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USSR Space Life Sciences Digest

Issue 9

Lydia Razran Hooke, Mike Radtke,
Ronald Teeter, and Joseph E. Rowe

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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 9 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 ninth issue of the USSR Space Life Sciences Digest. To date we have received over 150 responses to our second reader survey. We are gratified both by the level of response and the generally positive evaluation of our publication. On the basis of reader responses, we are retaining all Digest features, but will raise our criterion as to whether a published interview, book foreword or chapter, or book review warrants inclusion in a Digest issue. Although the majority of readers responding to our survey had no complaints about Digest readability, approximately a third cited minor problems with technical terms, and a handful referred to major problems. We again urge our readers to use the feedback form included in every Digest issue to correct our terminology, particularly if our misuse of a technical term is repeated.

The almost complete absence of book abstracts in the current Digest issue reflects the paucity of relevant available material, rather than a change of policy. Readers who would like to see a table or figure the title of which is cited in the Digest are invited to write to us. An index has been prepared of Digest issues 5-9 and should reach those on our distribution list shortly.

Please address correspondence to:

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Suite 209, West Wing
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ADAPTATION

(See also: Biological Rhythms: M97; Human Performance: P263; Life Support Systems: P397)

PAPERS:

P403(9/86) Khitrov NK, Toloknov AV, Bol'shakova TD, Vinnitskaya KB, Panteleymonov VA.
Mechanisms of adaptation to physical exertion and the effect of excess CO_2 [on its formation.]
Byulleten' Eksperimental'noy Biologii i Meditsiny.
CI(6): 655-658; 1986.
[11 references; 2 in English]
Affiliation: I. M. Sechenov Medical Institute of Moscow, (Departments of Pathophysiology and Problems of Laboratory Biochemistry of Tissue Hormones)

Adaptation; Cardiovascular System; Endocrinology, Norepinephrine;
Neurophysiology, Acetylcholine
Rats, Male
Physical Exercise, Maximum Exercise Capacity, Training; Hypercapnia

Abstract: In this experiment, white male rats were compelled to swim carrying weights equal to 7.5% of their body weights once a day for 6 days a week, over the course of 3 months. Water temperature was 32°C. In the initial week of adaptation, weights were not used and duration of swimming was gradually increased from 5 to 30 minutes. After the initial week the rats' maximum work capacity was measured every month by determining how long they could swim with the weight. During the first month, the duration of swimming increased from 10 to 50%. During the second month, it further increased from 30 to 60%, and during the third month duration increased from 50 to 60%. Group 1 was trained with normal CO_2 level (0.7%) and Group 2 with a hypercapnic atmosphere (3.9% CO_2). Group 3 spent 30 minutes a day for 6 days a week over 3 months in this same atmosphere; Group 4 was an untreated control. The animals were examined after the first, second and third months of training, 20-24 hours after completion of the previous swimming session. While the animals were anesthetized, systolic pressure in the left ventricle was measured, as was its maximum increase and decrease when the aorta was occluded for 30 seconds. Heart rate was also measured. To evaluate sympathetic and parasympathetic effects of the procedure, experimenters measured changes in systolic pressure in response to injection of norepinephrine, and changes in heart rate in response to injection of acetylcholine in the left jugular vein. Concentration of norepinephrine in the left ventricle, and of acetylcholine in the tissue of the auricles was measured.

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Training in the hypercapnic atmosphere substantially accelerated the increase in work capacity during the first two months. However, during the third month, work capacity of hypercapnic trained rats decreased slightly, while that of the animals trained in a normal atmosphere continued to increase. Maximum systolic pressure in the left ventricle under occlusion of the aorta increased in the hypercapnic rats in the second month, but only in the third month in rats breathing normal air. Decreases in heart rate and increases in heart size occurred in the normal rats during the third month and the hypercapnic rats during the second month of training. Sensitivity of the pacemaker to acetylcholine was increased by the training procedure; again, these effects occurred in month 3 under normal and month 2 under hypercapnic conditions. After 3 months of training in normal air, stability of the level of norepinephrine in the left ventricle after strenuous physical activity increased, while resting level was unchanged, and the inotropic effect was enhanced. When training occurred under hypercapnic conditions, the resting concentration of norepinephrine decreased after 2 months, while concentration after physical exertion increased. These changes persisted after the third month, but the reactivity of the myocardia of the left ventricle to epinephrine increased. The authors explain the facilitative effect of hypercapnia early in training with reference to the fact that CO_2 and HCO_3- increase the excitatory effects of physical training on circulation and possibly also optimize the linkage between the respiratory and hemodynamic systems in the lungs. The failure of this facilitation to persist late in training is associated with decrease in reactions to CO_2 because of a decrease in the sensitivity of specialized hemoreceptors, and decrease in the rate of growth of pCO_2 and level of HCO_3- resulting from enhanced utilization by the tissues. Attenuation of the the induction effect and increase in the metabolic effect of hypercapnia are accompanied by a decrease in the concentration and stability of acetylcholine in the heart, and also in the reactivity of the myocardium to choline. Increased pyruvate carboxylation in the cholinergic neurons leads to a decrease in their formation of acetyl-CoA, and to a weakening of acetylcholine synthesis. Anions of HCO_3- inhibit the pentose cycle, causing a decrease in intracellular K+ and a weakening of the hyperpolarizing effects of acetylcholine on the cells of the cardiac pacemaker. All this tends to decrease parasympathetic effects, while indicators of sympathetic regulation of the heart, along with the functional capacity and weight of the myocardia, remain at the levels of maximal training effects. These changes are hypothesized to lead to inadequate long-term retention of cardiac stimulating effects after cessation of training, possibly leading to decreased work capacity. CO_2 in moderate concentrations is recommended for use in accelerating adaptation to physical exertion in the early stages of training.

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Table: The effect of excess CO_2 in the atmosphere on parameters of rats' cardiac activity during training [AO=occlusion of the aorta]

Concentration %	Training Duration, Months	Heart rate at rest, per min.	Initial SBP, mm HG	Max SBP at AO	Max. SBP by 30 sec. AO	Drop in Max. SBP by 30 sec AO
Control	--	363.1 (27)	88.8 (29)	+82.6 (29)	+64.0 (29)	-18.6 (29)
0.7 (normal atmosphere)	1	370.4 (10)	89.4 (8)	+81.8 (8)	+67.6 (8)	-14.2 (8)
	2	357.6 (11)	82.9 (10)	+88.0 (10)	+74.4 (10)	-13.6 (10)
	3	308.5* (8)	85.2 (6)	+83.3 (6)	+73.7 (6)	-9.6* (6)
3.9 (hyper-capnia)	1	369.6 (11)	93.5 (8)	+79.7 (8)	+63.2 (8)	-16.5 (8)
	2	324.7* (11)	91.0 (10)	+83.0 (10)	+75.1 (10)	-7.9* (10)
	3	300.8* (8)	83.0 (6)	+85.8 (6)	+74.6 (6)	-11.2 (6)

Numbers in parentheses refer to number of observation; +/- refer to presence or absence of occlusion of the aorta; * - difference from control significant, $p < 0.05$

Figure 1: Change in maximal work capacity of rats during training

Figure 2: Concentration of acetylcholine in auricular tissues and amount of decrease in heart rate in response to acetylcholine in control rats and rats trained for 2 or 3 months

Figure 3: Concentration of norepinephrine in the tissue of the left ventricle and degree of increase in systolic blood pressure in response to norepinephrine in control rats and rats trained for 2 or 3 months

BOOK REVIEW:

BR10(9/86) Isabayeva VA, Slonim AD.
Review of: Nespetsificheskiye Mekhanizmy Adaptsii Cheloveka
[Non-specific mechanisms of human adaptation].
Leningrad: Nauka; 1984, 146 pages.
Fiziologiya Cheloveka.
12(4): 695-696; 1986.

Key Words: Adaptation, Human, Long-term, General; Hematology, Leukocytes; Biological Rhythms,

Review: The problem of specific and nonspecific mechanisms occupies an important place in current ideas about the adaptation of animals to extreme factors in the natural environment. For this reason, this monograph by I.A. Sapov and V.S. Novikov, which considers nonspecific hematological changes in human adaptation to conditions in the far north, is of undoubted interest.

This book presents a philosophical treatment of general aspects of human adaptation. The focus is on homeostatic regulatory interactions in the "organism -- environment system." However, this is not the sole reason for the importance of the book. The authors begin by hypothesizing that the leukocyte system is instrumental in the defense mechanisms of the body, which act to maintain general homeostasis. With this in mind, they studied the cellular mechanisms of homeostasis in healthy and sick individuals in the far north.

Analysis of a great deal of empirical material has allowed the authors to describe the principles underlying changes in and causes of the weakening of nonspecific protection of an organism exposed to extreme conditions, and to demonstrate that nonspecific adaptive reactions reflect general principles of adaptation and may serve as indicators of its effectiveness.

Many authors advocate evaluation of the adaptive process based only on changes in the quantity of red blood cells. However, this does not permit specific assessment of the amount of stress on the adaptive capacities of the organism, and cannot serve as a criterion for differential diagnosis of preclinical states. In the view of the authors of this monograph, it is precisely the nature of the quantitative and qualitative connections in a relatively closed physiological system which makes the diagnosis of its functional state possible. Experience has shown that parameters of cellular aspects of nonspecific protection (i.e., those reflecting the morphology and function of the leukocyte system), changes in which reflect degree of stress at various stages of adaptation, can act as objective indicators of preclinical states.

The material presented in the monograph makes it possible to reexamine the role played by nonspecific structures in human adaptation to extreme conditions. The analysis performed shows that human adaptation to conditions in the extreme north is achieved through major morphological and functional shifts; and that the most adverse changes in protective structures occur during the initial period, the duration of which fluctuates as a function of time of year. The authors note that during this initial period there is a substantial increase in susceptibility to

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disease especially acute respiratory infections. These infections are associated with suppression of the cellular components of protection, particularly phagocytosis, the level of which can serve as an indicator of resistance to bacterial infections. This premise leads to a valuable conclusion, viz., that study of variability in adaptive capacity and adaptive reactions belongs, to a great extent, in the realm of pathology. This becomes clear when the mechanisms for supporting homeostasis are insufficient to completely balance the shifts which have occurred and cannot support an adequate adaptive reaction in an organism exposed to new environmental conditions. The relative stabilization and synchronization of regulatory and homeostatic processes, which occurs during long-term adaptation, is evaluated as an outcome supporting the protection of the systems of the organism at a new metabolic level. The book presents data not previously cited in the literature on the role changes in the biological rhythms of protective systems play in adaptive mechanisms and presents an extensive new analysis of circadian and noncircadian rhythms in the components of nonspecific protection and of the blood system.

Most of the experimental material cited in the book is presented in four chapters. Of greatest interest is the material and its interpretation in Chapters III and IV, which describe the cyclic changes in protective functions of the organism and a number of adaptive reactions in sailors during long-term cruises in northern seas.

The authors devote substantial attention to disorders of adaptation, and pathological states. In this respect, the book compares favorably with many experimental and theoretical works on the physiological basis of human adaptation. The authors uphold the view that adaptive disorders result from overstressing the mechanisms of nonspecific protection. This seems open to question, since exposure of an organism to extreme environmental factors leads to a number of shifts in the regulatory physiological homeostasis of the effector systems, which have not yet been adequately studied from the standpoint of responses by the nonspecific protective system. It must also be remembered that effects of external factors themselves vary over the course of a long-term cruise. We also have some doubts about the authors' discussion of physiological reserves and bioenergetics (pg. 124); however, these questions could serve as the topic for a "round table" discussion.

These remarks do not detract from our overall positive evaluation of this work. Sapov and Novikov's monograph "Non-specific mechanisms of adaptation" is a major work making valuable theoretical as well as empirical contributions to physiology and medicine.

The book can be used as a methodological handbook, or manual. The data cited within may be used for predicting the state of health (especially, longterm) of new and lifelong residents of the North, and for developing means to increase human resistance in the polar regions of the Earth.

(See also: Adaptation: BR10; Cardiovascular and Respiratory Systems: P406)

PAPER:

P405(9/86) Kazin EM, El'bert VE, Grishayeva VS, Shorin YuP.
Diurnal and seasonal rhythms of physiological functions in adrenalectomized rats.
Problemy Endokrinologii.
XXXII(2): 63-67; 1986.
[15 references; 2 in English]
Authors' affiliation: Kemerov University (Department of Human Physiology and Anatomy); Institute of Clinical Experimental Medicine (Endocrinology Laboratory)

Biological Rhythms, Diurnal and Seasonal;
Rats, Male
Endocrinology, Adrenalectomy, Thymus, Liver, 11-Oxycorticoids, Glucose, Glycogen, Free Fatty Acids, Nucleated Cells

Abstract: Experiments were performed on a total of 240 white outbred male rats, aged 2-3 months, over a period of 2 years. Animals were maintained under standard laboratory conditions. The experiments were performed in spring and fall. The first group was an intact control group. Group 2 rats underwent a bilateral adrenalectomy 3 weeks before the beginning of the experiment. These animals were given a 0.9% solution of sodium chloride for drinking water. Seven animals in each group were maintained in metabolic chambers to study their locomotor activity. Animals were sacrificed and studied at 3:00, 9:00, 15:00, and 21:00. The following parameters were measured: concentration of 11-oxycorticoid (11-OXC) in blood plasma, level of glucose in the blood and of glycogen in the liver, concentration of free fatty acids in plasma, of urea in plasma, and of potassium, total quantity of nucleated cells in the blood and in thymus homogenate. In a third group of rats, intact and adrenalectomized subjects were injected with ACTH in a dose of 5 units/100 g body weight at 2:00, 8:00, 14:00 and 20:00 during the spring; 1 hour later animals were sacrificed and the quantity of 11-OXC in their blood determined.

In the spring there were pronounced circadian rhythms in the concentration of 11-OXC in animals with intact adrenal glands, with the peak during the afternoon, 6 hours before peak motor activity. Circadian rhythms were observed in glycogen in the liver, and glucose, free fatty acids, potassium, and urea in blood. Peak levels of nucleated cells in the blood and thymus occurred during the night, in contrast to the 11-OXC peak. On day 21 after bilateral adrenalectomy, mean daily level of 11-OXC was restored and a diurnal rhythm differing from that of the control group was established. In spite of this, concentration of nucleated cells was markedly higher than for normal animals and diurnal rhythms in glucose, glycogen and nucleated cells in blood and thymus were not observed, suggesting insufficiency, which is corroborated by the fact that adrenalectomized animals do not react to ACTH the way intact animals do. In the fall, animals with intact adrenal glands showed a lower mean daily level of 11-OXC than in the spring. Peak levels of 11-OXC occurred in the morning. Levels of glycogen in the liver, free fatty acids, and urea in blood plasma were higher than

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in the spring, while other parameters were unchanged. No diurnal rhythms in glycogen, glucose, potassium or nucleated cells in the thymus and blood were observed. After adrenalectomy, level of 11-OXC was restored and a circadian rhythm noted. Concentrations of glycogen, free fatty acids and urea were below those in the spring, while that of nucleated cells was unchanged. The circadian rhythms noted in these parameters had no direct relationship to rhythms of 11-OXC. The authors interpret these results as demonstrating that sensitivity to hormones differ for various tissues and that the adrenal glands play an important role in the formation of circadian rhythms of various physiological functions.

Table 1: Circadian rhythms in physiological functions in intact and adrenalectomized rats in spring and fall

Table 2: Circadian changes in the concentration of 11-OXC in the plasma of rats in the experimental groups after injection of ACTH

MONOGRAPH:

M97(9/86) Stepanova SI.
Bioritmologicheskiye aspekty problemy adaptatsii
[**Biological rhythm aspects of the problem of adaptation**].
Moscow: Nauka; 1986.
[244 pages; 5 tables; 56 figures; 31 pages of references; ca. 200 in English]
Affiliation: [Book] Interagency Scientific Council of the USSR Academy of Sciences and USSR Academy of Medical Sciences on the Fundamental Problems of Medicine

Key Words: Biological Rhythms; Adaptation; Personnel Selection, Cosmonauts

Annotation: This monograph advances the position that biological rhythms function to support the qualitative stability of a living system. Much attention is devoted to the periodicity of adaptive processes, and to demonstration of this phenomenon in responses of humans and animals to acute and chronic exposure to various stimuli. The use of biological rhythms for functional and diagnostic examinations in clinical and occupational practice is described. This book is intended for physiologists and physicians, as well as for biologists interested in problems related to adaptation and biological rhythms.

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

P400(9/86) Yakushev VS, Shkopinskiy YeA, Kuripka VI, Mironova YeV, Verzhikovskaya BG, Makoyed OB, Ryzhov AA.
Electrolyte concentration in the blood and tissue hydration in response to emotional-pain stress.
Fiziologicheskiy Zhurnal.
32(3): 363-367; 1986.
[6 references; 1 in English]

Body Fluids, Electrolyte Concentration, Tissue Hydration
Rats
Psychology, Stress, Emotional-Pain

Abstract: This experiment was performed on 155 Wistar rats, of which 32 were untreated controls (Group 1) and 123 were subjected to emotional-pain stress. [Note: for a discussion of the paradigm defining emotional-pain stress, see page 96 of this Digest issue.] These animals were further subdivided on the basis of whether they were sacrificed and studied during the formation of stress, 2, 4, or 6 hours into the stress-inducing treatment (Group 2); or 1, 2, 5 or 7 days after the treatment was terminated (Group 3). After sacrifice, blood was taken and the concentration of potassium, sodium, calcium, and magnesium determined through flame photometry or spectrophotometry. Venous blood pH was determined for some subjects. Fluid content of the left ventricle, brain hemispheres and liver was determined by vacuum desiccation. Changes in the concentration of blood electrolytes during and after procedures inducing emotional/pain stress are shown in Table 1. The most pronounced effect during the procedure is the development of hypernatremia, while levels of other electrolytes were below normal. After the treatment, levels of sodium and other minerals dropped to below baseline. Table 2 shows the results of stress induction on tissue hydration. Four hours into the stress procedure all organs showed significant dehydration. By 6 hours of treatment, brain and liver hydration had returned to baseline, while hydration of the ventricle was elevated. Ventricular hydration only returned to normal 7 days after treatment termination.

Table 1: Electrolytes in blood serum and erythrocytes, and venous blood pH, during and after induction of emotional-pain stress

Parameter (in mmole/l)	**Control**	**During stress induction**			**After stress induction**			
		2 hrs.	**4 hrs.**	**6 hrs.**	**day 1**	**day 2**	**day 5**	**day 7**
K^+: serum	6.19	4.68*	3.36*	4.68*	6.5	4.3*	6.4	5.13
eryth.	74.49	82.55*	83.85*	71.61*	68.63*	66.60*	75.65	64.90*
Na^+: serum	151.69	160.83*	178.46*	153.0	136.33*	147.66	140.16*	139.16*
eryth.	6.62	7.01	5.0*	4.26*	9.96	5.43	5.58	5.98
Ca^{++}: serum	2.11	1.63*	1.88*	1.48*	1.72*	1.60*	1.19*	2.19
Mg^{++}: serum	0.91	0.83*	0.75*	0.68*	0.83*	0.80*	0.92	1.15*
ph venous blood	7.336	7.362	7.386*	7.39*	7.328	7.365	7.34	--

* differs significantly from control, $p < 0.05$

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Table 2: Fluid content of organs during and after induction of emotional-pain stress, ml/kg dry tissue

Organ	Control	During stress induction			After stress induction			
		2 hrs.	4 hrs.	6 hrs.	day 1	day 2	day 5	day 7
Left cardiac ventricle	760.4	802.8*	639.2*	793.4*	792.9*	795.5*	798.5	788.1*
Cerebral hemispheres	800.7	799.1	755.6*	810.9	803.1	813.5	807.0	795.3
Liver	705.3	699.4	667.7*	706.2	704.2	727.6	727.6	715.3

* differs significantly from control, $p < 0.05$

BOTANY

(See also: Life Support Systems P394, P393, P397)

PAPERS:

P396(9/86) Tarasenko VA.
Ultrastructure of the root cap of *Arabidopsis* plants under normal conditions and microgravity.
In: Kovrov BG, Kordyum VA, editors.
Mikroorganizmy v iskusstvennykh ecosistemakh.
[Microorganisms in artificial ecosystems,]
Novosibirsk: Nauka; 1985. See Digest Issue #7, M78.
[pp. 23-28; 11 references; 3 in English]

Morphology and Cytology, Ultrastructure, Root Cap
Botany, *Arabidopsis thaliana*
Space Flight, "Salyut-6"

Abstract: This paper describes years of experiments examining the ultrastructure of root cap cells of mouse-ear cress (*Arabidopsis thaliana*) grown under clinostatting (2 revolutions per minute) in space on the "Salyut-6." In the first experiment, control plants were grown in vessels in an agarized medium or an ion-exchange substrate with continuous illumination at 8000 lux, at 24°C. In space and in the synchronous control condition, plants were grown in the "Svetoblok-1" apparatus, which provided sterile growth conditions and direct illumination of 2 to 4 lux. On the "Salyut-6," the experiments started with plants in the dicotyledon stage. The experiment lasted 65 days. The plants were illuminated for 14 hours per day during the first 16 days, and continuously for the subsequent period. The experimental treatment delayed the development of the plants, although experimental and control [not clear whether they mean synchronous or ordinary control] plants were at the same stage and did not differ in stem length, or in number of buds, or flowers by the end of the experiment. The authors attributed the delay of the generative phase to insufficient light in the experimental conditions. Mitosis and cytokinesis in the meristem of the root cap of flight plants from those grown under normal conditions. The most pronounced changes in the rosette stage involved the structure and topography of amyloplasts in the cells of the central statenchyme. In both flight and synchronous plants, amyloplasts were distributed throughout the cytoplasm, whereas normally they are concentrated in the distal end of the statenchyme. A decrease in the size of starchy grains was observed in both groups of clinostatted plants, accompanied by greater separation among the grains. During root ontogenesis, the cells of the central statenchyme of clinostatted plants showed more vacuolization than present in normal plants. In the beginning of the flowering phase, dense deposits on the membranous components of cells were found in individual root caps of control plants only in secretor cells, but throughout the root cap in clinostatted plants. Cells with electron dense deposits showed partial destruction of the organelles, in the form of breaks in the membrane of the amyloplasts, mitochondria, nuclei, and plasmalemma. Flight plants which at the end of the experiment were flowering or beginning to bear fruit showed pronounced vacuolization of cells throughout the cap of the main root. Plastids in the cells of the central statenchymes of the flight plants were distributed throughout the cytoplasm, and contained either small starchy grains or none at all.

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Vacuolization was more developed in flight than in synchronous plants for meristem cells, differentiating cells, and cells of the central statenchyme of the lateral roots. There was more variation in the content of the vacuoles for the flight plants, which in addition showed local destruction of tonoplasts and lysis zones in the cytoplasm and cell membranes. The authors attribute the fact that plants clinostatted in space were more severely affected to the stress of re-entry into Earth's gravity and note the possible contributing role of electromagnetic and HZE irradiation.

CARDIOVASCULAR AND RESPIRATORY SYSTEMS

(See also: Adaptation: P403; Human Performance: P363)

PAPERS:

P366(9/86) Bunyatin AM.
Electrical instability of the heart in animals showing different degrees of tolerance of immobilization stress.
Fiziologicheskiy Zhurnal SSSR im. I. M. Sechenova.
LXXII(6): 757-761; 1986.
[17 references; 7 in English]
Affiliation: Laboratory of Experimental Cardiology, I.P. Anokhin Scientific Research Institute of Normal Physiology, USSR Academy of Medicine, Moscow

Cardiovascular and Respiratory Systems, Heart, Electrical Instability
Rats, Species and Individual Differences
Immobilization Stress, Tolerance

Abstract: A total of 42 adult male rats of 4 different strains (Wistar, August, SHR, and outbred) were subjected to 30 hours in immobilization cages. During this period EKG and blood pressure (by means of a catheter in the abdominal aorta) were monitored continuously. After immobilization, the rats were anesthetized and their hearts exposed. Threshold for evoking ventricular arrhythmia was determined by applying electrical impulses during various phases of the cardiac cycle. From each strain, the 10 most stress-tolerant and adaptive and the 3 most susceptible to stress were selected. Of the total of 12 stress-susceptible rats, 9 showed a hypotensive type of stress response and 3 a hypertensive response. As a strain, Wistar rats are most and August rats least tolerant of immobilization stress. Tolerant rats showed no disruption of EKG rhythm and little blood pressure or heart rate fluctuation during the immobilization period. Adapting rats showed initial disruption of EKG (sinusoid tachycardia), blood pressure and heart rate, although these indicators had returned to baseline levels by the end of the period. The stress-prone rats were defined as those showing a drop or increase in blood pressure of 25-40 mm Hg compared to baseline by the end of immobilization, as well as animals which died during the treatment. These animals showed the most pronounced disruption of EKG, including extrasystole, and atrioventricular blockade. Five animals from each strain (including outbred) were not immobilized and served as controls. The control threshold (in terms of magnitude of electrical current) for arrhythmia (extrasystole, paroxysmal ventrical tachysystolis and ventricular fibrillation) was determined for each strain. For all strains, tolerant and adapting rats did not demonstrate statistically significant decreases in ventricular extrasystole threshold after immobilization, although there was a tendency in this direction. Tolerant and adapting animals of the August and SHR strain and outbred rats, showed decrease in the threshold for paroxysmal ventricular tachysystolis and ventricular fibrillation, while duration of the vulnerable phase of the cardiac cycle increased. The majority (80%) of Wistar rats showed a decrease in these two thresholds, but the duration of the vulnerable phase did not increase to a statistically significant extent. For the remaining Wistar rats (20%), levels of all these parameters remained at control levels. All 12 stress-prone rats showed

sharp decreases in the thresholds for fibrillation and its precursors. Most frequently fibrillation occurred immediately on application of minimal current strength and was prolonged and usually irreversible.

