emotional stress on pilot and cosmonaut performance. The main analysis is based on the author's informational theory of emotions (1964), which postulates that emotion is a joint function of strength of unfulfilled need and the estimated probability that the need will be fulfilled. Probability is estimated on the basis of what the author calls phylogenetic and ontogenetic experience concerning the means needed to fulfill the need and the availability of those means. An estimated low probability that the need will be met gives rise to negative emotions (those which the subject seeks to avoid). Increases in the probability estimate lead to positive emotions. Aircraft and space flight provide all the conditions for observing this theory in action. Needs (or motivations) operative in this environment are considered to include: desire for personal success, thirst for knowledge, goal attainment motivation, and concern for one's own safety and that of others. Virtually all space flight performance situations involve some element of uncertainty. The author cites physiological evidence that stress is felt during difficult or critical moments in space flight.

Simonov uses the Yerkes-Dodson law to derive the implications of the stress produced by flight situations for human performance. According to this law an intermediate level of stress is optimal. Low emotional arousal, which is said to result from low information need, leads to drowsiness, low vigilance, failure to attend to relevant stimuli, and increased reaction times. High levels of arousal lead to premature response, false alarms, and reversion to more primitive response types, e.g., trial and error. The author cites a previously published experiment [Aviation, Space, and Environmental Medicine; September, 1977; pp. 856-858] as illustrating these principles.

Subjects in these experiments were parachutists performing a signal detection task. Stress level was manipulated by having task performance occur at different intervals before a scheduled jump. Emotional stress was measured using ECG parameters. Each subject showed peak performance efficiency at some intermediate level of stress. When errors were examined, it was found that as stress increased misses decreased, but false alarms increased. Yerkes-Dodson does not explain the nature of the error pattern under different levels of stress. The author refers to "Uchtomsky's

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principle of dominant focus" to explain this phenomenon. Under high levels of stress the subject switches to a broadly generalized dominant reaction said to be typical of stress. Under this performance style, the subject can maintain a high level of vigilance, but is also prone to false alarms.

Experiments with animals are cited to postulate a physiological mechanism for these phenomena. Results of these experiments are said to suggest that the hypothalamus-amygdala systems maintains homeostasis among conflicting needs and directs behavior toward satisfaction of dominant motivation. Responses to signals varying in probability are regulated by the frontal neocortex-hippocampus system, with the neocortex primarily responding to high probability events and the hippocampus to low probability events. Under increasing emotional stress, the hippocampus-amygdala system influences the more cognitive frontal neocortex-hippocampus system by extending the set of traces retrieved from memory and relaxing the criteria for a positive (i.e., match) decision when these traces are compared to current environmental stimuli. Various neurotic disorders are attributed to different specific types of disturbances of this system.

Soviet scientists have developed a set of methods for diagnosing and predicting the 3 types of human functional state most relevant to flight performance, optimal work capacity, fatigue, and stress. These methods include: EEG spatial synchrony and slow oscillation, EEG coherence before stimulus presentation, eye and eyelid movement, electrocardiographic activity, acoustic analysis of speech. Analysis of speech is described as particularly useful, since it does not require any equipment which must be attached to the body and thus may disrupt job performance.

RADIOBIOLOGY

(See also: Neurophysiology: P556; Space Medicine: M112)

PAPERS:

P579(13/87) Akatov YuA, Nevsgodina LV, Sakovich VA (USSR), Feher I, Deme Sh (Hungary), Khashchegan D(Romania).
Radiation research in flight.
In: Gurovskiy NN, editor.
Rezultaty Meditsinskikh Issledovaniy Vypolnennykh na Orbital'nom Nauchno-issledovatel'skom Komplekse "Salyut-6"-"Soyuz"
[Results of Medical Research Performed on the "Salyut-6"-"Soyuz" Space Station Complex.]
Moscow: Nauka; 1986. Abstract: Space Medicine: M112, this Digest Issue.
Pages: 335-348. [22 references; 6 in English]

Radiobiology, Dosimetry, HZE, Gamma-radiation
Botany, Lettuce, Seeds; Humans, Cosmonauts
Space Flight, Salyut-6

Abstract: The "Integral" experiment studied the distribution of the absorbed dose of cosmic radiation and the fluence of heavy charged particles over long periods of time. After a predetermined period, detectors exposed on board the station were returned to Earth for processing. Detectors used included thermoluminescent crystal phosphorous and glass, plastic track detectors, and photographic plates, all of which are self-contained, require no power supply and can record and store information on radiation generated through interaction of the solid with the ionizing radiation. A set of detectors in a rigid container composed the "Integral" unit. Air-dried lettuce seeds were also contained in this unit. From 1979-1981, 9 stages of the experiment were performed lasting from 31 to 308 days and using 24 units (See Table 41). The characteristics of the apparatus which received the information from the detectors are presented in Figure 42. Detectors were calibrated on Earth using standardized sources of gamma-radiation and bundles of protons. The conversion factor between exposure dose and absorbed dose in the air was found to be $8.8 \cdot 10^{-3}$ Gy/R. Radiation dose absorbed by crewmembers was computed using the following formula:

$$D_{tiss}(p+) = D_{atm}(p+) \frac{S_{tiss}}{S_{atm}}$$

where D_{tiss} is absorbed dose of protons in the biological tissue; D_{atm} is absorbed dose of protons in the atmosphere; S_{tiss}/S_{atm} is ratio of the stopping power of biological tissue to that of the air in a given energy range. The energy range of protons on board the station was determined to be 20-1000 MeV. For this range the ratio can be taken as 1.14. Thus, for the range of proton energy considered, absorbed radiation is equal to $1.14 \cdot 8.8 \cdot 10^{-3} = 10^{-2}$ Gy/R. Dose levels obtained from the various types of detectors were in good agreement. The "Integral" experiment was conducted during the period of maximum activity in the solar cycle , during which absorbed radiation was at a minimum on the 21st orbit, between the end of 1979 and the beginning of 1980. Dose rate was also affected by orbital parameters during certain periods. During all periods, mean dose rate was higher in the transfer module than in the working module, undoubtedly as a result of the difference in shielding in these two modules.

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The "Pille" experiment represented the initial test of a method which could be used to study dose distribution and determine individual doses in a short period of time on board the station. The experiment was performed using a special dosimeter developed by Hungarian and Soviet experts as part of the "Intercosmos" program. This apparatus (Figure 32) consisted of a small onboard measurement unit and a set of 16 self-contained thermoluminescent sensors. The measurement device read the information from the sensor and displayed the result on a CRT. The sensor was a self-contained device with a crystal $CaSO_4$:Tm detector element contained in a fixed monolayer on a heating element and sealed in a glass cylinder. The "Pille" apparatus can measure radiation doses in the range of 10^{-5}-0.1 Gy with accuracy of $\pm$ 5%. The 16 sensors allowed simultaneous measurement of 16 different points. One measurement required about 1 minute. The sensors were placed in various locations in the crew modules and also on the cosmonauts' flight clothes. Five days later a measurement session occurred and the magnitude of the recorded dose was determined. The apparatus had been calibrated before launch, and during the flight error rate was less than 5%.

Results showed that the mean dose rate in the modules was virtually the same throughout the flight, indicating that the dose was mainly attributable to high energy components. However, the dose rate on the cosmonauts' clothes was 15-20% lower than in the modules, testifying to the body's shielding capability.

A third dosimeter, the "PPD-2," which measured the total dose of ionizing radiation in the range of 10^{-4} - 1.0 Gy with error of 20% and provided constant read-out on a dial, was placed in various locations in the manned modules for fixed periods of time. Absorbed dose was recorded at the end of each period. From December 1977 to July 1980 a series of values for absorbed dose was obtained at 5 locations throughout the inhabited portions of the space station (Figure 44). The results showed that over the course of the experiment the magnitude of the mean daily dose decreased at all measurement points. This is attributed to the increase in solar activity during this period. Differences among locations also decreased demonstrating the increasing importance of high-energy cosmic radiation.

In the "Integral" experiment, dielectric track detectors (made of nitrate of cellulose and lavsan /Soviet Dacron/) were used to measure the fluence of heavy charged particles. Layers of cellulose nitrate 800 um thick were used to hold biological subjects. After exposure, the track detectors underwent chemical processing -- etching in a alkaline solution. Observable tracks formed from those particles which had limited linear energy transfer (LET) above the threshhold for that type of detector. Threshhold LET for the track detectors used was determined empirically using bundles of particles with known charges and energies (Table 45).

The magnitude of flux density recorded on "Salyut-6" in 1979 corresponds to results obtained on previous Soviet, US, and Soviet-US flights. In orbital flight, one of the major sources of radiation is the radiation belt of the Earth, particularly when spacedraft fly over the South Atlantic anomaly, where the internal radiation belt drops to 200-300 km above the surface of the Earth. An experiment was performed to allow study of changes in charged particles along the routes which pass through the anomaly and to determine

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the contribution of Earth's radiation belt to the overall dosage. This experiment used the self-contained, modified "Mini-dosa-178" (Romania) apparatus, as well as the "Pille." The experiment was performed 18-19 May 1981 by the Romanian cosmonaut. Throughout a single orbit passing through the anomaly zone, periodic measurements were made of the flux of charged particles (every 15 sec. within the zone, every 10 min. outside it). The apparatus and the sensor were then placed in a single location for joint exposure for 34 hours.

