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Foreword

Regular contacts between specialists of the USSR and USA within the compass of the Joint Soviet-American Committee have enabled the preparation of an entire series of joint programs for medico-biological research in space biology and medicine.

At the eighth conference of the Joint Soviet-American Committee (Washington, Wallops Center, 1977), a program of experiments involving hypokinesia was coordinated.

At the ninth conference of the Joint Soviet-American Committee on Space Biology and Medicine (Leningrad, 11-17 October, 1978), the program of research received its final formulation and a protocol was signed for the conduct of a joint Soviet-American experiment.

The first such experiment consisted of two stages and provided for the alternating conduct of unified investigations in the USSR and the USA. These investigations will permit a refinement of the methods for modeling the physiological effects of weightlessness, in particular the use of bedrest with horizontal or antiorthostatic (-6°) positioning of the body as an experimental model of weightlessness.

Another important direction in the joint projects is the unification of the experimental conditions involving hypokinesia, the procedures of clinico-physiological and laboratory investigations and functional tests, and the order of carrying out individual investigations. The processes pertaining to the registration of medical information and the form of processing, analyzing, and presenting data have been unified. In this way, the work begun earlier at the third, fourth, and fifth conferences of the Joint Soviet-American Committee on the unification of the methods of preflight and postflight examination of astronauts was continued.

This report is devoted to the results of a joint experiment involving hypokinesia. It may be presumed that the subsequent exchange of reports on the Soviet and the American experiment and publications on the joint Soviet-American experiment with hypokinesia will serve as a good foundation for future cooperation between the USSR and the USA in the area of space biology and medicine and will have a great scientific and practical importance.

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JOINT SOVIET-AMERICAN EXPERIMENT ON HYPOKINESIA. EXPERIMENTAL RESULTS

1.0. Abstract

This report presents the results of a joint experiment on the action of hypokinesia. The experiment consisted of three periods: a 14-day control period, a 7-day strict regimen of bedrest, and a 10-14 day period of recuperation. Participating in the experiment were 10 healthy male volunteers in the age group 30-40. These were divided into two equal groups of 5 apiece. The subjects of group A reposed in the horizontal position during the bedrest regimen (0°), those of group B in the antiorthostatic position (-6°). In the control and recuperation periods, the subjects were fed with natural canned foods of approximately 2800 kcal total content, and during the bedrest regimen they were given the same foods with a calorie content of approximately 2500 kcal. The consumption of liquid was not restricted.

In the experiment, the biochemical and hormonal indices of the blood and urine, features of the water-salt metabolism and kidney functioning, hematological indices, and condition of the cardio-respiratory system at rest and under functional loads (action of LBNP , regulated physical load on the veloergometer in the lying and sitting positions) were investigated. The condition of the fluid media of the organism was studied by radioisotopic methods.

The results of these investigations permit a tentative conclusion that the antiorthostatic hypokinesia, with respect to clinical symptoms and individual physiological shifts, more adequately reproduces those reactions that are noted in the human being as a result of space flight than does a bedrest regimen with horizontal positioning of the body.

2.0. Introduction

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L. I. Kakurin, V. M. Mikhaylov

2.1. Goals and Problems of the Investigation

Investigations in the field of space biology and medicine began at the end of the 1940s and the beginning of the 1950s in the USSR and the USA and developed almost in parallel. This was also the time for the beginning of cooperation between Soviet and American scientists in this field. This consisted in a regular exchange of information and joint discussion of findings and was implemented in the compass of the yearly congresses of the

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International Federation of Astronautics and the International Academy of Aviation and Space Medicine, the conferences of the Committee on Space Research (COSPAR) at UNESCO, the international symposia "man in space", and the meetings of the joint Soviet-American committee on space biology and medicine. These meetings, which are held annually, alternately in the USSR and in the USA, made it possible to prepare an entire series of joint programs of medical and biological research in space biology and medicine. One of the examples of this cooperation was the development of a joint program for research on hypokinesia.

At the ninth conference of the Joint Soviet-American Committee on Space Biology and Medicine (Leningrad, 11-17 October 1978), a final agreement was reached and a protocol signed for the conduct of the first joint Soviet-American experiment on the action of hypokinesia (conference materials, supplement No- 4).

The principal goals and problems of the first experiment were:

2.1.1. evaluation of antiorthostatic hypokinesia as a weightlessness model.

2.1.2. comparison of investigation results obtained for the horizontal (0°) and the antiorthostatic positions of the body during bedrest. /8

2.1.3. standardization of hypokinesia conditions.

2.1.4. identification, standardization, and evaluation of operational laboratory methods and tests that may be used during hypokinesia experiments in both the USSR and the USA.

2.2. Survey of the Literature.

The large volume of factual and experimental material, presently accumulated during the preparation and implementation of manned space flights in the USSR, indicates that one of the primary extreme factors exerting an unfavorable influence on the human organism is the condition of weightlessness [1-5].

In this connection, it becomes specially urgent in space medicine to develop an adequate experimental model of weightlessness, which is essential both for the study of the phenomenology and extent of functional disturbances arising in the human organism and for predicting the state of health of the crew and evaluating the effectiveness of various preventive measures employed during space flight [6-9].

The medical-biological investigations, carried out in the flight programs of the Soyuz spacecraft and the Salyut orbital stations, revealed that one of the possible directions for the development of space medicine in the future may be a further study on the subtle adaptive mechanisms of the human organism to the

condition of weightlessness and the mechanisms of later readaptation to gravitational conditions [10,11].

An important role in the etiology behind the functional rearrangement of individual systems in these conditions is played by a purely physical phenomenon--the absence or sharp decrease in oscillations of the hydrostatic component of the blood pressure. It is customary to consider a regular consequence of this to be a redistribution of the blood, unusual for terrestrial conditions, with an increase in its flow to the organs and portions of the body lying above the level of the heart, followed by the development of compensation processes involving neuroreflex, myogenic, and metabolic mechanisms. The problem of gravitational redistribution of the blood, studied with special intensity in recent years, is still largely unclear, but its role in the development of individual disturbances is indisputable [12]. /9

Another very important pathogenic factor is the stereotype, unusual for Earth conditions, of the muscular activity in weightlessness with elements of hypokinesia and hypodynamia [13]. Both these pathogenic factors of weightlessness are accessible for duplication in Earth experiments and are the basis for the modeling of the physiological effects of weightlessness.

At present, two experimental models have received the greatest acceptance: the submersion of human beings in an immersion medium or a stay in conditions of a strict bedrest regimen [6-8]. The validity of such modeling has by now been scientifically confirmed by the large set of investigations, largely carried out in the USSR and the USA, and the special discussion of this problem at international conferences and at the meetings of the Joint Soviet-American Committee on Space Biology and Medicine.

Purposeful investigations for modeling the prolonged effect of weightlessness on the healthy human organism by means of a bedrest regimen were commenced in the USSR in 1961, while the first publications appeared in 1963 [14,15]. Afterwards, many experimental investigations of varying complexity and duration of hypokinetic period were carried out. The most important were the complex investigations that included several series of experiments: 15-day [16,17], 20-day [14,15], 30-day [18,19], 40-day [20], 45-day [21], 49-day [9,22], 60-day [23], 70-day [24], 120-day [25], and 182-day [26,27] observations, as well as individual clinical observations. /10

These investigations permitted the study, to a considerable extent, of the phenomenology of disturbances that arise in the simulation of weightlessness, and the beginning of an experimental evaluation of the effectiveness of various preventive means. The materials of several investigations on the problem of hypokinesia are presented in greater detail in surveys [28,29], individual publications [30-32], and special works [33-36].

Despite certain critical observations involving the imperfection of the models (immersion, bedrest regimen with horizontal position of the body), the results of the medical observations of Soviet astronauts conclusively demonstrated that the prognoses made on the basis of this research were valid. This refers foremost to those disturbances such as the lowering of the orthostatic stability and physical capabilities, the impairment in regulation of the vertical posture and coordination of walking motions, the lowering of the strength and tonus of the antigravitational musculature, and the disruption of a number of metabolic processes in the human organism, especially the water-salt equilibrium in the tissues [1-5, 10, 11].

The single-directed nature of the changes noted after space flights and model experiments involving hypokinesia indicates that, in the conditions of terrestrial gravitation, it is possible not only to reproduce certain effects of weightlessness, but also to evaluate /11
the various means of preventing and treating the discovered disturbances, the compass of which has already been rather clearly delimited [9,22,24,25,27,29]. Certain of these attain the upper or lower limit of physiological norms, while others may be qualified as subpathological alterations.

The experimental investigations in this field, carried out in the USSR, have recently been supplemented by a qualitatively new element--the antiorthostatic position of the subject in conditions of a strict bedrest regimen. The first such 30-day experiment with an angle of inclination of -4° (head lower than legs) was carried out in 1970 to evaluate the effectiveness of the preventive measures recommended for the crew of the orbital station Salyut-1 [37].

The use of the hypokinetic model with antiorthostatic position of the subject introduced certain new additional elements in the modeling of weightlessness effects which, in the horizontal position of the body, were reproduced less distinctly or not at all. This was revealed in the manifestation of a feeling of bloodrush to the head, gradually declining, hyperemia and a certain pastiness of the face, the illusion in certain cases of an inverted body position when the eyes are closed, and other phenomena that are intrinsic to weightlessness. The noted physiological reactions are accompanied by considerable changes in the redistribution of the blood, which the results of radioisotope investigations [38] clearly indicate. The gravitational redistribution of the blood is supported by the data of clinical observations [18], rheographical investigations [39], materials from the study of the condition of the visual [40] and vestibular [41] analyzers, results from determining the dynamics of the heart discharge [42], and other investigations.

It is convenient to begin a comparison of the physiological /12
effects, resulting from a bedrest regimen with horizontal and antiorthostatic positions of the body, by considering the influence of a transient antiorthostatic hypokinesia, modeling the "acute" period of adaptation to weightlessness, on the blood circulation and a number of analyzer systems that are of interest in this case. The

importance of this period, as is known, is especially great during brief space flights or flights in orbital stations, since it is precisely at this time that there occurs the docking of the ship at the orbital station, the transfer of the crew to the latter, the preparation of the equipment, and an entire series of important dynamic operations in guiding the orbital complex. Furthermore, it is precisely at this time that the process of gravitational redistribution of the blood is most pronounced and the symptoms of motion sickness most obvious.

In order to model the "acute" period of adaptation to the condition of weightlessness, a 5-day strict bedrest regimen was used with horizontal (0°) and antiorthostatic positions of the body at angles of -4°, -8° and -12°.

The investigation data permitted the transition to modeling the initial period of human adaptation to the condition of weightlessness and, in particular, the evaluation of the importance of gravitational redistribution of the blood in the occurrence of an entire series of unfavorable physiological reactions. It was shown that an antiorthostatic hypokinesia with angles of inclination from -4° to -12° more accurately reproduces those physiological reactions that are observed in astronauts as a result of orbital flight, than does the bedrest regimen in horizontal position of the body [43-46].

In other investigations, it was resolved to intensify the study of the experimental model for weightlessness by attempting to estimate the influence of the degree and directedness of the hydrostatic pressure drop in conditions of strict bedrest regimen [19]. Participating in the experiments were virtually healthy /13
subjects in the age group 19 to 35 years (24 people), arranged in four groups of 6 persons in each. Those in the first, second, and third experimental groups observed a strict 30-day bedrest regimen in the orthostatic (+6°) and antiorthostatic (-2° and -6°) positions of the body, respectively. The subjects of the fourth group (the control) were not subjected to a bedrest regimen. For the duration of the entire experimental period (30 days), they lived in the same conditions as the subjects of the experimental groups. The unavoidable deficit of movement in hospital conditions was made up by means of a special complex of physical exercises. An analysis of the findings showed that the clinical condition of the control group subjects and their ability to pass various functional tests (orthostatic, LBNP , physical load, etc.) were practically unchanged after the experimental period.

For the subjects of the first, second, and third groups, observing the bedrest regimen, a symptom complex of disturbances was observed in the first days, characteristic for the "acute" period of adaptation to conditions of hypokinesia, but the extent of expression of individual disturbances was in clear dependence on the position of the body in the bed: in the orthostatic position (+6°), the subjective and objective symptoms of the blood redistribution were insignificant, while in the antiorthostatic

(-2° and -6°) position they were distinctly expressed. Beginning with the second half of the experiment, the differences in the clinical status of the subjects in these three groups considerably leveled off.

At the end of the bedrest regimen, disturbances of various extent in the functioning of individual physiological systems were discovered in all the subjects of the first, second, and third groups, certain intergroup discrepancies being obtained for certain investigated parameters, and not for other parameters [19,47-49]. /14
This data indicates that the degree of restriction of muscular activity takes on a leading role in the case of a prolonged bedrest regimen. The change in the hydrostatic component of the blood pressure and the absence of hydrodynamic stimulations in these circumstances promote the development of gravitational circulatory disorders [23,50].

Despite these investigations, the selection of an adequate experimental model for weightlessness continues to be a topical problem. The standardization of the experimental conditions and the unification of the various laboratory methods and functional tests used to evaluate the condition of a person will be essential for further investigations in the problem of hypokinesia. The joint Soviet-American experiment on the action of hypokinesia is devoted to solving these problems, which are important in both a scientific and practical sense.

2.3. The Preparation of the Joint Experiment.

The preparation and the conduct of the joint experiment were implemented in several stages.

In the first stage, it was more important to achieve an agreement as to the conduct of a series of experiments on hypokinesia and the use of various preventive and rehabilitative measures (materials of the eighth conference of the Joint Soviet-American Committee on Space Biology and Medicine, USA, Washington, Wallops Center, 19-25 November 1977, supplement No. 4).

In the first experiment for a comparative evaluation of a bedrest regimen with horizontal and antiorthostatic position of the body as a model for weightlessness, the adequacy should be checked for the standard conditions, developed in the simultaneous conduct of hypokinetic experiments in the USSR and the USA. /15
The investigation includes a week-long period of hypokinesia and a 2-week ambulatory period of observation before and after the bedrest regimen. Participating in the experiment are 10 subjects in the age group 30-40 years, 5 of which observe a strict bedrest regimen in the horizontal position (0°), the other 5 being in the antiorthostatic (-6°) position.

The second stage provides for the development and exchange of projects for the experimental programs. At this stage in both

the USSR and the USA projects were worked out for programs to carry out a first joint Soviet-American experiment with hypokinesia, exchanged by both sides in May-June 1978. The following exchange of secondary documents (August-September 1978), which involved the pertinent supplements to the particular program projects and annotations to them, revealed that both parties were rather close to each other. This created the objective prerequisites for writing a final, joint experimental program.

At the third stage of the work, the joint experimental program was worked out and described. For this purpose, a separate section on hypokinesia was organized at the regular ninth conference of the Joint Soviet-American Committee on Space Biology and Medicine (Leningrad, 11-17 October 1978). Its problems included:

- clarifying the principles for both sides with respect to preparing and carrying out a first experiment with hypokinesia;
- the holding of frequent discussions on disputed points in the project of the experimental program;
- the coordination of the main experimental conditions, the extent and methods of the investigations to be carried out, the cyelogram of the investigations, the schedule of the experiments, and the representation of the data. /16

A result of this work was the coordinated "program for the joint Soviet-American experiment with hypokinesia" (materials of the conference, supplement No. 4). This defined the goals and problems of the experiment, the main conditions and layout of the experiment, the investigation procedure, the cyclogram for carrying out the investigations, the daily schedules, the program chart for carrying out the experiments in the USSR and the USA, the periods for presenting the research results, a control exchange of blood specimens, and also the exchange of two experts from each side for a period of 2-3 weeks.