Figure 1: Determination of the thresholds for ventricular arrhythmias during application of a unitary electrical impulse in the vulnerable phase of the cardiac cycle

Figure 2. Changes in EKG and blood pressure in a stress-prone rat with a hypotensive reaction pattern

Figure 3: Changes in threshold for the occurrence of ventricular arrhythmia and duration of the vulnerable phase of the cardiac cycle resulting from immobilization stress

P376(9/86)* Agadzhanyan NA, Krasnikov NP, Naydich SI.

Use of gas mixtures containing increased amounts of oxygen and CO_2 to normalize external respiration and acid/base balance in the blood during fatigue caused by physical exertion.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
20(4): 32-37; 1986.
[25 references; 11 in English]

Cardiovascular and Respiratory System, External Respiration; Hematology,
Acid/Base Balance
Humans, Athletes
Fatigue, Physical Exertion; Countermeasures, Hyperoxia, Hypercapnia

Abstract: A group of 12 young athletes, mean age 16.8 years, exercised on a bicycle ergometer to the point of extreme fatigue. There were 4 experimental sessions, separated by 48-hour intervals. In the first session, subjects breathed ordinary air after exercising. In the second session, after 20 minutes of rest, the athletes breathed a mixture containing 1% CO_2 and 35% O_2 for 20 minutes. In the third session, they breathed a hyperoxic (35%) gas mixture with normal CO_2 content. In the fourth session, they breathed a mixture containing increased CO_2 (1%) and normal oxygen (20.9%) External ventilation parameters measured 40 minutes after exercise terminated included: respiration rate, pulmonary ventilation volume, exhalation of CO_2, oxygen consumption, respiratory coefficient, and coefficient of oxygen utilization. To study acid/base balance, blood was taken from a capillary in the finger during the most strenuous portion of the exercise, and at minutes 20 and 40 in the recovery period. The following measurements were made: blood pH, number of buffer bases, excess of nonvolatile acids, concentration of actual and standard bicarbonates, total quantity of chemically bound and physically dissolved CO_2 (tCO_2), and partial oxygen pressure.

Approximately 50% of the physical work performed by the subjects on the ergometer (average of 19600 kg-m per subject) occurred under conditions of oxygen debt. Anaerobic glycolysis facilitated the accumulation of lactate and development of uncompensated acidosis, involving substantial shifts in a number of parameters, including accumulation of nonvolatile acids and decreases in blood pH, concentration of actual and standard bicarbonates, tCO_2 and partial oxygen pressure in the blood. During passive rest breathing ordinary air, there was a partial recovery of these acid/base balance parameters. Breathing the gas mixture containing 1% CO_2 and 35% O_2 enhanced this normalization process. Essentially similar results were obtained with the hyperoxic mixture, but no significant effects on acid/base balance could be attributed to the hypercapnic mixture. External respiration parameters returned to their baseline levels by the end of the rest period when ordinary air was breathed. Breathing the mixture which was both hyperoxic and hypercapnic increased most parameters of pulmonary ventilation and gas exchange over baseline level; this was also the case of the hyperoxic mixture, and to a lesser degree of the hypercapnic one. The authors state that when an altered gas mixture is breathed during passive rest after intense physical activity, VCO_2 is approximately 50% of VO_2 and the respiratory coefficient is decreased, suggesting retention of exogenous CO_2 in the body. They conclude that this experiment shows that the bicarbonate buffer capacity can be controlled by accumulating endogenous CO_2 in the human body, and that breathing gas mixtures which are both

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hyperoxic and hypercapnic in a recovery period after intense physical activity is effective in restoring acid/base balance.

Table: Parameters of external respiration and acid-base balance in athletes at rest, during maximum exertion and at minute 40 of the recovery period while breathing different gas mixtures

Parameter	**Baseline**	**During Exercise (maximum)**	**At minute 40 of recovery period, breathing:**			
			20.9% O_2	**1% CO_2+ 35% O_2**	**36.2% O_2**	**1% CO_2+ 20.9% O_2**
f, per min.	14.6	46.6	16.4	16.8	16.7	15.0
V_E, l/min	9.2	122.8	8.4	12.0*	12.6*	11.3*
VCO_2, ml/min	212.6	3886.0	174.8	216.3*	260.6*	232.0*
VO_2, ml/min	260.4	4070.2	270.3	548.6*	577.2*	430.6*
R	0.820	0.951	0.642	0.400*	0.446*	0.542*
O2 util. coeff., ml/l	28.2	33.2	31.7	45.8*	46.0*	38.2*
pH	7.412	7.090	7.344	7.372*	7.376*	7.348*
BE, mmole/l	+0.3	-20.1	-5.7	-4.2*	-3.7*	-5.4
BB, mmole/l	48.1	27.9	42.1	43.6*	44.4*	42.5
AB, mmole/l	24.2	9.7	18.5	20.0*	20.4*	18.7
SB, mmole/l	24.1	11.7	21.4	22.0	22.7	21.5
tCO_2, mmole/l	25.0	9.9	19.4	21.2*	21.4*	19.6
pCO_2, hPA	52.6	42.8	47.2	48.6	47.9	47.0

* differs significantly from results for subjects breathing ordinary air.

P386(9/86)* Fomichev VI, To Nam Zen.
Central hemodynamic parameters during dry immersion of patients with borderline arterial hypertension.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
20(4): 73-74.
[4 references; 3 in English]

Cardiovascular and Respiratory Systems, Central Hemodynamics
Humans, Males, Patients, Arterial Hypertension
Hypokinesia, Immersion, Dry

Abstract: Parameters of central hemodynamics were studied using dye and a Soviet made monochromatic aural sensing device. Of a total of 10 subjects, all males, aged 45-55, 2 were healthy, and 8 suffered from borderline arterial hypertension. The parameters, which included systolic and cardiac index, and total peripheral resistance, were measured before immersion, in the 24th and 120th hour of immersion, and during a readaptation period. Results are shown in the table below. The authors conclude that hypertensive subjects show marked individual differences in hemodynamic response to immersion. There is a tendency for peripheral resistance to decrease.

Table: Mean values of parameters of central hemodynamics in individuals with borderline arterial hypertension exposed to dry immersion

Parameter	**Baseline**	**Immersion**		**Readaptation**
		24 hrs.	**120 hrs.**	
Cardiac index, $l/min/m^2$	3.14	3.4	3.6	3.29
Systolic index, ml/m^2	52.0	57.6	57.4	50.7
Total peripheral resistance, $l/c \cdot cm^{-5}$	1498	1176*	1215*	1404

* $P < 0.05$.

P387(9/86)* Belkaniya GS, Dartsmeliya VA.
The relationship between individual somatometric characteristics [i.e., body measurements] and functional characteristics of the cardiovascular system in horizontal and upright positions, in healthy individuals and patients with arterial hypertension.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
20(4): 75-77; 1986.
[29 references; 2 in English]

Cardiovascular and Respiratory System, Functional Characteristics, Body Measurements
Humans, Males, Healthy, Patients, Arterial Hypertension
Horizontal and Upright Positions

Abstract: In this study, anthropometric measurements were made for 90 healthy males and 62 males with stage I or II arterial hypertension. Ages ranged from 24 to 55. For each group, the values of 11 somatometric parameters were measured and correlated with hemodynamic parameters (blood pressure, cardiac output, stroke volume, and peripheral vascular resistance) measured in minute 30 of lying in horizontal position, and in minute 1, 5, 0, 15 and 20 of standing upright. Healthy and ill individuals differed in body weight, rated fat, distance between the top of the head and heartbeat location, and ratio of this distance to distance between the heartbeat location and the ground. In horizontal position the highest correlation for healthy individuals was between body weight and amount of fat and totality of hemodynamic parameters. For the patients, amount of muscle showed the highest correlation with hemodynamic parameters. For both groups, correlations between hemodynamic parameters and body measurements were considerably higher in upright than in horizontal position. The authors point out that the overall patterns of correlations are similar for the two groups of subjects, suggesting that the same principles underlie the relationships between functional and morphological characteristics in both groups.

Table 1: Relative distribution of somatotypes in healthy individuals and patients with arterial hypertension

Table 2: Somatometric characteristics of healthy individuals and patients with arterial hypertension

Table 3: Comparison of the characteristics of horizontal and upright position on the basis of the relative numbers of significant correlations between somatometric and hemodynamic parameters

P391(9/86)* Gol'dovskaya MD, Mel'nichenko VP, Kulayev BS.
Orthostatic response of heart rhythm in alert *Macaca mulata* monkeys.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
20(4): 86-88; 1986.
[4 references; 1 in English]

Cardiovascular and Respiratory Systems, Heart Rhythm
Primates, *Macaca mulata*
Postural Effects, Orthostatic Position

Abstract: Measurements were performed on 10 clinically healthy rhesus monkeys, weighing 4.5-5 kg, using a tilt table and a supine start position. Stress was minimized by using soft straps to attach the monkeys to the table and a "saddle seat." Each monkey was subjected to only 1 trial per day. Electrodes had previously been implanted in one of the bipolar chest leads. Head movements were restricted. The monkeys were lightly anesthetized for attachment to the table. Measurements were made 2-2.5 hours after the monkeys were attached to the table, by which time normal behavioral and orienting responses had usually been restored. A television camera monitored the animals' behavior. Measurements were made during an initial baseline period lasting 15 minutes, followed by orthostatic position (+75^{o}) also lasting 15 minutes. EKG was recorded every 3 minutes, and heart rate determined. Parameters considered were maximum heart rate, minimum heart rate, and the difference between them, as well as mean and standard deviation. The orthostatic position was accompanied by an increase in heart rate, even when this position was not eliciting increased motor activity in the animals. Since heart rate increased in orthostatic position, even when animals were anesthetized, the authors conclude that this effect is not simply a result of emotional stress. Results of this experiment were used to develop a methodology for performing pre- and postflight postural tests on monkeys flown on the "Cosmos-1514" biosatellite.

Table: Heart rate in monkeys in horizontal and orthostatic position

Figure: Changes in heart rhythm of monkeys during orthostatic tests

P393(9/86)* Simonov LG, Gel'fenbeyn MS.
[The potential for] Ultrasound measurement of hemodynamic parameters of the cardiocerebrovascular system
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
20(4): 8-16; 1986.
[64 references; 24 in English]

Cardiovascular and Respiratory Systems, Hemodynamic Parameters, Head
Review and Discussion Paper
Ultrasound Methodology

Abstract: This paper reviews the use and potential use of ultrasound as a noninvasive means of studying cardiovascular function and blood circulation in the head. Ultrasound is currently used to diagnose vascular lesions and investigate hemodynamic effects of extreme environmental factors. The three major types of ultrasound techniques and their use in investigating hemodynamic parameters of the heart, brain and major vessels of the head are classified and described in the table reproduced below. Because of their noninvasive nature and safety for repeated use, and the quantitative nature of the data they produce, the authors consider that ultrasound methods should be used more extensively for prophylactic examinations and occupational selection.

Table 1: Modern noninvasive methods for evaluating central, regional and peripheral hemodynamics of organs and tissues

Table 2: Potential for use of ultrasound methods in studying the hemodynamic characteristics of elements of the cardiocerebrovascular system

Method	Heart	Brain	Major vessels of the head
Echo	Echocardiography: determination of geometric dimensions of the cardiac ventricles, and stroke volume magnitude	Echoencephalography: evaluation of pulsed perfusion of the brain hemispheres	Echoarteriography: determination of the linear dimensions of the vessels
Doppler	Dopplercardiography: determination of rate of motion of cardiac elements	Dopplerencephalography: method has not yet been developed for use	Dopplerography determination of rate of blood flow in arteries and veins
Echo-doppler	Echo-dopplercardiography: method has not yet been developed for use	Echo-dopplerencephalography: method has not yet been developed for use	Echo-dopplerarteriography: determination of volume of blood flow

P399(9/86) Navakatikyan AO, Buzunov VA, Tile V, Frentsel' Kh.
The effect of hypodynamia and emotional stress on physical work capacity of the circulatory and respiratory systems during physical exertion.
Fiziologicheskiy Zhurnal.
32(3): 278-284.
[19 references; 2 in English]
Authors' affiliation: Institute of Industrial Hygiene and Occupational Diseases, Ukrainian Ministry of Health; and E.M. Arndt University, Greiswald, GDR

Cardiovascular and Respiratory Systems; Human Performance, Physical Work Capacity, Exertion
Humans, Workers
Hypodynamia; Psychology, Emotional Stress

Abstract: Workers in 3 professions served as subjects for this study. The first group (N=62) worked in the electronics industry, described as requiring little physical exertion or nervous stress and involving a pleasant working environment, as defined by dust, noise and temperature conditions. The second group (N=44) worked as power station operators, involving little physical exertion, but moderate stress in a pleasant working environment. The third group (N=61) were farm workers whose jobs involved considerable physical exertion but little emotional stress and somewhat less pleasant working environments. Groups were equivalent in age, years on the job, height, and weight. Parameters indicative of cardiovascular and respiratory function and physical work capacity were measured at rest and under 3 different loadings: 50 W (considered equivalent to light work), 100 W (moderate work) and 150 W (heavy work), on a bicycle ergometer. The parameters which were considered most indicative of health and work capacity were the ratio of minute volume (V_E) to oxygen consumption (VO_2), as a criterion of respiratory efficiency; and to alveolar ventilation (V_A) as a criterion of efficiency of alveolar ventilation; oxygen consumption and its watt equivalent, as a criterion of metabolism during aerobic energy expenditure; respiratory quotient (RQ); acid/base balance BB, pH, as a criterion of metabolism during anaerobic lactate-producing expenditure of energy; the ratio of partial alveolar oxygen pressure to alveolar ventilation, as a criterion of the effectiveness of compensatory increase in alveolar ventilation to maintain normal gas parameters in the blood during exertion. Subjects spent up to 8 minutes on the ergometer at 50 W, rested for 5 minutes, spent up to 10-12 minutes at 100 W, rested for 10 minutes, and spent up to 10-12 minutes at 150 W.

Results showed significant differences among groups in PWC_{170} and the other parameters measured. These effects are presented in Table 1. The authors' conclusions follow. 1. Hypodynamia combined with moderate nervous tension (Group 2) leads to a worsening of aerobic and anaerobic metabolism during physical exertion, decreases in the efficiency of pulmonary respiration and the capacity to perform strenuous physical work.
2. Individuals whose working conditions involve high levels of stress combined with hypodynamia tend to show hyperventilation, hypertonic stress, decreases in PWC_{170} and in efficiency of alveolar ventilation, and relative hypoxemia during physical exertion. 3. Individuals whose work requires strenuous physical labor (Group 3) are typically physically

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fit, as demonstrated by the efficiency of regulation of respiration and circulation during physical exertion and high levels of PWC_{170}. 4. Functional ergometric studies which measure parameters of pulmonary ventilation, hemodynamics, and gas and acid/base balance in the blood make it possible to identify early changes in physical work capacity caused by the combination of hypodynamia and stress.

Table: Respiratory and hemodynamic parameters in workers in three different occupations during physical exertion of 100 W

Parameter	**Group** 1 (hypodynamia, low stress)	2 (hypodynamia, high stress)	3 (exertion, low stress)
V_E, l/min	32.2*+	31.6*+	29.4
V_A, l/min	26.4*+	24.6	23.7
V_E/V_A	1.22	1.28*	1.24
V_{O2}, l/min	1.25	1.30*+	1.22
V_E/V_{O2}	25.0+*	24.3	23.3
RQ	0.93*+	0.92	0.88
p_{aO2}, kPa	10.5*+	10.8*	11.6
p_{aO2}/V_A	0.40*+	0.43*	0.54
p_{aCO2}, kPa	5.05	5.17	5.21
BB, mequiv./l	44.6*+	45.9	46.8
pH	7.36*+	7.37	7.38
Heart rate, min^{-1}	116*+	118*	107
Systolic BP, kPa	18.1*+	22.9	16.7
N	62	40	61

* difference between groups 1 and 2 statistically significant (level not cited); + significantly different from group 3. Note: the indications of which differences are significant, which do not appear to be consistent, are exactly as cited in the original.

Figure 1: Systolic blood pressure as a function (regression) of level of work performed in various occupation groups

Figure 2: p_{aO2} as a function (regression) of level of work performed in various occupational groups

P406(9/86) Frolov VA, Chibisov SM, Kazanskaya TA.
A possible mechanism underlying the occurrence of sudden cardiac death [death from myocardial infarction] during geomagnetic storms.
Patologicheskaya Fiziologiya i Eksperimental'naya Terapiya.
1986(3): 31-35.
[7 references; 1 in English]
Authors' affiliation: Patrice Lumumba University of Friendship Among Peoples

Cardiovascular and Respiratory Systems, Sudden Cardiac Death, Synchronization of Parameters; Biological Rhythms
Chinchillas, Male
Radiobiology, Electromagnetic Indices

Abstract: The authors state that evidence indicates that increased solar activity causing significant fluctuations in the intensity of the Earth's magnetic field is associated with complications of myocardial infarction and increased numbers of sudden cardiac deaths. This study attempts to investigate the mechanism underlying this association by examining the correlation of cardiac parameters with fluctuations in the daily planetary magnetic index and the planetary activity (Ap) index. A total of 120 mature male chincillas were used as subjects . For a 3-day period cardiac measurements were made electromanometrically in anesthetized animals every 3 hours. Parameters measured were actual intraventricular peak systolic pressure within the right and left ventricular cavities and the maximal attained intraventricular pressure in both ventricles, determined during 5 seconds of occlusion of the ascending aorta for the left ventricle and of the pulmonary artery for the right ventricle. Correlation coefficients between the parameters measured and the values of daily planetary magnetic index and the Ap index were derived. On the basis of these indices an intense geomagnetic storm was identified as occurring on 23 September 1984 (magnetic index = 1.9; Ap = 112); on 21 September magnetic activity was comparatively low (magnetic index= 0.6; Ap = 10) and 22 September showed intermediate activity (magnetic index = 1.1; Ap = 22). When cardiac parameters were measured on these days, it was observed that increase in electromagnetic activity was associated with diminished circadian rhythms; for example, variability of the set of cardiac parameters on the day of the storm was 29% of that 2 days before. In addition, the high correlations between cardiac parameters of the left and right ventricle on electromagnetically calm days was decreased substantially on the day of the storm. The authors interpret this result as indicating that magnetic storms disrupt the normal rhythmic changes in physiological functions. Since synchronous functioning of various portions of the heart is tied closely with biological rhythms, leveling of biological rhythms by magnetic storms desynchronizes the function of the heart as a system. Since fibrillation occurs more readily under desynchronization, this may be the mechanism for sudden heart death during magnetic storms.

Table: Correlation between certain parameters of contractile activity of the right and left ventricles in normal chinchillas on magnetically calm days

Figure: Changes in the correlations between parameters of contractile functions of the left and right cardiac ventricle during the development of a geomagnetic storm

P407(9/86) Meyerson FZ, Krasikov SI, Ustinova YeYe, Golubeva LYu.
Preventing cardiac damage in response to maximal physical exertion and increasing resistance to acute overloading by means of the antioxidant ionol.
Kardiologiya.
XXVI(4): 70-74; 1986.
[11 references; 1 in English]
Authors' affiliations: Laboratory of Cardiac Pathophysiology, Institute of General Pathology and Pathophysiology, USSR Academy of Medicine, Moscow; Department of Biochemistry, Orenburg Medical Institute.

Cardiovascular and Respiratory Systems, Cardiac Damage, Cardiac Resistance
Rats, Male
Physical Exercise, Countermeasures, Drugs, Antioxidant, Ionol

Abstract: Subjects in this experiment were male Wistar rats divided into 4 groups (each N=8). Group 1 was a control; rats in Group 2 were given ionol in a dose of 20 mg/kg body weight once a day for 3 days; rats in Group 3 were required to run on a treadmill at a speed of 16 m/min until they were no longer able to do so; rats in Group 4 were given ionol in the same dose as group 2 and then required to run on the treadmill for periods matched to those of rats in Group 3. Rats in each group were further subdivided, with some rats used to study contractile function of the isolated heart and the amount of creatine kinase transferred to a perfusate, while others were used to study energy metabolism in the heart. Groups 3 and 4 were sacrificed immediately after the physical exercise, and the hearts removed. For the first set of subjects, isovolumic contractions were induced in the left ventricle by means of a latex balloon; pressure was measured using an electromanometer. The data recorded was used to derive values for systolic, diastolic, and developed pressure, and maximum rates of contraction and relaxation. The heart was then perfused for 60 minutes under conditions of normal oxidation (associated with minimal transfer of creatine kinase into the perfusate), then the oxygenated and glucose containing solution was replaced for 10 minutes with a solution without oxygen or glucose, after which the heart was reoxygenated. The activity of creatine kinase in the perfusate which had passed through the coronary tract was determined during minute 60 of normal oxygenation, minute 10 of anoxia and on minutes 2 and 10 of reoxygenation. Parameters of cardiac energy metabolism were studied in a state of physiological rest and after acute overloading of the heart. This was achieved by opening the chest cavity in anesthetized animals with artificial pulmonary ventilation and completely occluding the aorta for 90 seconds and then removing the heart. Next a homogenate was prepared of the tissue of the left ventricle in a 0.6 N solution of HCl, and centrifuging it for 15 minutes. The concentrations of ATP, ADP, AMP, creatine phosphate and lactic acid in the resulting supernatant were determined.

Exercise at maximal level decreased the pressure developed by the isolated heart by 30% compared to the control group. While ionol did not affect this parameter in control animals, it prevented depression of developed pressure in those exposed to physical exertion; indeed, animals given ionol and then forced to exercise strenuously showed cardiac pressure 20% higher than that of controls. The amount of creatine kinase passing from the isolated heart into the supernatant on minute 60 of full oxygenation was 3 times as high for the exercising animals as for control animals. When

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ionol was administered to exercising animals, this difference was completely eliminated. Results also showed that the hearts of the exercising animals were more vulnerable to anoxia than were those of controls, but ionol eliminated these differences. (See Table.) The authors interpret these results as indicating that maximal physical exertion leads to destruction of the cells of the myocardium. Results of in vivo experiments indicated that aortal occlusion in untreated animals decreases the concentration of ATP and creatine phosphate by 35 and 60% respectively, and increases the concentrations of ADP, AMP, and lactic acid by factors of 1.3, 2.1 and more than 2, respectively. Preliminary administration of ionol to control animals decreased these effects somewhat. Maximal physical exertion did not affect initial concentration of ATP in the myocardia, but decreased initial creatine phosphate by 40%, and was associated with substantial increases in ADP, AMP, and lactate (by factors of 1.5, 2.4, and 1.75, respectively). Effects of occlusion of the aorta in experimental animals were similar to those in controls, but concentrations of ATP was 20% lower and of creatine phosphate was 35% lower than in the controls while concentrations of ADP, AMP, and lactate were higher after occlusion. Preliminary administration of ionol to experimental animals limited the decrease in creatine phosphate and the increase in lactate in the myocardium (compared to unprotected animals) and eliminated the decrease in ATP and creatine phosphate and the increase in lactic acid observed in control animals after 90 seconds of occlusion. These results demonstrate that the antioxidant ionol prevents much of the decrease in the concentration of energy-rich phosphate compounds and the accumulation of lactate in the myocardium in response to occlusion in animals which have undergone extreme physical exertion. These results are interpreted as confirming the hypothesis that the decrease in the concentration of creatine phosphate and the increase in concentration of creatine are early regulatory shifts activating the resynthesis of ATP in the mitochondria and adaptive increases in transport of phosphates from the mitochondria to the myofibrils. It is consistent that the magnitude of this shift increases when the mitochondria are damaged and the efficiency of aerobic resynthesis of ATP decreases, as occurs in response to maximal physical exertion.

Table 1. The effect of maximal physical exertion on activity of creatine kinase in a perfusate of isolated hearts during anoxia and reoxygenation

Condition	Minute 60 of perfusion	Minute 10 of anoxia	Minute 2 of of reoxygenation
I - control	8.03	19.9	30.8
II - ionol	7.2	8.4	10.3
III - maximal physical exertion	23.1	32.1	83.6
IV - ionol + exertion	9.6	9.0	14.8
p I:III	< 0.001	< 0.01	< 0.001
p III:IV	< 0.001	< 0.001	< 0.001

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Table 2: The effect of maximal physical exertion and ionol on the concentrations of high-energy phosphate compounds and lactate in the myocardium (in um per 1 g tissue) in response to acute overloading of the heart

Parameter	Control		Ionol		Maximal Exertion		Ionol + Exertion	
	A	B	A	B	A	B	A	B
ATP	5.12	3.82	5.2	4.29	5.1	3.13	5.1	4.06
ADP	2.1	2.8	2.8	2.5	3.0	3.4	2.6	3.0
AMP	0.28	0.58	0.27	0.46	0.66	0.79	0.63	0.69
Creatine phosphate	8.3	3.5	8.2	4.5	4.8	2.3	6.3	3.8
Lactate	3.34	7.07	3.16	6.6	5.86	12.78	4.65	7.01

Figure: The effect of maximal physical exertion and ionol on developed pressure during induction of various contraction rates in an isolated heart

DEVELOPMENTAL BIOLOGY

PAPERS:

P381(9/86)* Ananasenko ZI, Kuznetsova MA, Korotkova VYu.
Behavioral responses of animals exposed to space flight during the prenatal period.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
20(4): 55-59; 1986.
[25 references; 11 in English]

Developmental Biology; Psychology, Behavioral Responses; Neurophysiology, Prenatal Cortical Development
Rats, Fetus
Spaceflight, "Cosmos-1514"

Abstract: Subjects in this experiment were the offspring (number not specified) of 4 female Wistar rats which had been flown on the "Cosmos-1514" on days 13-18 of their pregnancy. A first control group consisted of 19 rats whose 5 mothers had been kept in a simulation of the biosatellite during the same portion of their pregnancy. In a second control, 24 rats from 5 mothers were maintained in the laboratory during pregnancy. Rats were tested in a circular "open field" on days 30, 51-53 and 88 of their lives. Responses recorded included horizontal and vertical motor activity, relative frequency of time spent in the center of the field, relative path length, standing up, sniffing, grooming, and quantity of urine and feces. The rats were run in mazes of 3 different designs, on days 33-45 (3 radiating alleys and a central section with reinforcement occurring only when rats took a new path); 58-72 (maze with 6 parallel alleys each containing one unlocked and several locked doors with reinforcement occurring on a unique path); and 79-82 (maze with many blind alleys in which rat to be reinforced must find shortest path to finish).