Results showed that the flux density of charged particles increased by up to a factor of 20 when the station passed through the central portion of the anomaly. This led experimenters to conclude that about 70% of the total flux is comprised of particles of the Earth's radiation belt in the zone of the anomaly. Magnitude of the absorbed dose in the experiment was 0.127 mGy for 34 hours, total flux during that time was $1.88 \cdot 10^5$ particles per cm^2, while the size of the average dose for a single particle was $6.8 \cdot 10^{-10}$Gy. Thus, the mean along the energy of cosmic radiation protons on board was approximately 220 MeV.

Cytogenetic Effects of Exposure to Heavy Ions

Experiments were performed on "Salyut-6" to investigate the effects of heavy charged particles on the cellular structure of air-dried lettuce seeds (Lactuca sativa). The detectors used made it possible to determine the location and number of times the seeds had been hit by heavy ions. Tables 47 and 48 describe the conditions and results of this experiment. It was possible to determine location of hits with accuracy of 10-15 um. Nitrate cellulose detectors recorded hits by particles with charge (Z) ranging from 10-26, LET of 1740-18000 $MeV/g \cdot cm^2$ and particle energy (E) from 2-15 MeV/nuclon. Thermoluminescent dosimeters were used to record total radiation dose. Seed groups studied included a ground control group, and flight seeds which had and had not been hit by heavy ions. Two weeks after landing, the seeds were moistened and allowed to sprout. Sprouts were fixed and stained. Dependent variables were frequency of aberration in the cell, number of aberrations in a single cell, rate of cell division during anaphase and telophase for a single rootlet, and growth of the seed before the beginning of the first cell division.

Initial mitosis was delayed in all flight seeds (Figure 35). In the control condition, cells kept for longer periods before sprouting tended to show more mutations (Figure 36). In the 66-day condition, aberrations were significantly more frequent in flight cells which had been hit by heavy ions than in those which had not been hit. Differences were not significant in the longer-term conditions due to the low mitotic index in these conditions (Table 49). In these conditions, hit and unhit cells differed significantly in number of multiple aberrations and number of aberrations in a single cell. Multiply aberrant cells were totally absent in the control conditions, but present in cells which had been hit by heavy ions. These results are interpreted as indicating that heavy ions play an important role in the cellular effects of exposure to space.

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Table 41 Results of measurements of absorbed dose in manned space station modules over long periods of time ("Integral" experiment)

Exposure Dates	Exposure Duration	Detector location	Mean dose, mGy	Mean dose rate, mGy/day
3/12 - 6/13/79	93	Work module		
		1. Panel 101	13.84	0.149
		Transfer module		
		2. Point # 1	18.04	0.194
		Work module		
		3. Sleeping quarters 1	16.43	0.177
		4. Sleeping quarters 2	14.27	0.153
5/13- 6/13/79	31	Work module		
		5. Panel 50	4.65	0.150
		6. Panel 55	5.81	0.187
		7. Sleeping quarters 1	5.78	0.186
		8. Sleeping quarters 2	4.67	0.150
5/13- 8/19/79	96	Work module		
		9. Panel 101	20.78	0.212
		10. Post 1	20.31	0.217
		Transfer module		
		11. Point # 1	30.54	0.312
		12. Point # 2	30.71	0.312
5/26- 7/31/80	66	Work module		
		13. Sleeping quarters 2	8.42	0.128
		14. Panel 34	9.80	0.149
5/26- 9/26/80	123	Transfer module		
		15. Point # 1	17.27	0.140
		16. Point # 2	17.63	0.143
5/26- 10/11/80	138	Work module		
		17. Sleeping quarters 1	20.36	0.148
		18. Post 1	18.64	0.135
5/26/80- 3/30/81	308	Transfer module		
		19. Point # 1	34.53	0.112
		20. Point # 2	34.50	0.112
3/22- 5/22/81	61	Work module		
		21. Sleeping quarters 1	9.00	0.148
		22. Sleeping quarters 2	9.45	0.155
3/22- 5/26/81	65	Transfer module		
		23. Point # 1	10.65	0.164
		24. Point # 2	10.95	0.169

Table 42: Measurement apparatus of thermoluminescent detectors

Detector type	Measurement Apparatus	Major Characteristics: Temp. range, °C	Dose range, Gy	Error, %
Glass TLS-2	IT-1 (USSR)	320-400	$5\cdot10^{-4}-5\cdot10^{1}$	±7
$CaSO_4:D_y$			$5\cdot10^{-6}-10^{2}$	
$CaSo_4:Tm$	TLD-04B	50-500	$10^{-6}-10^{2}$	±2
^7Li	(Hungary)		$5\cdot10^{-5}-10^{2}$	
$CaF_2:Mn$	RDTs-64A/1(GDR)	Up to 300	$10^{-3}-2\cdot10^{-1}$	±20
6LiF	Harshaw-2000	Up to 400	$10^{-4}-10^{3}$	±3
^7LiF	(USA)			

Table 43: Distribution of dosage in inhabited space station modules during the period of 28 May to 2 June 1980 ("Pille" experiment)

Sensor site	Dose level, m/Gy	Mean dose rate during the period, mGy/day
Clothing		
prime crew commander	0.390	0.081
prime crew flight engineer	0.416	0.087
visiting crew commander	0.405	0.084
visiting crew payload specialist	0.393	0.082
Transfer module		
point # 1	0.524	0.109
point # 2	0.447	0.093
Work module		
panel 34	0.430	0.090
post # 1	0.320	0.067
sleeping quarters 1	0.515	0.107
sleeping quarters 2	0.500	0.104

Table 44: Changes in radiation conditions in manned space station modules from 1977-1980 according to data from the PPD-2 dosimeter

Period	Mean daily dose, mGy/day		
	Transfer Module	Working module, Sleeping quarters, No 1	No 2
12/25-12/30/77	--	0.178	--
1/4-1/11/78	0.324	--	--
1/30-3/2/78	--	--	0.136
6/24-7/10/78	0.246	--	--
7/16-7/21/78	--	0.160	--
7/21-7/30/78	--	--	0.112
4/23-5/3/79	--	0.120	--
5/3-5/13/79	--	--	0.084
5/13-6/2/79	0.146	--	--
6/15-6/25/80	--	0.080	--
6/25-7/5/80	--	--	0.069
7/5-7/15/80	0.114	--	--

Table 45: Processing schedule and recording threshholds of dielectric track detectors

Detector	Processing schedule			Recording thresh-hold, KeV/um
	NaOH concent.	Etching time, hr	Temp, ^{o}C	
Cellulose nitrate, 800 um	6 N	2.5	46	LET_{1000} = 200
Cellulose nitrate, Kodak CA 80-15, 100 um	2.5 N	10	40	LET_{350} = 80
Lavsan, 80 um	20%	48	20	LET_{1000} = 610

Table 46: Results of measurements of fluence of heavy ions in manned "Salyut-6" modules (1979-1980)

Unit #	Fluence of particles with $Z \geq 6$ and $LET^{1000} \geq 200$, KeV/um, cm^{-2}	Flux Density, cm^{-2} $days^{-1}$
1	20.1	0.21
2	51.0	0.33
3	20.7	0.22
4	15.8	0.17
5	4.9	0.16
6	7.5	0.24
7	7.7	0.25
8	5.7	0.18
9	13.1	0.14
10	13.5	0.14
11	23.0	0.23
12	24.0	0.24
13	7.0	0.11
14	8.1	0.12
15	9.5	0.08
16	11.5	0.09
17	13.9	0.10
18	10.1	0.07
19	36.9	0.12
20	31.0	0.10

Table 47: Exposure conditions and physical parameters in seed experiments

Date	Exposure duration, days	Fluence of particles, $LET \geq 200$, KeV/um, cm^{-2}	Flux Density, $cm^{-2} \cdot days^{-1}$	Cumulative dose, mGy	
				during flight	per day
5/22-7/31/80	66	7.5	0.114	9.00	0.136
5/26-9/26/80	123	10.5	0.085	16.50	0.134
5/26/80-3/30/81	308	34.0	0.110	35.80	0.116

Table 48: Frequency with which heavy ions hit seeds in flights varying in duration

Flight duration, days	Seeds hit by one particle		Seeds hit by two particles	
	Number	%	Number	%
66	66	20.3	4	1.2
123	132	15.4	11	1.3
308	151	31.4	16	3.3

Table 49: Cytogenetic analysis of sprouts of seed exposed on "Salyut-6"

Stage	Duration, days	Seeds	No. of shoots	Anatelophases N	With aberrations N	With aberrations %	Cells with multiple aberrations N	Cells with multiple aberrations %	No. of aberrations per cell	No. of anatelophases per root
I	66	Control	33	1505	25	1.66	0	--	1.00	46
		Flight:								
		not hit	31	1293	23	1.77	2	0.07	1.04	42
		hit	40	1855	10	3.80	4	0.26	1.05	46
II	123	Control	20	647	13	2.00	0	--	1.00	32
		Flight:								
		not hit	125	2520	81	3.21	4	0.15	1.04	20
		hit	62	1529	76	4.97	4	0.26	1.05	25
III	308	Control	5	149	6	4.00	0	--	1.00	24
		Flight:								
		not hit	54	256	40	15.60	10	3.90	1.38	5
		hit	45	320	64	20.00	15	4.70	1.25	7