The following (fourth) stage was the immediate preparation for carrying out the joint experiment, consisting of 2 parts: a Soviet (May-June 1979) and an American (July-August 1979).

After each of the sides ratified the materials of the ninth conference of the committee, accurate dates were designated for the commencement and conclusion of the Soviet and American experiments, and the cyclogram of the investigations and the procedure for dividing the subjects into 2 uniform groups were refined.

The Soviet experiment was carried out in the Institute for Medical and Biological Problems of the USSR Ministry of Public Health (Moscow) from 14 May to 22 June 1979. The scientific director of the Soviet experiment is Doctor L. I. Kakurin, and the operations chief is Doctor V. M. Mikhaylov. In the Soviet experiment, the technical observers from the USA were Doctor G. Sandler (Ames Research Center, NASA) and Doctor C. Alexander (the Lyndon Baines Johnson Center for Manned Space Flight, NASA).

The American experiment was carried out at the Ames Research Center NASA (Moffet Field, California) from 10 July to 15 August 1979. The scientific director of the American experiment is Doctor G. Sandler, the operations chief is Doctor C. Alexander. Participating in the American experiment as technical observers from the USSR were Doctor V. M. Mikhaylov and Doctor A. I. Grigor'yev (Institute for Medical and Biological Problems of the USSR Ministry of Public Health). /17

The preliminary results of the Soviet and American experiments were presented by each of the parties at the ninth conference of the Joint Soviet-American Committee on Space Biology and Medicine (USA, Houston, October 1979).

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3.0. General Characteristics of the Experiment /25

3.1. Selection of the Subjects

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For participation in the experiment, healthy male volunteers in the age group 30-40 were chosen. Each subject underwent a careful medical examination, including the measurement of height and body weight. The selection of the subjects took place in three stages.

At the first (preliminary) stage, the following tests were done on the subjects at a dispensary: anthropometric (height, weight, age); examinations by specialists (therapeutist, surgeon, otolaryngologist, oculist, neuropathologist); general (clinical) blood analysis; general (clinical) urine analysis; radiophotography of the thorax.

Additional tests included: biochemical blood analysis; examination of the cardio-vascular system; condition of the stomach secretion.

At the second (main) stage of the selection, the following functional tests were done in dispensary: a 3-hour test for glucose tolerance; determination of stability to the action of negative pressure on the lower body; determination of the maximum oxygen requirement during physical load on the veloergometer.

At the third (conclusive) stage of the selection, the subjects were compared by anthropometric indices, stability to negative pressure on the lower body, and maximum physical endurance, and were divided into two equal groups of five each. For participation in the Soviet experiment, approximately 60 male volunteers were /26 used. After the preliminary selection, 16 subjects were chosen and admitted to the following stage of testing with the use of functional loading tests. By these results, the final two groups of subjects were formed with five people in each.

3.1.1. Results of the Initial Selection of Subjects

All of the chosen subjects belonged to the average group of physical development, ranging in age from 31 to 40 years, in weight from 65 to 87.5 kilograms, and in height from 170 to 185 centimeters. For subject A-ev, the actual weight exceeded the standard by 13.5 kilograms, for T-n by 11.5 kilograms, and for S-v by 11 kilograms. For the subject K-ko the weight was lower than standard by 5 kilograms. The anthropometric data of the selected subjects is shown in table 3.1. Table 3.2 presents several indices for the functional condition of the cardio-vascular system of the subjects at rest and their endurance of the Master's two-step exercise test.

The results of the general (clinical) analysis of the blood samples are shown in table 3.3, those of the general (clinical) analysis of the urine samples in table 3.4, and those of several biochemical blood indices in table 3.5. The radiophotographic data of the thorax for the selected subjects did not indicate any pathology. The investigation of the secretory function of the stomach did not reveal substantial deviations from the norm. The results of the examination by specialists are shown in table 3.6. They indicate that all the subjects were healthy and that the existing peculiarities in the condition of their health are not contraindications for their participation in a short-term experiment with hypokinesia.

Table 3.1.

Anthropometric Data of the Subjects

№	Subjects	Age (Yrs)	Height (cm)	Weight (kg)
I.	S-ev	40	I83	81.3
2.	S-ov	33	I70	81.0
3.	P-ov	33	I73	74.8
4.	Sh-ov	3I	I70	72.0
5.	K-ko	32	I70	65.0
6.	A-ev	30	I73	66.5
7.	P-iy	36	I74	73.3
8.	T-in	34	I76	87.5
9.	Zh-ov	35	I72	81.0
I0.	L-iy	38	I85	83.3

Table

Several Indices for the Functional Condition of the Cardiovascular System of the Subjects.

	Subjects	At Rest		Master's Two-Step Exercise Test
		Pulse (beats/min)	Arterial Pressure (mm mercury)	(Endurance)
I.	S-ev	60	II0/70	good
2.	S-ov	62	I20/80	good
3.	P-ov	70	I20/80	satisfactory
4.	Sh-ov	68	I05/75	good
5.	K-ko	64	II0/70	good
6.	A-ev	68	II5/70	good
7.	P-iy	72	II0/70	good
8.	T-in	70	I30/80	satisfactory
9.	Zh-ov	70	I40/80	good
10.	L-iy	64	I20/80	good

Table 3.3

Results of a General (Clinical) Analysis of the Subjects' Blood Samples

No.	Subject	Erythrocytes	Hemoglobin	Color Index	Leucocytes	Reticulocytes	Basophiles	Eosinophiles	Leucocytes			Lymphocytes	ESR	Hematocrit
									Young	Rod Nucl.	Segment Nucl.			
I.	S-ev	4610000	I6.8	I.I	5250	-	-	2	-	4	48	38	5	44
2.	S-ov	4540000	I3.9	0.92	8550	-	-	2	-	2	57	33,5	5	44
3.	P-ov	4700000	I5.7	I.0	4900	-	-	-	-	I	65	32	2	44
4.	Sh-ov	4750000	I5,2	0.97	6700	-	-	I	-	I	64	34	3	44
5.	K-ko	5020000	I5,7	0.94	3650	-	I	4	-	3	55	35	6	44
6.	A-ev	4500000	I6,6	I.I	5700	-	-	4	-	5	53	30	5	42
7.	P-iy	4500000	I5,6	I.0	7600	-	I	2	-	2	55	35	2	44
8.	T-in	5I00000	I5,7	0.92	8500	-	I	I	-	5	62	28	4	44
9.	Zh-ov	4500000	I4,8	-	6I00	-	-	I	-	7	56	26	7	45
I0.	L-iy	4700000	I6,6	I.0	6800	-	-	5,5	-	4,5	57	35	2	44

Table 3.4.

Results of a General (Clinical) Analysis of the Subjects' Urine Samples.

No.	Subject	Color	Transparency	Specific Gravity	Reaction	Epithelial Cells	Leucocytes	Casts	Mucus	Bacteria
I.	S-ev	bright yellow	clear	I0I3	acid	few	single	-	little	-
2.	S-ov	bright yellow	clear	I027	acid	flat, single	I-2 in field of vision	-	little	-
3.	P-ov	bright yellow	clear	I023	acid	--	0-I in field of vis.	-	some	-
4.	Sh-ov	bright yellow	semiclear	I025	acid	some	I-2 in field of vis.	-	some	-
5.	K-ko	yellow	clear	I025	acid	some	I-2 in field of vis.	-	much	-
6.	A-ev	yellow	clear	I032	acid	single	0-I in field of vis.	-	little	-
7.	P-iy	yellow	clear	I0I5	acid	few	3-4 in field of vis.	-	--	-
8.	T-in	bright yellow	clear	I020	basic	few	I-2 in field of vis.	-	little	-
9.	Zh-ov	bright yellow	clear	I020	acid	few	I-2 in field of vis.	-	--	-
I0	L-iy	bright yellow	clear	I02I	acid	--	single	-	little	-

Table 3.5.

Results of Several Biochemical Investigations of the Subjects' Blood Samples.

No.	Subject	Bilirubin (mg%)			Cholesterol (mg%)	Sugar (mg%)	Total Protein (g%)	β-lipoproteins (mg%)	Kunkel test (units)
		total	direct	indirect					
1.	S-ev	0,88	0,44	0,44	I68	82,0	7,47	465	33
2.	S-ov	0,6	0,38	0,22	I62	72,0	7,28	744	23
3.	P-ov	0,70	0,25	0,45	I90	82,0	8,I7	430	27
4.	Sh-ov	0,77	0,27	0,50	208	97,0	7,37	826	32
5.	K-ko	0,5I	0,23	0,26	I56	74,0	7,57	523	30
6.	A-ev	0,58	0,24	0,34	I68	6I,0	8,0	658	29
7.	P-iy	I,I0	0,95	0,06	I80	64,0	7,7	79I	42
8.	T-in	0,66	0,38	0,28	I68	I04,0	8,I7	465	38
9.	Zh-ov	0,69	0,19	0,50	I68	I07,0	7,03	768	29
1.	L-iy	0,69	0,63	0,03	I56	90,0	7,95	942	55

NB. Commas in the tabulated values are to be understood as decimal points.

Table 3.5.
(Continued)

The Concentration of Electrolytes and Osmotically-active Substances in the Blood of the Subjects.

No.	Subject	Sodium (meq/l)	Potassium (meq/l)	Calcium (meq/l)	Magnesium (meq/l)	Chlorine (meq/l)	Osmolarity (mosm/l)
I.	S-ev	I4I	4,50	4,70	2,05	I02	290
2.	S-ov	I39	4,40	4,80	I,83	99	288
3.	P-ov	I45	4,25	4,75	2,I0	I07	299
4.	Sh-ov	I44	4,35	4,52	2,I4	I05	295
5.	K-ko	I42	4,30	5,0	2,20	I02	293
6.	A-ev	I42	4,20	4,75	2,06	I0I	293
7.	P-iy	I4I	4,30	4,67	I,95	99	286
8.	T-in	I4I	4,40	4,75	2,20	I02	290
9.	Zh-ov	I45	3,95	4,78	I,95	I03	297
[illegible]	L-iy	I4I	4,30	4,70	I,80	99	290

N.B. The commas in the tabulated values are to be understood as decimal points.

Table

Results of a Medical Examination of the Subjects by Specialists.

E	Subject	Therapeutician	Surgeon	L.O.R.	Oculist	Neuropathologist
1.	S-ev	healthy	healthy	healthy	healthy	healthy
2.	S-ov	healthy	healthy	healthy	healthy	healthy
3.	P-ov	healthy	healthy	healthy	healthy	healthy
4.	Sh-ov	healthy	healthy	healthy	healthy	healthy
5.	K-ko	healthy	healthy	healthy	moderate myopia: 2D	healthy
6.	A-ev	healthy	healthy	healthy	myopia 4D, both eyes	healthy
7.	P-iy	healthy	healthy	healthy	healthy	healthy
8.	T-in	healthy	shortening of 4th finger, right hand, flexion contracture, 5th finger, right hand	healthy	healthy	healtny
9.	Zh-ov	healthy	healthy	healthy	healthy	healthy
10.	L-iy	healthy	healthy	healthy	healthy	healthy

3.1.2. Results of the Functional Samples /34

3.1.2.1. Three-hour Test for Glucose Tolerance

In selecting the subjects for the experiment, the tolerance of their organism to carbohydrates was studied. The method of sugar loads was employed, the principle of which basically reduces to investigating the nature of the glycemic curve after the introduction of sugar in the amount of 1 g per 1 kg body weight. In blood removed from the finger, the glucose level was determined for both an empty stomach and after a sugar load with an interval of 30 minutes for the course of three hours. The content of glucose in the blood was studied by the glucosoxidase method, using hydrogen-o-dianisidine as the donor.

It is believed that the glycemic curve may be considered normal if the maximum glucose rise in the blood after sugar load is 40-60 mg% and the sugar level in the blood returns to the initial within 2-2.5 hours.

The results of the 3-hour test for glucose tolerance are shown in table 3.7.

For the majority of subjects participating in the experiment, a normal type of glycemic curve was observed. The level of glucose in the blood on an empty stomach was 56.2-126 mg%, the lowest level being noted for the subject L-iy, the highest level for A-ev.

For L-iy, a protracted type of glycemic curve was noted, with maximum rise of 33.8 mg% within 1.5 hours after the sugar load. The flat, protracted curve indicates a certain insufficiency in the hydrolysis and transport of carbohydrates in the gastrointestinal tract and a lowering of the glucose assimilation by the tissues of the organism.

For A-ev, the glycemic curve was of the opposite type: with an /36
elevated glucose level in the blood on an empty stomach, a substantial rise in the blood sugar by 72 mg% was observed after sugar load, with a rather quick drop after 2 hours, which indicates an irritative nature of the glycemic curve. This type of curve is most frequently explained by the labile nature of the vegetative nervous system. A similar type of glycemic curve was observed for P-ov.

A somewhat flattened glycemic curve was noted for Zh-ov and P-ov.

Table

Level of Glucose in Blood (mg%) of Subjects Before (Background) and After Sugar Load.

№	Subject	Background	After Load (min)				
			30	60	90	I20	
I.	S-ev	65	I20	65	62	62	
2.	S-ov	87	II8	I70	85	75	90
3.	P-ov	75	II5	I05	90	75	70
4.	Sh-ov	80	I45	I25	70	70	
5.	K-ko	60	II0	85	50	65	60
6.	A-ev	I25	I98	I60	I08	90	I20
7.	P-iy	70	I20	90	75	65	
8.	T-in	78	I23	I05	I00	90	
9.	Zh-ov	90	I25	II0	II0	63	
I0.	L-iy	55	85	85	75	68	50

3.1.2.2. Determination of the Stability to Negative Pressure on the Lower Body

/37

The goal of this investigation was to determine the preliminary stability of the subjects to negative pressure on the lower half of the body for their selection and later distribution into two equal groups.

The investigation procedure.

The test was done in the horizontal position. The scheme of the test was: background - 5 min; -25 mm mercury - 2 min; -35 mm mercury - 3 min; -40 mm mercury - 5 min; -50 mm mercury - 5 min; recuperation - 5 min. The tests were done in the morning from 10:00 to 12:00. The temperature of the surroundings was comfortable for the subject.

The recorded parameters:

- Frequency of the heart contractions (beats/min), constantly determined by ECG;

- Systolic and diastolic arterial pressure (mm mercury), every minute;

- Amount of rarefaction during NPLB (mm mercury), continuously determined.

The equipment:

- A vacuum chamber;

- An instrument to measure the arterial pressure by the sound method;

- An electrocardiograph;

- A manometer.

The frequency of the investigation: At the selection stage the test was carried out twice: 1 - introductory, 2 - the actual test.

Results of the investigations

All of the subjects withstood the LBNP (lower body negative pressure) in an entirely satisfactory manner. Taking into consideration the physiological reactions of the subjects as well as the possibility of performing echolocation of the heart on them, 10 people were chosen and later divided into two equal groups. The results of the selective tests with LBNP are shown in table 3.8. It can be seen that the mean values for the frequency of the heart contractions and arterial pressure of the blood, both at rest and

Table 3.8.