In the open field test, rats prenatally exposed to space showed depression of all the responses measured. No differences between groups were found in the number of subjects solving any of the mazes, nor in number of errors or latencies. However, flight rats were more likely to refuse to run the maze as the goal box was approached and were much more prone to engage in grooming responses and other goal-irrelevant responses while in the maze situation. When a stimulus which inhibited performance of the goal response (not specified in paper) was introduced, the flight group showed the most disruption of behavior. The authors conclude that prenatal exposure to space flight factors did not lead to any major changes in behavior. The flight animals readily oriented themselves in the new situation, assimilated the required response algorithms, and generalized what they learned to new situations. The changes observed in the flight animals representing slight decrements in the fine tuning of behavior may, in the authors' opinion, be viewed as resulting from attenuation of the inhibitory functions of the cortex on subcortical formation evidently caused by retardation of the maturation of cortical structure during prenatal exposure to space. These changes have only minor consequences under normal circumstances, but could decrease the functional capacity of the central nervous system and the level of adaptation to new environmental conditions.

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Table: Exploratory activity of rats in an "open field" at various times during the experiment

Behavior	Group of Rats	Age of animals, days 51	52	53	Reliability of Difference
Overall path length	Flight	75.7	79.7	64.4	F:V < 0.01
	Viv. Cont.	94.1	97.6	101.8	F:S < 0.01
	Syn. Cont.	92.5	100.6	91.6	
Visits to center of field	Flight	5.6	7.6	6.6	F:V < 0.001
	Viv. Contr.	12.3	11.8	12.1	F:S < 0.001
	Syn. Cont.	13.4	11.7	10.8	
Relative path length in center of field, %	Flight	3.2	5.6	3.7	F:V < 0.001
	Viv. Cont.	8.9	8.7	9.5	F:S < 0.001
	Syn. Cont.	13.0	11.7	10.3	
Number of times stood with front paws on wall	Flight	8.4	8.1	8.1	F:V < 0.01
	Viv. Cont.	12.1	13.6	11.9	F:S < 0.001
	Syn. Cont.	17.7	15.7	13.3	
Number of specifically exploratory responses	Flight	8.6	10.8	11.8	F:V < 0.01
	Viv. Cont.	14.5	22.3	14.0	F:S < 0.001
	Syn. Cont.	23.5	21.0	19.0	

Notes: Viv. Cont. = vivarous control group; Syn. Cont. = synchronous control group; F:V = significance level of difference between flight and vivarous control groups; F:S = significance level of difference between flight and synchronous control groups

Figure 1: Quantity of excrement produced by female and male rats in "open field" experiment [Not reproduced.]

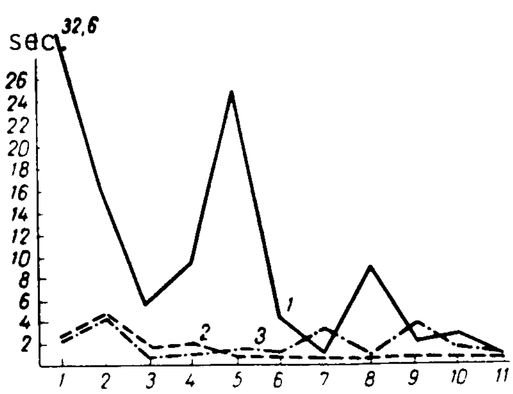

Figure 2: Time spent grooming by animals in different groups in a maze. Abscissa -- trial number; Ordinate -- time spent grooming during trial. $P_{1-2} < 0.01$; $P_{1-3} < 0.01$

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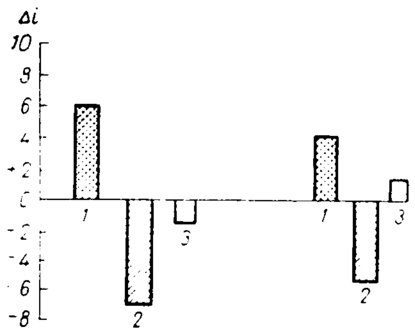

Figure 3: Change (Δ_i) in the number or goal-irrelevant movements (a) and errors (b) in a maze after introduction of external inhibitor. Ordinate: increase in irrelevant movements or errors after inhibitor introduced compared to number before introduced. P_{1_2} <0.01; P_{1_3} <0.001

P383(9/86)* Denisova LA.
The effects of weightlessness on skeletal development in the rat embryo.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
20(4): 60-63; 1986.
[2 references; 1 in English]

Developmental Biology, Musculoskeletal System, Skeletal Development
Rats, Embryos, Neonates
Space flight, "Cosmos-1514"

Abstract: Subjects in this experiment were newborn Wistar rats and rat embryos. The first (flight) group had been exposed to space flight conditions on board the "Cosmos-1514" biosatellite, during days 13-18 of their mothers' pregnancy; mothers of the second (synchronous control) group were kept in a ground-based satellite simulation and exposed to all space flight factors except weightlessness; mothers of the third (vivarous control) group were maintained in ordinary laboratory conditions. Diets of all groups of mothers were identical and water intake was not limited. Some embryos in all groups were removed from the mothers on the 18th day of pregnancy; 3 or 4 embryos from each mother were taken for study. The remaining animals were studied 2-3 hours after birth, which usually occurs on day 23 of pregnancy; 1-3 neonates from each litter were selected for study. A total of 20 embryos and 14 neonates from 9 mothers were used in the flight group; 20 embryos and 10 neonates from 9 mothers in the synchronous control; and 20 embryos and 20 neonates from 14 mothers in the vivarous control. The dimensions of ossification sites in the foundations of bones of the lower jaw, and bones of the shoulder girdles of the front and hind legs were measured. In addition, the length of the tail, and cartilaginous foundation in the brachia were measured in the 18-day embryos, and also in the brachia and femurs of neonates.

In 18-day embryos, virtually all portions of the developing skeleton of animals in the flight group showed significant retardation of ossification compared to the other two groups. (See Table 1.) The most sensitive structures were those which were least mature at this stage of development. The effect of weightlessness was also seen in retardation of the development of longitudinal cartilage. Development of animals in the synchronous control group showed virtually no difference from the vivarous control group, suggesting that weightlessness per se was the key factor. A previous study showed that although these embryos weighed less than those in the other groups, the concentration of Ca^{2+} per unit of tissue was no different than for the other two groups. This leads the authors to conclude that the retardation of skeletal development is caused not by a shortage of Ca^{2+}, but by disruption of the mechanism controlling the incorporation of calcium in the developing skeleton. Embryos of mothers readapting to normal gravity had significantly greater areas of ossification than embryos of control mothers. The cartilaginous skeleton was also more highly developed in the flight animals. Although this measurement was not taken in this study, the authors assume that during readaptation the embryo, like the mother, shows a positive Ca^{2+} balance, leading to acceleration of mineralization.

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Table 1: Length of areas (in mm) of ossification in foundations of bones of 18-day old fetuses exposed to space flight from days 13 - 18 of pregnancy

Bone	Flight (N=20)	Group Synchronous Control (N=20)	Vivarous Control (N=20)
Clavicle	1.42*	1.59+	1.45
Scapula	0.69*+	0.78	0.79
Humerus	0.82	0.89	0.89
Ulna	0.66*+	0.81	0.77
Radius	0.57*	0.67	0.63
Femur	0.34*+	0.44	0.43
Tibia	0.36	0.43	0.46
Fibula	0.29*+	0.37	0.39
Ischial	0.55*+	0.66	0.66
Lower Jaw	3.70	3.85	3.73

Note: Here and in Table 2, * - differs significantly ($p < 0.05$) from the synchronous control; + - differs significantly ($p < .05$) from the vivarous control

Table 2: Length of areas (in mm) of ossification in the skeleton of neonates, exposed to space flight factors between days 13-18 of intrauterine development

Bone	Flight (N=14)	Group Synchronous Control (N=10)	Vivarous Control (N=20)
Clavicle	4.51*+	4.06	4.23
Scapula	4.34*+	3.86	4.08
Humerus	4.55*+	4.14	4.34
Ulna	5.14*+	4.66	4.69
Radius	3.89*+	3.44+	3.63
Femur	3.73*+	3.33	3.45
Tibia	4.62*+	4.05	4.13
Fibula	4.25*+	3.76	3.82
Ischial	2.18*+	1.75	1.76
Pubic	1.81*+	1.44	1.57
Iliac	3.00*+	2.66	2.80
Lower Jaw	10.57*+	9.89	9.79

ENDOCRINOLOGY

(See also: Adaptation: P403; Biological Rhythms: P405, Psychology: P372)

PAPERS:

P390(9/86)* Kalita NF, Tigranyan RA.
Endocrine status of cosmonauts after long-term space flights.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
20(4): 84-86.
[6 references; 2 in English]

Endocrinology, Hormone Levels, Hypothalamus, Hypophysis, Adrenal
Humans, Cosmonauts
Space flight, "Cosmos-1514"

Abstract: The goal of this experiment was to study the concentration of a number of hormonal and biologically active compounds in 10 cosmonauts who had completed long-term (73-185 days) space flights, and to identify occurrence of the stress response during the acute period of readaptation to gravity. Measurements were performed on venous blood and urine. Preflight levels were determined by collecting blood and urine 30 days before the flight. In addition daily urine was collected 3-5 days preflight. Postflight measurements on blood were made on days 1 and 7 after landing; daily urine was collected on the day of landing and during the following 7 days. Blood samples were analyzed through radioimmune assay for the following substances: ACTH, hydrocortisone, aldosterone, renin, insulin, thyrotropic hormone (TRH), thyroxine (T_4), tri-iodothyrin (T_3), testosterone, somatotropic hormone (STH), cyclic adenosine monophosphate (AMP), cyclic guanosine monophosphate (GMP), and pressor and depressor prostaglandins (PGF_2, and PGA & E). In urine the concentration of aldosterone was measured by radioimmune assay, while excretion of total 17-oxycorticosteroids (17-OCS) was assessed by observing reactions with phenylhydrazine. Results from flights of different durations were compared and it was decided that the differences were sufficiently small to warrant combining data for analysis.

Results of the analyses are presented in Tables 1 and 2. Preflight studies indicated changes in the relationship between pressor and depressor prostaglandins toward predominance of depressor, and increase over normal levels of excretion of 17-OCS, both of which are typical responses to emotional stress. No statistically significant changes were found postflight in the parameters of the functional activity of the hypothalamus-hypophysis-adrenal cortex system (i.e., ACTH, hydrocortisone, total 17-OCS), which the authors interpret as resulting from the large individual differences in these parameters. On day 1 postflight there was a significant decrease in plasma renin activity and in level of aldosterone in the blood, accompanied by an increase in aldosterone excretion. The changes in aldosterone may be explained by increased metabolism of the hormone, since on day 1 postflight there is evidently a decrease in the activity of alanine aminotransferase. The prophylactic measures taken by the crews during long-term flights were associated with relatively rapid recovery of normal relationships in the renin-angiotensin-aldosterone system. On day 1 postflight there was a significant increase in the level of insulin in the blood; this is explained as a reaction to the increased concentration of glucose in their blood, indicative of stress. In contrast to results from shorter flights, there was a significant increase in

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thyroxine in the blood of these cosmonauts and tendencies toward increases in thyrotropic hormone and T_3. These changes parallel those reported in U.S. astronauts. Unlike cosmonauts on shorter flights, these cosmonauts showed a significant decrease in the level of testosterone, again indicating stress. The increased levels of insulin and T_4 and the decreased testosterone could facilitate the increased accumulation of triglycerides noted in these cosmonauts. Postflight, the concentrations of both types of prostaglandins decreased in the cosmonauts' blood, to a more marked extent for depressor PG(A+E), causing pressor prostaglandins to predominate. PG(A+E) dipped below the lower boundary of the norm. These effects, characteristic of emotional stress, are attributed to a compensatory response directed at increasing vascular tonus and overcoming orthostatic intolerance. The rapid reversal of the hormonal changes characteristic of stress testifies to the success of the conditioning and training procedures used to prepare the cosmonauts for flights of this length. However, it is not clear how flights of even longer duration will affect these parameters.

Table 1: Concentration of hormones and biologically active substances in the blood of cosmonauts (10 cosmonauts; flight duration: 73-185 days)

Substance	**30 days preflight**	**Days postflight**	
		1	**7**
ACTH, pg/ml	45.22	50.00	71.33
Hydrocortisone, ug%	16.04	18.46	15.33
Aldosterone, pg/ml	67.1	18.8*	68.9
Renin, ng/ml·hr	3.16	2.26*	2.37
Insulin, uk units/ml	17.00	22.17*	21.10
TRH, uk units/ml	1.87	2.04	1.74
T_4, ug%	6.61	8.86*	6.96
T_3, ng%	158.9	175.9	143.1
STH, ng/ml	1.88	1.78	1.26
Testosterone, ng%	640.0	537.0*	555.0
Cyclic AMP, pmole/ml	17.5	20.7	15.7
Cyclic GMP, pmole/ml	3.81	4.86	5.95
PGF_2, ng/ml	1.08	0.68	0.59*
PG A+E, ng/ml	3.81	1.41*	0.82*

* Here and in Table 2, differs statistically from preflight values, [significance level not cited].

Table 2. Excretion by cosmonauts of steroid hormones with daily urine

Hormone	**Day Preflight**			**Day Postflight**						
	30	5-3	0	1	2	3	4	5	6	7
17-OCS, total, mg/day	6.81	7.22	7.15	6.70	6.21	7.51	8.28	7.55	6.56	5.87
Aldosterone, ug/day	14.4	13.3	17.9	29.9*	20.8	21.3	17.7	22.5*	25.1	--

P384(9/86)* Alekseyev YeI.
Functional state of adenohypophysial somatrophs of rats undergoing hypokinesia.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
20(4): 63-67; 1986.
[21 references; 6 in English]

Endocrinology, Hypophysis; Cytology, Somatrophs
Rats
Hypokinesia, Immobilization Stress

Abstract: Wistar rats, aged 2.5 months, were confined in immobilization cages for as long as 165 days. A control group was maintained under normal laboratory conditions and given the same diet as the immobilized rats. A sample of 6 animals from each group were sacrificed and studied after 30, 90, and 165 days of immobilization, and after 2 months of readaptation following immobilization (a total of 30 immobilized and 30 control rats). The hypophysis was removed, fixed, prepared, and stained. Information was obtained about the size of cells and nuclei, and the relative sizes of nuclei and cytoplasm. Concentration of oxyphilic substance in the cytoplasm was determined on the basis of optical density after staining. As the control animals aged from 2.5 to 10 months, no significant differences were found in the somatroph parameters measured. On day 30 of hypokinesia the somatrophs of animals in the experimental group showed marked attenuation of oxidation. Cytoplasm showed diminished optical density associated with decrease in oxyphilic substances. However, cells and nuclei did not differ in size. Under a microscope the difference between cells from the two groups was obvious. After 90 days of hypokinesia, somatrophs showed extremely low concentrations of oxyphilic substances. At the same time, the volume of cytoplasm decreased by an average of 50%, while the nuclei remained at their baseline sizes. The decrease in cytoplasm made somatrophs difficult to identify, which in previous studies could have led to the erroneous conclusion that the number of somatrophs had decreased. After 165 days of hypokinesia, the majority of somatrophs remained diminished in size, but a number of larger cells appeared along the capillaries with cytoplasm content increased by an average of 20%. As before, the nuclei did not change in size. Two months after the termination of hypokinesia, the level of oxyphilic substances in the somatrophs had returned to normal, while the size of the cells themselves and their nuclei exceeded baseline levels. Degranulation of the cytoplasm was noted where somatrophs were in contact with the vessel walls. On the basis of these results, the authors conclude that one mechanism responsible for retardation of growth and disruption of tissue metabolism during long-term hypokinesia is depression of somatroph function in the anterior lobe of the hypophysis.

Figure: Anterior lobe of the hypophysis in rats.

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Table: Data from cytokaryometric analysis of adenohypophysial somatrophs of rats

Conditions/ Group	Size, um3 cells	P*	nuclei	P*	cytoplasm	Nucleus: Cytoplasm ratio
Control	417.5		138.9		279.5	1 : 2.0
After hypokinesia lasting:						
30 days	389.6	< 0.1	136.0	< 0.7	253.6	1 : 1.9
90 days	289.6	< 0.001	140.8	< 0.5	148.4	1 : 1.0
165 days	466.0	< 0.01	132.6	< 0.5	333.4	1 : 2.5
Readaptation (2 months)	482.8	< 0.001	158.9	< 0.01	323.9	1 : 2.0

* significance of difference between experimental and control groups.

P385(9/86)* Pchelenko LD.

Norepinephrine regulation of heat production and ATP utilization in a single muscular contraction under normal conditions and hyperoxia.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
20(4): 67-72; 1986.
[10 references; 4 in English]

Endocrinology, Norepinephrine, ATP Utilization; Musculoskeletal System, Muscle Contraction
Rats
Hyperoxia

Abstract: This experiment used 20 outbred white rats of both sexes. Rats in the control group (N=9) were maintained under normal laboratory conditions, while 11 rats were exposed to a 3-hour period of breathing 99% oxygen with normal pressure. The animals were then sacrificed and their diaphragms, removed and a portion attached to a specially developed thermopile. The muscle was then incubated for 30 minutes in a thermally constant chamber and stimulated by single electric impulses (20 V, 16 msec) every 5 minutes. A profile of the heat and tension produced during a single isometric contraction was recorded. Rate of heat emission in the first second after stimulation (V), isometric tension (F), and the energy cost of each gram of isometric tension developed by the muscle during a contraction (V/F) were calculated. Baseline measurements were made for each muscle. Norepinephrine (to reach concentration of 0.008 ug/ml) was added to the incubating solution and the measurement procedure was repeated after 10 minutes. Finally, for 6 of the muscles in each group, ATP (0.01 mg/ml) was added to the previous solution and the measurement procedure repeated after 5 minutes. Each time measurements were made, 3-4 thermal profiles were recorded.

Results showed pronounced differences between control and experimental animals. In the first set of measurements (before the addition of norepinephrine and ATP), rate of heat emission (V) of the control animals averaged 3.52 mcal/sec/g; after norepinephrine had been added, only insignificant increases in V and isometric tension (F) were observed; addition of ATP further increased V by a small amount. Across subjects, increases in V in the presence of norepinephrine were highly correlated with increases in the presence of ATP. When V/F was computed, it was found that addition of the two substances led to a statistically insignificant increase in energy cost. Muscles of animals exposed to hyperoxia presented a very different picture. First, baseline heat emission was 2.2 times that of the controls, and energy cost was increased by a like amount. Hyperoxia was also associated with increased sensitivity to both norepinephrine and ATP, involving significant increases in heat emission and energy costs. The increases in V when each of these substances was added to the medium were again highly correlated. The authors conclude that the results of this study indicate that the increased mechanical efficiency in muscle contraction which occurred in the animals of the experimental group was attained through a disproportionate increase in the energy cost of a single muscle contraction. They hypothesize that this effect involves norepinephrine-dependent acceleration of ATP-lytic processes during muscle contraction.

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Table 1: Rate of heat emission, mechanical tension, and energy cost of 1 g of tension during a single muscle contraction in an isolated diaphragm of rats maintained under normal conditions before and after addition of norepinephrine and ATP to the incubation medium

Table 2: Rate of heat emission, mechanical tension, and energy cost of 1 g of tension during a single muscle contraction in an isolated diaphragm of rats exposed to 3 hours of hyperoxia before and after addition to the incubation medium of norepinephrine and ATP

Table synthesized from means of Table 1 and Table 2

Condition	**Baseline**			**Norepinephrine added**			**ATP added**		
	V	**F**	**V/F**	**V**	**F**	**V/F**	**V**	**F**	**V/F**
Normal	3.52	15.0	0.29	4.73	17.1	0.32	4.88	14.2	0.33
Hyperoxia	7.81	17.2	0.48	11.96	20.3	0.64	18.76	23.6	0.78

Figure 1: Rate of heat emission during a single contraction of an isolated diaphragm of rats maintained under normal conditions or exposed to hyperoxia

Figure 2: Energy cost of 1 g of isometric tension developed by muscles during a single contraction

Figure 3: Flow chart of increase of heat emission during a single muscle contraction after 3-hours of hyperoxia

ENZYMOLOGY: See Radiobiology: P404)

EQUIPMENT AND INSTRUMENTATION

(See also: Human Performance: P370)

PAPERS:

P388(9/86)* Magedov VS, Koryakov YuS.
A special-purpose device for magnetic recording of physiological information for experiments on biosatellites.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
20(4): 79-80; 1986.
[7 references; 2 in English]

Equipment and Instrumentation, Magnetic Tape Recording Device
Physiological Signals
Biosatellites

Abstract: This paper describes the concepts underlying the development of a special-purpose magnetic recording device for long-term continuous recording of physiological signals on magnetic tape. This device utilized frequency modulated recording, since this method provides the maximum density of signal recording. The duration of continuous recording with such a device at a given frequency and adequate supply of magnetic tape is limited only by the minimum speed of the tape. Because physiological signals are attenuated at high frequencies, the device, by concentrating on the lower frequency range, was able to use a slower tape speed (3 mm/sec) than would be required for a general purpose recorder, and thus prolong the duration of continuous recording.

The magnetic recording system developed, the "Topol'-D," included a ground-based recorder/receiver and an onboard recording device. The latter, 280 x 250 x 160 mm in size, was capable of recording physiological signals continuously for 68 hours on a tape 27 um thick. This apparatus has 11 channels with a signal/noise ratio no worse than 40 dB. Using the receiver, signals obtained in space could be reproduced in the laboratory. The ground-based receiver has two tape speeds, 3 mm/sec and 3 cm/sec., and the band of frequencies recorded on the accelerated speed ranged from 0 to 1000 Hz. This device was used on the "Cosmos-936," "-1129," and "-1514" biosatellites.

Table: Values of the carrier and upper frequencies of the frequency modulated signal

GASTROINTESTINAL SYSTEM: See Radiobiology: P398

HABITABILITY AND ENVIRONMENT EFFECTS

PAPERS:

P375(9/86)* Lekarev AV.

Visual-optic evaluation of the threshold values of distortion of objects due to lens defects in the flat windows of transport vehicles.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
20(4): 29-32; 1986.
[7 references; 3 in English]

Habitability and Environment Effects; Perception, Visual Distortion
Humans, Operators
Windows, Lens Defects

Abstract: This study used a collimator to determine the thresholds of distance between lens and observer and angle of deviation from the line of sight at which a lens of a given diopter will distort an object seen through it. A total of 20 operators, aged 19-20, with normal vision made a total of 316 binocular observations to determine these thresholds. Subjects were required to say whether a test object viewed binocularly through the collimator looked the same or different from a standard. Distortions involved decreased size and increased distance of object for divergent lenses and the reverse for convergent lenses. Convergent and divergent lenses of 0.12, 0.08 and 0.04 diopters were tested. When threshold of distance was determined the lens was aligned at a right angle to the line of sight. When threshold of angle of inclination was determined, the lens was apparently located within the threshold for distortion by a vertical lens. Results are presented in Tables 1 and 2. The author proposes that these data be used as a basis for developing optical specifications for vehicle windows.