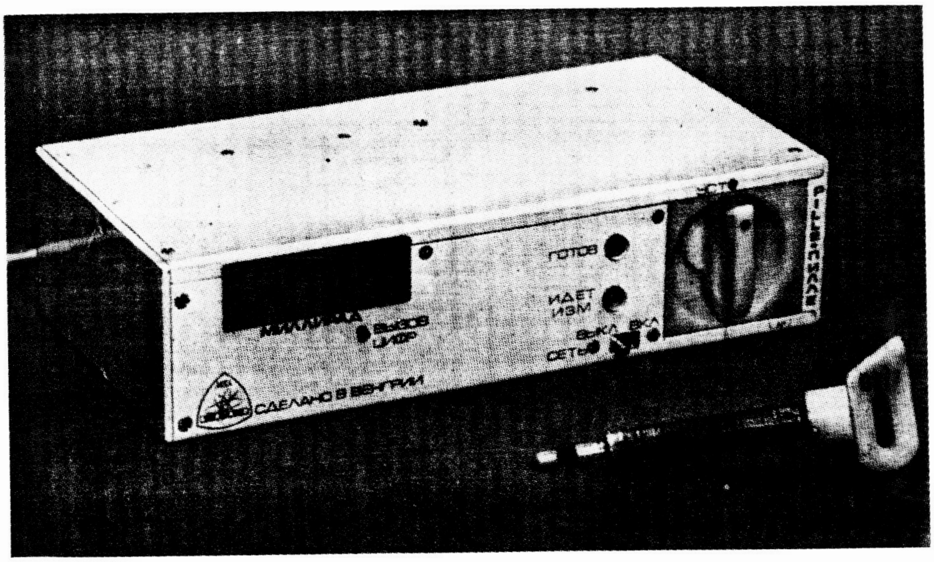

Figure 32: Inboard "Pille" dosimeter with sensor

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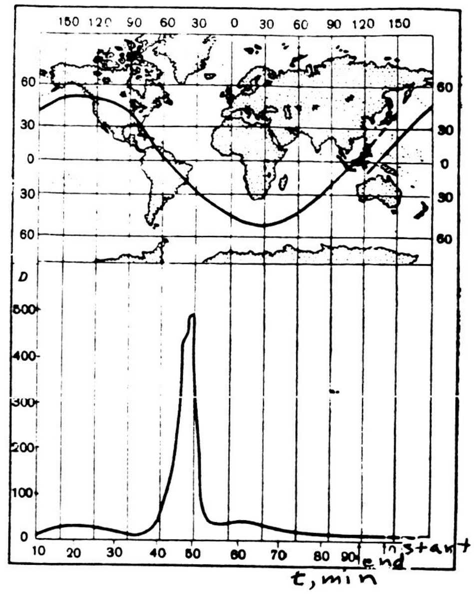
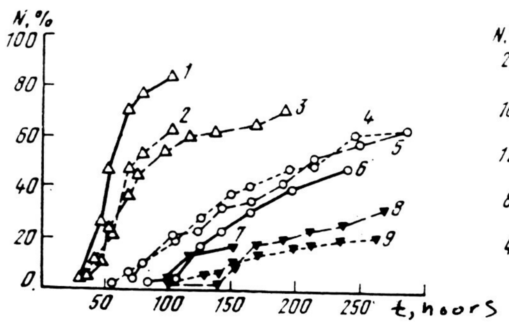


Figure 33: "Mini-dose-178" apparatus
Figure 34: Changes in flux density (D) of charged particles when space station passed through the zone of the South Atlantic anomaly of the Earth's radiation belt



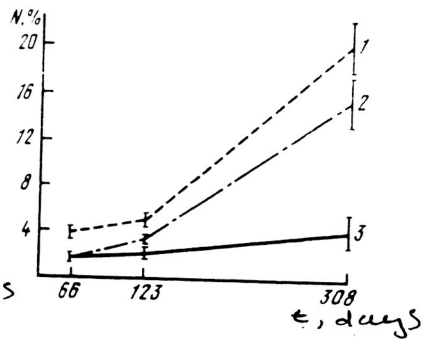


Figure 35: Number of sprouting seeds (N) as a function of time of first mitosis
66 day flight: 1 - control; 2 - seeds not hit; 3 - seeds hit by particles;
123 day flight: 4 - control; 5 - seeds not hit; 6 - seeds hit by particles;
308 day flight: 7 - control; 8 - seeds not hit; 9 - seeds hit by particles.

Figure 36: Number of aberrant cells (N) in the stage of ana- and telophase (on a single rootlet) as a function of flight duration
1 - seeds hit by heavy ions; 2 - seeds not hit; 3 - control

SPACE BIOLOGY

MONOGRAPH:

M113(13/87) No author or editor cited

Voprosy biologii v trudakh K.E. Tsiolkovskogo i ikh razvitiye v sovremennoy kosmonavtike: Trudy XVIII-XIX chtenii, posvyashchennykh razrabotke nauchnogo nasledii i razvitiyu idey K.E. Tsiolkovskogo (Kaluga, 1983, 1984)
[Biological issues in the works of K.E. Tsiolkovskiy and their development in modern cosmonautics: Papers presented at the XVIII-XIXth lecture series dedicated to further development of the ideas of K.E. Tsiolkovskiy (Kaluga: 1983, 1984)]
Moscow: 1985.
Participating Organizations: USSR Academy of Sciences, Commission on the Development of the Scientific Legacy of K.E. Tsiolkovskiy; K.E. Tsiolkovskiy State Museum on the History of Cosmonautics; Institute of Biomedical Problems, USSR Ministry of Health; Yu.A. Gagarin Cosmonaut Training Center; USSR Federation of Cosmonautics.

KEY WORDS: Space Biology, Space Medicine, Space Flight, Salyut-7, Gravitational Tolerance, LBNP, Hypokinesia with Head-down Tilt, Cardiovascular and Respiratory Systems, Hemodynamics, Immunology, Habitability and Environmental Effects, Hermetically Sealed Cabin, Vibration, Equipment and Instrumentation, Musculoskeletal System, Physical Exercise, Human Performance, Flight Performance, Life Support Systems, Greenhouse, Metabolism, Operational Medicine, Psychology, Stress, Hyperbaria, Hypobaria

CONTENTS

NOTE: Chapters marked with * have been abstracted in this Digest issue, other chapters will be abstracted in further issues.

Eighteenth Lecture Series

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SPACE MEDICINE

PAPERS:

P573(13/87) Grigor'yev AI, Stepantsov VU, Tishler VA, Mikhaylov VM , Pometov YuD, Dorokhova VR.
Means and methods for preventing the undesirable effects of weightlessness.
In: Gurovskiy NN, editor,
Razul'taty meditsinskikh issledovaniy vypolnennykh na orbital'nom nauchno-issledovatel'skom komplekse "Salyut-6"-"Soyuz"
[Results of medical research performed on board the "Salyut-6"-"Soyuz" orbital scientific research complex]
Moscow: Nauka; 1986; pages 125-145.
[47 references; 3 in English]

Space Medicine; Musculoskeletal System, Muscle Atrophy; Cardiovascular and Respiratory System, Cardiac Deconditioning; Human Performance, Adaptation
Humans, Cosmonauts
Space Flight, Salyut-6, EVA; Prophylactic Measures, Physical Exercise; Equipment and Instrumentation; LBNP; Body Fluids, Fluid and Salt Supplements, Drugs

Abstract: According to the authors of this chapter, the primary objectives of prophylactic measures used on space stations are:

o support of high levels of job performance by the crew during all stages of flight;

o prevention of disruptions of physiological systems during long-term space flight;

o preparation of the crew for the effects of acceleration during landing and of Earth's gravity during initial readaptation;

o prevention of debilitation and support of the crewmemberss psychological state.

The backbone of these prophylactic measures is physical exercise. Lower body negative pressure is used during the last days of the flight in combination with fluid and electrolyte supplements. During flight, certain pharmacological countermeasures may be used. Psychological support of the crew is ongoing throughout flight.

General Principles

The goals of physical exercise of space station crews are listed as follows:

o support of the body's tonus by creating a positive emotional state and improving overall work capacity;

o prevention of atrophy of antigravity muscles and bone;

o maintenance of muscular strength, and muscular and general endurance at or near baseline level;

o prevention of circulatory problems on return to Earth;

o maintenance of motor coordination after return.

Any physical training program for space station must meet the following criteria:

o program must continue uninterrupted throughout the flight;

o each exercise must serve several purposes; the majority must be directed at specific goals;

o exercises must be varied and involve alternation of training devices;

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- o the program must be cyclical (repetition of microcycles):
- o each microcycle must involve gradual increase in exertion.