Results of Sampling Tests with LBNP

Group	Subject	Frequency of Heart contractions (beats/min)		Systolic Pressure (mm mercury)		Diastolic Pressure (mm mercury)		Pulse Pressure (mm mercury)	
		Background	LBNP -50 mm mercury	Background	LBNP -50 mm mercury	Background	LBNP -50 mm mercury	Background	LBNP -50 mm mercury
	S-ev	54	68	III	95	80	75	31	20
	S-ov	87	I20	I22	I20	80	90	42	30
"A"	P-ov	92	II2	I37	II5	92	85	45	30
	Sh-ov	57	74	II5	I05	72	80	43	25
	K-ko	7I	82	I2I	I00	73	80	46	20
	M	72,2	9I,2	I2I,2	I07,0	79,4	82,0	4I,6	25,0
	A-ev	64	80	I22	I40	75	100	47	40
	P-iy	77	94	II0	I00	70	75	40	25
"B"	T-in	72	87	I40	I25	68	80	72	45
	Zh-ov	86	I08	I30	II5	90	95	40	20
	L-iy	74	97	I35	II5	70	85	65	30
	M	74,6	93,2	I27,4	[illegible]	74,6	87	52,I	[illegible]

in the test with LBNP, are rather similar for the subjects of both groups.

3.1.2.3. Investigation of the Physical Aerobic Efficiency

In accordance with the ratified program of the joint Soviet-American experiment with hypokinesia, bicycle ergometric testing was done during the selection period on all the subjects, in order to obtain initial data on the physical efficiency and the level of maximum oxygen consumption (Max V_{O_2} and Max V_{O_2}/kg weight), necessary for dividing the subjects into groups.

The procedure and conditions of the investigation

After stabilization of the sensors, the rest data was recorded.

Afterwards, the subject in the seated position began to turn the bicycle pedals without engagement.

After this, when the indicator of the speedometer attained 60-70 rev/min, a load of 100 kgm was engaged for one minute. From the second and for each succeeding minute, the level of load was increased by 100 kgm in stages (i.e. 1 min - 100 kgm; 2 min - 200 kgm; 3 min - 300 kgm; 4 min - 400 kgm; 5 min - 500 kgm and so forth).

The work on the bicycle was terminated at complete fatigue of the subject and inability to maintain the given pedaling rhythm (60-70 rev/min).

The conditions of the investigation

The temperature of the surroundings was comfortable for the subject. The investigation was carried out after not less than 2 hours following the meal. On the day of the investigation, the subjects underwent LBNP testing (another selective test). In working out on the bicycle, the subject was encouraged rather vigorously by the personnel conducting the investigation. There were no premature terminations of the test for medical reasons (pain in the chest or in the heart region, pathological changes in the ECG, and so forth).

The recorded parameters

Obligatory:

- Frequency of heart contractions (beats/min);
- Time on the bicycle ergometer (min);
- Final load level (watt);
- Amount of work performed (kgm);
- Maximum oxygen consumption Max V_{O_2} (l/min, STRD) Max V_{O_2}/kg weight (ml/kg/min);
- Lung ventilation (l/min, VTRS).

Facultative; other indices that do not interfere with the conduct of the main investigation.

Equipment:

- Electroveloergometer;

- Recorder of heart contraction frequency;
- The "Spirolit" (GDR) gas analyzer for O_2 and CO_2;
- Recorder for lung ventilation (a dry gas counter).

Frequency of the investigation

At the selection stage, the test was carried out twice: 1 - introductory, and 2 - the actual test. The test was not carried out after hypokinesia.

The investigation results

Table 3.9 shows the results of the veloergometric investigation for the physical aerobic efficiency of the subjects in both groups prior to the bedrest regimen.

In analyzing the reasons for which the subjects stopped working on the bicycle, it was found that in the majority of cases this was due to a considerable fatigue of the hip extensors. Much less /42
commonly, subjects complained of general excessive fatigue. There were no instances of stopping the work due to shortness of breath.

Our subjects did not include any highly trained athletes, but they were all fairly active in their style of life. The best prepared in a physical sense were P-iy (consistently involved in sightseeing and mountain climbing) and K-ko (hobbies are track and field sports, soccer). For these, the highest figures were noted for Max V_{O_2}/kg weight. For the remaining subjects, the values of Max V_{O_2} and Max V_{O_2}/kg body weight complied with those in the generally accepted literature data for healthy males of corresponding age group.

3.1.3. The Distribution of the Subjects into Groups

In order to assign the subjects to two equal groups, a point system was employed. In the version agreed upon, 50% of the significance for the results of the selective tests was accorded to the physical working capability of the person, 30% to LBNP stability, and 20% to the anthropometric indices. As criteria for estimating the endurance of the functional tests, it was proposed to use the following parameters. For the test with maximum physical load on the bicycle ergometer (MPL): the maximum oxygen requirement (V_{O_2} ml/kg); and the volume of work performed (VWP kgm).

For the test with negative pressure on the lower body (LBNR): the maximum frequency of heart contractions at a rarefaction of -50 mm mercury (FHC beats/min); and the minimum pulse pressure at a rarefaction of -50 mm mercury (P.A.P. mm mercury).

The coefficients of meaningfulness were defined in this /43
connection. For the test with maximum physical load, this coefficient was 0.5, while for the maximum oxygen requirement it was 0.3 and for the volume of work performed it was 0.2.

The corresponding coefficient of meaningfulness for the frequency of heart contractions in the test with LBNP (-50 mm mercury) was 0.2,

Table 3.9.

Results of Sampling Veloergometric Tests.

Group	Subject	Physical Capability			Aerobic Efficiency			
		work time (min)	final load level (Wt)	volume of work performed (kgm)	frequency of heart contractions (spec/min)	lung ventilation (l/min, VTRS)	Max V_{O_2} (l/min STRD)	Max V_{O_2} / kg body weight (ml/kg/ml)
	S-ev	I6	260	I3600	I84	95	3.I2	35.5
	S-ov	I4	230	I0500	I90	I0I	2.82	31.8
"A"	P-ov	I4	230	I0500	I84	69	3.I5	40.0
	Sh-ov	I6	260	I3600	I88	I07	3.04	42.2
	K-ko	I6	260	I3600	I76	78	3.I2	46.0
	M	I5	248	I2300	I84	90	3.05	40.7
	A-ev	I6	260	I3600	I80	96	3.00	34.9
	P-iy	I7	280	I5300	I78	90	3.36	46.9
"B"	T-in	I7	280	I5300	I80	85	3.27	37.2
	Zh-ov	I6	260	I3600	I90	I03	3.08	38.0
	L-iy	I5	245	I2000	I00	84	2.9I	[illegible]
	M	I6	265	I3[illegible]0	I02	9[illegible]	3.I3	[illegible]

while for the size of the pulse arterial pressure (-50 mm mercury) it was 0.1 (0.3 total for the test).

The coefficient of meaningfulness for the height was 0.1, that for body weight was 0.1.

The result for the distribution of the subjects into groups is shown in table 3.10. For each of the 10 subjects, points from 1 to 10 were calculated. In regard to the frequency of heart contractions during LBNP at -50 mm mercury, the calculation was done from the minimum values of the index to the maximum, while for the remaining indices, the maximum oxygen requirement, the pulse arterial pressure at LBNP with -50 mm mercury, and the volume of performed work in the tests with maximum physical load, the calculation was done in the inverse manner, i.e. from the maximum to the minimum values. Consequently, the subject with the best endurance of these functional tests received the least number of points and vice versa. An estimate of points was not made for the antropometric and age features, but also with regard to these indices an effort was made for an even balance between the groups.

Occasionally there occurred a situation in which two or three of the subjects had identical individual indices. For example, the pulse arterial pressure (P.A.P.) during LBNP for 3 of the subjects was equal to 30 mm mercury. They were given 4 points, i.e. the middle place for positions 3, 4, and 5. For two others, the P.A.P. was 25 mm mercury and they occupied positions 6 and 7; they were given 6.5 points apiece, and so forth. Afterwards, the points obtained for each index were multiplied by the corresponding coefficients of meaningfulness and the sum of the points was written /45 down for each subject. Furthermore, subjects with a point total close together were united into pairs, each group receiving one of the members. As a result, the following point total per group was obtained.

Table 3.11. Point Estimate for the Division of the Subjects into Groups.

Test	Index	Coefficient	Group I (points)	(points)
LBNP	FHC	0.2	29x0.2=5.8	[illegible]
	PAP	0.1	22.5x0.1=2.25	[illegible]
MPL	Max V_{O_2}	0.3	33x0.3=9.9	[illegible]
	VWP	0.2	21x0.2=4.2	[illegible]
Sum:			[illegible]	[illegible]

Table 3.10.

Distribution of the Subjects into Groups.

No.	Subject	Group	Height (cm)	Weight (kg)	Age (yrs)	NPLB -50 FHC (beats/min)	Points	PAP (mm merc)	Points	Maximum Physical Load Max V_{O_2} (ml/kg/min)	Points	VWP (kgm)	Points
I.	S-ev		I83	8I	40	68	I	20	9	38.5	5	I36C0	5
2.	S-ov		I70	8I	33	I20	I0	30	4	34.8	9	I0500	9,5
3.	P-ov	"A"	I73	75	33	II2	9	30	4	40,0	4	I0500	9.5
4.	Sh-ov		I70	72	3I	74	2	25	6,5	42,2	3	I3600	5
5.	K-ko		I70	65	32	82	4	20	9	48.0	I	I3600	5
	Av.		I73,2	74.6	34	9I,2		25		40.7		I2360	
6.	A-ev		I73	86	3I	80	3	40	2	34.9	6	I3600	5
7.	P-iy		I74	72	36	94	6	25	6,5	46.9	2	I5300	I.5
8.	T-in	"B"	I76	68	34	87	5	45	I	37,2	7	I5300	I.5
9.	Zh-ov		I72	8I	35	I08	8	20	9	33,0	6	I3600	5
I0.	L-iy		I85	85	38	97	7	30	4	31,2	I6	I3200	8
	Av.		I76	82,4	35	93,2		32		38,3		I3360	

Table 3.2.1.

Anthropometric Data of the Subjects and their Division into Groups.

Group	No. of Subject	Subject	Height (cm)	Weight (kg)	Age (yrs)	Body Surface (m^2)
	2	S-ev	I83	81	40	[illegible]
	4	S-ov	I70	81	33	[illegible]
"A"	6	P-ov	I73	75	33	[illegible]
	8	Sh-ov	I70	72	31	[illegible]
	I0	K-ko	I70	65	33	[illegible]
	M		I73.2	74.8	34	[illegible]
	I	A-ev	I73	86	31	[illegible]
	3	P-iy	I74	72	36	[illegible]
"B"	5	T-in	I76	88	[illegible]	[illegible]
	7	Zh-ov	I72	81	[illegible]	[illegible]
	9	L-iy	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]

3.2. The Experimental Conditions

V. M. Mikhaylov, V. S. Georgiyevskiy, A. N. Nazin, N. V. Kondrasheva

3.2.1. The Location of the Experiment

The Soviet experiment was carried out at the base of the clinico-physiological laboratory at the Institute for Medico-Biological Problems of the USSR Ministry of Public Health. The laboratory is in the form of a separate 2-storied structure. In the first story are: offices of the doctors and conductors of the experiment, rooms for the servicing personnel, a room to prepare (pantry) and take the meals (dining room for the subjects), a bath and lavatory. In the second story were two large isolation rooms for the subjects and, functionally connected to these, individual laboratories in which the following research could be done:

- The LBNP test;
- The physical load test on the bicycle ergometer;
- Radioisotopic investigations;
- Clinical blood analyses;
- Preparation of biochemical blood specimens;
- Collection and preparation of biochemical urine specimens;
- Hygienic routines (a bath and lavatory for the subjects).

The conclusive biochemical and radioisotopic analyses of the blood and urine samples were done in other specialized laboratories. The resulting medical information was sent to the computer center of the Institute for subsequent processing and creation of a data bank on the experiment.

3.2.2. The Scheme for Carrying Out the Experiment /47

The Soviet experiment consisted of three periods:

- A 14-day control period;
- A 7-day period of hypokinesia;
- A 14-day recuperation period.

3.2.3. The Main Experimental Conditions

In the Soviet experiment, 10 healthy male volunteers in the age group 30-40 years participated. They were divided into two equal groups of five each on the basis of anthropometric indices, stability to LBNP, and endurance of maximum physical load. The subjects of the first group ("A") maintained a horizontal position of the body during the 7-day bedrest regimen, while the second group ("B") maintained an antiorthostatic (-6°) position, i.e. the head was lower than the level of the legs. The anthropometric data on the subjects and their distribution into groups are shown in table 3.2.1.

The general scheme for carrying out the experiment is shown in table 3.2.2. The subjects began the experiment in succession (2 each time), so that the number of daily examinations would remain

within reasonable bounds.

Throughout the entire experiment, the subjects were in conditions of a clinical hospital. They were forbidden to leave the territory where the experiment was carried out. In the control and recuperation periods, the motor activity of the subjects corresponded to an enlarged ward discipline. They were allowed to walk about the laboratory building and to take brief strolls on the attached grounds, which were fenced. The average level of motor activity of the subjects by groups before and after the bedrest is shown in table 3.2.3., while individual data is given in supplement "B" (tables 8.3.2.1. - 8.3.2.4.). As can be seen, the level of motor activity on the whole did not differ greatly for the subjects of both groups. On the days when the functional tests were carried out, the motor activity of the subjects in both groups was lowered as compared to the usual. In the background period, there was a tendency for depression of the level of motor activity in proportion to length of stay in the hospital. In the recuperation period, the motor activity on day "0" was depressed for the subjects of both groups. It later increased and within 3 days after the conclusion of the bedrest regimen it was again at the background level.

In the hypokinetic period, the subjects maintained a strict bedrest regimen with continuous horizontal (group A) or antiorthostatic (group B) position of the body. They were forbidden to raise any portions of the body except the head, to the height of the forearm, when taking food four times a day. All of the physiological functions and hygienic routines were carried out with maintenance of the given body position for each group.

The motor activity of the subjects during the bedrest period was reduced to a minimum. The usual position was lying on the back. They were forbidden any type of movement in the bed, except for individual turns about the longitudinal axis of the body (from side to side).

The lighting was regulated in order to maintain a 16-8 hour day-night cycle. The temperature in the wards was maintained at comfortable levels and was recorded three times a day (morning, afternoon, and evening). A graph for the actual temperature conditions in the wards is shown in table 3.2.4.