Table 1: Threshold of optical distortion of an object as a function of distance between the observer's eyes and the lens defects in the glass having various optical powers and signs (lens vertical with respect to line of sight)

Distance between observer's eyes and lens, mm		Optical Power of the lens, diopters	P
Convergent (+)	Divergent (-)		
250	175	0.12	< 0.05
425	315	0.08	< 0.05
650	650	0.04	> 0.05

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Table 2: Threshold of optical distortion of an object as a function of angle of inclination of lens defects for lenses of various optical powers (lens apparently at non-distorting distance for vertical orientation)

Permissible angle of inclination from the vertical (°)		Optical power of the lens, diopters	P
Convergent (+)	Divergent (-)		
35±1.4	35±1.5	0.12	< 0.05
35±1.5	35±1.7	0.08	< 0.05
35±1.8	35±1.9	0.04	< 0.05

P389(9/86)* Sukhorukov OA, Azarova MV, Avetisyants BL.
Evaluation of a methodology for sampling and concentrating trace atmospheric contaminants.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
20(4): 81-83; 1986.
[7 references; 1 translated from English]

Habitability and Environment Effects, Atmospheric Contaminants
Methodology Evaluation
Sampling and Concentration

Abstract: One of the best ways of maximizing information about trace contaminants in an atmosphere is to concentrate the sample. This paper evaluated the standard methodology (diffusion through capillaries) of sampling and concentrating trace contaminants. The system used consisted of two blocks for drying and cleaning the air using silica gel and activated charcoal, a diffuser for obtaining small concentrations of organic contaminants, Dewar flask for coolants, 4 traps, a gas flow booster, and connecting pipes. Each trap had an internal diameter of 10 mm, and a capacity of 7.85 cm^3. The first trap was empty and cooled to 0°C, the second contained up to 5 cm^3 of chromosorb with 10% emulfor to trap alcohols or 5% dexcyl-300 to trap ketones, aromatic and saturated hydrocarbons, while the third and fourth traps contained silichrome. The fourth trap served to verify whether difficult-to-sorb substances had been fully trapped. The second, third and fourth traps were cooled with dry ice to -78°C. Samples of the same air were repeatedly passed through the system with variability in room temperature and rate of air flow. Concentrations of trace contaminants caught in the traps were determined using flame ionization chromatography and the standard error was computed. It was found that over 5-10 trials standard error of concentration for 11 substances varied from 31 to 7 %. Standard errors for concentration measurement clearly exceeded variability in temperatures and air speed. Lowest standard errors occurred in the measurement of saturated and aromatic hydrocarbons, and highest for alcohols.

Table 1: Vapor pressure of substances studied and their coefficients of diffusion in the air at temperature range of 0-20°C, and concentration with air speed of 146 cm^3/min

Table 2: Statistical parameters of experimental results

Figure 1: Diagram of apparatus for trapping trace contaminants

Figure 2: Chromatogram of aromatic hydrocarbons

Figure 2: Chromatogram of saturated hydrocarbons

HEMATOLOGY

(See also: Adaptation: BR10; Cardiovascular and Respiratory Systems: P376)

PAPERS:

P369(9/86) Shchukina MYa.

Lactic acid concentration in the blood and erythropoiesis as a response to hypoxia

Fiziologicheskiy Zhurnal SSSR im. I.M. Sechenova.
LXXII(5): 668-673; 1986.
[20 references; 3 in English]

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Hematology, Lactic Acid, Erythropoiesis
Rats, Males
Hypoxia, Anemic, High Altitude

Abstract: Subjects in this experiment were 134 outbred white male rats. Anemic hypoxia was created in some animals by removing 20-25% of the body's blood supply at somewhat elevated altitudes (foothill conditions: 760 m above sea level), or during the 3-5th or 30th day of adaptation to moderately high altitudes (1700 m above sea level). Blood parameters were measured for various groups of animals before anemia was created and 20 minutes, 1, 3 and 7 days afterward. In other animals, short-term hypoxic hypoxia was created by rapidly elevating the rats to an altitude equivalent of 16,000 m on days 3-5 and 40-50 of adaptation to moderately high altitude. Total time for elevation and descent in the barochamber was 10-15 minutes. Blood samples were taken before and immediately after the animals were placed in the chamber. Concentrations or erythrocytes and hemoglobin were determined photometrically. Concentration of lactic acid was determined using a method developed by Barker and Sammerson. The experiment at 760 m showed no significant changes in the blood concentrations of erythrocytes or hemoglobin in the rats' blood 20 minutes after blood loss; however, the concentration of lactic acid had increased by a factor of 3. Lowest levels of erythrocytes and hemoglobin occurred on days 1 and 3, at which time lactic acid concentration was below the level reached immediately after blood loss, but still elevated compared to baseline. All 3 parameters had virtually normalized 7 days after blood loss. The authors conclude that the production of erythropoeitin is induced by lactic acid.

After 3-5 days of adaptation to an altitude of 1700 m, level of lactic acid began to drop only on day 3 after blood loss, and increase in erythropoeisis was more pronounced than at the lower altitude. [NOTE: not clearly supported by data in Table 2.] The longer period of high altitude adaptation decreased the initial concentration of lactic acid in the blood. After 30 days of adaptation to the high altitude, although lactic acid was higher 20 minutes after blood loss than it was before the loss, it did not differ from that of control animals. The barochamber treatment was associated with some decrease in erythrocytes and hemoglobin and significant increase in lactic acid. Male rats which had been preadapted to moderate altitude for 40-50 days showed higher pre- and postascent levels of erythrocytes and hemoglobin and lower pre- and postascent levels of lactic acid than those preadapted for only 3-5 days. Female rats adapted for 40-50 days and then put in the barochamber showed lower

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preascent and postascent levels of erythrocytes and hemoglobin and a higher preascent level of lactic acid than males treated identically. The authors conclude that the extent of lacticacidemia occurring at high altitudes in response to induction of additional hypoxia depends on duration of altitude adaptation. Individual and sex differences are also a factor.

Table 1: Effect of blood loss on rats at relatively low altitudes (foothills conditions)

Condition	**n**	**Erythrocytes** $10^{12}/l$	**Hemoglobin** g/l	**Lactic acid** mM
Control	5	6.12	194.0	5.94
After blood loss				
20 minutes	5	5.51	195.0	16.08*
1 day	5	4.43*	153.0*	8.20
3 days	5	4.80	154.0*	10.38*
7 days	5	5.10	180.0	5.22

Table 2: Effects of blood loss on rats on days 3 - 5 of adaptation to moderately high altitude

Condition	**n**	**Erythrocytes** $10^{12}/l$	**Hemoglobin** g/l	**Lactic acid** mM
Control	14	4.89	168.1	5.78
After 20 minutes	9	4.95	176.0*	12.06*
After 1 day	8	3.32*	111.0*	11.6*
After 3 days	6	4.40	136.0*	7.48*

Table 3: Effects of blood loss rats on the 30th day of adaptation to moderately high altitude

Condition	**n**	**Erythrocytes** $10^{12}/l$	**Hemoglobin** g/l	**Lactic acid** mM
Before blood loss	7	5.66	196.0	3.56
After 20 minutes	7	5.42	165.1*	6.34*

Table 4: The effects of a single "ascent" in a barochamber on rats adapted to moderately high altitude

Duration of adapt.	**Conditions**	**Sex**	**n**	**Erythrocytes,** $10^{12}/l$	**Hemoglobin,** g/l	**Lactic acid,** mM
3-5	Before ascent	M	8	6.07	190.6	8.05
3-5	After ascent	M	5	5.79	169.0	17.8*
40-50	Before ascent	M	6	7.58	250.0	4.54
40-50	After ascent	M	6	6.46	222.0*	14.96*
40-50	Before ascent	F	12	6.04	174.0	8.74
40-50	After ascent	F	12	5.24	172.0	14.49*

* Differs significantly from appropriate control.

P382(9/86)* Kiselev RK, Chayka AM, Legen'kov VI.

The effects of coamide [a cobalt derivative] and folicobalamine [a mixture of vitamin B_{12} and folic acid] on erythropoiesis under normal living conditions and during hypokinesia with head-down tilt.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
20(4): 48-53; 1986.
[11 references; 4 in English]

Hematology, Erythropoeisis
Humans, Males
Hypokinesia, Head-down Tilt; Countermeasures, Coamide; Nutrition, Vitamin B_{12}, Folic Acid, Cosmonaut Rations

Abstract: A total of 41 healthy men, aged 19 to 40, participated in this experiment. Some continued to follow their normal schedules; others were subjected to short- or long-term hypokinesia with head-down tilt. Hypokinesia conditions consisted of either 7 days at -6°, 50 days at -6° or 120 days at -4.5°. Subjects were observed for 45 days following the experimental period. Some subjects in each group received a diet similar to that given cosmonauts (4000 calories/day), while the remainder ate ordinary food. To stimulate hemopoiesis, some subjects received a cobalt derivative (a 1% solution of coamide); others received folicobalamine, a combination of Vitamin B_{12} and folic acid; still others received both or neither. The coamide was injected intramuscularly in a dose of 1000 mg/day, while the oral dose (30 ug/day) of folicobalamine exceeded the MDR of both vitamins by a factor of 8. Efficacy of these preparations was evaluated by determining the total weight and concentration of hemoglobin, and quantity of erythrocytes and reticulocytes.

In healthy individuals following their normal schedules, coamide (after 7 days) and folicobalamine (after 10 days) led to an increase in these parameters. Total weight of hemoglobin increased by 5-7%. The maximum increase was obtained after 2-3 weeks, and maintained for a month and a half. After the preparations had been taken for a month, the number of reticulocytes had increased by 12-15%, demonstrating increased bone marrow erythropoiesis. Quantities of erythrocytes and hemoglobin remained at baseline levels, indicating absence of pachemia. The two preparations also had a stimulatory effect on erythropoiesis under conditions of short-term (7-day) hypokinesia with head-down tilt. When no countermeasures are administered, the first few days of hypokinesia with head-down tilt are typically accompanied by pachemia and decrease in reticulocytes, serving to trigger a depression of hemopoiesis. The two preparations administered served to increase hemopoiesis during short-term hypokinesia, but did not restore it to normal level. (See Table 3.) One and 2 weeks after termination of hypokinesia, subjects receiving either of the preparations showed significant increases in the weight of hemoglobin compared to baseline, but no changes in concentrations of other substances were observed. The authors note that the preparations administered did not fully counteract the depression of hemopoiesis associated with short-term hypokinesia.

In the long-term condition, only folicobalamine was administered; coamide was eliminated because in the earlier experiments its effects did not appear to differ from those of folicobalamine. The experimental group in the long-term study received folicobalamine daily for 2 weeks preceding

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a 50-day hypokinesia period, and again from days 31 to 42. The control group received no countermeasures and underwent a 120-day period of hypokinesia with head-down tilt. Results of these treatments are given in Table 4. The authors state that these data indicated that folicobalamine taken before and during a 50-day hypokinesia period, by stimulating blood marrow hemopoiesis, can partially restore hemoglobin weight during the treatment and accelerate recovery after the treatment. (Editor's note: it's not clear that data in table supports this conclusion.) No side effects of this preparation were observed.

Table 1: Experimental treatments

Table 2: The effects of stimulation of erythropoiesis on hematological parameters under normal conditions

Table 3: The effects of stimulation of erythropoiesis on hematological parameters during a 7-day period of hypokinesia with head-down tilt

Parameter	**Treatment**	**N**	**Base-line**	**Day of Hypo-kinesia**		**Day of Readaptation**			
				3	7	3	7	14	42
Hemoglobin weight, g	Folicobalamine	3	747	--	759	--	774*	763	741
	Coamide	5	748	--	770	--	781*	772*	743
	Placebo	4	748	--	751	--	--	746	--
Concentration of hemoglobin, g/l	Folicobalamine	3	152	169	158	139	--	--	--
	Coamide	5	155	165	167	145	147	113	--
	Placebo	4	151	166	162	--	--	148	--
Number of reticulocytes 1000 per, 1 mm^3	Folicobalamine	3	28.0	16.0**	18.2**	18.7**	--	27.0	--
	Coamide	5	28.8	12.9**	18.8**	21.4**	--	23.7*	--
	Placebo	4	29.3	15.2**	19.9**	--	--	21.3*	--
Number of erythrocytes, million per 1 mm^3	Folicobalamine	3	5.34	4.69	4.34	4.97	--	4.97	--
	Coamide	5	4.89	5.13	4.58	4.52	--	4.50	--
	Placebo	4	4.84	4.36	4.64	4.09	--	4.49	--

Notes: Here and in Table 4, * - differs significantly [from baseline?], $p < 0.05$; ** - $p < 0.001$

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Table 4: Effects of folicobalamine on hematological parameters during long-term hypokinesia with head-down tilt (HHDT)

Time	50-day HHDT (folicobalamine)			120-day HHDT (control)		
	wt. hemoglobin g	conc. hemoglobin, g/l	# erythrocytes mln. per 1 mm^3	wt. hemoglobin g	conc. hemoglobin, g/l	# erythrocytes mln per 1 mm^3
Baseline	712	151	4.42	755	138	3.85
Days HHDT:						
3	--	173*	3.81	--	153**	4.19
5	--	175*	4.68	--	152**	4.25
20	634*	165**	4.63	680*	143	4.20
30	604*	159	4.35	650*	140	4.09
Folicobalamine administered between days 31 and 42.						
36	576*	158	3.96**	--	--	--
42	616*	160	4.20	624*	147	4.56*
49	638*	161	4.10	--	--	--
85	--	--	--	552*	138	4.30**
110	--	--	--	533*	141	4.61*
Days Recovery:						
30	722	148	3.60	647**	148	3.83

HUMAN PERFORMANCE

(See also: Cardiovascular and Respiratory Systems: P399; Perception: P392; Psychology: P372; Radiobiology: P368)

PAPERS:

P363(9/86) Bayevskiy RM, Semenova TD.
Evaluation of the functional state of an operator undergoing sensory deprivation.
Fiziologiya Cheloveka.
12(4): 676-678; 1986.
[12 references; none in English]

Human Performance, Functional State, Psychological Work Capacity, Neurophysiology, Autonomic, Sympathetic and Parasympathetic Nervous Systems; Cardiovascular and Respiratory Systems, Cardiac Parameters; Adaptation, Monotony
Humans, Operators
Perception, Sensory Deprivation

Abstract: This paper derives a method of measuring the functional state of operators who are awaiting a signal or command under conditions of sensory deficit (i.e., low levels of sensory stimulation) accompanied by significant nervous or emotional tension. The method is based on measurement of a number of EKG parameters which are described as being indicative of the autonomic, sympathetic and parasympathetic nervous systems. Parameters utilized were: arithmetic mean of the duration of a cardiac cycle (M); mean nonquadratic deviation (σ); difference between the maximum and minimum values of cardiac cycle duration (ΔX); number of cardiac cycles of the modal duration, expressed in % (*AMo); and an index of tension computed according to the formula I = *AMo/2Mo· X. For each individual operator the baseline level of these parameters was determined and compared with their values after a certain period of task performance (in the example given, 2 hours). For each operator, change in each parameter from baseline was assigned a score (ranging from 0 to 4) depending on percentage and direction (adaptive or maladaptive) of the difference. The sum of these values is assigned a value of 1 - 5 depending on magnitude and this score is taken as an overall indicator of functional state, with 1 indicating moderate (appropriate) working tension and 5 strong maladaptive reaction. Data is cited for 5 operators after 2 hours of task performance, but no further description of task performance conditions is given.

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Table: parameters derived from mathematical analysis of heart rhythm after performance of operator tasks for 2 hours

Parameter	1		2		3		4		5	
	A	B	A	B	A	B	A	B	A	B
M, sec	0.91	0.84 (0)	0.81	0.72 (0)	0.63	0.72 (2)	0.67	0.74 (2)	0.90	1.06 (4)
σ, sec	0.088	0.066 (0)	0.078	0.052 (1)	0.035	0.017 (1)	0.053	0.064 (4)	0.133	0.173 (4)
ΔX, sec	0.302	0.244 (0)	0.273	0.192 (0)	0.108	0.084 (0)	0.191	0.229 (2)	0.360	0.339 (0)
*AMo, %	27	32 (0)	30	41 (1)	53	71 (1)	42	37 (2)	25	19 (4)
I, arbit. units	56	84 (1)	70	159 (1)	446	589 (1)	186	132 (4)	66	39 (4)
Sum of scaled scores		1		3		8*		14		19*
ICFC**		1		2		3		4		5
Work capacity, rated***	7.8	8.7	7.7	7.9	7.0	6.3	7.0	6.1	7.8	6.5

A: baseline; B: after 2 hours of task performance. Numbers in parentheses refer to ratings assigned as follows. 0: parameter remains virtually unchanged (±5%) or changes by $\leq$ 20% in the direction considered adaptive; 1: parameter changes in direction considered adaptive by > 20%; 2: parameter changes in direction considered maladaptive by $\leq$ 20%; 4: parameter changes in direction considered maladaptive by > 20%.

*, if there is evidence of "desynchronization" among a subject's scores, i.e., some changes in one direction and some in the other, 3 points are added to the total.

**, integral criterion of functional changes, computed as follows: if total = 0-2, ICFC = 1; if total = 3-5, ICFC = 2; if total = 6-10, ICFC = 3; if total + 11-18, ICFC = 4; if total $\geq$ 19, ICFC = 5.

***, apparently rated independently on basis of task performance (no details cited) as a check on the proposed measurement system.

P370(9/86)* Oboznov AA, Boyarskiy AN, Buturlin AI.
Psychophysiological aspects of color coding of flight and navigational information on onboard (airborne) electronic displays.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
20(4): 16-19; 1986.
[10 references; 5 in English]

Human Performance; Psychology, Psychophysiological Parameters
Humans, Pilots
Equipment and Instrumentation, Instrument Displays; Perception, Color Coding

Abstract: This study was concerned with evaluating pilot performance as a function of number of colors (1 or 3) used in the display of flight and navigational information on the instrument panel. The experiment used a flight simulator and 6 pilots. The assigned task was to perform a landing approach on the basis of directional signals. The following parameters were used to evaluate performance: accuracy in maintaining landing trajectory, allocation of attention (assessed by recording direction of focus), and rate of readout from instruments. The instrument displays (apparently CRTs) were either monochromatic (green) or trichromatic (green, yellow and red). A relatively simple and a more complex (involving sideways diversion of the aircraft) version of the landing task were used. The more complex task is described as requiring rapid and differential evaluation of the display. The pilots' visual perception was evaluated before and after a one-hour task performance session, on the basis of visual perception latency, contrast sensitivity, critical flicker fusion rate, and acuity of color perception. It was found that for the simpler landing task the measured parameters of pilot task performance did not depend on the number of colors used in the information display. Display color also had no effect on perceptual accuracy and speed after task performance. In both conditions there was a very slight decrement. However, when asked for subjective evaluation, all 6 or 5/6 of the pilots (depending on question asked) preferred the multicolor display. This preference is discussed by the authors in relation to the tendency to prefer redundant information even when the redundancy is not required for task performance. When the landing task was made more complex, pilot performance was superior (by 17%) with the multicolored display. Thus, addition of redundant color cues may or may not influence "output" performance parameters depending on task demands.

Table 1: Comparison of pilot performance with two types of display illumination

Table 2: Visual perception parameters with two types of display illumination

P371(9/86)* Epishkin AK, Skrypnikov AI.
Prediction of operators' work capacity during prolonged uninterrupted work periods.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
20(4):19-22; 1986.
[9 references; none in English]

Human Performance, Sensorimotor, Pursuit and Tracking; Neurophysiology, EEG Parameters
Humans, Operators
Fatigue, Uninterrupted Work, Sleep Deprivation; Countermeasures, Autogenic Training

Abstract: Experiments were performed with 3 healthy operators, aged 19-32, participating in each. [Not clear whether same 3 were in all experiments; sex not specified.] Operators were required to perform assigned tasks with no time for rest. EEG and heart rate were recorded every four hours approximately 1 hour before performance parameters were measured. The tasks included sensorimotor pursuit and compensatory tracking, both involving a light signal. Heart rate and EEG data indicated that subjects went through 4 phases during the experimental period. The first phase, 1-6 hours, was characterized by increased heart rate and delta and beta wave activity, reflecting excitation and stress on functional systems as they adapted to the task. The second phase, 6-24 hours, showed a stabilization of the parameters at approximate baseline values. The distinctive feature of the third phase, beginning at 24-26 hours, was instability of heart rhythm parameters, with mean value below baseline. Delta and theta wave activity increased during this period, while alpha wave activity decreased. These parameters are described as reflecting a state of "compensated" fatigue. The last phase, beginning at 36-38 hours, was marked by increased (by more than 30%) delta and theta activity, decrease in high frequency activity, and continual increase in heart rate. Performance data shows a marked increase of errors beginning in the third phase, i.e., at about 24 hours.

In a second experiment, operators received preliminary training in "Autogenic Training" (AT); AT procedures (not described here, but see pages 96-98 for a description) were followed every 6 hours, beginning in the first hour of the experimental period. Operators following these procedures showed less pronounced changes in heart rate than control counterparts. EEG data from AT-trained operators showed higher levels of beta activity throughout the period; theta activity increased only after the 36th hour of work. The authors interpret these results as showing that AT slows the development of inhibition in the central nervous system, and describe AT-trained operators as showing only "compensated fatigue" up to the last hour of the experiment. Although the AT-trained operators do show a task performance decrement after the 39th hour, their performance is 17% better than operators in a control group. The authors also conclude that physiological changes tend to precede associated performance decrements by 1-4 hours.

Figure 1: Changes over time in heart rate, strength of EEG rhythms, and performance errors in operators performing a sensorimotor tracking task during 56 hours of continuous work

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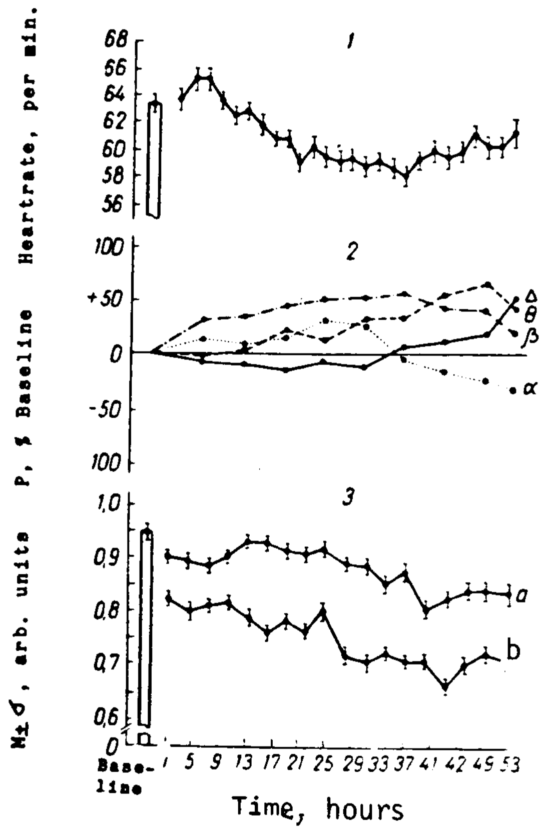

Figure 2. Change over time in heart rate (1), intensity of EEG rhythms (2), and the quality of compensatory tracking performance (3) in operators using AT-stimulation during 56 hours of uninterrupted task performance

a - quality of performance with AT stimulation; b - quality of performance without AT stimulation.

P402 (9/86) Nasolodin VV, Rusin VYa, Gladkikh IP.

Correlation between physical work capacity and certain direct and indirect parameters of trace metal metabolism.

Gigiyena i Sanitariya.
1986(7): 83-85; 1986.
[25 references; 9 in English]
Affiliation: Yaroslav University; K.D. Ushinskiy Pedagogic Institute, Yaroslav

Human Performance, Physical Work Capacity,
Humans, Age Groups
Metabolism, Trace Metals, Nutrition

Abstract: The goal of this study was to investigate the interrelationship between physical work capacity and metabolism of iron, copper, and manganese in individuals engaging in strenuous physical work. A total of 76 subjects were studied for a year, 19 blacksmiths aged 25-45, 24 physical education students aged 18-20, 11 young skiers and 22 school children aged 13-16. Blood was taken from the ulnar vein in fall, winter, spring and summer, under fasting conditions. Quantity of hemoglobin, level of peroxidase activity, ceruplasm activity, level of vitamin C, total amount of protein in serum, and protein serum fraction were determined using traditional methods. Physical work capacity was measured using the Harvard step test index. Concentrations of iron, copper and manganese in plasma and blood cells were also determined. Rank-order correlations were computed among the parameters, as shown in the table. The authors conclude that weak but significant correlations exist between physical work capacity and certain direct and indirect parameters of trace metal metabolism, Metabolism of iron and copper is correlated with level of vitamin C, and ceruloplasm may affect the concentrations of hemoglobin and of iron in the blood.

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Table: Correlations between physical work capacity and certain direct and indirect parameters of trace metal metabolism

Parameters	N	Correlation Coefficient	P
HSTI* - plasma iron	220	0.145	< 0.05
HSTI - vitamin C level	216	0.184	< 0.02
HSTI - peroxidase activity	225	0.386	< 0.001
HSTI - iron in blood cells	216	0.140	< 0.05
HSTI - copper in blood cells	208	0.221	< 0.01
HSTI - Mn in blood cells	190	0.244	< 0.001
Hemoglobin - plasma iron	233	0.229	< 0.001
Hemoglobin - total protein	243	0.360	< 0.001
Hemoglobin - vitamin C level	222	0.455	< 0.001
Plasma iron - vitamin C level	201	0.287	< 0.001
Peroxidase - hemoglobin	243	0.217	< 0.001
Peroxidase - erythrocytes	244	0.423	< 0.001
Peroxidase - total protein	243	0.125	< 0.05
Peroxidase - vitamin C level	213	0.315	< 0.001
Plasma copper - ceruloplasmin	235	0.158	< 0.02
Plasma copper - $_2$-globulin	242	0.184	< 0.002
Ceruloplasmin - total protein	244	0.346	< 0.001
Ceruloplasmin - $_2$-globulin	245	0.206	< 0.01
Ceruloplasmin - vitamin C	235	0.326	< 0.001
Plasma iron - ceruloplasmin	245	0.230	< 0.001
Hemoglobin - ceruloplasmin	238	0.577	< 0.001
Iron - copper in blood cells	222	0.393	< 0.001
Copper - Mn in blood cells	206	0.263	< 0.001

* Harvard Step Test Index

IMMUNOLOGY

PAPERS:

P401(9/86) Shubik VM, Pul'kov VN, Mashneva NI.
Immunological parameters following physical exercise under chronic exposure to radioactive and non-radioactive toxic chemicals.
Gigiyena i Sanitariya.
1986(7): 39-41; 1986.
[2 references; none in English]
Affiliation: Leningrad Scientific Research Institute of Radiation Hygiene, RSFSR Ministry of Health

Immunology, Nonspecific Immunity, Humoral Factors
Mice
Exercise, Stress; Radiobiology, Radioactive Chemicals; Toxic Chemicals

Abstract: This study used 360 outbred mice as subjects. These animals were divided into 3 groups: Group 1 was given no specific opportunity for exercise; mice in Group 2 (moderate exercise) were given access to an exercise wheel on which they averaged 1.5 - 2 km per day; Group 3 mice were forced to run on a drum revolving at 44 rev/min for 30 minutes 2-3 times per week; Group 4 was compelled to swim in warm water 2-3 times per week for 30 minutes carrying a weight 5% of their body weight. Treatment apparently continued for 1.5 years, but temporal parameters are not specified. Animals in each group were either given a normal diet, or fed daily either 100 kBq/kg of the radionuclide ^{90}Sr or a dose of 0.3 mg/kg of stable lead or both. Immunological studies were performed every 3 months for 1.5 years and included a number of humoral factors of nonspecific immunity. Parameters measured included bacteriocidal properties of serum with respect to a number of different microorganisms, serum concentration of complement, lysozyme, beta lysines, and anti-tissue complement binding autoantibodies.