Experience with previous Soyuz and other space flights has shown that occasional exercise in space is not sufficient to prevent undesirable effects even during relatively short-term flights. Another factor which mandates adherence to a rigorous training program is the need for EVA. The authors consider that to counteract the effects of weightlessness a physical training program involving two 1-hour sessions per day must require work equivalent to approximately 400-550 calories/hour (1676-1885 kJ/hr), with pulse increasing to 140-160 beats/min. Exercises (such as running, walking, and jumping) which entail rhythmic shifts of body fluids, and thus changes in intravascular pressure, are essential to prevent orthostatic intolerance upon return to Earth. To be effective, exercise in space, like all exercise programs, must conintue to the point of oxygen debt, accompanied by fatigue.

Exercise Methods and Devices

The conditioning "microcycle" used in space must include exercise directed at speed, strength, and general endurance. The total exertion required must increase daily and the day-off must be sufficient to allow full recovery of depleted resources. The optimum microcycle in space involves 3 days of exercise followed by 1 day of rest. Research has shown that cycles with more than 3 consecutive days of exercise are not suitable for use during long-term hypokinesia, since fatigue is not dissipated sufficiently. Experiments with hypokinesia lasting up to 6 months have shown that a 3+1 microcycle with 2 1-hour exercise sessions per day is sufficient for maintaining strength, speed, endurance, and physical work capacity at baseline level or even above. However, certain muscle groups (those of the back and legs) fall below baseline. It is essential that methods are found to prevent this on long-term space flights. Since the muscles in question are primarily antigravity, it is suggested that myoelectrostimulation be used to provoke prolonged contractions of moderate strength.

It was determined that a "treadmill" type trainer was most appropriate for exercise in weightlessness. For this reason, the trainer developed for the "Salyut" space stations has a treadmill as its major component. This trainer also uses a system of harnesses, an exercise suit with shoes, a movable horizontal bar, and a set of expanders. Using a set of cords, this trainer can produce a static tension (up to 70% of body weight) along the body's vertical axis simulating in weightlessness the effect of "standing" on the treadmill.

The exercise suit exerts tension on the waist and shoulders, avoiding discomfort from local pressure, and creates uniform tension on the antigravity muscles. The treadmill belt allows the cosmonaut to perform such exercises as walking, running, jumping, knee bends, and weight lifting. These exercises maintain motor skills important for readaptation to gravity and exert inertial-impact tension along the body's longitudinal axis, fully equivalent to the fluctuations in intravascular hydrostatic pressure which occur on Earth while running and walking. This trainer has been used on space stations and its reliability and high performance demonstrated.

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Medical examination of "Salyut-6" cosmonauts postflight indicated that the training program had substantially reduced physiological deconditioning and accelerated full recovery.

A bicycle ergometer was used to supplement the treadmill exercise and assess cosmonauts' physical work capacity and cardiovascular functioning under exercise conditions that were controlled telemetrically. This device was shown to have good performance characteristics and was positively evaluated by the cosmonauts.

The TNK-2 and "Penguin" suits were part of the set of prophylactic measures used on all space station flights. These suits are designed to counteract the lack of tension on the musculoskeletal system while cosmonauts are working, during the intervals between exercise sessions. The pull of the suit's elastic components exerts a compressing force on the body's vertical axis (from the shoulders to the feet), producing loadings on the skeleton and antigravity muscles for long periods of time.

A set of expanders of various types were used in the performance of additional 10-15 minute exercises for maintaining weight and strength of antigravity muscles.

The "Tonus-2" electrostimulation device was used as an auxiliary means of maintaining muscle strength and preventing muscular atrophy.

From a physiological standpoint, a long-term flight can be divided into 3 stages, each with its own exercise goals: 1) acute stage of adaptation; 2) stabilization; 3) final stage.

No exercise program should be followed during the first stage, because of the demanding work required on the station, and also in view of the possibility of motion sickness. During this stage, static tension (lasting 5-7 seconds) are sequentially applied to the muscles of the neck, back, legs, and arms for a total of 2-3 minutes with the head held in a fixed position as a means of improving the cosmonauts' general state. This treatment may be repeated periodically when precursors of motion sickness occurr.

When symptoms of motion sickness are pronounced, physical conditioning exercises start on day 5. These are mainly performed on the bicycle ergometer with loading decreased by a factor of 2, at a rate of 500-900 kgm/min. During this period, one of the two training sessions can be omitted on certain days depending on the cosmonaut's health. The loading is increased progressively so that it has reached full capacity by the end of the period. Aside from the obligatory session (twice a day) the cosmonauts can perform additional exercises with the expanders in thier free time in order to exercise groups of muscles which may not be receiving sufficient contractile stimulation -- e.g., the posterior muscles of the calves, the trunk extensors. There may be several sessions per day, lasting 5-15 minutes each.

The full exercise program is followed during the second period, which constitutes the major portion of the flight. Cosmonauts are allowed some leeway in modifying the exercises to suit their individual needs and

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desires. Modifications must be consistent with attainment of a pulse rate of 160-180 after exercise.

The need for periodic EVAs requires supplementary exercises of the shoulders, arms, and hands. Use of expanders, the horizontal bar of the multipurpose trainer, rubber bands, and pedaling with the hands are recommended.

In general, an effective exercise program should involve continuous increase in the amount and rate of exertion. However, in long-term space flights, the limited time available each day and the dangers of overexertion, preclude such unlimited increases. The authors recommend an oscillating level of exercise, so that during the third month there is a decrease in the total amount of exercise performed, on the fourth month the level is again increased to that of on month 2, in month 5 there is again a decrease, and in 6 another increase.

During the third stage of flight, which lasts up to 20 days, exercise level must correspond to the cosmonauts' maximum physiological capacity (i.e., pulse should increase to 180). The basic exercise used during this period is running on the treadmill for a burst of 3-4 minutes, with intervals of 2-3 minutes of walking or other exercise. A single session should contain 4-5 alternations, in which running rate is never less than 160 steps per minute, and may reach 200-240 steps/minute and more for periods of 30 seconds to 1 minute.

Although the general principles described above determined the exercise protocol for all cosmonauts, there were considerable individual differences in adherence to the prescribed program and in preference for various types of exercise and loadings. After the 140-day flight [of the "Salyut-6" prime crew], the cosmonaut who preferred running on the treadmill to other types of exercise, and who regularly exceeded recommended loadings by a factor of two or more, showed greater tolerance of terrestrial conditions than the other cosmonaut who preferred the bicycle ergometer and adhered strictly to the recommended loading. However, tolerance and adaptation of the latter crewmember was fully satisfactory.

Records were kept of all exercise performed by cosmonauts on a 175-day flight. It was found that the prescribed amount of exercise was exceeded on the bicycle ergometer and almost met on the multipurpose trainer. Of particular interest was the fact that overall exercise performed was actually somewhat greater during the second half of the flight than during the first.

The authors emphasize the desirability of adhering not only to the total amount of exercise prescribed by the program, but also to the rate, sequence and nature of the exercise schedule. Thus, on the first day of the cycle, exercises are directed at speed: walking speed must be at or above the mean (120-140 steps/min), and running speed should be high and submaximal (200-300 steps/min), building up to a speed of 15-18-24 km/hour, with the support of the arms. Rapid running facilitates the development of strength and speed of muscle contractions and relaxation, and improves anaerobic processes and cardiorespiratory functioning. Prolonged maintenance of fast and particularly submaximal running rate is not

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possible due to fatigue. Thus, alternation of running and resting is recommended.

Slow, monotonous running (for 10-15 minutes and longer) and particularly pedaling the bicycle ergometer at a moderate rate (60 rev/min) is accompanied by stable oxygen balance, decrease in vascular tonus in the exercising muscles, expansion of the vascular bed, and relatively low tension on the heart, but is not conducive to the retention of orthostatic tolerance. Only on day 3 should the program include alternation of slow and moderate rates of walking and running. Thus, during days 1 and 2 of the training cycle (regardless of whether the legs are restrained by straps), the total amount, speed, and rate of movement must facilitate solution of the problem that exercise on the treadmill is meant to solve -- that of retention of the capacity to stand and walk upright.

Medical observations of cosmonauts immediately after landing support the conclusion that orthostatic and vestibular problems in crewmembers were directly related to the nature and amount of exercise they had performed in flight. Most cosmonauts adhered closely enough to the exercise program to support high work capacity in flight and rapid readaptation post flight.