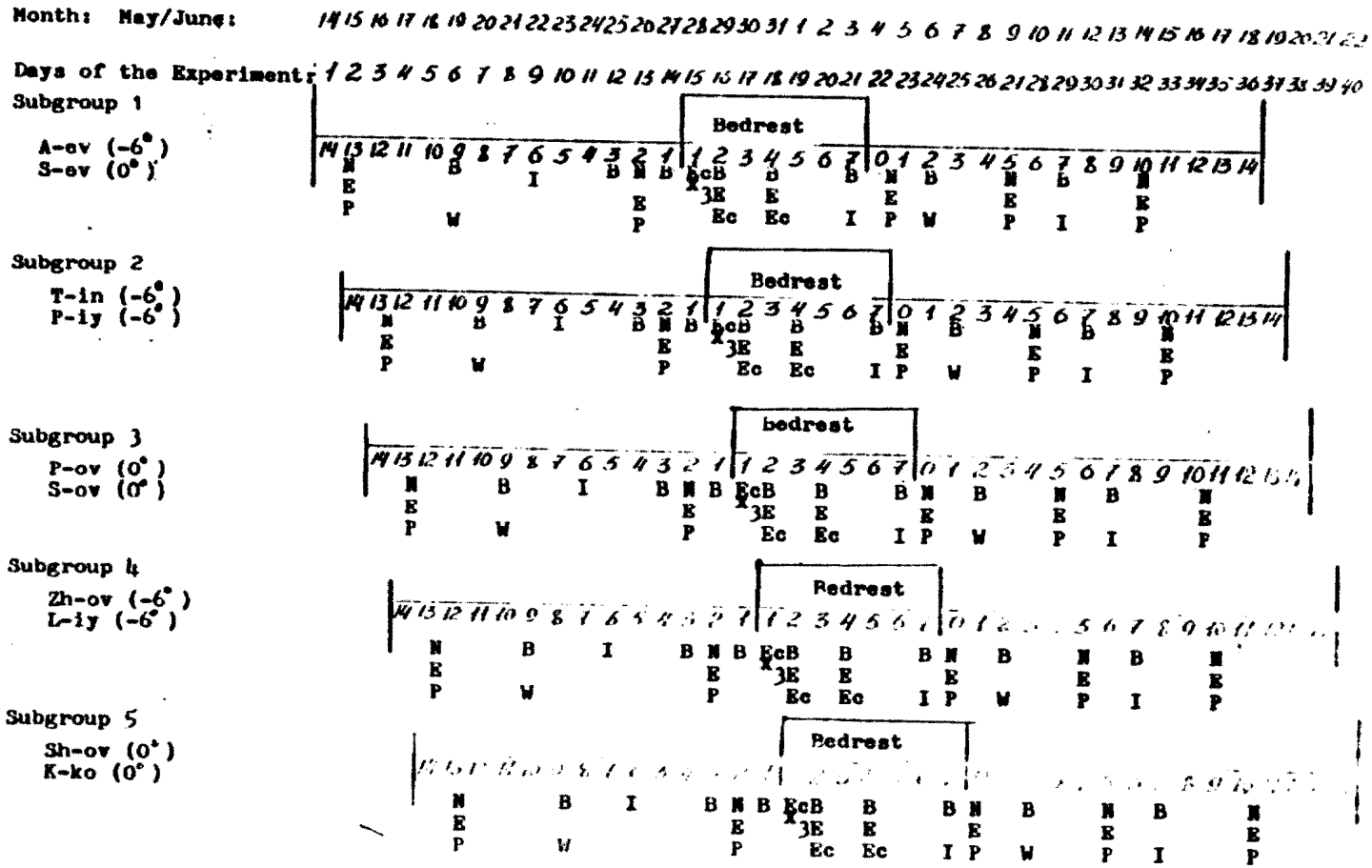
Meals were taken four times a day. The total energy worth of each ration was calculated on the basis of the body weight of the subject and was analyzed.

The calorie content of the ration was approximately 2800 kcal in the control and recuperation periods and approximately 2500 kcal during bedrest. The subjects were required to eat the entire meal. /53
The consumption of liquid was not restricted, but carefully followed.

The personal hygiene accessories were in the form of moist and dry napkins and towels. In order to maintain a normal composition

N - LBNP
P - Physical Load
B - Blood
W - Water Load
I - Isotopes

E - ECG
Ec - Echocardiogram
Ec x3 - Echocardiography 3 times a day with a 4 hour interval



CYCLOGRAM OF THE EXPERIMENTAL PROCEDURE

Table 3.2.3. The Level of Motor Activity (Number of Steps per Day) for the Subjects of Group A (Dotted Line) and Group B (Solid Line) before (Background) and after (Recuperation) the Termination of Bedrest.

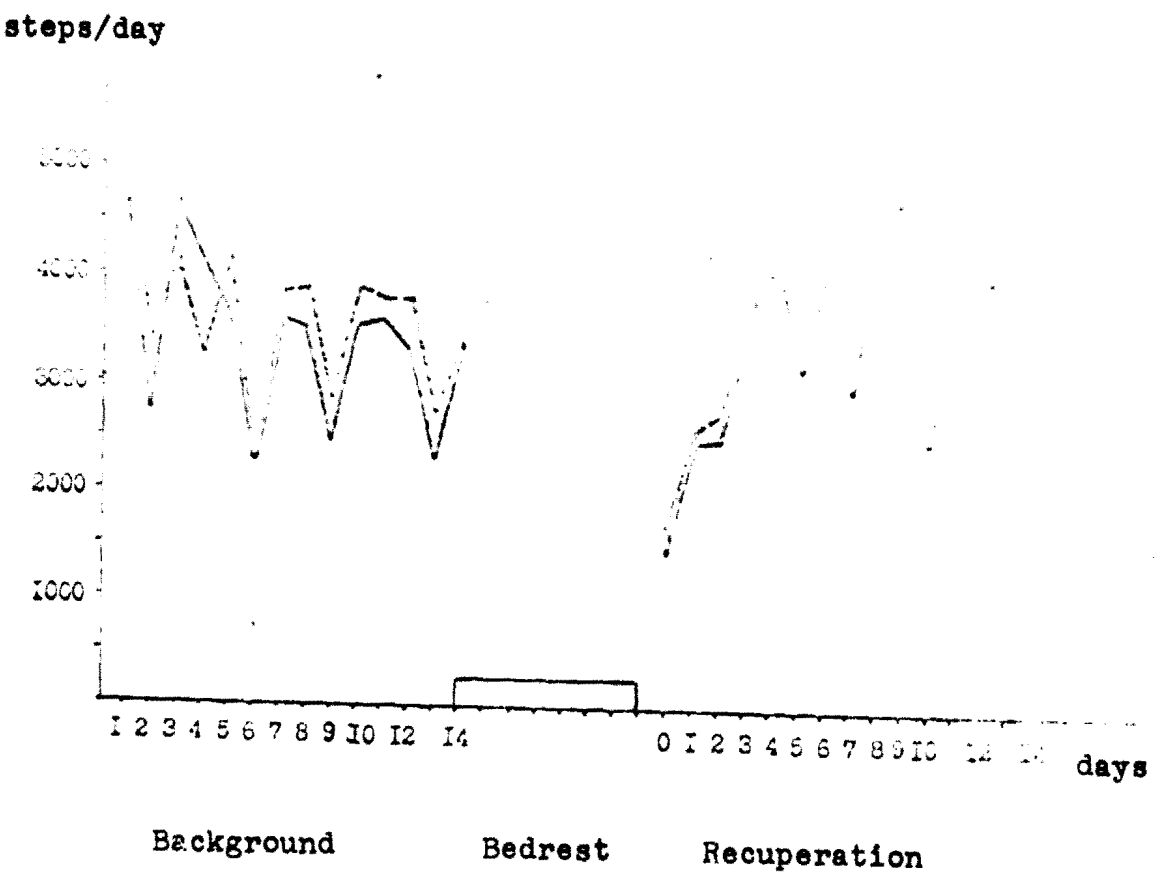


Table 3.2.4.

Graph of Temperature in the Wards (C).

Day of the Experiment	Date		Ward A Morning 8:00	Ward A Afternoon 14:00	Ward A Evening 21:00	Ward B Morning 8:00	Ward B Afternoon 14:00	Ward B Evening 21:00
[illegible]	[illegible]	May	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	May	[illegible]	[illegible]	20	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	May	[illegible]	[illegible]	19,5	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	May	[illegible],5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	May	[illegible]	[illegible]	21	20,5	[illegible]	[illegible]
[illegible]	[illegible]	May	20,5	[illegible]	20	[illegible],5	[illegible]	[illegible]
[illegible]	[illegible]	May	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	May	[illegible]	[illegible]	20	20	[illegible]	[illegible]
[illegible]	[illegible]	May	[illegible]	[illegible],5	20,2	[illegible],8	[illegible]	[illegible]
[illegible]	[illegible]	May	[illegible]	[illegible],3	[illegible],1	20	[illegible]	[illegible]
[illegible]	[illegible]	May	[illegible],8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	May	[illegible]	[illegible]	[illegible]	21	[illegible]	[illegible]
[illegible]	[illegible]	May	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	May	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	May	20	22	20	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	May	20	21	[illegible]	[illegible]	[illegible]	[illegible]
17	30	May	21	22	21	[illegible]	[illegible]	[illegible]
[illegible]	31	May	21	22	20	[illegible]	[illegible]	[illegible]
[illegible]	1	June	[illegible]	[illegible]	22	[illegible],2	[illegible]	[illegible]
[illegible]	[illegible]	June	[illegible]	[illegible]	21,2	[illegible]	[illegible]	[illegible]
[illegible]	3	June	[illegible]	21	[illegible],1	[illegible],2	[illegible]	[illegible]
[illegible]	[illegible]	June	18,5	19,[illegible]	1[illegible],5	1[illegible],0	[illegible]	[illegible]
[illegible]	[illegible]	June	[illegible]	[illegible]	19	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	June	1[illegible],5	20,0	18,7	[illegible],5	[illegible]	[illegible]
[illegible]	[illegible]	June	[illegible]	[illegible]	[illegible]	[illegible],5	[illegible]	[illegible]
[illegible]	[illegible]	June	18,5	18,5	18,5	1[illegible],5	[illegible]	[illegible]
[illegible]	[illegible]	June	18,2	18,5	18,3	[illegible]	[illegible]	[illegible]
[illegible]	10	June	18,5	19	19	1[illegible],7	[illegible]	[illegible]
[illegible]	11	June	18,5	18,5	19	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	June	18	18,4	18	18	[illegible]	[illegible]
[illegible]	[illegible]	June	18	18.5	18,2	18,5	[illegible]	[illegible]
[illegible]	[illegible]	June	18	19	18,5	[illegible]	[illegible]	[illegible]
[illegible]	15	June	19	21,5	21	[illegible]	[illegible]	[illegible]
[illegible]	16	June	20	22	21,5	20,2	[illegible]	[illegible]
[illegible]	17	June	20	22	20,6	20,5	[illegible]	[illegible]
[illegible]	[illegible]	June	21	20,5	20,5	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	June	21	20,5	20,5	21	[illegible]	[illegible]
38	20	June	20	21	20	20	21	[illegible]
39	21	June	19	21	20	19	21	[illegible]
40	22	June	19	21	20	19	21	[illegible]
			19,8	21	20,1	19,7	20,7	[illegible]

N. B. Commas in the tabulated values are to be understood as decimal points.

Table 3.2.5.

Daily Schedule of the Subjects.

[illegible]	Wake-up	[illegible]
[illegible]	Morning Examination[1]	[illegible]
[illegible]	Morning Gymnastics[2]	[illegible]
[illegible]	Morning Toilet	[illegible]
[illegible]	Breakfast	[illegible]
[illegible]	Relaxation	[illegible]
7.	Investigations	[illegible]
[illegible]	Lunch	[illegible]
[illegible]	Relaxation	[illegible]
[illegible]	Investigations	[illegible]
11.	Dinner	[illegible]
[illegible]	Free Time	[illegible]
[illegible]	Supper	[illegible]
14.	Free Time	[illegible]
[illegible]	Evening Examination	[illegible]
16.	Evening Toilet	[illegible]
17.	Sleep	[illegible]

Notes: [1]Blood samples are taken during the morning examination.

[2]During bedrest the morning gymnastics are not done.

of microflora of the skin for the subjects during their stay in the experiment, the napkins and towels were made of a fabric in which antimicrobial substances were incorporated. To intensify the antimicrobial action of these materials, the napkins were moistened with a special lotion containing an aromatic additive.

The napkins and towels were placed in packages, each of which was intended for the individual use of one package per man per day. The napkins were used to wipe the hands and face and for care of the mouth cavity after the nightly sleep, as well as for wiping the hands before taking meals. According to the comments of the subjects, these personal hygiene accessories produced a good sanitary effect.

The daily medical supervision of the state of health of the subjects throughout the entire experimental period was provided by round-the-clock attendance of physicians and average medical personnel. In case of emergency, it was possible to obtain immediate qualified and specialized medical aid.

The subjects were daily (morning and evening) measured for important vital indices: frequency of heart contractions, arterial pressure, and body temperature. The measurement of the body weight in the control and recuperation periods was done each morning from 7:00 to 8:00 in the vertical position of the body after emptying the urinary bladder. During the bedrest period, the subjects in group A were weighed in the horizontal position, those in group B in the antiorthostatic position. /55

All the physiological measurements and functional tests were done in standard conditions. The general daily schedule for each subject is shown in table 3.2.5. The experiment could be interrupted by request of the subject or indication by a physician.

Table 3.3.1.

Daily Food Ration No. 1 (2800 kcal)

1. Day (calculated data).

Food Products	Net Mass (g)	Contents (g)				Energy value (kcal)
		Water	Protein	Fats	Carbohydrate	
Breakfast:						
1. Steak	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2. Borodinskiy Bread	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3. "Ledokol" toffee	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4. Coffee with Milk	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sum:	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lunch:						
1. Curds w. Apple Jam	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2. Walnut Wafers	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3. Fruit Dessert, Plums, Cherries	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sum:	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Dinner:						
1. Beet Soup	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2. Beef Tongue Galatine	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3. Prunes w. Walnuts	60	7,6	0,8	12,2	[illegible]	[illegible]
4. Table Bread	45	17,6	2,8	1,4	[illegible]	[illegible]
5. Sweetened Apple-Cherry Juice	[illegible]	[illegible]	0,4	–	[illegible]	[illegible]
Sum:	335	345,8	40,4	46,7	[illegible]	[illegible]
Supper:						
1. Sweet & Sour Meat	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2. Honey Cake	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3. Tea w. Sugar	200	0,04	–	–	[illegible]	[illegible]
4. Candied Fruit	50	7,0	–	–	[illegible]	[illegible]
Sum:	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total:	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

N. B. Commas in tabulated values are to be understood as decimal points.

3.3. Nutrition

A. S. Ushakov, A. N. Kochetkova, R. S. Pushko, I. A. Ul'yanova /56

The nutritional requirements of the subjects in the joint experiment to study the action of antiorthostatic hypokinesia were supplied by a food ration of natural canned products, being an analogue of the food ration for the crews of the orbital station Salyut.

The total energy worth of the food ration was 2800 kcal before and after the bedrest, and approximately 2550 kcal during bedrest (the hypokinesia period).

Before and after the bedrest, the main characteristics of the food ration were the following: protein content - 111.7 grams, fat content - 109.4 grams, carbohydrate content - 371.1 grams. During the bedrest period, the protein content was 104.4 grams, that of fats 95.10 grams, and that of carbohydrates 317.4 grams. The rations of all periods were arranged by a 3-day menu with four meals a day.

In all the periods of the investigation, the subjects ate the entire meal. The consumption of liquid was not restricted, but was watched (cf. section 4.3 of the report).

The meals were taken four times a day: breakfast, lunch, dinner, and supper (section 3.2, table 3.2.5). The menu, contents, and calorie value of the ration by meals and days of the experiment before and after the bedrest period are shown in tables 3.3.1 - 3.3.3, those during the bedrest in tables 3.3.4 - 3.3.6. The amount of food consumed by one subject per day is shown in table 3.3.7. Data as to the analytical studies on the mineral composition of the food ration is considered in greater detail in section 4.3. From the table it follows that the daily consumption of basic foodstuffs by a subject is similar to the values stipulated by the program of the joint experiment. The general appraisal of the food ration by /57 the subjects was positive.

Summary

The subjects in the experiment on the action of antiorthostatic hypokinesia were given food of natural canned products, similar to the ration intended for the crews of the orbital station Salyut. The composition and calorie value of the food ration before, during, and after the bedrest period corresponded to the requirements of the subjects for nutritional substances and energy in these conditions. The food ration used in the experiment complied on the whole with the stipulated requirements and was given a positive appraisal by the subjects.

Table 3.3.2.

Daily Food Ration No. 1 (2800 kcal)
Day 2. (calculated data).