For mice not fed toxic substances, moderate exercise (Group 2) increased the stimulation of humoral nonspecific protection parameters by 10-25%, and increased the production of antitissue autoantibodies by a factor of 2.5-4. Greater amounts of exercise, especially when combined with stress (Group 4), stimulated only some parameters (lysozyme, b-lysine); bacteriocidal properties of serum were decreased 15% in mice in this group, compared with the controls. In addition, concentration of antibodies in the blood decreased. Prolonged ingestion of ^{90}Sr, stable lead, or their combination led, under a number of conditions, to stimulation of humoral factors of nonspecific protection, increase in production of antitissue autoantibodies, depression of formation of antibodies to exogenous antigens, and decrease (with lead) in resistance to infection. Repeated moderate exercise on the exercise wheel preceding the ingestion of ^{90}Sr or concomitant with long-term ingestion of the radionuclide stimulated the majority of the humoral parameters measured and led to a decrease in formation of antitissue autoantibodies. However, in the latter case, a greater decrease in the bacteriocidal properties of blood serum was observed. More strenuous exercise, combined with stress and ^{90}Sr ingestion also facilitated normalization of some parameters and concentration of antitissue autoantibodies. However when the toxic substances were administered in combination on a long-term basis, exercise did not lead to changes in autoantibodies and beta-lysine activity decreased.

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Table 1: Immunological parameters in white mice exposed to a combination of ^{90}Sr and physical exercise

Table 2: Immunological parameters in white mice after long-term administration of ^{90}Sr, lead, and both toxins

(See also: Botany: P396)

PAPERS:

P394(9/86) Manukovskiy NS, Abrosov NS, Kosolapova LG.
A mathematical model of the oxygenation of wheat straw by microorganisms.
In: Kovrov BG and Kordyum VA, editors,
Mikroorganizmy v iskusstvennykh ekosistemakh
[Microorganisms in artificial ecosystems].
Novosibirsk: Nauka; 1986. See Digest Issue # 7 M78.
[pp. 166-171]

Life Support Systems, CELSS, Substrate Oxygenation, Cellulose, Lignin
Botany, Wheat Straw; Microorganisms
Mathematical Model

Abstract: The theoretical possibility of biological conversion of wheat straw in a CELSS has been demonstrated by the USSR Academy of Sciences. However, when the proposed technology was implemented in detail, there were significant problems mainly concerning incomplete oxidation of the substrate. Attempts to optimize the process failed, and the nature of the limiting factors was unclear. For this reason, mathematical modeling was used to analyze the limiting factors which attenuate the bioconversion of lignocellulose from wheat straw in the presence of large quantities of substrate in the medium. In addition, the behavior of the system was studied under conditions of nitrogen deficit. The model was based on 4 biological premises. 1) Ninety percent of lignified plant tissue consists of polysaccharides [C] (cellulose and hemicellulose) and lignin [L]. In wheat straw, the concentration of the latter reaches 25% of the dry tissue mass. The cell walls of adjacent cells form a layer in which the concentration of lignin increases from the periphery to the center. When there is a moderate break in the plant tissue (size of the particles 1 mm) microorganisms can access only the peripheral portions of this layer, which face toward the interior of the cell cavity and contain relatively little lignin. 2) Microorganisms cannot directly assimilate polymers of the cell walls, but operate by means of enzymes excreted into the medium. For example, hydrolysis of cellulose requires 4 types of enzymes, and hydrolysis of hemicellulose requires several more. For simplicity, these enzymes are designated in the model by a single symbol [E_C]. How microorganisms degrade lignin with enzymes is less well understood. The group of lignolytic enzymes are designated [E_{LP}] in the model.
3) Enzymes act on the surface of the substrate [S] and can penetrate the cell wall to a depth [h]. Enzyme action results in the formation of relatively low-molecular products -- sugars, P_c and phenol compounds P_l which are absorbed by the cells of the microorganisms [X]. In turn, this leads to growth in number of cells and additional synthesis of enzymes. 4) As the cells grow, most types of microorganisms prefer to consume glucose and other sugars. Consumption of phenol compounds and synthesis of lignolytic enzymes is blocked when there is a sufficient supply of sugars. When the concentration of sugars drops, the consumption of products of the enzymatic decomposition of lignin and the synthesis of the appropriate lignolytic enzymes begins.

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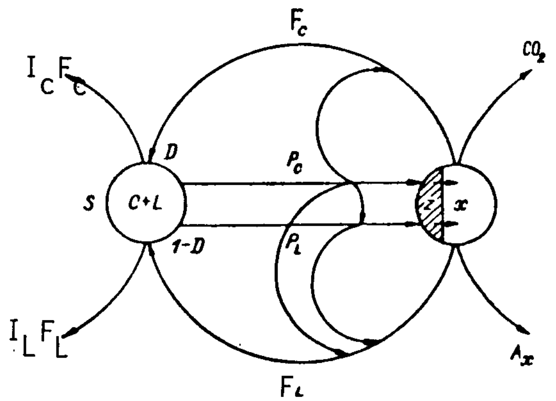
Comparison of model-generated and empirical data was apparently described in a previous paper. Computer implementation of the model, facilitated derivation of a probable mechanism underlying the attenuation of bioconversion of lignocellulose from wheat straw. The preferential growth of microorganisms on a single component of the substrate, i.e., polysaccharides, leads to an accumulation of cell biomass and a relative increase in the proportion of lignin on the surfaces of the substrate particles. Since the rate of consumption of lignin is a factor of 10-20 below that of polysaccharides, the formation of products of its degradation is insufficient for the synthesis of growth and life-supporting enzymes. As the concentration, of the first substrate decreases, autolysis occurs, in spite of the increased consumption of products of lignin degradation (see Figure 2). Analysis of the model showed that the quantity of unutilized substrate depends on the ratios between the rates of consumption of its components. Thus, if the rate of consumption of lignin is no less than 1/5th that of cellulose, then the substrate is almost fully oxidized. The observed attenuation of bioconversion is thus related to a shift in the basis for biomass growth -- from cellulose to lignin.

When nitrogen is limited, there is a decrease in the maximum biomass of cells and a corresponding increase in the time required to synthesize enzymes. If the concentration of nitrogen is maintained at a level which allows enzyme synthesis but does not support cell growth, then the synthesis of lignolytic enzymes is stimulated and catalysis of lignin increases.

The laws governing the process of lignocellulose oxidation derived with the help of the mathematical model demonstrate why traditional optimization methods had no effect -- because the limiting factor was not a controllable parameter.



A_x - autolysis rate
D - proportion of polysaccharides on substrate surface
Z - level of specific intraclular reserves
Other designations explained in text.

Figure 1. A diagram of the process of oxidation of lignocellulose by microorganisms.

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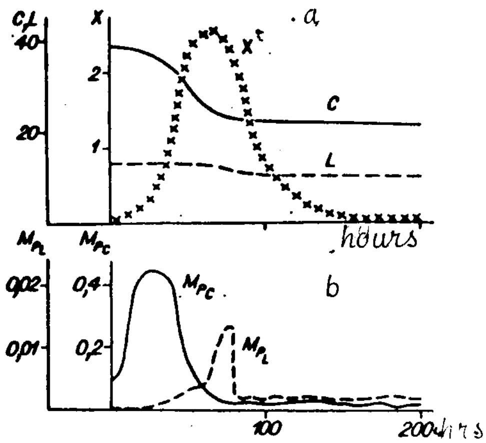

Figure 2. Growth of microorganisms (X), and removal of cellulose (C) and lignin (L) from the medium (a) over time; rates of cellulose M_{PC} and lignin $_{PL}$ consumption over time (b).

Figure 3. Lignin oxidation over time under nitrogen deficit (a) and with sufficient nitrogen (b)

P393(9/86) Shepelev YeYa, Shaydorov YuI, Popov VV.
Microbiological decomposition of plant wastes on a solid substrate under artificial conditions.
In: Kovrov BG and Kordyum VA, editors,
Mikroorganizmy v iskusstvennykh ekosistemakh
[**Microorganisms in artificial ecosystems**].
Novosibirsk: Nauka; 1986. See Digest Issue # 7 M78.
[pages 176-183; 8 references; none in English]

Life Support Systems, Closed Ecological Life Support Systems (CELSS)
Botany, Higher Plants, Wheat, Straw; Microbiology, Decomposition
Substrate

Abstract: In a CELSS, a solid substrate such as soil may serve many functions, e.g., transformation of organic wastes, and supply of minerals and biologically active substances to the plants. A study of some of these processes over a long period of time was performed by periodically introducing plant residues into a solid substrate. Minced straw was placed in a layer in a substrate at a depth of 3-5 cm in amounts of 70 g dry mass per vessel (2 kg). Hothouse mulch was used. The substrate and water were aerated continuously. In some vessels, wheat was grown until plants reached an age of 10 days. To determine gas metabolism, the vessels were hermetically sealed. During the 3 year experiment, 1.2 kg of straw was added to each vessel (36 g/m^2 per day). This is equivalent to the rate of production in a CELSS greenhouse. Ten days after the straw was added, the rate of CO_2 emission increased by a factor of 10 (from 200 to 2300 ml/day) and subsequently decreased to initial level by day 30.

It required 6 months for an adapted soil biocomplex to form. During this time there was a slight increase in the weight of the substrate. In subsequent months the weight of the substrate over a single decomposition cycle decreased by more than the weight of the added straw, due to decomposition of organic substances in the humus. Near the end of year 3, the rate at which the straw was transformed into humus became equal to its decomposition. After the process stabilized, the concentration of microflora fluctuated as a function of the decomposition cycle. As a rule, microflora increased after the introduction of straw, and reached its maximum on days 12-20 of decomposition, dropping back to initial value by day 30. Amount of cellulose-destroying microorganisms and fungi did not fluctuate significantly however. At the beginning of the experiment 30 earthworms and 250 epkhitreids [we cannot determine what type of creature this is] were added to each vessel. After 15 months the number of worms had stabilized at a mean of 70 per vessel. The number of epkhitreids fluctuated throughout the experiment but showed a tendency to decrease toward its termination. This suggests that the size of the population developed was greater than the critical value for the given amount and nature of the substrate. Growth of the wheat biomass indicated that the minimal productivity of the plant occurred during early decomposition cycles and increased up until the 12th month. Starting from the 20th month (after 8 cycles) biomass growth stabilized. Initial inhibition of growth is associated with immobilization of nitrogen and formation of toxic products generated by incomplete decomposition of straw. This experiment demonstrated that the formation of a stable self-regulating soil biocomplex is possible under artificial conditions.

P397(9/86)* Sidorenko PG, Zhad'ko SI, Popova AF, Karnaukh IM, Il'in VP.
On the adaptation of one-celled algae and tissue cultures of higher plants to microgravity.
In: Kovrov BG and Kordyum VA, editors,
Mikroorganizmy v iskusstvennykh ekosistemakh
[**Microorganisms in artificial ecosystems**].
Novosibirsk: Nauka; 1986. See Digest Issue # 7 M78
[pages 61-66; 4 references; none in English]

Life Support Systems, CELSS
Microorganisms, Chlorella; Botany, Higher Plant, Haplopappus, Metabolism
Adaptation, Microgravity, Clinostatting

Abstract: If unicellular plant organisms and tissue cultures of higher plants are to be used as components of CELSS on spacecraft, it is important to discover how these organisms adapt to space flight factors. One-celled algae Chlorella vulgaris (LARG-1 strain) and tissue cultures from a higher plant Haplopappus graetis were used in this study. The latter cultures were grown in light and darkness at 24°C in an agarized nutritive medium, and the Chlorella culture was grown in darkness. Microgravity was modeled by means of clinostatting at or 50 rotations per minute for periods of 30 minutes, and 1, 2, 3, 6, 12 or 24 hours. The Haplopappus cells selected for use were in the logarithmic (day 7) and stationary (day 21) growth phases and the Chlorella had been growing for 21 days. The cells were studied by the biochemoluminescence method, which is one of the most sensitive ways to study the homeostasis of biological entities. This method makes it possible to follow the initial processes of metabolic changes of a population of cells without submitting them to strong chemical agents. Cell samples were suspended in an isotonic solution with pH equal to that of the culture milieu, and chemical luminescence was intensified by adding luminole [??] and water. Intensity of luminescence was measured using a quantometric luminometer, which is sensitive to superweak radiation fluxes. For both types of cells, clinostatting led to substantial changes in chemoluminescence for cells grown in the dark or in light. The exact nature of the effects of clinostatting depended on growth conditions and phase of growth; however, in all cases clinostatting was associated both with increases and decreases in chemoluminescence. Clinostatting had the least effect on cells in an active state of proliferation. These effects are represented in detail in Figures 1 and 2. The authors interpret these effects as demonstra 'ng that unicellular plant organisms respond to clinostatting with changes in their metabolic rates. This is taken as demonstrating that such cells are potentially highly adaptable to weightlessness and, thus, are promising candidates for inclusion in spacecraft life support systems.

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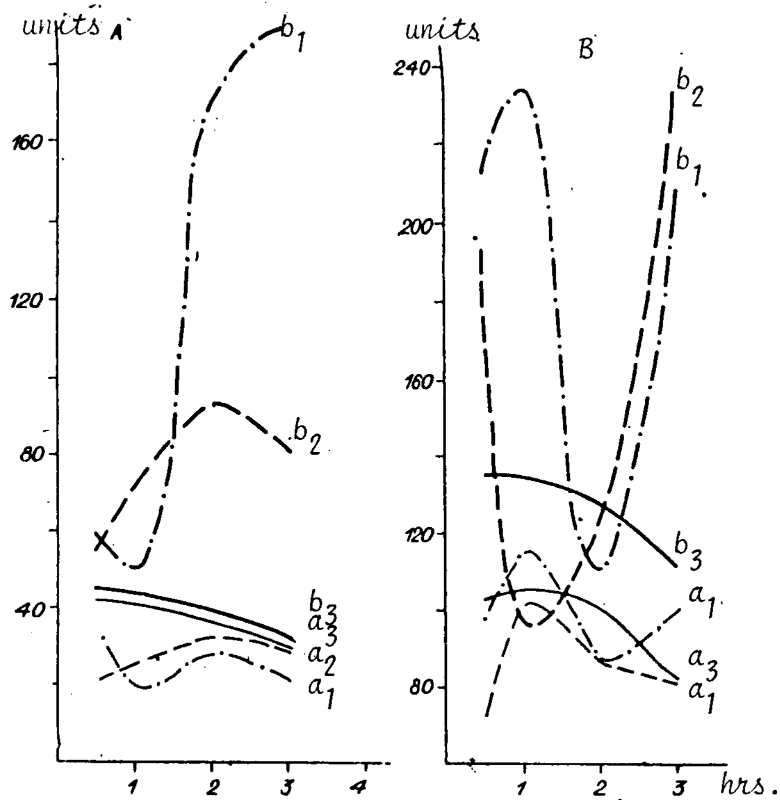

Figure 1: Chemoluminescence of cultured <u>Haplopappus</u> cells in response to clinostatting.

A - darkness; B - light; a - logarithmic growth phase; b - stationary growth phase; 1 - clinostatting at 5 rev/min; 2 - 50 rev/min; 3 - control

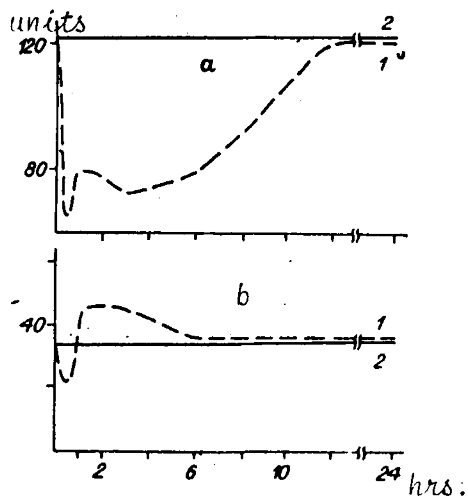

Figure 2: Chemoluminescence of cultured cells

a - <u>Chlorella</u>; b - <u>Haplopappus</u>; 1 - clinostatting at 5 rev/min; 2 - control

MATHEMATICAL MODELING

(See also: Life Support Systems: P394; Psychology: P372)

PAPERS:

P377(9/86)* Obraztsov IF, Konakhevich YuG, Lyapin VA, Mar'in AV.
Mathematical modeling of kinematic reactions of the human body to impact.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
20(4): 37-42; 1986.
[3 references; 2 in English]

Operational Medicine, Kinematic Reactions
Mathematical Modeling, Humans
Impact

Abstract: This paper describes the development of a general model of "kinematic" responses of the human body to impacts as a basis for development of specific models of the effects of various types of air- or spacecraft accidents. For this purpose the authors have provided a selection of kinematic models of various levels of complexity, as well as a formulation algorithm which permits the model to be adapted to specific situations without losing time on iterative formulation of equations. To meet these criteria, the general model was based on a method described by Wittenburg, which includes the concepts of graph theory, and symbolic matrix and tensor notation. The structure of the model can be described by a graph in which the nodes are the bodies being modeled and the arcs are joints; this structure is described mathematically by an incidence matrix. The mathematical procedure for developing this model for a given situation is implemented by a FORTRAN program, which has 4 variants differing in whether a 2- or 3-dimensional system is considered and whether information on the rate and direction of movement of the body as a whole is available. In each version, the following steps are performed: computation of constants which are not a function of time, integration of equations of motion, calculation of transport criteria, and comparison with experimental data. All four versions have the same structure. This program automatically recalculates all the inertial and dimensional parameters of a kinematic model of any structure based on a 17-element model of the human body. The program estimates the kinematic reactions of the human body to impacts lasting 10...1000 usec, and is suitable for the study of the characteristics of such reactions in simulation. Although its use in specific situations presents some problems associated with the identification of parameters of the kinematic models and with the analytic description of the external forces acting on the body (primarily, contact and aerodynamic), it should prove useful for estimating the effectiveness of various safety devices.

Figure 1: Flow chart of the program

Figure 2. 17-element kinematic model of the human body.

Figure 3: Eight-element model of the human body (1) and acceleration impulse (2) used in a simulation.

Figure 4: Changes in coordinates of the center of inertia of the head and shoulder points as a function of time, for the situation in Figure 3.

METABOLISM: See Human Performance: P402; Nutrition: P379; Psychology: P372; Radiobiology: P397; P404

Microbiology: See Life Support Systems: P394

MORPHOLOGY AND CYTOLOGY: See Botany: P396; Endocrinology: P384 P396

MUSCULOSKELETAL SYSTEM

(See also: Developmental Biology: P383; Endocrinology: P385, P397)

PAPERS:

P361(9/86) Kirenskaya AV, Koslovskaya IB, Sirota MG.
The effects of immersion hypokinesia on the characteristic rhythm of [activity of] motor units in the soleus muscle.
Fiziologiya Cheloveka.
12(4): 627-632; 1986.
[14 references; 6 in English]

Musculoskeletal System, Electrical Activity, Soleus
Humans
Hypokinesia, Immersion

Abstract: As a simulation of weightlessness, 7 individuals underwent 5 days of immersion in water. Activity of motor units of the soleus muscles was studied as subjects performed a task involving tonic maintenance of a stipulated muscular tension (5-10% of maximum). Tension was maintained with the help of visual feedback on an oscilloscope screen. Measurements were made before the beginning of immersion and on days 3 and 5 of the treatment. Steps were taken to preclude participation of other muscles in the tension maintenance. Motor unit activity, measured with bipolar electrodes, was recorded on an oscillograph. To analyze the records, the interimpulse intervals were calculated and the following manipulations made: 1) histograms of the sequence of interimpulse intervals were constructed, their normal distribution ascertained and mean and standard deviation computed; 2) correlations between adjacent interimpulse intervals were computed; 3) the relationship between mean and standard deviation was derived; 4) the level of synchronization of the activity of simultaneously working motor units was determined by computing correlations. Immersion hypokinesia did not prevent subjects from performing the muscle tension task. However, it was found to lead to significant changes in patterns of motor unit activity during task performance: the variability of interimpulse intervals increased substantially; the percent of motor units showing synchronized activity increased; and the mean duration of the interimpulse intervals increased as a result of activation of low-frequency motor units. The rapidity with which these changes occurred suggests that they are reflexive in nature. The authors interpret these results as suggesting that disruptions of motor activity after weightlessness or its simulations are caused by a number of factors, of which the most important is the decrease in proprioceptive feedback related to unloading of the weight-bearing muscles and decrease in muscular tonus.

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Table: Synchronization of motor (MU) unit activity before and during immersion

Time of testing	# MU pairs	# studied interimpulse intervals in each MU pair	Synchronized MU activity # MU pairs	Synchronized MU activity r	Independent MU activity # MU pairs	Independent MU activity r	% Synchronization
Baseline	6	60	1	0.455	5	0.086	16.7
Immersion:							
Day 3	12	60	6	0.727	6	0.084	50.0
Day 5	13	60	5	0.582	8	0.053	38.54

Figures:

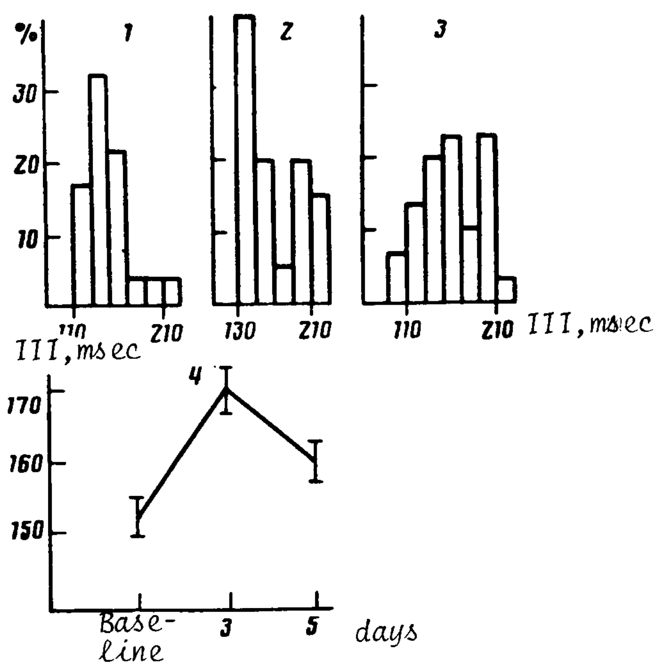

Figure 1: Changes in duration of interimpulse intervals of MU during immersion. 1, 2 and 3 -- histograms of the distribution of MU on the basis of interimpulse interval duration before immersion and on days 3 and 5, respectively. 4 -- changes in mean interimpulse interval duration in the course of immersion. (Abscissa -- time of testing; Ordinate -- interimpulse interval duration, msec).

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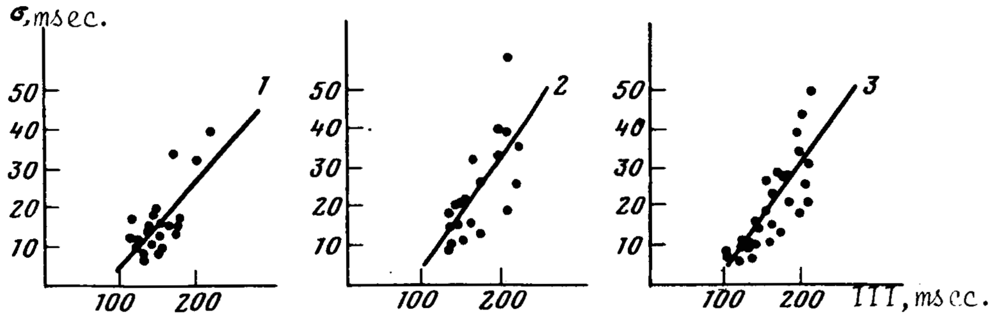

Figure 2: Standard deviation and duration of interimpulse intervals of MU during baseline (1) and on days 3 (2) and 5 (3) of immersion. Abscissa -- standard deviation, msec. 1 -- r = 0.70; y = 18.10 ±0.23 x [sic.]; 2 -- r = 0.73; y = -25.2+0.29x; 3 -- r = 0.82; y = -25.78 + 0.29x.