The effects of lower body negative pressure (LBNP) are associated with a decrease in the amount of blood in the upper portion of the body and blood pooling in the lower limbs, so that volume of circulating blood decreases and causes a cardiovascular response similar to that seen in response to orthostatic tests. The first attempts to use LBNP on a space station involved a "rigid" vacuum space. Subsequently, a pneumovacuum suit was developed in which a cosmonaut could perform physical exercise (e.g., walking). A number of exercise regimens were proposed for use while wearing these suits. When these regimens were tested on subjects undergoing hypokinesia with head-down tilt, positive results were achieved in preventing orthostatic intolerance. One successful regimen involved a 2-day program with the LBNP suit worn once a day for 45 minutes with pressure reduced from 25 to 60 mm HG, in combination with simulated walking and jumping in place. The first prime crew of "Salyut-6" wore the LBNP suit for the last 5 days of flight. Training on the first day of the LBNP program involved two microcycles lasting 60 minutes each. On days 2-5, the cosmonauts wore the suit for 3 microcycles lasting 90 minutes each. Twenty to 30 minutes before each LBNP session the cosmonauts ingested 300 ml of liquid. On subsequent flights, the training schedule was altered somewhat. Instead of the 5-day schedule, a 2-stage program was adopted beginning approximately 18 days before landing. While the suit was being worn, information about the cosmonauts' physiological responses was recorded and analyzed on Earth and pressure levels controlled telemetrically allowing pressure schedules to be individualized. Not all cosmonauts on all flights performed the entire training program. No extreme effects of LBNP were reported by any crewmember, but individual differences in physiological response (heart rate and blood pressure) were noted. In the third prime crew, the lowest blood pressure noted in the flight engineer was 112/70 mm at LBNP of 45 mm Hg on day 157; while for the commander this level was 120/62 mm Hg at LBNP of 35 mm Hg on day 154. During the last 2 days of flight, each crewmember was exposed to LBNP for 55 minutes per day. Crew tolerance of sessions was good.

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In response to weightlessness, extracellular fluid is reduced by diuresis. The new level of fluid-electrolyte homeostasis facilitates adaptation to weightlessness, but is inadequate for return to normal gravity, leading to orthostatic intolerance. An initial test of the effects of salt and water loading on orthostatic intolerance after hypokinesia and head-down tilt indicated that fluid and salt supplements were lost from the body after 6-10 hours. However, when LBNP was combined with administration of extra fluid and salt and subjects undergoing bed rest had engaged in a program of physical exercise, long-term retention of fluid and electrolytes was enhanced. It was found that individuals undergoing hypokinesia with head-down tilt who received the set of measures to enhance fluid and electrolyte retention showed higher levels of renin and aldosterone than control subjects.

Because of the positive results achieved in tests of fluid and salt supplements, all cosmonauts were given 3-6 g sodium chloride and 600-1200 ml liquid, in addition to exercise and LBNP as described above, during the last two days of long term space flights. Before the final stage of flight, the cosmonauts' response to LBNP and additional fluid and salts was tested. All cosmonauts responded satisfactorily, but some showed a hypertensive reaction to the treatment. These cosmonauts were given a reduced dose of salt during the final stage of flight.

Postflight tests of extracellular fluid indicated that the set of prophylactic measures used had been generally successful in preventing changes in content of sodium and osmotically active substances in blood serum. This was not, however, true for the 2 cosmonauts who had ingested a reduced amount of salt or none at all.

Pharmacological countermeasures were also used to prevent various hemodynamic problems and support work capacity. These pharmacological countermeasures including: inoziya-F, panagin, potassium orotate, decamevit, and others. Specific drug regimens were determined on the basis of flight stage, individual differences in responses to space flight and specific drugs, and possible drug interactions.

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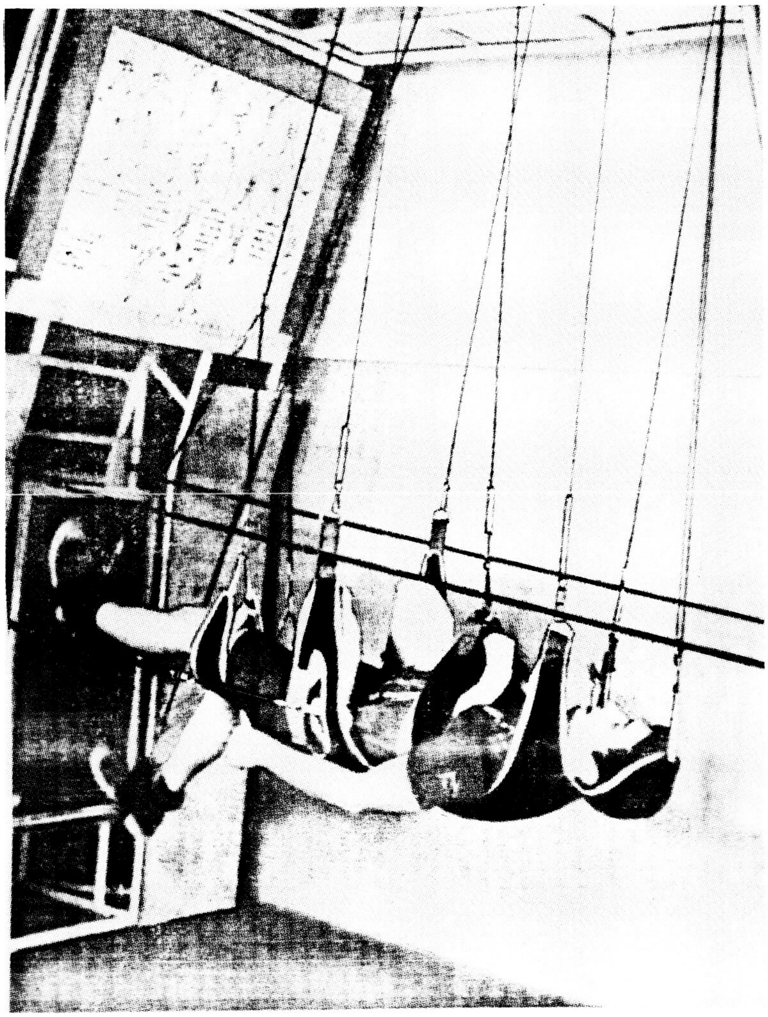

Figure 19: Trainer for conditioning exercises in a simulation of weightlessness

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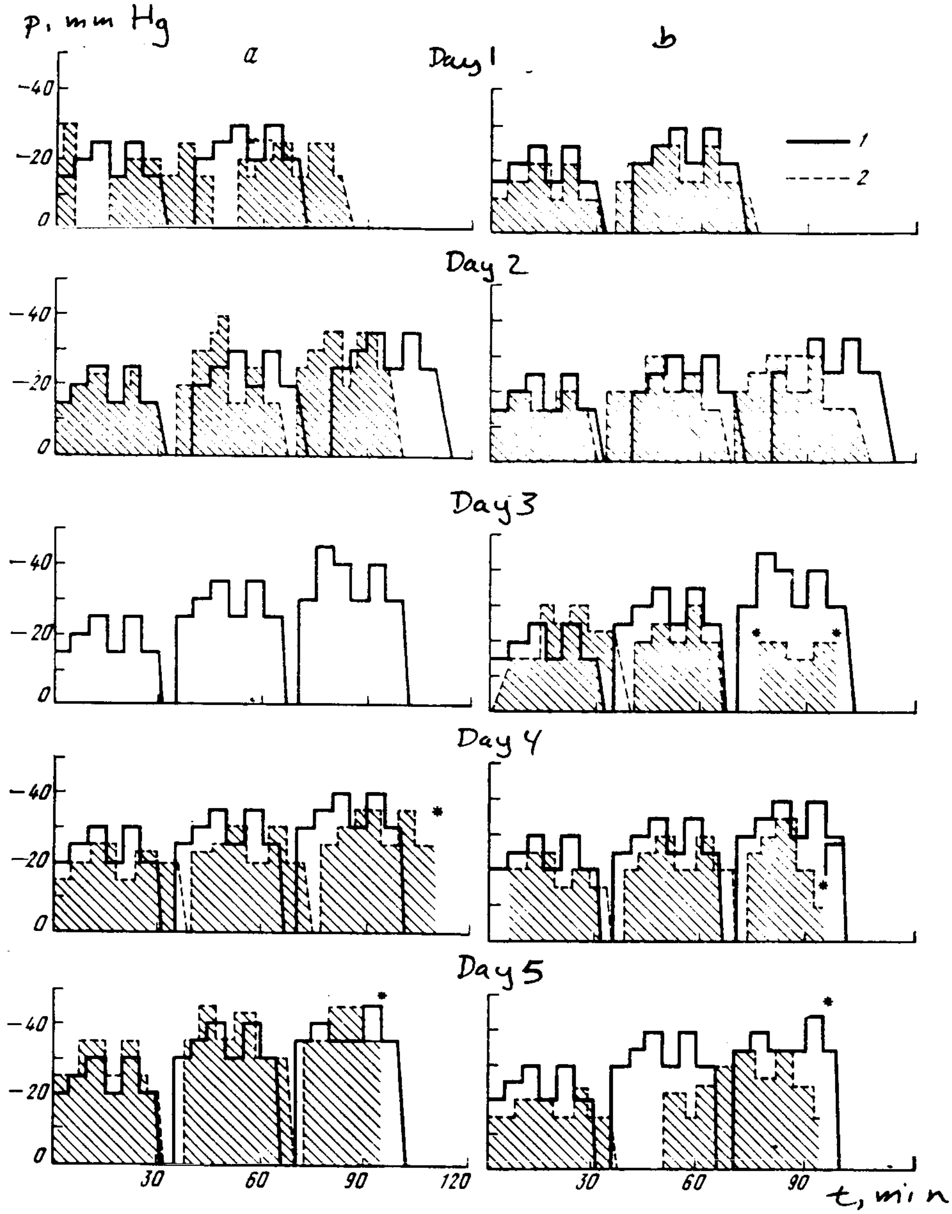