Food Products	Net Mass (g)	Contents (g)				Energy Value (kcal)
		Water	Protein	Fats	Carbohydrate	
Breakfast:						
1. Veal	I00	70,0	25,0	I,0	[illegible]	[illegible]
2. Borodinskiy Bread	45	I8,9	2,9	I,0	2I,0	[illegible]
3. Coffee w. Milk	I50	I22,4	2,I	2,4	[illegible]	[illegible]
4. "Ledokol" toffee	50	3,0	2,I	4,5	36,3	[illegible]
Sum:	345	2II,3	[illegible],I	8,9	84,7	[illegible]
Lunch:						
1. Curds w. Cranberry Jam	I65	86,8	I3,3	22,4	[illegible]	[illegible]
2. "Sakharnoye"-Pastry	30	I,5	2,5	2,4	23,I	[illegible]
3. Fruit Stick of Apples & Plums	50	8,5	0,7	-	[illegible]	[illegible]
Sum :	245	96,8	I6,5	24,8	[illegible]	[illegible]
Dinner:						
1. Sauerkraut Soup	I65	I26,5	6,9	I5,0	9,7	[illegible]
2. Russian Cheese	I00	45,0	2I,I	27,5	-	[illegible]
3. Table Bread	45	I7,5	2,8	I,7	22,5	[illegible]
4. Prunes w. Walnuts	60	7,6	6,3	I2,2	[illegible]	2I5
5. Black Currant Juice w. Pulp	I65	I20,6	0,7	-	[illegible]	[illegible]
Sum:	535	3I7,2	39,8	56,4	I32,8	I05I
Supper:						
1. Meat & Vegetables	I65	II4,0	20,5	I6,3	9,7	268
2. "Arktika" biscuit	25	2,2	2,5	2,3	I7,2	[illegible]
3. Fruit Dessert, Plums & Cherries	50	II,5	0,9	-	[illegible]	[illegible]
4. Tea w. Sugar	23	0,04	-	-	[illegible]	[illegible]
Sum:	268	I28,04	23,9	I6,9	[illegible]	[illegible]
Total:	I4I3	753,I4	II2,3	I09,0	388,3	[illegible]

N. B. The commas in the tabulated values are to be understood as decimal points.

Table

Daily Food Ration No. 1 (2800 kcal).

Day 3. (Calculated Data).

Food Products	Net Mass (g)	Contents (g)				Energy Value (kcal)
		Water	Protein	Fats	Carbohydrate	
Breakfast:						
1. Ham	100	55,5	20,5	8,[illegible]	[illegible]	[illegible]
2. Moscow Rye Bread	[illegible]	18,9	2,9	1,1	[illegible]	[illegible]
3. "Ledokol" toffee	50	3,0	2,1	4,[illegible]	[illegible]	[illegible]
4. Cocoa w. Milk	150	114,6	4,0	4,2	[illegible]	[illegible]
Sum:	345	202,0	29,5	17,8	[illegible]	[illegible]
Lunch:						
1. Curds w. Black Currant Jam	165	85,8	13,5	22,4	[illegible]	[illegible]
2. Pastry w. Cheese	25	1,3	3,2	6,2	[illegible]	[illegible]
3. Prunes	50	9,0	1,2	-	[illegible]	[illegible]
Sum:	240	95,9	17,9	28,6	[illegible]	[illegible]
Dinner:						
1. "Kharcho" soup	165	120,0	14,7	10,8	[illegible]	[illegible]
2. Choice Sausage	100	60,0	14,5	16,5	[illegible]	[illegible]
3. Plum Cake	50	2,5	3,1	11,1	[illegible]	[illegible]
4. Rye Bread	45	17,6	2,1	1,4	[illegible]	[illegible]
5. Sweetened Cherry Juice	165	134,0	0,4	-	[illegible]	[illegible]
Sum:	525	337,1	34,8	48,8	[illegible]	[illegible]
Supper:						
1. Pickled Mutton	165	109,7	26,2	10,9	[illegible]	[illegible]
2. "Sakharnoye" Cake	30	1,5	2,5	2,4	[illegible]	[illegible]
3. Tea w. Sugar	23	0,04	-	-	[illegible]	[illegible]
4. Fruit Stick of Apples and Plums	50	8,5	0,7	-	[illegible]	[illegible]
Sum:	268	119,4	29,4	21,3	[illegible]	[illegible]
Total:	1378	754,74	111,6	114,0	387.[illegible]	[illegible]

Table 3.3.4.

Daily Food Ration No. 2 (2500 kcal)
Day 1. (Calculated Data).

Food Products	Net Mass (g)	Contents (g)				Energy Value (kcal)
		Water	Pro-tein	Fats	Car-bohy-drate	
Breakfast:						
1. Steak	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2. Borodinskiy Bread	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3. "Ledokol" toffee	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4. Coffee w. Milk	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sum:	[illegible]	211,3	31,1	[illegible]	[illegible]	[illegible]
Lunch:						
1. Curds w. Apple Jam	165	88,6	18,4	22,[illegible]	[illegible]	[illegible]
2. Walnut Wafers	25	0,6	2,5	[illegible]	14,[illegible]	[illegible]
3. Fruit Dessert, Plums, Cherries	50	11,[illegible]	0,9	-	[illegible]	[illegible]
Sum:	240	90,0	18,8	23,0	[illegible]	[illegible]
Dinner:						
1. Beet Soup	165	121,9	3,9	19,8	10,1	[illegible]
2. Beef Tongue Galatine	80	63,0	21,0	13,0	1,0	[illegible]
3. Table Bread	45	17,5	2,8	1,7	22,5	[illegible]
4. Sweetened Apple-Cherry Juice	165	135,5	0,4	-	26,7	[illegible]
5. Apricot pastilki	8,5	0,4	0,3	-	7,2	[illegible]
Sum:	463,5	338,3	34,3	34,5	67,5	[illegible]
Supper:						
1. Sweet & Sour Meat	165	108,6	20,6	17,9	[illegible]	[illegible]
2. Tea w. Sugar	23	0,04	-	-	[illegible]	[illegible]
3. Candied Fruit	50	7,0	-	-	[illegible]	[illegible]
Sum:	238	115,64	20,6	17,9	73,1	[illegible]
Total:	1306,5	763,24	102,8	90,3	321,3	[illegible]

Table 3.3.5.

Daily Food Ration No. 2 (2500 kcal)
Day 2. (Calculated Data)

Food Products	Net Mass (g)	Contents (g)				Energy Value (kcal)
		Water	Protein	Fats	Carbohydrate	
Breakfast:						
1. Veal	[illegible]	70,6	[illegible]	[illegible]	[illegible]	[illegible]
2. Borodinskiy Bread	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
3. Coffee w. Milk	[illegible]	122,4	[illegible]	2,4	[illegible]	[illegible]
4. "Ledokol" toffee	50	3,0	2,1	4,6	[illegible]	[illegible]
Sum:	345	211,3	32,1	8,5	[illegible]	[illegible]
Lunch:						
1. Curds w. Cranberry Jam	165	86,6	13,3	22,4	[illegible]	[illegible]
2. "Sakharnoye" Cake	30	1,5	2,5	2,1	[illegible]	[illegible]
3. Fruit Stick of Apples and Plums	50	8,5	0,7	–	[illegible]	[illegible]
Sum:	245	96,6	16,5	24,6	[illegible]	[illegible]
Dinner						
1. Sauerkraut Soup	[illegible]	136,5	3,9	15,0	[illegible]	[illegible]
2. Russian Cheese	100	45,0	21,1	27,3	–	[illegible]
3. Table Bread	45	17,5	2,8	1,7	[illegible]	[illegible]
4. Black Currant Juice w. Pulp	165	120,6	0,7	–	[illegible]	[illegible]
Sum:	475	309,6	33,5	44,2	[illegible]	[illegible]
Supper:						
1. Meat & Vegetables	165	114,0	20,5	18,3	[illegible]	[illegible]
2. Tea w. Sugar	25	0,04	–	–	[illegible]	[illegible]
3. Fruit Dessert, Plums & Cherries	50	11,8	0,9	–	[illegible]	[illegible]
Sum:	238	126,84	21,4	18,3	[illegible]	[illegible]
Total:	1303	743,54	103,5	94,2	[illegible]	[illegible]

Table 3.3.6.

Daily Food Ration No. 2 (2500 kcal)
Day 3. (Calculated Data)

Food Products	Net Mass (g)	Contents (g)				Energy Value (kcal)
		Water	Protein	Fats	Carbohydrate	
Breakfast:						
1. Ham	[illegible]	65,5	[illegible]	[illegible]	[illegible]	[illegible]
2. Moscow Rye Bread	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3. "Ledokol" toffee	[illegible]	3,0	[illegible]	[illegible]	[illegible]	[illegible]
4. Cocoa w. Milk	15	114,0	4,0	[illegible]	[illegible]	[illegible]
Sum:	[illegible]	202,0	29,5	[illegible]	[illegible]	[illegible]
Lunch:						
1. Curds w. Black Currant Jam	[illegible]	85,0	13,5	[illegible]	[illegible]	[illegible]
2. Pastry w. Cheese	25	1,3	3,2	6,2	[illegible]	[illegible]
3. Prunes	50	9,0	1,2	-	[illegible]	[illegible]
Sum:	[illegible]	95,3	[illegible]	[illegible]	[illegible]	[illegible]
Dinner:						
1. "Kharcho" Soup	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2. Choice Sausage	[illegible]	60,0	[illegible]	[illegible]	[illegible]	[illegible]
3. Rye Bread	45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4. Sweetened Cherry Juice	165	[illegible]	[illegible]	-	[illegible]	[illegible]
Sum:	475	334,6	31,7	35,2	[illegible]	[illegible]
Supper:						
1. Pickled Mutton	[illegible]	[illegible]	26,2	[illegible]	[illegible]	[illegible]
2. Tea w. Sugar	23	0,04	-	-	[illegible]	[illegible]
3. Fruit Stick of Apples & Plums	50	8,5	0,7	-	[illegible]	[illegible]
Sum:	[illegible]	[illegible]	26,9	[illegible]	[illegible]	[illegible]
Total:	[illegible]	750,74	[illegible]	[illegible]	[illegible]	[illegible]

Table 3.3.7.

Consumption of Basic Food Substances (g), Mineral Elements (mg), and Vitamins (mg) (calculated & actual data per 1 person per day).

Components	Periods of the Experiment		
	prior to bedrest	bedrest	after bedrest
Protein	[illegible],7	I[illegible],I	[illegible]
Fats	[illegible],4	[illegible],[illegible]	[illegible]
Carbohydrates	[illegible],I	3I7,4	[illegible]
Mineral Elements			
Sodium	[illegible]±222[x]	[illegible]±I[illegible][x]	[illegible]
Potassium	[illegible]±90[x]	[illegible]±32[x]	[illegible]
Calcium	[illegible]±200[x]	[illegible]±I[illegible][x]	[illegible]
Magnesium	[illegible]±I4[x]	[illegible]±0	[illegible]
Phosphorus	I[illegible]5,03	I440,44	[illegible]
Iron	I04,68	3I,53	[illegible]
Vitamins			
A	3,8	3,76	[illegible]
B_1	I,II	I,[illegible]	[illegible]
B_2	I,44	I,4I	[illegible]
C	34,02	35,3I	[illegible]
PP	I5,6I	I5,4[illegible]	[illegible]
Fiber (g)	4,38	3,96	[illegible]

Note: x - data from analytical investigations.

N.B. Commas in the tabulated material are to be understood as decimal points.

Table 3.4.1

Body Temperature (°C) of the Subjects at Various Periods of the Experiment.

Time of Measurement	Group	Values	before BR	BR (days)							after BR (days)									
			Mean	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	8	9	10
morning	"A"	M	36,0	35,7	35,9	35,9	36,1	36,0	36,1	35,8	36,0	36,0	36,0	36,1	35,8	36,1	35,8	35,8	36,1	36,0	35,6
		σ	0,17	0,15	0,20	0,28	0,42	0,26	0,33	0,23	0,27	0,27	0,13	0,15	0,23	0,24	0,21	0,35	0,02	0,15	0,[illegible]
		m	0,02	0,07	0,09	0,12	0,19	0,12	0,15	0,10	1,12	0,12	0,06	0,07	0,10	0,11	0,09	0,16	0,04	0,07	0,[illegible]
	"B"	M	36,1	36,2	36,0	36,0	36,0	36,1	36,2	36,0	35,9	35,9	36,1	36,0	36,0	35,9	36,1	36,0	36,2	36,0	36,[illegible]
		σ	0,32	0,36	0,13	0,11	0,27	0,39	0,18	0,38	0,44	0,17	0,24	0,23	0,19	0,21	0,30	0,16	0,33	0,15	0,[illegible]
		m	0,04	0,16	0,06	0,05	0,12	0,17	0,08	0,17	0,20	0,08	0,11	0,10	0,09	0,09	0,13	0,07	0,15	0,07	0,[illegible]
evening	"A"	M	36,5	36,2	36,5	36,4	36,4	36,5	36,3	36,6	36,3	36,4	36,4	36,4	36,6	36,4	36,6	36,5	36,4	36,5	36,[illegible]
		σ	0,23	0,55	0,36	0,17	0,29	0,15	0,28	0,14	0,34	0,28	0,24	0,27	0,33	0,42	0,22	0,14	0,17	0,33	0,[illegible]
		m	0,03	0,25	0,16	0,07	0,13	0,07	0,12	0,06	0,15	0,13	0,11	0,12	0,15	0,19	0,10	0,06	0,08	0,11	0,[illegible]
	"B"	M	36,5	36,5	36,3	36,4	36,5	36,3	36,3	36,5	36,4	36,5	36,5	36,6	36,4	36,5	36,5	36,6	36,[illegible]	[illegible]	[illegible]
		σ	0,21	0,18	0,29	0,21	0,24	0,22	0,29	0,29	0,13	0,15	0,29	0,13	0,23	0,09	0,13	0,12	0,1[illegible]	[illegible]	[illegible]
		m	0,03	0,03	0,13	0,09	0,11	0,10	0,1[illegible]	0,13	0,06	0,07	0,13	0,07	0,10	0,04	0,06	0,05	0,08	0,0[illegible]	0,[illegible]

Note: BR - bedrest

N.B. Commas in the tabulated material are to be understood as decimal points.

3.4. Clinical Observations

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The purpose of the clinical observations was to discern possible illnesses and to compare the general state and well-being of the subjects in the horizontal and in the antiorthostatic positions.

3.4.1. Survey of the Literature

Hypokinesia exerts a considerable polymorphic influence on the human organism, serious in view of the fact that the possibility of disease cannot be excluded, since the restriction of the motor activity depresses the resistance of the organism to the negative action of environmental factors [1-3]. In particular, hypokinesia is considered one of the risk factors for ischemic heart disease [4,5].

In the view of L. I. Kakurin, "prolonged restriction of the afferent condition of the analyzers and receptors of the blood circulation and neuromuscular apparatus may substantially change the internal environment of the human and animal organism and be attended by persistent functional disorders."[1] For this reason, the basic condition in carrying out an experiment of this kind is strict medical supervision of the subjects' state of health, both for their safety and to exclude stochastic results.

Clinical observations on healthy people in conditions of clinostatic and antiorthostatic hypokinesia have been described more than once [6,7], but it is desirable to possess a more distinct and differentiated clinical picture for the horizontal and antiorthostatic positions. The reaction of the heart contraction frequency and the size of the arterial pressure in these two positions have a peculiar dynamics, although the quickening of the pulse upon transfer from the hypokinesia regimen to normal motor activity has been very clearly noted [8-11]. All of this is the reason for the current investigation.