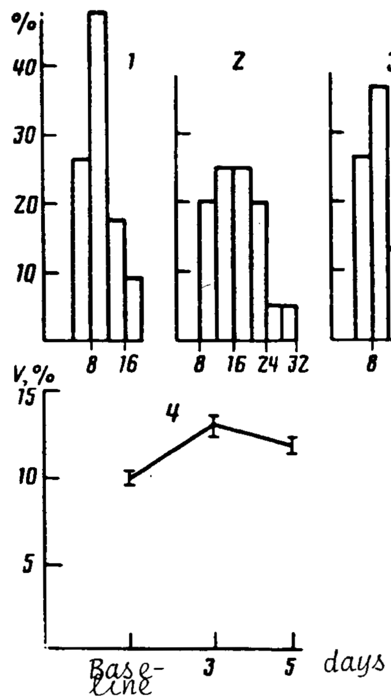

Figure 3: Changes in variance of interimpulse intervals during immersion. 1, 2 and 3 -- histograms of distribution of variance for a group of MUs before immersion and on days 3 and 5 of immersion, respectively. 4 -- changes in mean variance during immersion (Abscissa -- time of testing; Ordinate -- coefficient of variance, %).

NEUROPHYSIOLOGY

(See also: Adaptation: P403; Developmental Biology: P381; Human Performance: P363, P371; Personnel Selection: P373)

PAPERS:

P362(9/86) Slavinskiy YeYu, Trinus KF.
Cortical potentials evoked by threshold vertical acceleration in humans.
Fiziologiya Cheloveka.
12(4): 651-656; 1986.
[10 references; 1 in English]
Affiliation: A.I. Kolomiychenko Scientific Research Institute for Otolaryngology, Kiev

Neurophysiology, Evoked Cortical Potentials
Humans, Men and Women; Patients, Vestibular Disturbances
Acceleration, Vertical, Threshold

Abstract: Subjects in this experiment were 17 healthy adults (aged 21-38) of both sexes and 2 patients suffering from labyrinthine areflexia. Threshold vertical acceleration was produced with a specially modified otolaryngological chair. The threshold of acceleration at which a subject perceived movement with eyes closed was determined separately for each person and then used in subsequent trials. Cortical potential was measured with 3 electrodes attached to the head. Every 4 to 5 seconds an EEG record 512 msec in duration was input to a computer, along with the tension in the potentiometer which recorded acceleration. Spectral analysis was performed on the data recorded in the computer using Fourier transforms, and degree of synchronization of the spectral components (component synchrony measure) was computed. Perception of movement occurred in healthy subjects at a vertical acceleration of 10-20 cm/sec^2. The authors draw the following conclusions: 1) Evoked cortical potentials can be recorded in response to threshold vertical acceleration. This method may be used to determine the threshold of stimulation of a person's vestibular system, particularly the utricular otoliths. 2) The cortical potentials evoked by acceleration for various individuals generally have rather stable positive and negative components and correlate within the range of $r = 0.6 - 0.9$. The spectrum of the potentials thus evoked is concentrated at frequencies of 4 and 6 Hz. The phase synchronization of Fourier components of individuals at 6 Hz is approximately twice as great as at a frequency of 4 Hz. 3) The induced potential component at 6 Hz in the spectrum can serve as an objective indicator of the processes occurring in the specific conduction tract in the genesis of the acceleration evoked potential. Potential at 4 Hz may reflect subjective perception of vestibular sensations. 4) A total of 10-12 data points are sufficient for recording acceleration-evoked potentials. Biofeedback on theta rhythms is useful in determining the vestibular thresholds for the perception of vertical linear acceleration.

Figure 1. Examples of potentials evoked by acceleration in a healthy subject in response to acceleration of 15 cm/sec^2 and in a patient with labyrinthine areflexia in response to acceleration of 40 cm/sec^2

Figure 2. Spectra of strength and component synchrony measure of acceleration evoked potential in healthy subjects

P364(9/86) Petrova YeI, Alekseyeva NS.

The nystagmic component of the vestibular response in diagnosing vestibular pathology.

Vestnik Otorino-laringologii.
1986(4): 27-31.
[8 references; 2 in English]

Affiliation: Department of Otolaryngology, I.M. Sechenov Medical Institute, Moscow; Scientific Research Institute of Neurology, USSR Academy of Medicine

Neurophysiology, Vestibular System, Nystagmus
Humans, Healthy and Patients, Vestibular Pathology
Rotation

Abstract: Twenty healthy individuals and 80 patients suffering from pathology of the labyrinth and related disorders, including initial symptoms of disruption of cerebral hemodynamics, were subjects in this study. Subjects were given clinical, otolaryngological, audiological, vestibulometric, rheoencephalographic, ultrasound and Dopplerographic examinations. Characteristics of vestibular function were determined on the basis of sensory, autonomic and nystagmic reactions during and after rotation. Subjects were rotated 3 consecutive times at 30, 45, and 60°/sec, with acceleration of $15^{\circ}/sec^{2}$ over the course of a minute and intervals of 2 minutes between rotations. Frequency, amplitude, and slow phase rate were recorded. For normal individuals, postrotation nystagmus was characterized by left-right symmetry in all parameters. Nystagmus during rotation never exceeded -- and frequently was less pronounced than -- postrotational nystagmus. Nystagmus evoked by caloric irrigation was similar to postrotational nystagmus. The patients showed 3 nystagmus patterns. The first type, characteristic of patients with Meniere's disease, was marked by lowered vestibular excitation. The second pattern was marked by stronger nystagmus during than after rotation, and by asymmetry. This occurred in patients who complained of prolonged dizziness and headache, and only in those under the age of 40. No focal neurological symptoms occurred in these patients. The third pattern showed diminished nystagmus both during and after rotation, with the former being more pronounced. Those showing this pattern had pronounced sensory and autonomic reactions to positive acceleration, and almost no reaction to termination of rotation. The third type of pattern occurred in those over 40 with arterial hypertension, complaining of long periods of dizziness, and showing symptoms of impaired brain function. Rheoencephalography revealed signs of impaired cerebral blood circulation in most of the subjects with patterns of the second and third types. When a group of 20 additional subjects suffering from cerebral circulation disorders were given rotation tests, none showed normal nystagmic patterns and half showed more pronounced nystagmus during rotation than after it. Treatment with vasoactive substances was effective for all subjects showing this latter pattern, but not effective for patients who did not manifest this pattern. The authors conclude that this pattern of rotational nystagmus is an early sign of cerebral hemodynamic disorders. To corroborate this claim, one healthy subject was maintained in a head-down position (angle -30°) for 6 hours. Nystagmic response during rotation was four times as great during the first hour of head-down tilt than in the baseline period.

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Table: Postrotational and rotational nystagmus in patients and controls

Group	Duration, sec.	Frequency, Hz	Amplitude, °	Slow Phase Rate, $°.sec^2$
Healthy, (control)	20 / 21	16.5 / 11.4	9 / 11	26.0 / 26.0
Patients with vestibular dysfunction				
Pattern 1	0 / 6.3	0 / 7.2	0 / 2.9	0 / 17.1
Pattern 2	28.0 / 12.6	17.0 / 15.0	5.0 / 4.2	24.0 / 21.0
Pattern 3	31.0 / 13.0	6.5 / 7.5	1.7 / 1.8	22.0 / 21.0

The top number refers to rotational nystagmus and the bottom one to post-rotational nystagmus.

Figures: Figure 1. First type reaction pattern.

Figure 2. Second reaction pattern. Greater intensity of rotational nystagmus.

Figure 3. Third reaction pattern.

Figure 4. Rotational and postrotational nystagmus in patient V.

Figure 5. Nystagmic reaction before and during head-down tilt.

P378(9/86)* Nekhayev AS, Vlasov VD, Ivanov VV.
Use of central electroanalgesia to facilitate recovery from motion sickness.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
20(4): 42-44; 1986.
[17 references; none in English]

Neurophysiology, Motion Sickness
Humans
Countermeasures, Treatment, Electroanalgesia

Abstract: The goal of this experiment was to test the effectiveness of central electroanalgesia (stimulation of the central nervous system with pulsating electric current) on symptoms of motion sickness induced by acceleration. Subjects were 9 healthy volunteers aged 30-45. Subjects were exposed to angular and Coriolis acceleration to the point of marked nausea and the urge to vomit. After a 1-hour rest interval a second acceleration session was conducted using the same termination criterion. In the control condition, subjects spent the interval between sessions and the period after the second session lying down and resting. In the experimental condition (apparently, the same group of 9 participated in both conditions; order not specified) subjects were exposed to central electroanalgesia with current of 0.5-0.8 mA, frequency of 800-950 Hz and duration of 0.15 msec. Electrodes were attached to the forehead below the mastoid process, and to the neck. At the beginning and end of each condition, cardiovascular parameters were measured at rest and during a postural test involving alternating 5-minute periods in an upright upright position (inclination of +80°) and tilted head-down (angle of -30°). Parameters recorded included: heart rate, RR EKG, pulsed blood pressure, cardiac stroke volume and total peripheral resistance. In the postural test, the parameters recorded represented the mean value over 5 minutes in a given position, as compared to the corresponding value for the horizontal. Before acceleration, the upright position led to increased heart rate and peripheral resistance, and decreased stroke volume and blood pressure; the head-down tilt position led only to increased stroke volume. After acceleration, subjects experienced pallor, copious cold sweat, hypersalivation, pronounced nausea with the urge to vomit, dizziness, lethargy and sleepiness. No differences were observed in the rated symptoms in the control and experimental conditions. Some symptoms persisted for most control subjects for 7-10 hours. The time during which they were able to tolerate the second acceleration session increased by an average of 19.1%. In upright position, increase of heart rate was somewhat greater, while increase in peripheral resistance was somewhat less with respect to horizontal values than before acceleration. The authors infer a decrease in the quality of cardiovascular function. There was also a tendency to bradycardia at rest, suggesting an effect on the parasympathetic system. When subjects were asked to perform work (task not specified), 7/9 members required considerable effort to do so. In the experimental condition, the autonomic symptoms disappeared completely after the electroanalgesia treatment. After the second acceleration session and second treatment, subjects experienced improved mood, to the point of euphoria in one case. No decrement in work capacity was noted. Duration of acceleration tolerance increased by 76% from the first session. Of the 9 subjects, 6 receiving electroanalgesia showed no evidence of effects on the parasympathetic system. The postural test showed less evidence of strain

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on the cardiovascular system than in the control condition. The authors conclude that central electroanalgesia is a promising means of preventing and treating motion sickness.

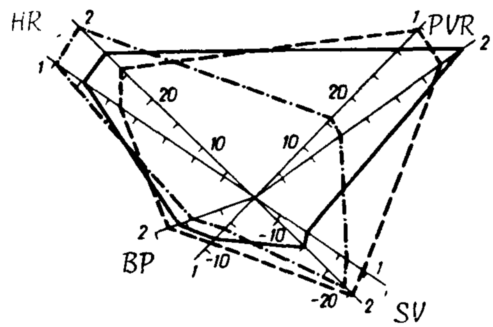

Figure: Changes over time in parameters of cardiovascular system in response to a postural test.

Dotted line -- before acceleration; dashed line -- after acceleration; solid -- line after central electroanalgesia. 1 and 2 -- first and second time in upright position. Deviation of parameters from values registered in the horizontal position are cited in terms of percentage.

NUTRITION

(See also: Hematology: P382; Human Performance: P402)

PAPER:

P379(9/86)* Bychkov VP, Vlasova TF, Gryasnova VN, Sedova YeA, Sivuk AK, Tret'yakova VA, Ushakov AS.
The biological value of the protein included in the rations of the crews of the "Salyut" orbital stations.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
20(4): 44-48; 1986.
[7 references; none in English]

Nutrition, Biological Value; Metabolism, Protein
Humans
Cosmonaut Rations (Salyut), Protein; Hypodynamia, Hermetic Quarters

Abstract: This paper describes three experiments investigating the biological value of the protein components of freeze-dried foods contained in the rations of "Salyut" space station crews. In the first study 10 male volunteers consumed special rations for 60 days. Of the foods they consumed, 15% were freeze-dried and 85% were preserved by other methods. The 2880 calorie a day diet consisted of 141 g protein, 94 g fat, 346 g carbohydrates, 0.7 g calcium, 1.7 g phosphorus, 0.4 g magnesium, 2.8 g potassium, and 4.2 g sodium. Subjects received their meals in the laboratory, but otherwise maintained a normal schedule. In the second experiment, 4 male subjects participated in a 68-day study. An experimental diet was consumed during this entire period. Throughout the first 20 days, called the baseline, subjects otherwise maintained a normal schedule. During the next 42 days, they lived in a small hermetically-sealed compartment. Starting on day 6 the atmosphere of this compartment contained ca. 2 mg/m^3 ammonia. The last 6 days of the 68-day period were considered a follow-up period. Subjects' rations contained up to 65% freeze-dried food. The daily ration totalled 3300 calories and contained 159 g protein, 131 g fat, 396 g carbohydrates, 0.9 g calcium, 2.5 g phosphorus, 0.5 g magnesium, 3.8 g potassium, and 6.1 g sodium. In the third experiment, the diet was enriched with a number of nutritive substances suggested by the results of the two previous studies. These substances (glucose, phosphatide concentrate, vitamins, and minerals) are considered to have a normalizing effect on metabolism during periods of emotional stress. The diet consisted mainly of freeze dried foods, but contained some dishes prepared from fresh foods and subsequently frozen. Containing 3400 calories/day, the diet consisted of 152 g proteins, 133 g fats, 420 g carbohydrates, 1.1 g calcium, 2.3 g phosphorus, 0.4 g magnesium, 4.6 g potassium, and 6.0 g sodium. The subjects, 6 men, consumed this diet for 16 days under normal conditions, followed by 14 days of hypokinesia with head-down tilt (-8^{o}) and a 26-day recovery period.

In the first experiment, no deviations from normal protein metabolism were noted and body weight did not change significantly. In the second experiment, protein assimilation was relatively high (87%); only one subject, who was overweight at the start, lost weight (5.5 kg). No statistically significant changes in the protein fractions, total proteins, free amino acids in the blood, nor in renal excretion of end products of nitrogen metabolism were noted. Nitrogen balance was positive in the

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preliminary and follow-up periods, and close to 0 in the sealed compartment. In the third experiment, subjects retained normal appetite levels and experienced no digestive problems. The protein assimilation ratio and protein content in the diet indicated that the subjects were getting 124 g protein per day before and after hypodynamia, and 106 g/day during the treatment. During the baseline period, the subjects had normal levels of urea, creatinine, and uric acid in their blood serum. There was some increase in the concentration of urea on day 7 of hypodynamia and some decrease in creatinine on days 7 and 14, apparently attributable to decreased motor activity. On days 12 and 14 of hypodynamia there was an increase in uric acid. During the recovery period these parameters returned to normal. During hypodynamia, there was a decrease in the total amount of protein in blood serum attributable to decreases in albumin, component globulins, and immunoglobulins. However, in spite of these decreases the parameters remained within normal levels. Changes in free amino acids in blood plasma and urinary excretion of total nitrogen, urea, ammonia, and uric acid in the majority of cases remained within normal limits. By the end of the hypodynamia period, levels of methionine, aspartic acid, and glutamic acid had decreased significantly. Nitrogen balance remained positive before and after hypokinesia and was 0 during hypokinesia. The authors conclude that the diets tested supply sufficient proteins, even under simulations of weightlessness. They recommend the diet variant used in the third experiment, which utilized a more varied set of products and contained supplements intended to correct for the effects of emotional stress.

OPERATIONAL MEDICINE

(See also: Mathematical Modeling: P377)

PAPERS:

P365(9/86) Bodrov, VA.
The problem of flight crew fatigue.
Voyenno-meditsinskiy Zhurnal.
1986(5): 40-43.
[No references]
Affiliation: [Military] Medical Corps.

Operational Medicine, Fatigue
Humans, Flight Crews
Review Article; Classification System

Abstract: This article is concerned with description and classification of fatigue in flight crews. "Flight fatigue" is defined as a functional state in a pilot or other flight crewmember which occurs as a result of meeting the demands of flight, accompanied by psychological and nervous tension and other adverse factors. It involves disruption of a number of functions, and a decrease in the effectiveness and quality of performance. Four degrees of flight fatigue are distinguished and their causes, symptoms and recommended treatments outlined as follows:

I Manageable fatigue
- A Causes: short-term occurrence of moderate demands
- B Symptoms
  - 1 Professional
    - a Efficiency and level of job performance: not impaired
    - b Behavior: not affected
  - 2 Functional
    - a Subjective
      - 1) General state: tired at end of flight shift or long flight
      - 2) Sleep: not impaired
      - 3) Attitude toward flights: normal
    - b Objective (physiological, psychological, biochemical, autonomic, and neurological): Slight changes in autonomic functions (at end of flight shift or long flight)
- C Measures to restore normal functioning: short-term rest

II Acute fatigue
- A Causes: short-term occurrence of intense demands
- B Symptoms
  - 1 Professional
    - a Efficiency and level of job performance: not impaired (sometimes decreases at end of flight shift or long flight)
    - b Behavior: Slight deterioration
  - 2 Functional
    - a Subjective
      - 1) General state: tired at end of flights, listlessness, weariness
      - 2) Sleep: not impaired (sometimes difficulty in falling asleep)
      - 3) Attitude toward flights: normal

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b Objective (physiological, psychological, biochemical, autonomic, and neurological): decreased sensitivity of senses, impairment of autonomic functions (at end of flight or flight shift)

C Measures to restore normal functioning: short-term rest

III Chronic fatigue

A Causes: repeated occurrence of intense demands

B Symptoms

1 Professional

a Efficiency and level of job performance: significantly impaired (at end of flight or flight shift)

b Behavior: deteriorates to significant extent (at end of flight or flight shift)

2 Functional

a Subjective

1) General state: Constantly tired throughout the flight, general weakness, decrease in appetite

2) Sleep: difficulty in falling asleep and waking up, disrupted sleep

3) Attitude toward flights: stress, decrease in interest, loss of confidence

b Objective (physiological, psychological, biochemical, autonomic, and neurological): marked decrease in sensory sensitivity, disruption of autonomic functions, deterioration of cognitive processes, changes in biochemical parameters, neurological impairment (at end of flight or flight shift)

C Measures to restore normal functioning: prolonged rest

III Exhaustion

A Causes: repeated, long-term occurrence of intense, excessive demands, accompanied by physiological changes

B Symptoms

1 Professional

a Efficiency and level of job performance: sharply impaired to the point of commission of elementary errors and failure to perform flight mission

b Behavior: deteriorates sharply throughout the flight or flight shift

2 Functional

a Subjective

1) General state: Unremitting fatigue, even in the absence of demands, apathy, irritability, pain in the area of the heart, loss of appetite, etc.

2) Sleep: difficulty in falling asleep and waking up, insomnia, sleepiness during the day, etc.

3) Attitude toward flights: loss of interest, indifference, decrease in awareness, alertness during flight

b Objective (physiological, biochemical, autonomic, and neurological): marked decrease in perceptual sensitivity, disruption of autonomic functions, deterioration of cognitive processes, changes in biochemical parameters, neurological impairment (throughout flight or flight shift, lasting weeks or months)

C Measures to restore normal functioning: treatment and medical rehabilitation

P380(9/86)* Kozlovskiy AP, Lushchikov YeA.

Human tolerance of skin contact with high heat.

Kosmicheskiy Biologiya i Aviakosmicheskaya Meditsina.
20(4): 53-55; 1986.
[6 references; 1 in English]

Operational Medicine, Tolerance, Skin, Arm
Humans,
High Temperatures

Abstract: Heating of the outside of space suits can increase the temperature of the internal surfaces which are in contact with the skin. This experiment was designed to determine the limit of human tolerance of high temperatures in contact with the skin. Subjects were 22 males, aged 26 to 45. Heat was applied to an area of $1.6 \cdot 10^{-3}$ m^2 on the skin of the inside of the forearm, an area selected for its sensitivity. To simulate actual space suit conditions, the contact area was covered with cotton or wool material. Actual EVA conditions were further simulated by applying a pressure of $(0.5 \pm 0.1) \cdot 10^5$ n/m^2 on the heated material. Heat was applied as the subject inserted his arm into a heating cabinet and pressed it against the contact service. Other areas of the arm and hand were protected by a heat screen. The criterion of the upper tolerance limit was unbearable pain. A total of 182 trials were performed: 110 with cotton and 72 with wool fabric. For temperature values ranging from 60-180° C, curves were constructed relating probability of unbearable pain and duration of contact. Heat-flow values corresponding to the contact temperatures using the formula for stationary thermal conductivity and curves relating tolerance to heat flow were constructed, The authors conclude that their methodology is adequate for use in testing space suits and selecting their thermal characteristics.

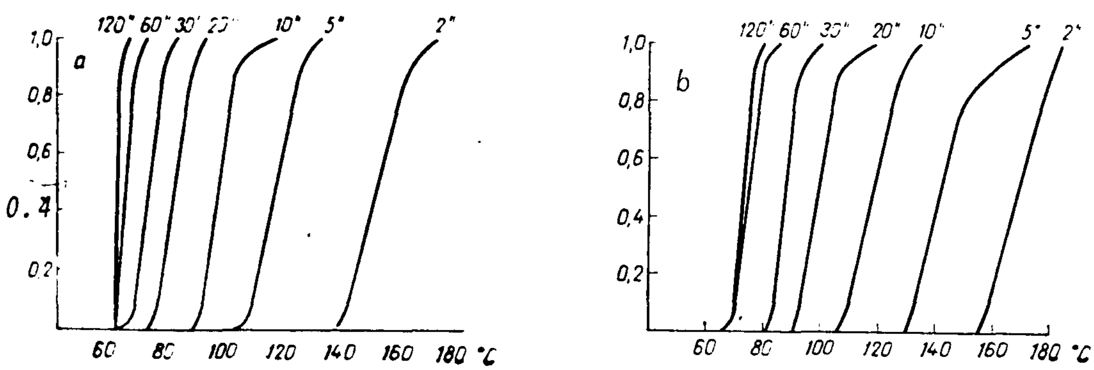

Figure 1: Probability of occurrence of unbearable pain in contact with cotton (a) and wool (b) fabric with varying exposure times.
Abscissa -- contact temperature; ordinate -- probability of unbearable pain occurring.

Figure 2. Equiprobable curves of the tolerance limit of contact with high temperatures.

Figure 3: Heat tolerance limits

PERCEPTION

(See also: Habitability and Environment Effects: P375;
Human Performance: P363)

PAPER:

P392(9/86)* Malinin ID, Ponomarenko VA.
Characteristics of visual monitoring of information on instruments during flight requiring maneuvers.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
20(4): 4-7; 1986.
[12 references; 2 in English]

Perception, Eye Fixations, Instrument Dials
Humans, Pilots
Flight Maneuvers, Pitch, Bank

Abstract: The goals of this study were to determine the quantitative principles underlying the distribution of eye fixations among the various dials of a flight and navigation instrument panel; to develop a taxonomy of the sequential patterns of fixation and their psychological correlates; and to identify the dynamic features of eye movements during flight as a function of type of flight task being performed by a pilot. Four pilots with "first class" licenses participated in the series of experiments. The experimental apparatus combined a flight training simulator with an eye movement monitor. Pilots were required to perform the following maneuvers: take-off, ascent/climb with left banking, horizontal flight, left 360° turn with bank of 30°, right 360° turn with bank of 30°, dive with pitch of 30°, ascending spiral with banking of 30°, descending spiral with banking of 30°, landing on automatic pilot. Eye movement data indicated that between 50 and 70% of the total time the pilots' eyes were focused on instruments relevant to maintaining the angular spatial coordinates of the aircraft along the pitch and bank axes, with the pitch reading comprising the largest portion of the fixation. The amount of time spent focused on reading the bank angle is considerably greater for left turns and spirals than for right turns and spirals. The authors conclude from their data that the degree of tension associated with perceiving and processing information is not dependent on the number of instruments involved per se, but is determined by the subjective significance of the parameter being controlled and its probability of changing. The authors define fixation cycles as division of attention exclusively between two instruments or dials during a given period of time. They conclude that the majority of cycles involve alternations between pitch and bank angle readings, and that the nature of these cycles -- and particularly the percentage of time spent focusing on them -- is a function of flight task being performed. The authors interpret their results as suggesting that during flight maneuvers the pilot is not merely checking the instrument readings against expected values, but is using the readings for ongoing solution of quantitative problems involving pairwise relations between two parameters. The general thrust of the theoretical analysis is that instrument flight is not just an automated, relatively mechanical process involving performance of movements to maintain instrument readings, but rather involves active problem solving.