Figure 20: Recommended (1) and actually performed (2) schedules of LBNP combined with exercise by the commander (a) and flight engineer (b) of the first "Salyut-6" prime crew

* - no telemetric data available

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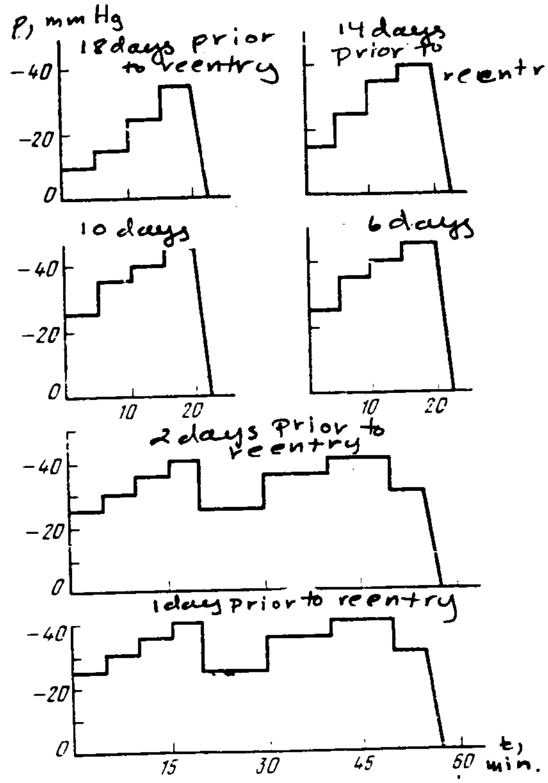

Figure 21: Diagram of preliminary (18-6 days before) and primary (2-1 days before) prelanding LBNP in members of the second and third prime crews

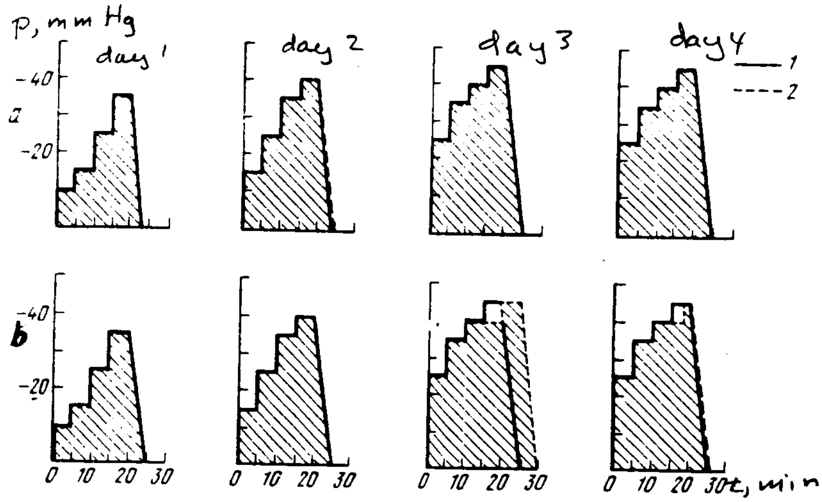

Figure 22: Recommended (1) and performed (2) preliminary LBNP regimens for commander (a) and flight engineer (b) of the third prime crew

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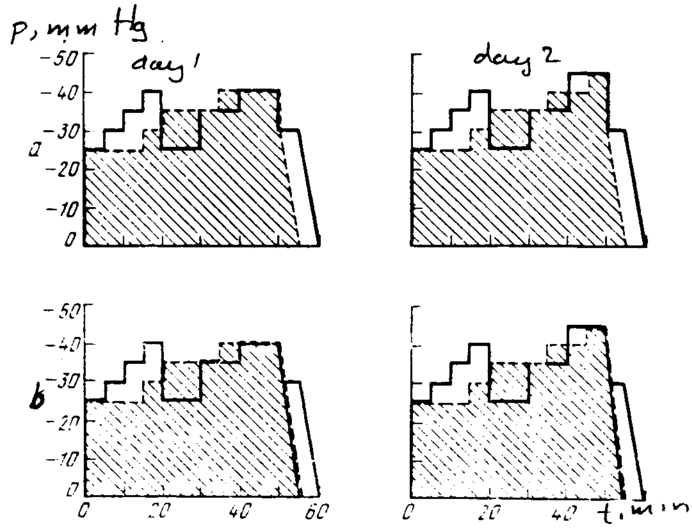

Figure 23: Recommended (1) and performed (2) primary LBNP treatment by commander (a) and flight engineer (b) of the third prime crew

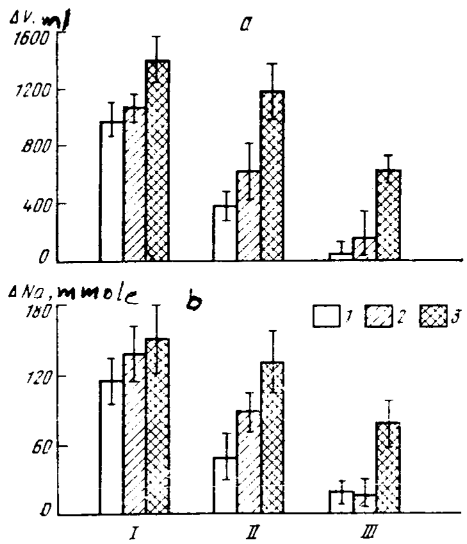

Figure 24: Difference between intake and renal excretion of fluid - V (a) and sodium - Na during long-term bed rest after administration of a fluid-salt supplement

I - after 1 - 2 hours
II - after 8 - 10 hours
III - after 24 hours
1 - bedrest
2 - bedrest and physical exercise
3 - bedrest, physical exercise, and LBNP

P574(13/87) Gazenko OG, Yegorov AD.
Preliminary results of medical research during a 211-day space flight.
In: Voprosy biologii v trudakh K.E. Tsiolkovskogo i ikh razvitiye v sovremennoy kosmonavtike: Trudy XVIII-XIX chtenii, posvyashchennykh razrabotke nauchnogo nasledii i razvitiyu idey K.E. Tsiolkovskogo (Kaluga, 1983, 1984)
[Biological issues in the works of K.E. Tsiolkovskiy and their development in modern cosmonautics: Papers presented at the XVIII-XIXth lecture series dedicated to further development of the ideas of K.E. Tsiolkovskiy (Kaluga: 1983, 1984)]
Moscow: 1985; pages 3-15.

Space Medicine, Body Fluids, Cardiovascular and Respiratory System, Endocrinology, Enzymology, Hematology, Immunology, Musculoskeletal System, Psychology, Human Performance, Metabolism
Humans, Cosmonauts
Salyut-7, 211-day Flight

Abstract: This paper outlines the results of the medical research and observations performed during the 211-day space flight by cosmonauts A.N. Berezovoy (commander) and V.V. Lebedev (flight engineer) on the "Soyuz T-5-Salyut-7" complex from 13 May - 10 December, 1982. This flight allowed cosmonauts considerable leeway in scheduling their time and marked the first use of a new meal system where cosmonauts had some limited choice of foods. The cosmonauts on this flight modified their prescribed exercise program so that they were doing considerably less high speed running than recommended.

General State: Cosmonauts evaluated their overall feeling of well-being as good throughout the flight. At the same time, both cosmonauts experienced the illusion of being upside-down during initial exposure to weightlessness. The sensation of blood rushing to the head was most pronounced at the beginning of the flight and then gradually diminished, disappearing completely after 6 weeks inflight. This sensation never appeared to interfere with job performance.

Psychological State: Over the course of the flight the cosmonauts psychological state never went beyond adequate adaptive changes and facilitated successful performance of flight duties. During periods of particular stress, the crew occasionally showed signs of fatigue with components of emotional lability (moodiness) and debilitation
These phenomena were limited through optimization of the work and rest schedule.

The duration (7-8 hours) and quality of the crew's **sleep** met their physical needs.

The crew's **physiological responses** to take off and landing were appropriate.

Anthropometric measurements revealed that there was weight loss overall and in the calves which reached a minimum in the middle of the third month in flight. During this period, the captain's weight was 2.9 kg below baseline and the engineer's, 6.5 kg below; the calf circumference decreased by 15.5 and 26.5 %, respectively. Subsequently body weight and calf circumference fluctuated, showing some tendency to recover at certain periods.

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Most attention was devoted to those systems expected to undergo the most substantial changes due long-term space flight.

Study of the **cardiovascular system at rest and during exercise** revealed that responses stabilized within approximately 4 weeks and remained at a relatively constant level throughout the entire 7-month flight. As a rule, both cosmonauts showed decreased cardiac stroke volume, and the engineer showed a slight increase in minute volume attributable to increased heart rate. In the flight engineer, heart rate fluctuated during months 2-7 of the flight within the range of 76-100, while preflight it was 64-72; in the commander heart rate was 56-70 in flight, and 50-60 preflight. The latter's blood pressure remained at baseline level throughout the flight; while some elevation was noted in the engineer's blood pressure. Venous pressure in the jugular vein was elevated in both cosmonauts.