3.4.2. The Procedure

All 10 subjects were under medical observation for 35 days, including a daily examination by a therapeutist. Selected as indices for the general condition of the subjects were: pulse frequency, systolic and diastolic arterial pressure, temperature, and body weight. All the measurements were done in the morning at 8:00 and in the evening at 10:00.

3.4.3. The Findings

Before, during, and after the bedrest, the general condition and well-being of all the subjects in both groups remained satisfactory. There were no complaints indicative of illness. An

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[1] In the book: Fiziologicheskiye Problemy Detrenirovannosti [Physiological Problems of Deconditioning], Moscow, 1968, p. 36.

exception are three subjects. For two of them, T-in and A-ev, slight headaches were noted prior to the bedrest, apparently involving a tendency to a slight hypertension, since a raising of the arterial pressure to 130-140/90-100 mm mercury was noted in them toward evening. Other clinical symptoms were not observed. The sleep remained undisturbed. Medicinal therapy was not employed. For P-iy, a toothache (pulpitis) developed after the bedrest period, which was remedied after sanitation.

An analysis of the body temperature graphs also gives no reason to suppose that illness was present (table 3.4.1). The maximum body temperatures only reached 36.9°C (S-v: P-3, P-1, W-4; Sh-ov: W-4; T-in: P-8, P-9; Zh-ov: P-3). /68

No unpleasant sensations were reported by the subjects during the first hours of their stay in conditions of horizontal positioning. On the contrary, the subjects in antiorthostasis even in the first minutes perceived a feeling of heat, bloodrush to the head and chest, a heaviness in the head, a blockage of the nose and, in isolated cases, of the ears and, associated with this, a difficulty in nose breathing. Certain subjects experienced a bulging in the vicinity of the sinus epididymidis of the nose, a feeling of pressure on the eyeballs, and a pressure behind the chest. For these same subjects, a swelling of the face and injection of the sclera and conjunctiva was observed. In isolated cases, there was hoarseness of the voice (table 3.4.2).

By the end of the first days, the subjects in the horizontal position experienced unpleasant sensations in the area of the back, occasionally pain, physical discomfort, and inconvenience in lying. Those in antiorthostasis, in addition to these sensations, also experienced pain in the back and coldness in the legs. By the end of 2-3 days, these unpleasant sensations disappeared, except for a puffiness of the face, which remained until the end of the bedrest period for the subjects in group B.

At the conclusion of the bedrest, especially in the first days, the subjects experienced a general weakness and dizziness upon standing up. Their face and neck were pale, and acrocyanosis of the extremities was observed. By the end of the day, pains appeared in the muscles of the back and, especially, of the legs. The alterations later diminished gradually and practically disappeared by 2-3 days for the subjects of group A and 3-4 days for those of group B.

The analyzed indices for the functional condition of the organism, with the exception of the arterial pressure, as noted earlier, remained for the entire length of the experiment within the bounds of transient fluctuations natural to a healthy person. /70

The frequency of heart contractions during the bedrest was somewhat less, for both groups, than it was during the background examinations, especially in the evening hours. As concerns the

Table 3.4.2.

Clinical Symptoms of the Subjects During Bedrest.

Symptoms	Groups A	B
Lowered threshold of gustatory and olfactory sensitivity	-	
Sensation of bloodrush & feeling of heaviness in head	-	
Stuffy nose	-	
Feeling of discomfort in nasopharynx, hoarseness	-	-
Dizziness	-	
Spatial illusions	-	
Nystagmoid movements of the eyeballs	-	
Swelling of the face and injection of the vessels of the sclera and conjunctiva	-	
Sensation of "fullness" in the eyes, eye fatigue when reading	-	

Note: the symbol (+) indicates the degree of expression of the symptom, (-) indicates its absence.

Table 3.4.3.

Frequency of Heart Contractions (beats/min) for the Subjects at Various Periods of the Experiment.

Time of Measurement	Group	Values	before BR mean	BR (days) 1	2	3	4	5	6	7	after BR (days) 0	1	2	3	4	5	6	7	8	9	10
morning	"A"	M	64	62	60	61	64	58	57	58	63	66	63	62	68	64	66	62	63	67	63
		σ	5,7	2,2	7,0	5,2	4,0	8,7	6,7	8,8	3,9	7,3	5,2	3,6	8,8	11,7	3,6	4,6	8,7	10,3	3,.
		m	0,7	1,0	3,1	2,3	1,8	3,9	3,4	3,9	1,7	3,3	2,3	1,6	3,9	5,2	1,6	2,0	3,9	7,1	1,.
	"B"	M	68	65	62	61	62	70	64	63	60	64	66	60	64	64	62	66	61	6.	6.
		σ	7,5	7,2	6,1	9,6	7,8	7,4	8,9	5,9	7,3	11,2	8,2	6,1	9,6	9,4	6,0	7,3	5,9	4,1	4,.
		m	0,9	3,2	2,7	4,4	3,5	3,3	4,0	2,7	3,3	5,0	3,7	2,7	4,3	4,2	2,7	3.3	2,7	1..	2,.
evening	"A"	M	71	62	64	60×	61	62	66	66×	82	77	71	78	68	74	78	81	74	7.	7.
		σ	9,5	7,3	8,8	7,5	3,0	4,6	4,5	5,4	8,8	4,4	6,3	9,0	7,5	11,9	11,5	8,9	10,4	4,.	6,.
		m	1,1	3,3	3,9	3,4	1,4	2,0	2,0	2,4	3,9	2,0	2,8	4,0	3,4	5,3	5,2	4,0	4,7	2,.	4,.
	"B"	M	75	71	70	71	66	70	68	74	80	80	74	78	79	75	76	82	78	6.	7.
		σ	7,8	5,2	6,9	5,8	10,4	8,3	6,8	4,9	6,3	12,7	4,0	3,8	10,2	8,9	4,6	11,0	4,8	8,.	
		m	0,9	2,3	3,1	2,6	4,7	3,.	3,0	2,.	2,.	5,7	1,.	1,.	4,.	3,0	2,.	4,.	4,1		6,.

Note: BR = bedrest, x = $r < 0.05$

N.B. Commas in the tabulated material are to be understood as decimal points.

dependence on the position of the body in the bed, the slowing of the pulse was more expressed for those subjects in the horizontal position. The greatest deviation was on the fifth day of bedrest in the morning and on the third and seventh days in the evening. The mean difference was, respectively, 11.6, 11.2, and 7.6 beats/min.

In the first days of the recuperation period, the pulse frequency not only increased as compared to the bedrest period, but also in comparison to the background examinations, by 10 beats/min in group A and 5 beats/min in group B ($r < 0.05$). There was no difference between the groups: 81.6 ± 3.92 and 80.0 ± 2.83 beats/min (table 3.4.3).

No significant alterations were observed in the arterial pressure during all three periods (tables 3.4.4 and 3.4.5). Mention can be made of a depression in the systolic and diastolic pressure for the subjects in antiorthostatic conditions in the morning for the first days of bedrest. The systolic arterial pressure was lowered from 113.1 ± 1.41 mm mercury in the background period to 99.0 ± 3.23 mm mercury ($r < 0.05$), while the diastolic pressure was lowered from 74.2 ± 1.22 to 65 ± 2.24 mm mercury ($r < 0.05$). The discrepancy between the groups is also certain. Moreover, in three days of bedrest the systolic arterial pressure in the subjects of this same group increased to 120 ± 3.16 mm mercury, which exceeded the corresponding index for the subjects of group A ($r < 0.05$). /74

We may also note the weight loss of subjects in both groups (table 3.4.6). On the average, this was 0.7 kilograms in all in group A, while in group B it was 1.7 kilograms. The principal change in the body weight occurred in the first three days of hypokinesia. Evidently, this was due, not to pathological processes in the organism, but to a change in its hydration level, in consequence of the new conditions of hydrostatic pressure. For this reason, a careful analysis of the subjects' weight is presented in the section on the water-salt metabolism [4.3].

In conclusion it must be noted that, although no cases of serious disease were observed in the subjects during the experiment, the sojourn in hospital conditions permitted the development of a hypertensive reaction and local inflammation in certain of the subjects. On the one hand, this should serve as a caution for a more careful selection of subjects and, on the other hand, the use of hospital observation may be recommended for the selection of those destined to work in the experimental conditions.

The absence of major changes in the general health and well-being of the subjects at rest after a week's stay in bedrest conditions was in keeping with the preceding studies [12].

The alterations in the general health and well-being of the subjects in antiorthostatic conditions are rather similar to the pattern observed during space flight [13]. The leveling off of the differences in the general health indices of subjects in both groups toward the end of the bedrest supports the assumption of a smoothing

Table 3.4.4.

Systolic Arterial Pressure (mm mercury) of the Subjects at Various Periods of the Experiment.

Time of Measurement	Group	Values	before BR Mean	BR (days) I	2	3	4	5	6	7	after BR (days) 0	I	2	3	4	5	6	7	8	9
morning	"A"	M	III	I06	II0	I09	III	I08	I09	I09	II5	I04	II2	II6	I06	II0	I03	I06	II6	I07
		σ	7,3	II,9	3,5	6,5	3,5	I0,4	2,2	8,9	7,I	9,6	9,8	9,6	4,2	II,7	8,4	8,2	7,I	8,4
		m	I,0	5,3	I,6	2,9	I,6	4,6	I,0	4,0	3,2	4,3	4,4	4,3	I,9	5,2	3,7	3,7	3,2	3,7
	"B"	M	II3	99	I09	I09	II4	I09	I06	III	I07	III	III	II5	I08	II0	I02	I02	I07	II3
		σ	II,4	7,4	I5,2	I2,5	5,5	8,9	6,5	6,9	I5,7	I0,8	I0,8	7,I	I2,6	9,4	I0,4	I0,8	I3,6	8,4
		m	I,4	3,3	6,8	5,6	2,5	4,0	2,9	4,3	7,0	4,9	4,9	3,2	5,6	4,2	4,6	4,9	5,3	3,7
evening	"A"	M	II5	II0	II0	II2	I07	III	II5	II4	II0	II3	II2	II3	I20	II5				
		σ	8,5	6,I	5,0	5,7	I2,6	8,9	I4,I	9,6	I2,9	I0,4	I0,4	8,4	I2,3	5,0	8,4	9,6	6,7	
		m	I,0	2,7	2,2	2,6	5,6	4,0	6,3	4,3	5,8	4,6	4,6	3,7	5,5	2,2	3,7	4,3	3,0	
	"B"	M	I22	II4	II0	I20x	II4	II6	II2	II5	II8	II8	I2[illegible]	II5	I23	I30	I08	I26		
		σ	I2,6	I0,8	I4,6	7,I	6,5	9,6	I2,6	7,I	I5,3	II,5	[illegible]	[illegible]	I2,0	I2,8	II,5	I2,2		
		m	I,5	4,9	[illegible]	[illegible]	2,9	4,3	5,6	[illegible]	6,8	5,2	[illegible]	6,I	5,4	5,7	[illegible]	[illegible]		

Note: BR = bedrest, x = $r < 0.05$

N.B. Commas in the tabulated material are to be understood as decimal points.

Table 3.4.5.

Diastolic Arterial Pressure (mm mercury) of the Subjects at Various Periods of the Experiment.

Time of Measurement	Group	Values	before BR Mean	BR (days) 1	2	3	4	5	6	7	after BR (days) 0	1	2	3	4	5	6	7	8	9
morning	"A"	M	74	79x	74	75	79	79	76	73	78	72	77	74	74	76	72	71	76	72
		σ	5,8	12,5	2,4	10,0	8,9	8,9	6,5	4,5	4,5	9,8	5,7	4,2	5,5	5,5	2,7	5,5	4,2	6,7
		m	0,7	5,6	1,0	4,5	4,0	4,0	2,9	2,0	2,0	4,4	2,6	1,9	2,5	2,5	1,2	2,5	1,9	3,0
	"B"	M	74	65	77	73	73	75	73	77	73	73	76	73	72	74	75	76	72	
		σ	9,9	5,0	12,0	8,4	8,4	6,1	4,5	10,4	13,0	8,4	4,2	11,0	10,4	9,0	6,1	9,6	10,4	
		m	1,2	2,2	5,4	3,7	3,7	2,7	2,0	4,6	5,8	3,7	1,9	4,9	4,6	4,3	2,7	4,3	4,6	
evening	"A"	M	77	80	76	80	79	79	77	77	76	75	75	73	78	74	74	74	69	
		σ	7,0	6,1	4,2	4,1	10,8	2,4	5,7	2,7	6,5	6,1	5,0	6,7	14,8	6,5	4,2	6,5	8,9	
		m	0,8	2,7	1,9	2,7	4,9	1,0	2,6	1,2	2,9	2,7	2,3	3,0	6,6	2,9	1,9	2,9	4,0	
	"B"	M	81	71	76	82	77	76	76	77	82	79	82	78	79	77	75	65	82	80
		σ	10,0	8,2	6,5	13,0	2,7	4,2	8,2	5,7	9,1	9,6	7,6	6,5	7,4	11,0	5,0	14,6	11,0	8,2
		m	1,2	3,7	2,9	5,8	1,2	1,9	3,7	2,6	4,1	4,3	3,4	3,2	3,3	4,9	2,2	6,5	4,9	3,1

Note: BR = bedrest, x = r 0.05
N.B. Commas in the tabulated material are to be understood as decimal points.

Table 3.4.6.

Body Weight (kg) of the Subjects at Various Periods of the Experiment.

Time of Measurement	Group	Values	before BR Mean	BR (days) I	2	3	4	5	6	7
morning	"A"	M	74,I	73,6	73,5	73,5	73,5	73,5	73,8	73,[illegible]
		σ	6,0	6,5	6,5	6,4	6,4	6,4	6,4	6,[illegible]
		m	I,0	2,8	2,8	2,8	2,8	2,8	2,8	2,[illegible]
	"B"	M	8I,5	8I,I	80,8	80,4	80,3	79,9	79,9	79,9
		σ	5,2	6,3	5,4	5,3	5,4	5,6	5,6	5,6
		m	0,9	2,4	2,4	2,4	2,4	2,5	2,5	2,[illegible]
evening	"A"	M	74,6	74,8	73,5	73,3	73,9	73,5	73,9	73,[illegible]
		σ	5,8	5,2	6,5	5,3	6,3	5,2	6,I	5,[illegible]
		m	0,7	2,8	2,6	2,4	2,8	2,8	2,8	2,[illegible]
	"B"	M	82,I	8I,9	8I,8	80,8	80,9	80,4	80,8	73,8
		σ	5,0	5,3	5,3	5,4	5,6	5,5	5,4	5,3
		m	0,6	2,4	2,3	2,5	2,5	2,4	2,5	1,[illegible]

Note: BR = bedrest

N.B. Commas in the tabulated material are to be understood as decimal points.

of the differences in their physiological reactions in the recuperation period. /77

3.4.4. Summary

A week's stay in bedrest conditions, both in the horizontal and in the antiorthostatic position, does not produce pathological alterations in healthy people. More pronounced changes in the well-being and general health of the subjects is observed in conditions of antiorthostatic hypokinesia.

Table 3.4.6.
(Cont'd)

Body Weight of the Subjects (kg) at Various Periods of the Experiment.