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Table 1: Visual monitoring during performance of a flight mission (% of the total time devoted to looking at each instrument dial)

Table 2: Major variants and amount of time devoted to fixation cycles in the overall structure of attention distribution by pilots (in % of total time)

PERSONNEL SELECTION

(See also: Biological Rhythms: M97)

PAPERS:

P373(9/86)*Kotovskaya AR, Vil'-Vil'yams IF, Luk'yanyuk VYu.
Tolerance of non-pilots of varying age to $+G_z$ acceleration.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
20(4): 25-29; 1986.
[9 references; 4 in English]

Personnel Selection, Pilots, Cosmonauts
Humans, Age Differences
Neurophysiology, Tolerance, Acceleration, $+G_z$

Abstract: A total of 96 nonpilot male subjects, aged 21-50, were assigned to one of 6 age groups (at five year intervals) and accelerated on a centrifuge in the head-pelvis ($+G_z$) direction, up to a level of 3-5 x gravity, lasting 30 seconds. Rate of increase and decrease of acceleration was 0.2g/second, and the interval between consecutive accelerations was 10-15 minutes. Subjects, who were healthy and had never before experienced acceleration, were advised to tense the muscles of their stomachs and legs, but no countermeasures were administered. Acceleration tolerance was assessed using an unspecified procedure. Physiological parameters such as heart rate, blood pressure and reaction time to a light signal were also recorded. All subjects tolerated accelerations of 3- and 4-g well. Subjects aged 31-40 showed the best tolerance, with those on either end of the continuum showing somewhat decreased tolerance. Symptoms of decreased tolerance varied with age. Subjects aged 21-25 tended to show symptoms indicative of decreased blood supply to the brain (drop in systolic blood pressure and pulse strength, loss of consciousness, etc.). Older subjects were more likely to be limited by disruptions of cardiac rhythm (e.g., group or polytropic extrasystole). Younger individuals were much more likely to react to acceleration with increased heart rate. After termination of acceleration, the blood pressure of the oldest group (aged 41-45) required significantly more time to return to normal than that of the youngest group (21-25). Subjects over 40 were more likely to show autonomic responses such as paleness and weakness after the centrifuge stopped than were the other subjects. In spite of the age differences, the good or satisfactory acceleration tolerance shown by the majority of the older group is interpreted by the authors as suggesting that many individuals over 40 could tolerate space flight without medical problems.

PSYCHOLOGY

(See also: Body Fluids: P400; Cardiovascular and Respiratory Systems: P366; P399; Developmental Biology: P381; Endocrinology: P384; Human Performance: all entries)

PAPERS:

P372(8/86)* Kan YeL, Kupriyanov VA, Korovin KF, Malinovskaya OO.
Biochemical parameters of emotional stress in air traffic controllers.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
20(4): 22-25; 1986.
[17 references; none in English]

Endocrinology, Sympathetic-adrenal System; Metabolism, Lipids
Humans, Air Traffic Controllers
Psychology, Human Performance, Job Stress; Man-machine Systems, Automation

Abstract: This study was performed on 23 air traffic controllers (male, aged 20-30) at the Pulkovo airport. Of these, 9 worked with a non-computerized air traffic control system (group 1) and 4 [sic.; possibly 14] (group 2) with a computerized system. The state of the sympathetic-adrenal system was assessed on the basis of concentrations of epinephrine, norepinephrine, dopamine, and DOPA in urine collected over a 3-hour period of uninterrupted work during the daytime shift (9:30-12:30). Baseline parameters were obtained from urine sampled from the same individuals during the same hours on their days off. Blood serum was obtained before and after the work shift, and a number of lipid metabolism parameters were measured. These included: total lipids, total beta and pre-beta lipoprotein fractions, total cholesterol, free fatty acids and total phospholipids. Subjects did not eat fats on the day of the experiment. Job performance was associated with increased epinephrine excretion in all subjects and increased norepinephrine excretion in approximately half the subjects in both groups, testifying to the development of marked emotional stress. The authors state that a greater increase in epinephrine than in norepinephrine indicates that the stress had a greater emotional than cognitive component. Although controllers working with the computerized system handled a greater workload, their excretion of catecholamines indicated a lower level of stress than the group using the noncomputerized system. [Editor's note: this is not clearly demonstrated by data in Table 1.] Both groups showed a decreased norepinephrine/epinephrine excretion ratio after the work shift. This pattern of response to emotional and cognitive stress is described by the authors as being more characteristic of hypertensive individuals than healthy ones. Both groups displayed increased excretion of dopamine and decreased excretion of DOPA, and increase in the ratio of epinephrine+norepinephrine+dopamine : DOPA, indicating to the authors a decrease in the reserve capacity of the sympathetic adrenal system associated with increased formation of catecholamines from DOPA. No significant effects were found in concentration of blood lipids; however, most of the individuals were found to have very high normal or high values of the lipid metabolism parameters measured.

Table 1: Excretion of catecholamines and DOPA (in ng/min) of air traffic controllers before (1) and after (2) work shift

Group	Work-load	Epinephrine		Norepinephrine		Dopamine		DOPA		NA:A		A+NA+DA: DOPA	
		1	2	1	2	1	2	1	2	1	2	1	2
1 (non-computerized)	16.5	3.4	15.4*	12.9	36.1*	56.3	79.6	17.7	17.6	3.8	2.3	4.1	7.4
2(computerized)	28.2	4.7	15.9*	14.7	36.0*	55.6	84.2*	18.8	17.5	3.1	2.3	4.0	7.8

* $P < 0.05$ compared to baseline

Table 2: Lipid metabolism parameters in air traffic controllers before and after work shift

RADIOBIOLOGY

(See also: Cardiovascular and Respiratory Systems: P406; Immunology: P401)

PAPERS:

P368(9/86) Arlashenko NI, Oparina DYa, Adamchik ZhG, Sheyn VI.
Comparison of methods for studying the physical work capacity of irradiated animals.
Izvestiya Akademii Nauk SSSR: Seriya Biologicheskaya.
1986(4): 577-583.
[24 references; 4 in English]
Affiliation: Institute of Biomedical Problems, USSR Ministry of Health,

Radiobiology, Postirradiation Physical Work Capacity
Rats, Mice
Measurement Methods

Abstract: This paper compares the results of tests of methods for studying physical work capacity of small laboratory animals which had previously been irradiated. In one test, rats were compelled to run along a treadmill moving at 0.5 m/sec with a horizontal inclination of 10° horizontal. The animals had the choice of running on this device or remaining on an electrified grid (current = 40 V). Physical work capacity was considered to equal the amount of work performed before the animal chose to remain on the grid. The second method tested involved compelling the animal to swim. In the variant used by the authors, a rat was forced to swim with a weight 20% of its body weight attached with a harness, preventing it from floating. Animals were removed as soon as they began to sink, thus eliminating swallowing water and choking. The third test involved measuring the amount of time rats were able to cling to a vertical pole?? [paradigm not described]. This was really a measure of static endurance and the derived estimates of work capacity can best be expressed in arbitrary units. In the present study, the authors gave these 3 tests of physical work capacity immediately, and 1, 2, 3, 6 and 12 hours and 1 and 3 days after irradiation. Work capacity was expressed in terms of percentage of the corresponding control value (derived by testing nonirradiated rats). Rats in the experimental group were irradiated with gamma rays (dose rate 0.81 Gy/sec.) and pulsed high voltage electrons (dose rate: 0.34 Gy/sec.) in doses of 5; 7.5 and 10 Gy. In another experiment, mice were compelled, 30 times in a row, to swim a fixed distance in warm water to a resting place. Mean swimming time of trials 20, 25 and 30 were used as the measure of interest. A total of 400 outbred rats and 60 male mice were used in the various experiments. Results of these experiments are compared in Figures 1 and 2. All 3 methods for estimating decline of work capacity after irradiation show clear drops in this parameter as radiation dose increases. However, the relationship appears less pronounced with the treadmill method. The authors believe that the fixed-distance swimming test has advantages over the other 3 methods, since it eliminates the stress involved when animals reach utter exhaustion. This method clearly shows the sharp decrease in activity at the height of radiation sickness, and its increase during the period of apparent return to normal. The authors recommend the use of this method to supplement the other 3, which mainly provide an indication of the total level of resources an animal can summon to save its life.

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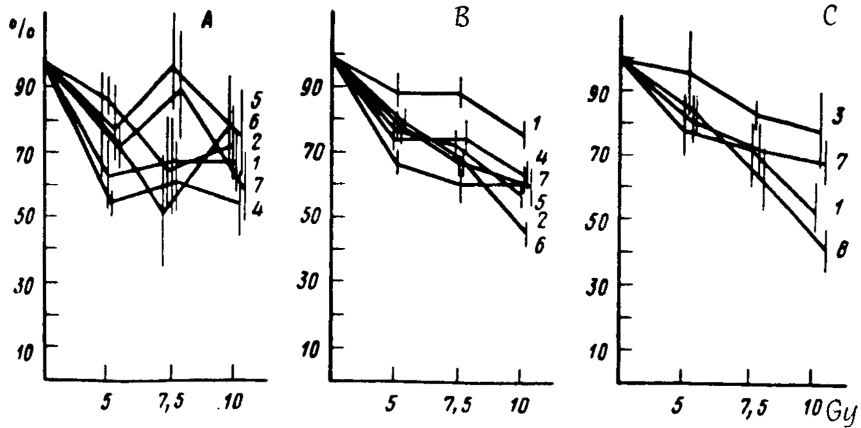

Figure 1: Physical endurance of rats estimated on the basis of tests: treadmill (A), static endurance (B), swimming to exhaustion (C); determined at various periods after irradiation: immediately - 1, after 1 hour 2, after 2 hours - 3, after 6 hours - 4, after 12 hours - 5, after 1 day - 6, after 3 days. Ordinate - length of time animals continues to perform activity in % of control; abscissa - radiation dose, Gy.

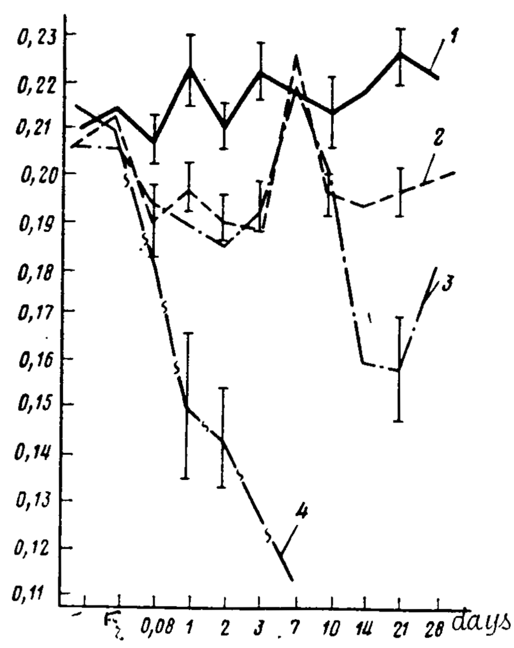

Figure 2: Mean swimming speed for a limited distance by a group of nonirradiated mice (1), and groups of mice irradiated in doses of 5 (2), 7.5 (3) and 10 Gy. Ordinate: swimming speed, m/sec.; Abscissa: time elapsed after irradiation, days; F_1 and F_2 are first and second test before irradiation.

P397(9/86) Kolomiytseva IK, Novoselova YeG, Kulagina TP, Potekhina NI, Kaznacheyev YuS, Markevich LN, Kuzin, AM.

Lipid metabolism in rat tissues after radiation doses leading to interphase cell death.

Radiobiologiya.
XXVI(3): 313-317; 1986.
[18 references; 8 in English]

Authors' Affiliation: Institute of Biological Physics, USSR Academy of Sciences, Pushchino

Radiobiology, Interphase Cell Death, Metabolism, Lipids; Lymphocytes, Thymocytes, Liver
Rats, Males
Gamma Irradiation

Abstract: In this experiment male Wistar rats were irradiated with ^{60} Co gamma rays at a dose rate of 3 Gy/minute, with total dose varying from condition to condition. Blood and tissue samples were apparently obtained at different intervals after irradiation, but this is not specified. Rats were given 3.7 MBq of Na 2-^{14}C-acetate by injection 1 hour before they were sacrificed. Fresh blood was diluted twice with a solution containing 2% glucose, 0.8% citrate Na and 4% NaCl in water with a pH of 6.1, and lymphocytes precipitated out. Thymocytes were obtained from thymus tissue. Number of dead cells was counted. Lipids were extracted from the lymphocytes, thymocytes, and livers of irradiated and control rats. Thymocytes were studied in rats irradiated at 4 and 7.5 Gy. Seven hours after rats were irradiated at a dose of 4 Gy, 55% of the cells of the thymus had disappeared; after 10-15 days the normal number of cells had been restored. Irradiation of 7.5 Gy led to destruction of 75-80% of the thymus cells and no recovery was noted. The lower dose of radiation led to increased inclusion of Na 2-^{14}C-acetate in the phospholipid fraction of total lipids. The most pronounced changes involved the inclusion of the marker in cholesterol. Inclusion of the marker was at a maximum 1 hour after irradiation, but subsequently declined. The larger dose of irradiation led to substantial changes in lipid composition of thymocytes, as shown in Table 1. At the high dose of irradiation there was little change in the inclusion of the marker in total thymus lipids, while its inclusion in cholesterol steadily decreased. The authors conclude that a radiation dose of 4 Gy stimulates, while a dose of 7.5 Gy inhibits, synthesis of cholesterol.

Lymphocytes were studied in rats irradiated at 4 and 10 Gy. Patterns of inclusion of the marker in cholesterol of the lymphocytes indicated that both doses of radiation accelerated the synthesis of cholesterol, but to a more pronounced extent with the lower dose. When total lipids were examined, there was no statistically significant increase over control level. Synthesis of total phospholipids was somewhat stimulated by the lower dose, but depressed by the higher one. Forty-eight hours after rats were irradiated at 200 and 270 Gy, there was a significant decrease in quantities of protein, cholesterol and cholesterol esters in the liver. These doses accelerated synthesis of total lipids. The dose of 200 Gy only accelerated synthesis of phospholipids in the liver. A dose of 200 Gy and, to a lesser extent 270 Gy, increased cholesterol synthesis. The authors conclude that irradiation of animals in doses lethal for a given population of cells causes a number of shifts in lipid metabolism, the nature of which

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depends on dose level. When dosage approaches a level lethal to 80-90% of the cells there is a loss of cholesterol and the activation of lipogenesis noted at lower doses is replaced by inhibition. Effects at lower doses are described as adaptive.

Table 1: Quantities of lipids and protein in thymocytes of rats irradiated at 7.5 Gy

Time after irradiation, minutes	**Free cholesterol, ug/mg protein**	**Cholesterol esters, ug/mg protein**	**Total phospholipids, ug P per mg protein**	**Protein content per cell, ug·10^5**
0	10.00	1.03	1.60	4.20
2	8.10	1.09	1.45	4.10
60	6.00*	1.10	1.50	3.94
120	5.90*	2.14*	1.40	4.20

* $p < 0.05$, difference from control

Table 2: Effect of gamma irradiation in doses of 200 and 270 Gy on the weight, liver weight and quantities of protein and lipids in the livers of rats 48 hours after irradiation

Radiation Dose, Gy	**Body weight, g**	**Liver weight, g**	**Proteins, mg/g**	**Cholesterol**	**Cholesterol esters, ug/mg protein**	**Phospholipids, ug/mg protein**
Control	160	6.0	238	5.7	2.5	105.7
200	---	---	190*	4.60*	1.53	90
270	92	7.9	180*	3.95*	0.92*	117

* difference from control, $p < 0.05$

Figure 1: Inclusion of Na 2-^{14}C-acetate _in vitro_ in thymocyte lipids of rats in a control group and a group irradiated at a dose of 4 Gy

Figure 2: Quantities of free cholesterol in thymocytes of rats irradiated at doses of 4 and 7.5 Gy

Figure 3: Inclusion of Na 2-^{14}C-acetate _in vitro_ in thymocyte lipids of rats in a control group and a group irradiated at a dose of 7.5 Gy

Figure 4: The effects of gamma irradiation on the inclusion of Na 2-^{14}C-acetate _in vitro_ in lymphocyte lipids of peripheral blood of rats

Figure 5: Inclusion of Na 2-^{14}C-acetate _in vitro_ in liver lipids of rats 48 hours after irradiation

P398(9/86) Grigor'yeva YeV, Pozharisskaya TD, Chigareva NG.
The effect of radioprotective agents on the epithelium of the mucous membrane of the small intestine in irradiated animals.
Radiobiologiya.
XXVI(3): 410-413; 1986.
[6 references; 3 in English]
Authors' affiliation: S.M. Kirov Academy of Military Medicine, Leningrad

Gastrointestinal System
Rats
Radiobiology, Gamma Irradiation, Countermeasures, Radioprotective Agents

Abstract: Subjects in this experiment were outbred male rats irradiated with gamma quanta at a dosage of 10 Gy and dose rate of 1.9 Gy/min. One of two radioprotective agents, cystamine in a dose of 150 mg/kg and S-(w-aminopropyl)-beta-aminoethylthiophosphoric acid [APAETP] in a dose of 100 mg/kg, was injected intraperitoneally 20 minutes before irradiation. Gastrointestinal function was evaluated by absorption of a stain (uranin). The intestinal system was studied using histoautoradiography. ^{3}-H-thymidine was injected intraperitoneally on days 1 and 3 after irradiation. Animals were sacrificed 1 or 24 hours after the introduction of the isotype. The number of epithelial cells in cross sections of the crypts and follicles, as well as the number of mitoses and marked cells were calculated from X-rays of the small intestine stained with hematoxylin and eosin. Absorption of the gastrointestinal tract had already decreased to 60% of control level 24 hours after irradiation in animals receiving no radioprotective agents. Subsequently, absorption further declined. When the radioprotective agents were administered, absorption declined only 15 and 20% on day 1, 20 and 35% on day 2, and 20 and 45% on day 3, with cystamine and APAETP, respectively.

Effects of irradiation and radioprotective agents on morphological parameters of the intestinal crypts and follicles are presented in Table 1. These data show that the agents used stimulated recovery of the epithelial crypts of the small intestine. Three days after irradiation, cystamine was found to have a greater effect than APAETP. Increase in the number of marked cells 24 hours after introduction of the radioactive isotope is the result of the division of cells which had absorbed the isotope in the first hour after its introduction. In untreated control animals this number had increased by a factor of 5.6; in irradiated unprotected animals by a factor of 2.6; and in animals protected by cystamine and APAETP, by a factor of 5 and 3.3 respectively. The authors interpret these results as indicating that cystamine is more effective in preventing post-mitotic death of epithelial cells in the mucous membrane of the small intestine. This in turn may be used to explain the relative effectiveness of the two agents on gastrointestinal function.

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Table 1: The effect of radioprotectors on parameters of crypts and follicles on day 2 after irradiation and 24 hours after administration of ^{3}H-thymidine

Condition	**N**	**Number of cells in crypt and follicle**		**Number of mitoses in crypt**	**Maximum distance of marked cell from follicle base**
		Total	**Marked**		
Untreated Control	8	183	90.8 (16.6)	2.4	57.7
10 Gy	4	68.7	12 (4.6)	0.65	3.6
10 Gy + cystamine	4	90.6	24.5* (4.9)	2.1*	14*
10 Gy + APAETP	4	98.3	21.1* (6.4)	2.2*	6.8

Numbers in parentheses are number of marked cells 1 hour after administration of ^{3}H-thymidine

* Difference from irradiation alone significant at $p < 0.05$

Figure 1: Intensity of fluorescence of uranin in blood plasma of mice irradiated at a dose of 10 Gy and protected with cystamine or APAETP

Figure 2: Effect of radioprotectors on the epithelium of crypts of the small intestine after irradiation in a dose of 10 Gy with protection by cystamine or APAETP

P404(9/86) Khanina NYa, Desnitskaya MM.

Lipidogram, isoenzyme spectrum and total activity of nonspecific esterases of blood serum in rats exposed to a constant magnetic field.

Patologicheskaya Fiziologiya i Eksperimental'naya Terapiya.
1986(2): 26-29.
[18 references; 3 in English]
Authors' affiliation: Kalinin Medical Institute

Radiobiology, Enzymology; Metabolism, Lipid Metabolism
Rats
Magnetic Field, Constant

Abstract: Subjects of this experiment were white male rats. The experimental group was exposed to a constant magnetic field created by an electromagnet with induction of 0.008T. The polar surface was 100 X 100 mm in area. The experiments were performed during the fall and winter. The animals were placed between the poles for periods of 1 hour for 3 consecutive days at the same time of day. A control group was exposed to identical conditions with the exception of the magnetic field. Thirty minutes after exposure, animals were sacrificed and concentrations of very low density and low density lipids, cholesterol esters, free cholesterol, triglycerides, free fatty acids, and phospholipids were determined. Animals exposed to the magnetic field showed increased total fractions of low density and very low density lipids, but no qualitative changes in individual lipoprotein fractions. Ratios of low to high density lipids were identical in both groups, indicating that quantity of high density lipids had also increased. The lipid spectrum of the blood was altered in animals exposed to the magnetic field, with proportions of total cholesterol, cholesterol esters and free fatty acids increasing at the expense of the other components. At the same time, total esterase activity dropped to 0.39 ug of alpha-naphthol per 1 ml blood serum in an hour, while the comparable figure in the control was 0.57 ug. Enzymograms of blood serum esterase for experimental and control animals were similar; however, rats exposed to the magnetic field showed greater activity of the slow moving fractions. When proserine (a deactivator of acetylcholinesterases) was added, activity of slow moving enzymes was inhibited, demonstrating that exposure to a magnetic field increases acetylcholine esterase activity. When unithol (dimercapryl BP) was administered to rats prior to exposure to the magnetic field, hyperlipemia was avoided. The authors conjecture that the effects observed are related to the activation of the sympathetic nervous system, to increased synthesis of lipoproteins, and to decreased rates of catabolism and release from the blood vessels because of the disruption of the functioning of lipolytic enzymes.

Table 1: Concentration of cholesterol and total fraction of very low density and low density lipids in blood serum of rats exposed to a constant magnetic field before and after administration of unithiol

Table 2: Lipid profile of blood serum from rats exposed to a constant magnetic field

Figure: Isoenzymes of esterase in the blood serum of rats exposed to a constant magnetic field

CONFERENCE REVIEW:

CR4(9/86)* Ratner GS.
Review of sessions devoted to: **Problems in Aviation and Space Medicine, Biology and Psychology at the XVth Gagarin Scientific Lectures.**
In: Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
20(4): 88-94.

Translation: The XVth Gagarin Scientific Lectures were held between 1 and 10 April 1985. They were dedicated to the 40th anniversary of the victory of the Soviet people in the Great Patriotic War of 1941-1945, and the 25th anniversary of the Center for Cosmonaut Training. The plenary sessions took place at the Hall of Columns in the House of Unions in Star City, and at the Institute for Problems in Mechanics of the USSR Academy of Sciences. The first session included the presentation of a paper by Professor A.D. Yegorov, entitled **Biomedical problems of long-term space flight.** The speaker analyzed the biological effects of weightlessness and other space flight factors on the human body, based on a synthesis of the results of research and experience with space flights. The identified principles and derived recommendations have enabled humans to perform active work in space for record periods of time. The speaker also indicated some future directions for research, including studies on accelerating adaptation to weightlessness and readaptation to Earth's gravity.

Two papers were presented at the general meeting of the section on **Problems of aerospace medicine and psychology**, chaired by Academician O.G. Gazenko. O.Yu. At'kov, USSR Pilot-Cosmonaut and candidate in medical sciences, discussed his research in the course of a 237-day flight on the "Salyut-7" orbital station. In all, 34 types of biomedical measurements were taken, involving more than 300 experimental sessions. The major issues addressed by the research program were: intensive studies of the cardiovascular system using the "Argument" Soviet ultrasound system and the French "Echograph" instrument; study of the functions and interactions of the vestibular and visual systems and the mechanisms underlying motion sickness; and biochemical studies of blood and urine. The major innovations in the utilization of countermeasures were the use of more strenuous physical exercise on the conditioning and bicycle ergometer apparatus, and new provocative tests. During the flight the crew retained a high level of work capacity, enabling them to complete their entire program of work.

The experiments performed on board the orbital complex support the conclusion that the human body passes through two stages of adaptation to weightlessness, viz., acute and stable adaptation. The acute stage lasts from 2-3 days to a week. During the initial hours of flight, there is an increase in venous return of blood to the heart, accompanied by fluid shifts, primarily to the upper body. This leads to alterations in vascular and cardiac reflexes resulting in a moderate decrease in blood pressure and slight tachycardia. The Henry-Gauer response occurs, ultimately leading to a decrease in the volume of circulating blood. During this period, the vestibular system also undergoes adaptation. Subsequent to this is the stage of stable adaptation. The most important elements of this stage are attainment of balances in the redistribution and pooling of blood and in excretion of the necessary fluid. By these means, the body attains a new

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physiological homeostasis. No pathological changes were noted in the crewmembers throughout the 237-day orbital flight and the changes which occurred in physiological parameters were reversible.

A paper by I.A. Skibi, I.K. Tarasova and V.V. Kalinichenko was devoted to problems in biomedical preparation for space flights. The concept of **"biomedical preparation (BMP)" of cosmonauts** has itself undergone considerable evolution during the short history of manned cosmonautics, moving from a "process increasing human tolerance of space flight factors" (Mey M. Link, N.N. Gurovskiy, 1975) to "a system of substantively and temporally interrelated measures preparing cosmonauts physically and psychologically, providing them with the knowledge, skills and habits appropriate to life in space, and enabling them to perform their program of work." Thus, the evolution of the concept of BMP was determined by the increasing complexity of space flight missions, which progressed from mere survival to the capacity to perform complex tasks (including EVAs) during long-term space flights.

The following measures are currently included in BMP:

-- selection of candidates on the basis of health and personality traits, continued observation during the training process;

-- determination of baseline functional physiological and psychological capacities of the cosmonaut, development of an individually tailored set of health recommendations, and a schedule for conditioning to space flight factors;

-- general and specific physical training;

-- specialized preconditioning to space flight factors;

-- medical psychological conditioning;

-- training in the medical aspects of the flight program;

-- sanitary-hygienic and antiepidemiological support;

-- medical support of occupational training on trainers and in extreme environments with complex living conditions.