Cardiovascular studies also showed that during the 7-month space flight there were some shifts in blood perfusion in various areas. As the flight continued, there was some tendency toward stabilization. As in previous long-term flights, flight there was a persistent decrease in pulsed blood perfusion in the calves. However, in distinction from the first long-term space flights, pulsed blood perfusion in the vessels of the brain decreased in both cosmonauts, or showed a tendency to do so. These changes partially compensated for the increase in heart rate. At the same time there was also a change in the tonus of the small vessels of the brain.

Provocative tests using graded physical exercise and LBNP enhanced the response of heart rate and blood pressure to weightlessness. LBNP induces redistribution of blood into the lower limbs and simulates the fluid shifts occurring when an upright position is assumed on Earth. At the same time it is important to note that the physiological responses to these functional tests were not a direct function of flight duration. Starting on month 2 of the flight the fluctuations of cardiovascular parameters in response to provocative tests stabilized at a relatively constant level, which in the commander corresponded to, and in the flight engineer exceeded preflight values.

After the flight, the cardiovascular system showed heightened response to vertical position (active standing or passive vertical position in a tilt test) and to exercise, compared to preflight levels. Electrocardiography did not reveal any significant divergence from the norm. In- and postflight the flight engineer showed an adrenergic type reaction, involving increased heart rate and certain blood pressure parameters, to provocative tests. His response is attributed to individual differences in regulation of cardiac activity, and also to some "deconditioning" in these regulatory mechanisms.

Muscle changes were noted. These included decrease in the tonus of the posterior muscles of the calf, sharp decrease in the strength of the anterior and posterior groups of muscles in the thighs and calves, and some decrease in the commander of the threshhold of sensitivity to vibration in the feet and a tendon T-reflex of the gastrocnemius muscle. Both cosmonauts experienced problems assuming a vertical stance. In- and postflight, there were decreases in the circumference of the thighs and calves, and decreased body weight, which however, recovered fully after the flight.

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The results of **biochemical studies** yielded data on changes in **hormone and enzyme activity,** characteristics of **protein, fat, carbohydrate, and vitamin metabolism** during exposure to space flight factors.

The results obtained generally agree with data from previous flights. However, a number of changes were newly identified. These primarily involved: decrease in the activity of the enzyme acetylcholinesterase, increase in concentration of a number of free amino acids in blood plasma, increase in the concentration of reduced glutathione, and depression of the rate of glycolysis in erythrocytes. Analysis of data on changes in catecholamine concentration demonstrate that in the early postflight period, the commander showed predominant activation of the hormonal link of the sympathetic-adrenal system, which manifested itself primarily by excretion of epinephrine into the blood, and activation of lipolysis in the form of increased concentration of free fatty acids in the blood. In the flight engineer, activity of the mediator link of the sympathetic-adrenal system predominated, as manifested primarily through the excretion of norepinephrine into the blood.

A significant decrease in the oxidase activity (malate dehydrogenase and isocitrate dehydrogenase) in the blood, which was also observed after a number of other long-term flights, may reflect a decrease in the rate of the oxidative component of metabolism, which requires a compensatory increase in the activity of anaerobic stages of the glycolytic reactions and mediatory metabolic links that provide the organism with energy.

On day 7 postflight, concentrations of epinephrine and norepinephrine in blood remained above preflight levels in both cosmonauts, and the ratio of these two substances indicated the predominance of the mediator link of the sympathetic adrenal system. One hypothesis is that the intensified lipolysis and lipomobilization (elevated levels of free fatty acids in the blood) observed during the first few weeks of the flight is a consequence of increased secretion of epinephrine into the blood. The increased level of free amino acids in plasma suggests the predominance of catabolic over anabolic processes. Similar effects were observed previously only after a 96-day flight.

Study of **fluid-electrolyte metabolism and renal function** revealed fluid retention and decreased urine volume despite increased fluid intake in both cosmonauts during the first 3 days postflight. In the initial postflight period, both men displayed increased concentrations of sodium and osmotically active substances in blood serum, an indirect indication of decreased blood volume, in addition to increased ionized calcium fraction and decreased potassium. Starting on day 3 postflight, concentrations of sodium and osmotically active substances returned to baseline. At the same time, potassium and the ionized fraction of calcium did not return to their preflight levels, while renal excretion of these ions increased. The negative potassium balance may be related to the decrease in muscle mass and decrease in the capacity of cells to assimilate the full amount of potassium.

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The results of investigation of the **blood system** are of great scientific interest since it is well known that the mean lifespan of red blood cells (erythrocytes) is approximately 120 days. Thus a 7-month flight represents the lifespan of almost 2 generations of these cells. If weightlessness disrupted erythrocyte formation, anemia would develop during a flight of this duration. However, our investigation showed that space flight conditions led only to a temporary, relatively slight decrease in the number of erythrocytes, which gradually (over 1.5-2 months) returned to normal postflight, corroborating results from earlier long-term flights. This result is related to the inflight decrease in circulating blood volume and significantly more rapid recovery of the liquid portion of blood postflight. The amount of decrease in erythrocytes remained constant when the flight was lengthened to 7 months. These data justify an optimistic assessment of the blood system's capacity to adapt to long-term space flight and to recover postflight.

Immunological studies revealed decreased numbers of blood cells responsible for immunity (T-lymphocytes) and depression of their functional activity, as well as a disruption of regulatory processes within the immune system, such as a decrease in T-helper activity and activation of T-suppressor lymphocytes.

Both cosmonauts were found to have weakened antiviral resistance, manifested by decreases in the cytotoxicity of natural killers. These data suggest an increased risk of infection during the early postflight period.

The immunological studies allowed us to examine the factors which determine the cosmonauts' immune status. **Microbiological studies,** directed at establishing the major principles underlying the formation of microflora on the cosmonauts and their environment, revealed a tendency for the composition of this microflora to change during the flight. All of this is of practical significance for the development of hygienic and epidemiological countermeasures for use on long-term flights.

Overall, the medical studies performed testify to the success of the readaptation process and do not differ substantially from studies of other cosmonauts returning from long-term flights. The present cosmonauts did, however, show somewhat more marked effects in motor coordination and other parameters of the motor system, and one cosmonaut lost more weight than had previously been the case. However, the prophylactic measures taken helped to maintain good health and high work capacity in the cosmonauts throughout the flight.

At the most general level, these studies revealed no substantial alterations in vital systems which could prove counterindicative to further prolonging the duration of space flights.

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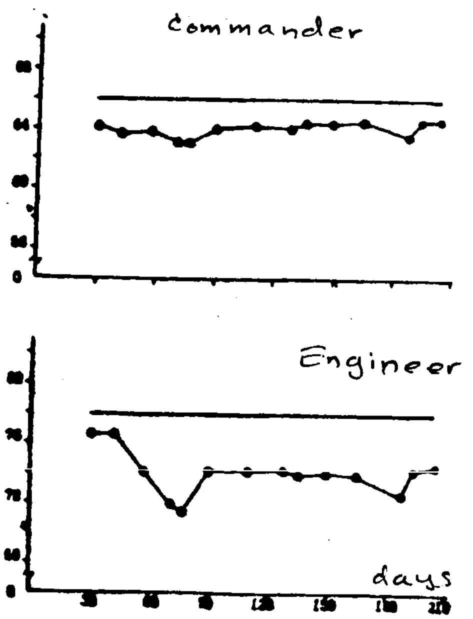

Figure 1: Weight of the first prime crew during flight

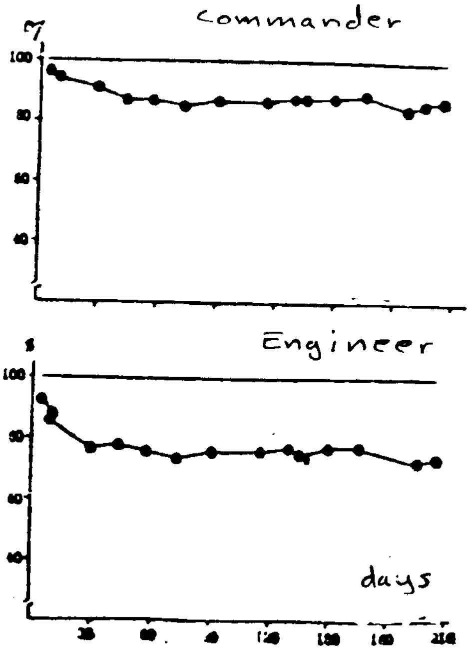

Figure 2: Calf volume in the first prime crew during flight

Solid line - preflight level

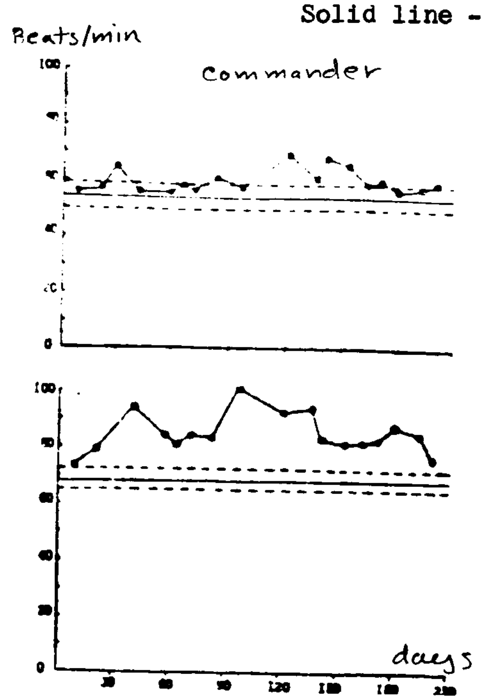

Figure 3: Resting heart rate of first prime crew during flight
Solid line - mean preflight level; dotted line - range of preflight fluctuations