Time of measurement	Group	Values	after BR (days) 0	I	2	3	4	5	6	7	8	9	I0
morning	"A"	M	73,3	73,6	73,8	73,5	73,3	73,4	73,4	73,3	73,3	73,3	73,2
		σ	5,9	6,I	6,I	6,0	6,3	6,I	6,0	6,I	6,2	6,I	6,2
		m	2,6	2,7	2,7	2,7	2,7	2,7	2,7	2,8	2,8	2,7	2,8
	"Б"	M	79,8	80,0	80,I	80,I	79,7	79,9	79,7	79,6	79,7	79,7	79,6
		σ	5,4	5,4	5,7	5,5	6,0	5,2	5,2	5,I	5,2	5,2	5,I
		m	2,4	2,4	2,5	2,4	3,0	2,3	2,3	2,3	2,3	2,3	2,3
evening	"A"	M	73,9	74,3	74,I	74,0	73,I	73,8	74,0	73,8	73,3	73,8	73,7
		σ	5,9	5,9	5,8	6,0	5,4	6,2	6,2	6,2	6,I	6,0	6,I
		m	2,6	2,4	2,6	2,7	2,6	2,6	2,6	2,6	2,5	2,7	2,8
	"Б"	M	80,5	80,9	80,4	80,2	80,I	80,4	80,2	80,0	80,0	79,2	80,3
		σ	5,4	5,7	5,5	6,I	5,5	5,2	5,I	5,2	5,I	5,4	5,5
		m	2,4	2,5	2,5	3,0	2,4	2,2	2,4	2,4	2,4	2,7	2,5

Note: BR = bedrest

N.B. Commas in the tabulated material are to be understood as decimal points.

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3.5. The Gathering and Analysis of the Data

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The contemporary level of experimental medico-biological research is being characterized to an ever greater extent by the transition from particular evaluations to complex assessments of the "experimental environment." Scientific, as well as economic, aspects make it essential to employ a systematic approach in the realization of a research program: from the formulation of the problem and the planning and organization of experiments to the integration, storage, and analytical processing of data. In the realization of such experiments, the computer plays an active role. Moreover, in recent years one notes a qualitatively new appraisal for the role of computer hardware and software in biomedical research. The enthusiastic expectation of "exclusively intellectual" capabilities of the "electronic brain" gave birth, in its time, to the opinion that automatic data processing systems would be able to compete successfully with thought and the experience of serious investigation. But time showed that such an opinion is confirmed only in relatively simple situations. Despite the indisputable importance of the current achievements in the automation of experimental projects, it must be recognized that, in the field of analytical working with data, automatic systems do not yet play a noticeable role, which is left to the investigator (especially at the stage of making a decision as to the scientific problem). It appears that the reason for this lies not only in the complexity of the research object, but also in the insufficient effectiveness of the formal (mathematical) data analysis procedures and the failure to take into consideration the "heuristic" approach of a competent investigator to the interpretation (pattern of thinking) of data in the process of logical deduction.

Man-machine systems, combining the "intellect" of the computer /81
with that of the researcher, are now playing an evermore noticeable role in the praxis of medico-biological research. The current state of development of these systems may be described as a stage of mutual approximation, the fundamental working principle being an "interaction" that allows the researcher to avail himself of the hardware and software of the computer at his own discretion, taking into account the peculiar logic of its data analysis, but under the operational control of the computer environment. One can discern three levels in this type of information processing system:

- specialized complexes of laboratory measuring and calculating equipment, capable of producing an initial set of experimental data with possibility of preliminary processing, extraction of informational features, and condensation of information for transmission to the data bank of an upper-level computer;
- programmed information-computer complexes for analytical working with integrated data banks in a "researcher-computer" dialogue on a basis of languages that are similar to natural speech;
- programmed systems for administrative control (planning) of scientific research in the problem area.

At each of the above levels, there are distinctive subsystems for processing an appropriate level of information.

The interpretation and processing of the experimental data from the joint Soviet-American experiment was carried out in conformity with the above considerations.

In accordance with the schedule of work for this experiment, the following divisions of labor were set up:

3.5.1. An information model of the experiment was developed (including the stages of designating the experimental data, the unified formats in representing the primar material for entry into the computer data bank, unified forma for issuing of reference information and findings from the computer data bank, etc.). /82

3.5.2. A specialized data bank for the experiment was generated (with capability of entering data furnished by the Americans).

3.5.3. The computer bank was filled with primary data obtained at the Soviet end.

3.5.4. A complex of programs was written for calculating secondary indices by request of the researchers.

3.5.5. Using the dialogue program complex, results from a calculation of secondary indices and results of a standard statistical processing of all the material were obtained and issued to the researchers (in conformity with the stipulated agreement).

3.5.6. Using the dialogue program complex, Supplement B was formulated (individual and statistical data on the joint Soviet-American experiment with hypokinesia).

Summary

A computer data library (bank) has been organized for the joint Soviet-American experiment with hypokinesia (SAEG-1).

The possibility was created for a later, more profound study of the data from this experiment (the analysis by both individual research procedures and their totality for systems analysis) on the basis of the dialogue program complex.

4.0. Clinical and Laboratory Analyses /83

4.1. Collection of Blood and Urine Specimens

Blood was taken from the ulnar vein in a lying position on an empty stomach at 7:30 in the morning. During the baseline period and during recovery, the test subjects were in a horizontal position for two hours before the blood sample was taken: the blood was studied according to the following schedule: the baseline study was performed 6, 12 and 14 days before the beginning of the bed rest, then 2, 4 and 7 days during hypokinesia and 2 and 7 days after the end of bed rest. The blood was centrifuged at +4°C for 20 min at 3000 rpm. The total amount of venous blood in a single sample did not exceed 50.0 ml.

Blood was taken from the finger to study the acid-base balance at the same time as the venous blood was taken.

Urine was collected daily throughout the experiment from each test subject. Each separate urine specimen was poured into a separate bottle and stored in a refrigerator (at +4°C). At the end of the daily collection, the volume of the urine obtained was measured and the urine designated for the electrolyte analysis was acidified with nitric acid (0.25 ml of concentrated acid per 12 ml of urine).

4.2. Biochemistry and Endocrinology /84

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4.2.0. Literature Review

Results of biochemical analyses performed during space flight [1] and after landing of the cosmonauts [1-4] demonstrate that existence under weightlessness causes specific metabolic and hormonal changes.

The acquisition of valuable information on the direct effect of space flight factors on the human body are difficult because of the low number of crew members in space ships and the considerable limitation of the material studied; because of this, research on simulating isolated space flight factors under terrestrial conditions acquires considerable significance.

Many researchers use the effect of bed rest for simulating effects of weightlessness.

It is known that gravitational redistribution of blood in combination with immobilization is accompanied by changes in tissue metabolic activity [5-7]. The disturbance of the enzymatic

coordination of chains of various types of metabolism within internal organs under extreme situations is reflected in changes in serum enzyme spectrum as a result of specific dysfermentemia mechanisms. The study of various types of enzymopathies has great significance for diverse enzymatic shifts participating in the /85
transformation of various metabolic processes during body adaptation to changing conditions.

It was established that the activity of certain serum enzymes in humans change after prolonged bed rest [8], and also as a result of space flight factors [2,9]. Study of aminotransferase activity in arterial and mixed venous blood after 5-day antiorthostatic hypokinesia (ANOH) revealed an increase in their activity, with the increase in AST activity much more evident than ALT activity [10]. The increase in ALT activity was also noted by other investigators [11]. Other authors observed a decrease in the activity of alkaline phosphatase and the isozyme LDH_3 during a 14-day—long hypokinesia, whereas blood ALT activity increased [12].

Study of protein metabolism parameters during prolonged immobilization revealed both a decrease in the total protein level [13], and its invariability at different periods of hypokinesia [14,15] with a simultaneous decrease in uric acid and albumin content and an increase in globulins in blood [16].

During the first half of a 7-week ANOH, there was an increase in the lactic and pyruvic acid level with a stable blood glucose level, whereas the second half of the experiment was characterized by a decrease in lactate and pyruvate concentration and a significant increase in blood glucose level [6]. American researchers also noted the invariability of blood glucose during the first 30 days of a 56-day hypokinesia, however glucose level decreased noticeably if the bed rest was prolonged [17]. /86

There are isolated reports on the study of acid-base balance (ABB) parameters during hypokinesia [6,18]. Since iron is necessary for the transport of oxygen in blood, transfer of oxygen to tissues, hemoglobin synthesis and erythrocyte formation, the study of this element is of great interest and directly related to the study of the blood buffer system. The literature contains information on the increase in iron loss during space flight [19]. The authors studied the quantitative balance of iron consumed with food and excreted with feces and noted that the value for iron excretion was 1.9-fold greater than its absorption value.

No one doubts the fact that the neuroendocrine system plays an important role in homeostasis mechanisms. In this regard, the study of processes occurring within the body during hypokinesia should include investigation of the functional status of the hypothalamohypophyseal system and peripheral endocrine glands, which finely control metabolism. However, this became possible only with the development in recent years of highly sensitive and accurate radioimmunological techniques for determining hormones and their metabolites in

biological fluids. Taking into account that after exposure of the human body to various extreme factors the endocrine system actively participates in homeostasis, one can expect the appearance of specific changes in the activity of many endocrine glands, and above all, in the hypophysis-adrenal system.

It has been demonstrated that after exposure to various durations of hypokinesia, a decrease is observed in animals in the norepinephrine content in organs such as the myocardium, hypothalamus, and adrenals [20,21]. On the other hand, it has been demon- /87
strated that limited motor activity is a stress factor for animals and produces changes not only in body levels of catecholamines, but also in their synthesis and inactivation [22-24], because of variation in the control of activity of enzymes responsible for these processes.

Many investigators have established that urine norepinephrine level in subjects after various periods of bed rest decreased significantly, but epinephrine level either did not change or increased [25-26]. Experiments we conducted on the analysis of SAS activity in subjects during a 7-week antiorthostatic (-4°) hypokinesia demonstrated that the activity of SAS mediator link decreased and the hormonal link was significantly elevated, which indicates an emotional response in subjects [27].

Information on the functional status of the adrenal cortex during limited activity is contradictory. In some investigations there were indications of a decrease in adrenal cortex functional activity [28], and in others the activation of the glucocorticoid function [2,29-32]. In some cases, a significant deviation was noted from initial values during prolonged hypokinesia, although the authors noted a tendency for 17-HCS excretion to increase at the end of the experiment [33]. Interesting is the fact that during prolonged antiorthostatic hypokinesia (-4°) the ACTH level in blood in subjects was notably elevated with a simultaneous decrease in the 11-HCS blood level and excretion of total 17-HCS with urine was significantly elevated [34]. A similar dissociation between the ACTH and cortisol content in blood was noted by American researchers [35]. The /88
causes of this phenomenon remain unexplained.

Plasma renin activity during bed rest increased, whereas blood aldosterone level and its excretion with urine varied insignificantly [36]. A decrease in the blood aldosterone level was also noted in subjects in the initial stage of the experiment; in this case, its excretion with urine did not increase throughout the investigation [35].

Significant changes in the relationship between glucose and insulin in blood were noted during a 56-day hypokinesia [17], i.e, an increase in the insulin level with a stable blood glucose level. Elevated STH secretion during the second half of the experiment was observed in many subjects in the same experiment; this indicated

changes in the status of the hypothalamus or hypophyseal dysfunction. During a 7-week antiorthostatic hypokinesia (-4°), other investigators also noted elevation of the blood insulin level; however, the STH level in blood was reduced during the entire experiment; in this case FSH activity decreased and the LH level in blood increased in subjects [33].

Analysis of the blood TTH, T_4 and T_3 levels in individuals after bed rest demonstrated that the TTH and T_4 concentration [34], similar to the T_3 level [37], did not vary. American investigators also noticed that bed rest had no significant effect on the general T_4 level, but induced a stable increase in blood T_3 levels [38].

Thus, the analysis performed of information presented in the literature reflects a certain inconsistency in results obtained and a certain spottiness of biochemical parameters studied, which makes it impossible to compare the overall picture of hormonal responses and the status of the most important control links in metabolism during hypokinesia.

The purpose of this work included the analysis of the /89
hormonal metabolic response of the human body to 7-day-long hypokinesia.

4.2.1. General Biochemistry

4.2.1.1. Procedures

The method of kinetic spectrophotometry and colorimetry with the use of equipment produced by the firm Boehringer Mannheim Gmbh (West Germany) was used to determine blood serum enzyme activity, expressed in international units (IU/ml). The activity of the following enzymes was studied: glutamate dehydrogenase (GDH) [39], sorbitol dehydrogenase (SDH) [40], gamma-glutamyl transferase (γ-GT) [41], leucine arylamidase (LAP) [42], nonspecific cholinesterase (ChE) [43], alkaline phosphatase (AP) [44], aldolase [45], lactate dehydrogenase (LDH) [46], malate dehydrogenase (MDH) [47], isocitrate dehydrogenase (ICDH) [48], creatine phosphokinase (CPK) [47], alanine aminotransferase (ALT) [47], aspartate aminotransferase (ACT) [47]. The LDH and MDH isozymes were separated by polyacrylamide gel electrophoresis [49] followed by densitometry; the activity of each fraction was expressed as a percentage of total enzyme activity. The activity of pancreatic carbohydrase-amylase in blood serum and urine was determined by the procedure in [50] with modifications in [51], and the activity of the gastric proenzyme pepsinogen in urine by an absorption colorimetric method [52].

Serum levels of glucose [53], lactate [54], pyruvate [55], triglycerides [56] and total cholesterol [57] was determined by enzymatic methods, and the level of total lipids [58], nonesterified fatty acids (NEFA) [59], phospholipids [60] and beta-lipoproteins /90
[61] by colorimetric techniques with the use of units produced by Boehringer Mannheim Gmbh (West Germany). Lipoproteins were separated

into fractions by paper electrophoresis [62]. Found on electrophoregrams for three bands which corresponded to the alpha-lipoprotein, beta-lipoprotein and lipid residue fractions. Lactate and pyruvate concentration was determined in whole blood. The serum total protein and bilirubin levels and serum and urine urea, uric acid and creatinine were determined by automatic analysis using the Auto Analyzer II system manufactured by Technicon (USA). The protein fractions were identified by acetate cellulose electrophoresis using the electrophoresis system produced by Photovolt (USA).

The acid-base balance parameters for blood were determined by the Siggaard-Andersen method [63].

4.2.1.2. Results and Their Discussion

Results of the analyses performed are presented in Tables 4.2.1.1.—4.2.1.25.

In relation to the fact that the indices studied during the baseline period essentially did not differ from each other, we considered it possible to average the baseline data for all points. Values for indices studied throughout bed rest and during recovery were compared with averaged baseline values. Variation in the activity of specific enzymes or variation in the coordinated enzyme system activity is the basis of not only pathological states, but also of adaptive processes after exposure of the body to extreme conditions. On the basis of this fact, we attempted to evaluate the effect of hypokinesia on the state of the blood enzyme spectrum.

No significant differences were found in the results of /91
investigations on subjects during clinostatic and antiorthostatic hypokinesia. The activity of the enzyme studied together representing biochemical indices of the status of the hepatobiliary system, oxidative enzymes and energy metabolism enzymes [Tables 4.2.1.1--4.2.1.10] did not change significantly during hypokinesia or during readaptation, which may demonstrate the satisfactory status of membrane permeability and hepatic metabolic processes.