The BMP process includes, along with previously identified methods of training and conditioning, work directed at improving adaptive capacities and the physiological and psychological flexibility of the cosmonaut, the unity and opposition of the process of adaptation -- readaptation in the space flight cycle, preadaptation to the effects of space flight factors, and the formation of a conceptual model of the flight in the cosmonauts' minds. The implementation of this BMP system has substantially improved the effectiveness of the cosmonauts' job performance which, in turn, has enhanced the success of the Soviet space program. The increased complexity of flight programs, including the increase in EVAs requires further refinement of BMP techniques.

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Subsection 1 was entitled **Physiological-hygienic problems of manned space flights and flight practice; space biology** and was chaired by A.I. Grigor'yev, I.D. Pestov, and V.V. Kalinichenko, with V.S. Kazeykin and G.S. Ratner as scientific secretaries.

Of the papers devoted to physiological problems, one must single out the paper given by F.A. Solodovkin called **Certain theoretical aspects of motion sickness in cosmonautics.** Synthesizing the results of numerous experiments, the speaker showed that no increases in the sensitivity or reactivity of the vestibular apparatus, nor any pathological vestibular symptoms, have been noted in weightlessness. All this testifies to the normal functioning of the vestibular system during space flight and the absence of a connection between motion sickness in cosmonauts and disorders of vestibular function. One might then hypothesize that the motion sickness from which cosmonauts suffer is related to the regulation of autonomic functions and adaptive reactions by the limbic-resorption complex.

A paper by N.Ye. Panferova, B. M. Baranova and V.I. Pervushin on **Evaluation of human tolerance of graded physical exercise** touched on the problem of identifying methods developed on Earth which can be adapted to the needs of flight research. The results of the research demonstrated the importance of selecting appropriate tests for the study of the mechanisms underlying the effects of weightlessness on cosmonauts' tolerance of physical exercise. In particular it was established that conditioning on the bicycle ergometer leads to a decrease in the "physiological cost" of exercise; pulse rate, energy expenditure, oxygen consumption and exhalation of carbon dioxide all drop.

A.D. Voskresenkiy demonstrated the possibility of using methods of **discriminant and factor analysis** for identifying physiological norms against which the condition of cosmonauts can be evaluated. Calculation of a linear discriminant function enabled the experimenter to delimit the preflight and postflight reactions to a LBNP tests and identify increased sensitivity to lower body negative pressure during flight. The results of a separate factor analysis of ground and flight data on **reactions of the cardiovascular system to LBNP** showed that an increase in the minute volume of blood during flight as compared to the preflight level is associated with a marked decrease in orthostatic tolerance and an increased reaction to LBNP during flight.

Changes in the skeletal system in microgravity remain a serious problem in space biology and medicine. An interesting report on this subject was presented by G.P. Stupakov, V.S. Kazeykin and A.I. Voloshin. The authors performed a comparative physiological analysis and synthesized data on changes in the skeletal systems of humans and animals (rats, dogs, tortoises) which had spent various periods of time in space. They concluded that there are differences in the characteristics of osteodystrophic process developing relatively early and those occurring during later exposure to microgravity. During the early stage, there is some decrease in the concentration of calcium in the organic component, and a decrease in bone strength without pronounced signs of decrease in bone weight. These changes may be explained with reference to a transient decrease in the strength of the collagen. At a later stage, there is

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resolution of the bone substance with dissociation of the mineralization processes, and also synthesis and resorption of bone.

The goal of ensuring that crews will be safe from **decompression problems** during the first days of flight and the study of probability of altitude-decompression disorders under conditions of simulated weightlessness were discussed in two presentations (by V.I. Chadov, A.S. Tsivilashviliv, L.R. Iseyev, and L.R. Iseyev, A.F. Zubarev, and V.I. Chadov). The authors were able to identify the relationship between the minimal acceptable amount of working pressure in the space suit and the time it takes to eliminate nitrogen from the body in a hypobaric (550 mm Hg) normoxic medium after a preliminary 2-hour period of saturation breathing of air with a pressure of 840 mm Hg. It was also demonstrated that ultrasound location of gas bubbles in a blood channel is a practical and promising technique, since decompression aeroembolism located by the ultrasound method appears in the blood of the pulmonary artery earlier than symptoms of altitude-decompression disorders, and lasts longer than the symptoms.

A paper presented by A.A. Koreshkov et al., titled **Changes in the concentration of carbon dioxide under normal and compressed work and rest schedules (sleep-waking cycle) on the "Salyut-7"-"Soyuz-T" orbital complex,** demonstrated the great practical significance of determining changes in the concentration of carbon dioxide on board manned spacecraft as a means for analyzing the level of motor activity of cosmonauts and evaluating their tolerance to changes in the daily cycle.

A wide range of papers concerning **metabolism in weightlessness** and its simulations was presented (N.D. Radchenko, A.A. Drozhzhin, V.P. Matveyev, I.G. Popov, and A.A. Latskevich; Ye.G. Vetrov; V.Ye. Potkin and I.O. Pakhlavuni; I.A. Popova et al). A correct understanding of the role of amino acids, vitamins and enzymes in metabolism continues to be important for management of cosmonauts' diets during long-term flights.

V.G. Doroshev, et al., reported on a study of the characteristics of **venous pressure during 120-days of hypokinesia with head-down tilt.** They demonstrated that the changes in blood circulation in the veins over the course of this treatment are subject to significant individual differences; and that individual parameters of venous pressure may be utilized to predict orthostatic tolerance of subjects.

The potential for using **ultrasound vasography** [to monitor effects of] work overloads lasting for long periods of time was discussed in a paper by V.A. Degtyraev, N.V. Soloshenko and M.N. Khomenko. The potential usefulness of a methodology developed by the authors for identifying early indicators of changes in blood supply to the central nervous system was demonstrated.

A paper by R.A.Vartbaronov et al., devoted to investigation of the relationship between long-term adaptive and cumulative **effects of long periods of systematic overload (overwork)** at the tolerance limits, identified functional changes in the cardiovascular and respiratory systems of animals and developed a set of essential criteria for monitoring the functional state of the organism.

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V.V. Yasnetsov and V.S. Shashkov attempted in their paper to elucidate the role of an endogenous morphine-like substance in the pathogenesis of motion sickness. Data they obtained will help to develop a more complete understanding of the **mechanism underlying motion sickness** and to suggest new ways to prevent this condition.

The biomechanical basis for optimizing a **"man-ejection seat" system** upon impacts was the subject of a study by G. P. Stupakova et al. Using an original technique for measuring the deformation of vertebrae, the authors quantitatively determined the effects of starting position, and fixation of the shoulder girdle to prevent damage to the lumbar discs on impact.

V.I. Korol'kov, M.A. Dotsenko, A.N. Truzhenikov, et al. studied the adaptive responses of primates to **impact and vibrational acceleration.** The data obtained helped to ensure the successful flight of animals on the "Cosmos-1514" biosatellite.

A.P. Kozlovskiy et al. discussed the major trends in developing optimal means to protect the arms and hands of a pilot from the air stream. The maximum acceptable values of mechanical forces tending to tear the hands off the catapult lever were determined.

V.Ye. Potkin, V.I. Plakhotnyuk and A.G. Gavrilenko used a multivariable experimental design to determine criteria for evaluating **lipid metabolism** in flight crews.

A number of papers were concerned with **physiological/hygienic problems of manned space flights.** T. P. Tikhonova reported on a new methodological approach to determining, for humans, the maximum acceptable level of one-time exposure to adverse environmental factors. Her method is based on determination of the probability of the occurrence of specific changes using a minimum number of experimental trials.

V.I. Belkin et al. discussed the **measurement of air pollution** in hermetically sealed chambers by products of the combustion of nitrogen containing polymers.

A report by K.D. Rokhlenko et al. contained information about the **dust content of the atmosphere of a hermetically sealed compartment,** factors leading to the formation of dust particles, and the need to take measures to minimize these factors.

V.I. Korol'kov et al. presented data on the parameters of the atmosphere, microclimate, and sanitary/hygienic conditions characterizing the **living environment** of animals on board the "Cosmos-1514" biosatellite. Introduction of a number of modifications made it possible to improve these parameters.

Two papers concerned **the embryological development of amphibians (E.A. Oygenblik) and fish (Ye. M. Cherdantseva) in weightlessness** and microgravity. The data obtained facilitated a better understanding of the changes occurring in living organisms in response to certain changes in the force of gravity.

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M.G. Tayrbek presented interesting material on the **development of plants in weightlessness.**

A series of papers on space biology culminated in an interesting report by L.L. Zhurni on **The use of the concept of scalarity in predicting remote biological effects of weightlessness.**

In summing up the work of this subsection, I.D. Pestov and A.I. Grigor'yev noted that the majority of the papers served to stimulate discussion during the sessions. It was proposed that the work of this subsection for the next Gagarin lectures concentrate on one or two of the more important of today's problems, particularly on motion sickness in weightlessness.

Subsection 2, **Laws governing the interaction of psychological and physiological processes during flights,** was chaired by P.V. Simonov, G.M. Zarakovskiy, and O.I. Zhdanov, with V.A. Kurashvili and S.L. Rysakova as scientific secretaries. A total of 18 papers was presented at the subsection session. All of these were directed toward increasing the effectiveness of pilot performance and maintenance of the health of pilots, cosmonauts and flight controllers.

The first of these means involves **structuring jobs** in an optimal way. A.B. Smetanin and V.F. Nesterov demonstrated that a rational grouping of the tasks performed by cosmonauts and alternation of job tasks with different psychophysiological demands substantially increased productivity during space flight. With reference to this topic, a paper by V.I. Makarov and L.R. Pravdina emphasized that it is essential to station psychoneurologists at flight control centers to monitor the cosmonauts' psychological state. It was found that compressed work and rest schedules stimulated productivity. This effect may be associated with the emotional lift provided by relief of the monotony of long flights. With the goal of increasing objectivity in evaluating functional state during sleep deprivation, V.I. Myasnikov, B.N. Ryzhov and I.R. Abramov proposed a set of normed criteria (with possible values of 0 and 1) with regard to performance level, level of psychophysiological stress and a general indicator of performance efficiency (derived from the other two). These criteria were used to demonstrate how quality and psychophysiological cost of performance increase with increasing motivation. Psychophysiological concomitants of the mobilization of the body's resources under the influence of various types of motivation were revealed by G.M. Zarakovskiy and V.I. Savchenko. Based on data from their research, it was demonstrated that the relative expenditure of psychophysiological resources per unit increase in performance is less when the operative motive is attainment of success than when it is avoidance of failure.

An interesting idea for **increasing the reliability of the performance of a human operator** was expounded by L.G. Dikaya. For work under extreme conditions, job training and physiological conditioning should be simultaneous, i.e., job training should be conducted in the context of a variety of functional states. This will lead to specific "activation patterns." V.A. Slmatov presented new data on fluctuations characteristic of nonspecific activation of performance and the role of cyclical processes in functional states.

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The usefulness of concurrent analysis of the mechanisms underlying physiological and psychological processes was clearly demonstrated in reports devoted to **pharmacological means of controlling human work capacity.** S.I. Sytnik and L.K. Pashchuk attempted to influence peripheral components of the functional structure which generates emotional responses. They were able to find adrenal blocker preparations capable of normalizing emotional stress. V.M. Kalosh, N.A. Davydov, I.B. Goncharov, and L.G. Polevyy demonstrated that psychotropic drugs can facilitate adaptation and demonstrated a technique for using them to increase the level of flight performance.

A number of papers were devoted to specific issues in the **optimization of flight performance.** A.A. Medenkov and S.L. Rysakova analyzed the errors in a verbal exchange between flight controllers and aircraft crews and made a number of recommendations. V.D. Vasyuta discussed the characteristics of chairs (e.g., contour backs, air cushions) intended to decrease fatigue.

I.F. Chekirda and A.A. Malofeyev, and also A.K. Yepishkin, Ye.A. Ivanov and L.S. Khachatur'yantz presented data concerning the structuring of movements and the improvement of **sensorimotor tracking** during space flights. Some results of the study of higher nervous activity in primates, seemingly not directly related to identifying the psychophysiological foundations of effective flight performance, turned out to be extremely interesting. A paper by G.G. Shlyk, et al. cited data concerning the links between characteristics of higher nervous activity of primates and their adaptation to space flight conditions. In particular, these data demonstrate the importance of psychophysiological characteristics in determining the individual's **position in a group and his social behavior.**

V.G. Voloshin et al. proposed new psychophysiological methods to improve reliability in predicting the future **performance of aerobatic pilots.** S.V. Panferov and T.I. Milyavskay presented data from research on the parameters of binocular vision in civil aviation pilots.

A report on post-graduate **training of flight surgeons,** by N.A. Razsolov, K.A. Pimenov, V.N. Razsudov, and V.D. Yustova, presented a way that all the recommendations made at this session could be applied in the practice of flight medicine.

[The third subsection of the conference devoted to **Problems and space and aviation psychology** was already described in Issue #6 of the Digest and thus is not repeated here.]

A joint "round table" session, involving 4 of the 10 divisions participating in the conference and devoted to the problem of **Man and automated systems in cosmonautics and aviation** was particularly outstanding. The chairman of this session was N.N. Rukavishnikov, and the scientific secretary was N.V. Krylova.

Amidst animated and interesting discussion, this session illuminated a number of issues directly relevant to medicine, physiology and psychology. In the presentations by B.F. Lomov, A.N. Lebedev, G.M. Zarakovskiy and V.A. Ponomarenko, specific examples were used to demonstrate the necessity for

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rational utilization of data concerning **human physiology and psychology in the development of automated devices,** including so-called "artificial intelligence programs." Principles were formulated to facilitate optimal interaction between the pilot, cosmonaut or operator and the automated system for the performance of various flight tasks. It should be noted that, in spite of a number of points of contention, the majority of representatives from the technological sciences and engineering (N.N. Rukavishnikov, A.A. Krasovskiy, V.V. Malozemov, et al) who participated in the discussion, spoke out against becoming too infatuated with automation and excluding humans from the control loop. The need for painstaking psychophysical, as well as technological study of all the concrete issues relating to automation in aviation and cosmonautics was noted.

SPECIAL FEATURE: INFORMATION ON TWO PARADIGMS FREQUENTLY CITED IN SOVIET SPACE MEDICINE LITERATURE

1. INDUCTION OF "EMOTIONAL PAIN-STRESS"

The Soviet literature on the effects of stress frequently refer to the induction of what they call "emotional pain stress" (cf., abstract P400, Digest Issue 9, page 9). While the procedure for producing this state is typically unspecified, occasionally an original paper by Desiderato, MacKinnon and Hissom is cited. We have tracked down the original reference, viz: Desiderato O, MacKinnon JR, and Hissom H. **Development of gastric ulcers in rats following stress termination.** Journal of Comparative and Physiological Psychology. 87(2): 208-214; 1974. The experimental procedure described in this work involved initially placing rats on an electrified grid producing continuous shocks. A nonelectrified platform was accessible from the grids and the animals were assisted manually to this platform to escape shocks. After 30 minutes, by which time all subjects were consistently remaining on the platform, shock was also delivered on the platform and shock intensity was increased. Animals were sacrificed and examined for signs of ulceration either immediately after the stress treatment, which lasted from 2 to 24 hours, (0 delay group), or a varying number of hours after the termination of the stress, during which animals were maintained in nonstressful conditions (poststress delay group). The most interesting aspect of the results is the small amount of ulceration present in the 0 delay groups, no matter how long the exposure to the stressor. Results indicate that significant gastric ulcer production in shock-stressed rats appears only after a minimum of 2 hours after the stress session. However, increase of the delay beyond 2 hours did not increase ulceration. The authors speculate that it is the abrupt switch from stress to non-stress which is the key factor, and associate this with parasympathetic overreaction. Another factor identified as crucial to this procedure is the punishment of effective coping behavior. The Soviets appear to use this procedure when they are interested in immediate and remote effects of stress on a variety of physiological systems. It should be noted that the term used to designate this paradigm, "emotional pain stress," is never mentioned in the original work. We have no information as to its source.

2. "AUTOGENIC TRAINING" AS A FATIGUE REDUCING PROCEDURE

Information on autogenic training comes from a series of articles published in the Soviet journal Aviatsiya i Kosmanavtika [Aviation and Cosmonautics], 1979, volumes 1 (pages 22-22), 2 (pages 8-9), and 3 (pages 26-27). All articles are by L. Grimak, Doctor and Colonel in the Medical Corps, and Lieutenant Colonel Yu. Isaulov, a pilot trainer. The articles are collectively titled "Alertness Management."

So-called "autogenic training" (AT)is a technique used in the Soviet Union, particularly in work with flight and space crews, for management of fatigue and restoration of high levels of alertness. Claimed effects of this technique include increased physiological tolerance of various flight factors, optimal allocation of physiological and psychological resources, and minimization of stress. Three means are used to achieve these effects: voluntary (progressive) muscle relaxation, creation of appropriate mental imagery, and verbal autosuggestion. First, a number of component skills are developed: management of attention (with some similarity to self-hypnosis or transcendental meditation), voluntary manipulation of mental imagery, and verbal autosuggestion. Subjects then participate in a preliminary training course involving repetition of a number of exercises. The "text" of the exercises is first read aloud by the subject himself, then performed in accordance with the taped text and, finally, after the subject has learned it, without external guidance. Subjects listen to the exercises, first lying down, and then, after proficiency has been developed, sitting upright. At first subjects are advised to practice in isolation, free from noise and interruption, but later practice in less ideal conditions is recommended.

The first exercise is directed at muscular relaxation by means of imaging a sensation of heaviness in the arms, legs, and trunk. The second exercise is supposed to develop skill at voluntarily dilating blood vessels in the arms, legs and trunk in the order followed in exercise 1, by means of imaging the sensation of warmth. The third exercise trains voluntary control of breathing. The fourth exercise develops voluntary dilation of the blood vessels of the visceral organs in the region of the solar plexus. The fifth exercise is directed at voluntarily altering heart rate, and the sixth aims at controlling vascular reactions in the head, particularly contraction of the blood vessels. To achieve the latter, the subject first experiences and then imagines the cooling of the face. As a sample, the "text" of the first part of the first exercise follows:

1. I am in a comfortable position. My body is free, relaxed, unrestrained. I concentrate my will power on the control of my nerves, body, and general state. I am in full control of my body and mind.

2. There is no rush to do anything. I mentally draw a circle around myself. I leave all my cares outside this circle. I am in a state of absolute peace. It is easy to control my body and mind.

All my cares are gone. I am completely calm. I am totally immersed in my inner world. I am inside myself. My consciousness has merged with my body. I am present in every cell of my body. And each cell of my body readily does what I want it to.

3. And now I have concentrated my attention on my face. I control and relax the muscles of my forehead, cheeks, and lips. My eyelids are closing, my mental gaze is directed at my forehead.

My teeth are not clenched and the tip of my tongue rests against my upper teeth.

My face is calm and motionless like a mask. My face is a mask .....

4. The muscles of my neck are completely relaxed. They are not playing any part in supporting my head.

The muscles of my trunk are completely relaxed.

5. I inhale and exhale calmly and breathe at a calm and relaxing rate. My breathing is peaceful, even, rhythmic, I inhale peace. With each breath peace fills my head, chest, body,

6. And now I very much want my right arm to grow heavy.
I very much want my right arm to grow heavy.
Want my right arm to grow heavy.
My right arm to grow heavy.
Right arm to grow heavy.
Arm to grow heavy.
Grow heavy.
Heavy.

I turn my attention to my left arm...... Repeat 6 for left arm

A pleasant, motionless heaviness has filled my right and then my left arm. I clearly feel the heaviness of my arms. (Pause)

7. I have had a good rest in this state of relaxation, and have freed myself from nervous tension. I am very calm. This calm has given me confidence, strength and health. I am healthy, even-tempered and energetic in any situation. I have had a good rest.

8. And now my breathing is getting deeper and more energetic.. I feel a pleasant tension in my muscles, which chases away the extra heaviness in my body and clears my head. I am alert and full of energy.

I make fists, raise my arms and open my eyes. I jump up and readily feel myself to be in a state of alertness....

The entire set of exercises is said to occupy approximately fifteen minutes.

In a typical Soviet experiment (Cf., e.g., Issue 9, P371, page 50), one group of subjects receives preliminary autogenic training (AT), and is then placed in a situation conducive to extreme fatigue and decreased work capacity (e.g., long periods of continuous work with sleep deprivation), during which brief periods are set aside for performance of the autogenic exercises. Performance and indicators of fatigue in this group are compared to those of a control group with no autogenic training and the short intervals used merely for rest. Results indicate that subjects undergoing AT show higher work capacity with fewer signs of exhaustion.

CURRENT TRANSLATED SOVIET LIFE SCIENCE MATERIALS AVAILABLE TO OUR READERS

Translations of recent Soviet publications, including those of interest to specialists in space life sciences, are published by Joint Publications Research Service (JPRS). JPRS publications may be ordered from the National Technical Information Service (NTIS), Springfield, Virginia 22161. The phone number of NTIS is (703)-487-4600 and telephone orders are encouraged. Each individual issue of a JPRS report must be ordered separately. 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 is a significant and variable lag period between the time a JPRS publication is completed and the time it is orderable from NTIS.

Two JPRS USSR Report Series appear of particular interest to NASA life scientists. These are: 1) Space, and 2) Life Sciences: Biomedical and Behavioral Sciences. In addition, JPRS translates the entire issue of the bimonthly Space Biology and Aerospace Medicine. As a service to our readers we will regularly provide publication information for these 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 in this Digest.

USSR REPORT: LIFE SCIENCES
BIOMEDICAL AND BEHAVIORAL SCIENCES

JPRS-UBB-86-015 4 AUGUST 1986

Selected Contents:

USSR REPORT: LIFE SCIENCES
BIOMEDICAL AND BEHAVIORAL SCIENCES

JPRS-UBB-86-018 17 SEPTMEBER 1986

Selected Contents:

Biological Effects of Microwave Radiation
(V.V. Varetskiy, et al.; Journal Article Translation; 6 pages)

Radioactive Aerosols in Moscow Air and Food in 1982 and 1983
(A.S. Zykova, et al.; Journal Article Translation; 8 pages)

USSR REPORT: LIFE SCIENCES
BIOMEDICAL AND BEHAVIORAL SCIENCES

JPRS-UBB-86-019 22 SEPTMEBER 1986

Selected Contents:

Space Botany Application of Discovery About Cell Division
(R. Akhmetov; Newspaper Article Excerpt; 1 page)

New Data on Interferon
(No Author; Newspaper Article Translation; 1 page)

Aviation Instrument Builders Develop Medical Instruments
(No Author; Newspaper Article Translation; 1 page)

Immunological Sequelae of Vibration Sickness
(M.M. Asadullayev; Journal Article Abstract; 1 page)

Soviet Discovery of New Cardiac Hormone Aurekuline
(No Author; Newspaper Article Translation; 1 page)

Directional Preponderance in Experimental Nystagmus Following Adequate and Inadequate Vestibular Stimulation
(M.M. Levashov, et al; Journal Article Abstract; 1 page)

Treatment of Radiation Sickness in Chernobyl Accident Victims
(E. Gorbunova; Newspaper Article Excerpt; 2 pages)

Suceptiblity of Human Lymphocyte Chromosomes to Radiation Damage by 6 MeV Fast Electrons in Relation to Mitotic Cycle
(Ye.Ye. Chebotarev, et al; Journal Article Abstract; 1 page)

USSR REPORT: LIFE SCIENCES
BIOMEDICAL AND BEHAVIORAL SCIENCES

JPRS-UBB-86-020 29 SEPTMEBER 1986

Selected Contents:

USSR REPORT: LIFE SCIENCES
BIOMEDICAL AND BEHAVIORAL SCIENCES

JPRS-UBB-86-0210 30 SEPTMEBER 1986

Selected Contents:

USSR REPORT: SPACE

JPRS-USP-86-0005 12 SEPTMEBER 1986

Selected Contents:

Interview with Chief of Glavkosmos International Liaison Department
(Newspaper Article; 4 pages)

Memorandum Signed on Soviet-French Manned Mission in 1988
(Newspaper Article; 1 page)

Commentary on Soviet-French Cooperative Space Programs
(Yu. Kovalenko; Newspaper Article Translation; 3 pages)

Feokistov Comments on Manned Versus Unmanned Space Research, Future Types of Orbital Station
(G. Lomanov; Interview Abstract; 1 page)

Shatalov Comments on Cosmonaut Missions
(B. Tril; Article Abstract; 1 page)

Conference on Aviation and Cosmonautics Concludes
(M. Dmitruk; Newspaper Article Translation; 2 page)

Kazakh Scientists Urge Creation of Republic Level Remote Sensing Organizations
(U. Sultangazin; Newspaper Article Excerpt; 1 page)

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16\. Abstract

This is the ninth issue of NASA's USSR Space Lifes Sciences Digest. It contains abstracts of 46 papers recently published in Russian language periodicals and bound collections and of a new Soviet monograph. Selected abstracts are illustrated with figures and tables from the original. Additional features include reviews of a Russian book on biological rhythms and a description of the papers presented at a conference on space biology and medicine. A special feature describes two paradigms frequently cited in Soviet space life sciences literature. Information about English translations of Soviet materials available to readers is provided. The abstracts included in this issue have been identified as relevant to 28 areas of aerospace medicine and space biology. These areas are: adaptation, biological rhythms, body fluids, botany, cardiovascular and respiratory systems, developmental biology, endocrinology, enzymology, equipment and instrumentation, gastrointestinal system, genetics, habitability and environment effects, hematology, human performance, immunology, life support systems, mathematical modeling, metabolism, microbiology, morphology and cytology, musculoskeletal system, neurophysiology, nutrition, operational medicine, perception, personnel selection, psychology, radiobiology, and space biology and medicine.

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