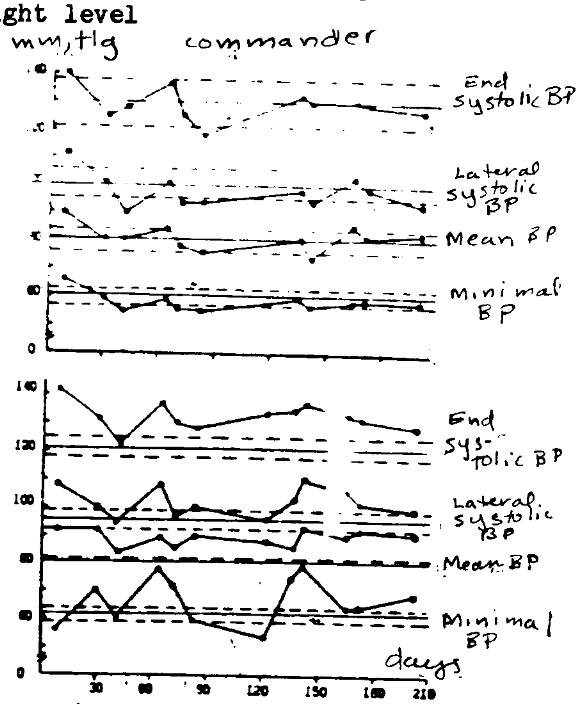

Figure 4: Resting blood pressure parameters in first prime crew during flight
Min - minimal; M - mean; LS - lateral systolic; ES - end systolic

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CURRENT TRANSLATED SOVIET LIFE SCIENCE MATERIALS AVAILABLE TO OUR READERS

Translations and abstracts of recent Soviet publications, including those of interest to specialists in space life sciences, are published by Joint Publications Research Service (JPRS). There are three series of JPRS reports relevant to space life science: Series USB, Science & Technology, USSR: Space Biology and Aerospace Medicine includes a cover to cover translation of the Soviet journal Kosmicheskaya Biologiya if Aviakosmicheskaya Meditsina (8 issues per year); Series ULS, Science & Technology, USSR: Life Sciences, containing mainly short abstracts with some complete translations (20 issues per year); and Series USP, Science & Technology, USSR: Space, containing translations of newspaper reports, short abstracts, and translations (6 issues per year). Individual JPRS publications may be ordered from the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22161. The phone number of NTIS is (703) 487-4600 and telephone orders are encouraged. Prices depend on number of pages; a recent issue of Space Biology and Aerospace Medicine, for example, cost $16.00. When ordering, it is recommended that the JPRS number, title, date and author, if applicable, of publication be cited. An order takes 9-30 days to arrive. Rush orders are possible, but involve an additional charge. There a significant and variable lag period between the time a JPRS publication is completed and the time it is orderable from NTIS.

As a service to our readers we will regularly provide publication information for relevant JPRS reports and cite the titles of articles selected as particularly relevant to NASA. Translations of titles are those of JPRS. JPRS entries marked with * were previously abstracted by us. Readers should be aware that JPRS abstracts are considerably shorter and less detailed than Digest abstracts

USSR REPORT: LIFE SCIENCES
BIOMEDICAL AND BEHAVIORAL SCIENCES

JPRS-UBB-87-009 29 April 1987

Selected Contents:

Circulatory Changes in Carotid Artery Basin in Response to Antiorthostasis and Antiorthostatic Bed Rest (Fedorov, et al.; Abstract; 1 page)* (Digest Issue 5)

Hemodynamic Effects of Negative Pressure in Lower Body (Mirrakhimov, et. al; Abstract; 1 page)* (Digest Issue 5)

Interaction of Macula and Semicircular Canal in Angular Stabilization of Man in Space (Gusev & Kislyakov; Abstract; 1 page)* (Digest Issue 7)

Effects of Cosmo-Helio-Geophysical Factor on in Vitro Bacterial Agglutination (Opalinskaya & Agulova; Abstract; 1 page)* (Digest Issue 7)

Effects of Pharmacological Agents for Preventing Motion Sickness on Cardiovascular System (Ilina et al.; Article Translation; 1 page)

USSR REPORT: LIFE SCIENCES
BIOMEDICAL AND BEHAVIORAL SCIENCES

JPRS-UBB-87-010 13 May 1987

Selected Contents:

Changes in Hemostasis System of Animals Under Conditions of Granulocytopoiesis Inhibition Under Effect of Decreased Barometric Pressure (Lunina & Poltavsky; Abstract; 1 page)

Cytomorphology and Ultrastructure of Corn Root Meristem in Weightlessness (Tairbekov, et al.; Abstract; 1 page)* (Digest Issue 10)

Effects of Ship's Habitation Environment on Conditioned-Reflex Activity of Experimental Animals During a Long Voyage (Netudykhatka, et al.; Abstract; 1 page)

USSR REPORT: LIFE SCIENCES
BIOMEDICAL AND BEHAVIORAL SCIENCES

JPRS-UBB-87-011 28 May 1987

Selected Contents:
No specifically relevant articles identified.

USSR REPORT: LIFE SCIENCES
BIOMEDICAL AND BEHAVIORAL SCIENCES

JPRS-UBB-87-012 29 May 1987

Selected Contents:

Effects of Immobilization Stress, Heart Infarction and Short-Immobilization Adaptation on Brain Levels of Endogenous Peptides (Meyerson, et al.; Abstract; 1 page)

Hypokinesia, Nutrition and Lipid Metabolism: Effects of Protein and Vitamin Deficiency on Serum Lipids and Lipoproteins in Hypokinesia (Abdraimova, et al.; Abstract; 1 page)

Comparative Evaluation of Methods for Testing Physical Capacity for Work of Irradiated Animals; Abstract; 1 page)* (Digest Issue 9)

JPRS REPORT
SCIENCE AND TECHNOLOGY
USSR: LIFE SCIENCES

NOTE: This is a new name and code for the biological report.

No specifically relevant articles found in JPRS-ULS-87-001.

JPRS REPORT
SCIENCE AND TECHNOLOGY
USSR: LIFE SCIENCES

JPRS-ULS-87-03 9 July 1987

Selected Contents:

JPRS REPORT
SCIENCE AND TECHNOLOGY
USSR: LIFE SCIENCES

JPRS-ULS-87-009 5 August 987

Selected Contents:

JPRS REPORT
SCIENCE AND TECHNOLOGY
USSR: SPACE BIOLOGY AND AEROSPACE MEDICINE

JPRS-USB-87-004 15 June 1987

VOL 21, NO 2, March-April 1987. Abstracted in Digest Issue 12.

USSR REPORT
SPACE
JPRS-USP-87-003 29 April 1987

This report contains 50 pages of Soviet "Manned Mission Highlights" concerning the Mir space station. These highlights consist mainly of translations of newspaper articles.

ENGLISH TRANSLATIONS OF SOVIET SPACE LIFE SCIENCES BOOK

We have recently learned of the possible availability of an English translation of the book Kosmicheskaya Biologiya i Biotekhnologiya: Sbornik Nauchnykh Trudov [Biology and Biotechnology: A Collection of Scientific Papers] by K.M.Sytnik. This book was extensively abstracted in Digest Issues 11 (Microbiology: M106) and 12 (Botany: P531, P532, P533; Microbiology P534, P535, P536. P537). For further information, NASA personnel should contact: NASA Headquarters, Scientific and Technical Information Branch (Code NIT-4), at (202) 453-2912. Other readers should direct inquiries to:

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15. Supplementary Notes

* Joseph Rowe: Library of Congress

16. Abstract

This is the thirteenth issue of NASA's USSR Space Life Sciences Digest. It contains abstracts of 39 papers recently published in Russian language periodicals and bound collections, two papers delivered at an international life sciences symposium, and three new Soviet monographs. Selected abstracts are illustrated with figures and tables from the original. Also included is review of a recent Soviet-French symposium on "Space Cytology." Current Soviet Life Sciences titles available in English are cited. The materials included in this issue have been identified as relevant to 31 areas of aerospace medicine and space biology. These areas are: adaptation, biological rhythms, body fluids, botany, cardiovascular and respiratory systems, cosmonaut training, cytology, developmental biology, endocrinology, enzymology, equipment and instrumentation, gastrointestinal systems, genetics, habitability and environment effects, hematology, human performance, immunology, life support systems, mathematical modeling, metabolism, microbology, musculoskeletal system, neurophysiology, nutrition, operational medicine, perception, personnel selection, psychology, radiobiology, space biology, and space medicine.

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