The activity of enzymes studied in subjects changed over a broader range during the baseline period. Although individual variations in activity were primarily within normal limits, in some cases deviation from the norm was noted. These include increases in SDH activity found in most subjects (7 of 10) at various times of the experiment. The baseline levels in subject P for the activity of ChE, leucine arylamidase, GDH and gamma-GT, as well as SDH, differed from conventional values. Cholinesterase activity in subject T during hypokinesia, and also during one of the baseline periods and the period after completion of bed rest was below normal values. It is known that in some pathological changes in the liver, such as hepatocellular insufficiency, disturbance of hepatocyte integrity or permeability, cholestasis syndrome, inflammation of the reticuloendothelium, etc., there is a synchronous change in most hepatic

enzymes in comparison with the accepted norm. The suggestion on pathological changes in the liver apparently may be excluded when anomalous activity of a single enzyme in blood is not accompanied /92 by changes in other hepatic enzymes, as we observed in most of the cases listed. The reasons for the appearance of similar deviations from the norm are difficult to explain, but apparently they are not related to the action of hypokinesia, i.e., they are also found during the baseline study. During the baseline period, the indices studied for carbohydrate [Tables 4.2.1.1--4.2.1.12], fat [Tables 4.2.1.13--4.2.1.16] and protein [Tables 4.2.1.17--4.2.1.23] metabolism, and also on the iron content, iron-binding capacity and the acid-base balance parameters in blood [Tables 4.2.1.24 -- 4.2.1.25] were primarily within normal limits, with the exception of the serum bilirubin level, urine and serum creatinine level and urine uric acid level that were higher than the normal values; the albumin level in blood was at the upper boundary of the norm, whereas the serum globulin level and globulin fractions were significantly lower than the norm.

Analysis of indices of carbohydrate, fat, protein and mineral metabolism did not reveal essential significant changes throughout bed rest, or in the recovery period. We should note the significant elevation in blood glucose level in group "B" on Day 2 of bed rest, followed by a significant decrease at the end of bed rest [Table 4.2.1.11], the significant increase in triglyceride level during bed rest in group "B" [Table 4.2.1.13], and the significant increase in blood globulin level in both groups [Table 4.2.1.18] during various periods of bed rest because of an increase in $alpha_2$-and gamma-globulin level [Table 4.2.1.19].

We should also note that the ABB system during hypokinesia and readaptation in both groups remained totally compensated due to minor shifts in either respiratory or metabolic components.

TABLE 4.2.1.1. ACTIVITY (mU/ml) OF SORBITOL DEHYDROGENASE (SDH) AND GLUTAMYL TRANSFERASE (γ-GT) IN BLOOD OF SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)				Bed rest (days)			After bed rest (days)	
			6	12	14	Mean	3	4		2	
SDH	"A"	M	0,132	0,216	0,248	0,199	0,056	0,088	0,180	0,075	0,2
		σ	0,107	0,429	0,347	0,305	0,045	0,502	0,207	0,087	0,1
		m	0,048	0,192	0,155	0,079	0,020	0,152	0,104	0,0	
	"B"	M	0,210	0,330	0,440	0,328	0,308	0,338	0,146	0,2	0,3
		σ	0,056	0,341	0,456	0,327	0,344	0,190	0,351	0,5	0,2
		m	0,025	0,153	0,204	0,083	0,154	0,085	0,112	0,149	0,1
γ-GT	"A"	M	32,52	26,48	23,14	28,047	22,38	21,88	21,91	2	
		σ	23,745	22,335	13,073	19,190	15,125	14,188	12,43	1	11,87
		m	10,619	9,988	5,846	4,955	5,869	6,085	5,564	5	4,75
	"B"	M	23,26	18,10	13,18	18,86	11,92 x)	12,26 x)	11,66 x)	1 x)	x)
		σ	7,182	6,902	3,363	7,063	2,48	2,934	3,716	2,5	2,7
		m	3,212	3,457	1,504	1,88	1,19		0,762	1	

x) - 1 < 0,05

[Commas in tabulated material in Tables 4.2.1.1.--4.2.1.25. are equivalent to decimal points.]

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TABLE 4.2.1.2. ACTIVITY (mU/ml) OF ALKALINE PHOSPHATASE (AP) AND LEUCINE ARYLAMIDASE (LAP) IN BLOOD OF SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)				Bed rest (days)			After bed rest (days)	
			6	12	14	Mean	2	4	7	2	7
AP	"A"	M	108,560	104,600	98,660	103,940	99,64	101,91	[illegible]	[illegible]	[illegible]
		σ	40,199	29,467	33,882	32,409	43,024	38,674	[illegible]	[illegible]	[illegible]
		m	17,977	13,467	15,153	6,388	19,241	17,296	[illegible]	[illegible]	[illegible]
	"B"	M	117,78	108,88	106,32	110,993	106,9	104,82	95,88	[illegible]	[illegible]
		σ	27,374	19,647	25,426	23,126	36,276	36,001	[illegible]	[illegible]	[illegible]
		m	12,242	8,786	11,371	5,972	11,751	11,696	[illegible]	[illegible]	[illegible]
LAP	"A"	M	21,64	20,32	16,66	19,54	15,52 x)	17,[illegible]	[illegible]	[illegible]	[illegible]
		σ	4,676	7,459	3,569	5,526	[illegible]	2,767	4,46	5,[illegible]	[illegible]
		m	2,091	3,336	1,596	1,427	[illegible]	1,237	[illegible]	2,[illegible]	[illegible]
	"B"	M	20,84	17,50	14,5	17,613	14,82 x)	14,66 x)	14,82	18,5 x)	[illegible]
		σ	3,375	4,862	3,044	4,411	[illegible]	2,000	2,99	[illegible]	[illegible]
		m	1,487	2,174	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

x) - $P < 0,05$

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TABLE 4.2.1.3. ACTIVITY (mU/ml) OF CHOLINESTERASE (ChE) AND GLUTAMATE DEHYDROGENASE (GDH) IN BLOOD OF SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Significance	Group	Before bed rest (days)				Bed rest (days)			After bed rest days	
			6	12	14	Mean	2	4	7	2	5
ChE	"A"	M	2783,4	3236,8	2854,6	2958,267	2667,0	2814,0	2711,8	2[illegible]	[illegible]
		σ	620,374	703,105	209,867	553,402	299,189	345,055	[illegible]	313,[illegible]	[illegible]
		m	277,440	314,438	93,855	142,888	131,118	109,592	[illegible]	[illegible]	[illegible]
	"B"	M	2943,8	2766,6	2376,4	2695,60	2414,2	2561,2	2425,0	[illegible]	[illegible]
		σ	346,098	722,64	600,443	588,746	362,822	521,041	446,086	[illegible]	[illegible]
		m	154,78	323,174	268,526	152,014	162,259	233,077	199,573	[illegible]	[illegible]
GDH	"A"	M	1,680	2,540	2,420	2,213	2,46	2,633	2,166	1,9[illegible]	[illegible]
		σ	0,672	2,908	1,610	1,855	0,963	1,10	1,153	0,8[illegible]	[illegible]
		m	0,301	1,301	0,720	0,479	0,431	0,550	0,516	0,3[illegible]	[illegible]
	"B"	M	1,36	1,16	1,44	1,330	1,28	1,44	1,64	1,630	1,84
		σ	0,865	0,623	0,854	0,679	0,729	0,615	0,886	0,[illegible]	[illegible]
		m	0,387	0,279	0,253	0,175	0,325	0,[illegible]	[illegible]	[illegible]	[illegible]

x) $p < 0.05$

TABLE 4.2.1.4. TOTAL ACTIVITY (mU/ml) OF MALATE DEHYDROGENASE (MDH) AND ITS ISOZYMES (%) IN BLOOD OF SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)				Bed rest (days)			After bed rest (days)	
			6	12	14	Mean	2	4	7	2	7
MDH	"A"	M	62,72	63,96	65,64	64,107	61,90	54,66[x)]	48,28[x)]	59,02	63,120
		σ	6,124	2,532	7,204	5,377	2,901	4,753	11,259	9,877	6,656
		m	2,739	1,133	3,222	1,388	1,297	2,125	5,035	4,417	2,977
	"B"	M	63,14	64,36	65,40	64,30	60,68	56,54[x)]	51,56[x)]	54,66[x)]	62,92
		σ	4,012	2,693	12,371	7,164	6,833	6,765	9,614	4,602	9,228
		m	1,794	1,205	5,533	1,850	3,950	3,025	4,299	2,058	4,127
MDH_1	"A"	M	26,30	26,20	25,62	26,04	25,78	26,28	25,46	26,16	25,50
		σ	2,432	2,202	1,898	2,050	1,590	2,095	1,939	2,366	1,821
		m	1,088	0,985	0,849	0,529	0,711	0,937	0,867	1,058	0,814
	"B"	M	21,88	22,36	22,90	22,38	22,60	22,50	21,92	22,54	22,88
		σ	4,427	3,717	2,962	3,499	2,458	3,330	3,541	2,419	2,630
		m	1,980	1,662	1,325	0,903	1,099	1,489	1,583	1,082	1,176

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TABLE 4.2.1.4. CONTINUATION

MDH_2	"A"	M	26,84	26,70	26,32	26,62	25,9[illegible]	2[illegible]	28,76	26,[illegible]	[illegible]
		σ	2,797	2,682	3,357	2,75I	3,66I	3,3I7	2,756	3,[illegible]	[illegible]
		m	I,25I	I,200	I,50I	0,7I0	I,637	I,483	1,233	I,[illegible]	I,3[illegible]
	"B"	M	23,76	25,46	24,760	24,66	24,0[illegible]	2[illegible]	2[illegible]	[illegible]	[illegible]
		σ	4,57I	3,406	3,355	3,609	3,55I	3,[illegible]47	4,2[illegible]	3,5[illegible]	[illegible]
		m	2,044	I,523	I,50I	0,952	I,588	I,497	I,88[illegible]	I,506	I,[illegible]
MDH_3	"A"	M	46,88	47,I00	48,06	47,34	48,34	47,02	47,58	[illegible]	[illegible]
		σ	5,045	4,620	5,068	4,589	4,967	5,II6	4,530	5,[illegible]	[illegible]
		m	2,256	2,066	2,275	I,I85	2,22I	2,[illegible]08	2,0[illegible]	2,[illegible]	[illegible]
	"B"	M	54,36	52,I8	52,34	52,96	53,32	52,90	54,8[illegible]	53,[illegible]	[illegible]
		σ	8,870	6,I98	6,05I	6,706	5,8[illegible]	6,297	[illegible],643	5,692	5,[illegible]
		m	3,967	2,772	2,706	I,732	2,600	2,8I6	3,[illegible]I8	2,[illegible]	[illegible]

x) - p<0,05

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TABLE 4.2.1.5. TOTAL ACTIVITY (mU/ml) OF ISOCITRATE DEHYDROGENASE (ICDH) AND LACTATE DEHYDROGENASE (L_DH) IN BLOOD OF SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)				Bed rest (days)				After bed rest (days)	
			6	12	14	Mean	2	4	7			
ICDH	"A"	M	1,28	1,42	1,380	1,36	1,16	0,98 x)	1,02	1,36		
		σ	0,228	0,455	0,130	0,287	0,241	0,396	0,259			
		m	0,102	0,203	0,058	0,074	0,108					
	"B"	M	1,12	1,02	1,16	1,10	0,94	0,92		1,18		
		σ	0,554	0,239	0,445	0,405	0,477	0,303				
		m	0,248	0,107	0,199	0,105	0,214					
LDH	"A"	M	178,80	190,00	194,80	187,867	194,60	198,00	182,00			
		σ	29,550	46,217	30,647	34,297	46,355					
		m	13,215	20,669	13,706	8,855	20,728					
	"B"	M										
		σ										
		m										

x) – [illegible]

TABLE 4.2.1.6. ACTIVITY OF LDH ISOZYMES (%) IN BLOOD OF SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)				Bed rest (days)			After bed rest (days)	
			6	12	14	Mean	2	4	7		
LDH_1	"A"	M	31,16	30,78	30,78	30,91	31,18	30,36	30,90	[illegible]	[illegible]
		σ	0,288	1,299	1,918	1,262	0,713	1,426	0,418	[illegible]	[illegible]
		m	0,129	0,581	0,858	0,326	0,319	0,638	0,187	[illegible]	[illegible]
	"B"	M	28,92	29,96	28,80	29,23	30,42	30,16	30,66	[illegible]	[illegible]
		σ	2,068	1,617	2,207	1,911	2,816	1,570	2,538	[illegible]	[illegible]
		m	0,925	0,723	0,987	0,495	1,259	0,702	1,135	[illegible]	[illegible]
LDH_2	"A"	M	39,50	39,80	38,14	39,15	38,56	41,30	39,64	[illegible]	[illegible]
		σ	3,653	3,555	4,619	3,753	5,769	5,033	4,397	[illegible]	[illegible]
		m	1,634	1,590	2,066	0,969	2,580	2,251	1,967	[illegible]	[illegible]
	"B"	M	46,56	46,86	48,06	[illegible]	45,90	47,340	46,710	[illegible]	[illegible]
		σ	6,615	5,124	4,224	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		m	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE 4.2.1.6. CONTINUATION

LDH_3	"A"	$\bar{x}$	18,54	18,56	19,640	18,68	18,32	18,20	18,64	[illegible]	[illegible]
		σ	2,794	3,286	3,641	3,074	3,292	3,537	[illegible]	2,8[illegible]	[illegible]
		m	I,250	I,470	I,628	0,794	I,4[illegible]	I,582	I,781	I,278	I,3[illegible]
	"B"	$\bar{x}$	I6,20	I4,58	I5,00	I5,26	I5,38	I4,50	I3,96	I4,08	I3,9[illegible]
		σ	4,092	I,808	2,I87	2,755	2,345	I,65I	I,767	2,002	I,5[illegible]
		m	I,830	0,808	0,978	0,7II	I,049	0,738	0,790	I,I6[illegible]	0,65[illegible]
LDH_4	"A"	$\bar{x}$	9,I0	9,32	9,70	9,3[illegible]	9,22	8,9[illegible]	[illegible]	8,70	8,8[illegible]
		σ	3,447	3,003	3,009	2,935	3,741	3,[illegible]	3,205	3,[illegible]	[illegible]
		m	I,542	I,343	I,343	0,758	I,673	I,500	I,433	I,482	I,3[illegible]
	"B"	$\bar{x}$	6,66	6,74	6,74	6,7I	6,60	6,56	6,66	6,[illegible]	[illegible]
		σ	2,562	2,25I	2,064	2,I3I	2,II5	2,458	2,[illegible]	2,[illegible]	[illegible]
		m	I,I46	I,00[illegible]	0,923	0,550	0,[illegible]46	I,0[illegible]9	I,063	I,0[illegible]	[illegible]
LDH_5	"A"	$\bar{x}$	I,70	I,74	1,74	I,72	1,70	I,02	I,I8	2,[illegible]	[illegible]
		σ	0,803	0,876	I,0II	0,83I	0,495	0,[illegible]	0,280	I,[illegible]	[illegible]
		m	0,[illegible]	0,[illegible]	0,452	0,2II	0,22I	[illegible]	0,[illegible]	0,[illegible]	0,[illegible]
	"B"	$\bar{x}$	I,[illegible]	[illegible]	I,[illegible]	I,[illegible]	[illegible]	[illegible]	I,[illegible]	I,[illegible]	[illegible]
		σ	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		m	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE 4.2.1.7. ACTIVITY (mU/ml) OF ALANINE AMINOTRANSFERASE (ALT) AND ASPARATATE AMINOTRANSFERASE (AST) IN BLOOD OF SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)				Bed rest (days)			After bed rest (days)	
			6	12	14	Mean	2	4	7	2	
ALT	"A"	M	9,06	9,20	9,96	9,407	11,30	10,34	10,24	9,22	
		σ	4,927	4,259	3,683	4,020	4,642	4,156	3,823	3,470	
		m	2,203	1,904	1,647	1,038	2,076	1,856	1,708	1,552	
	"B"	M	8,84	9,60	8,66	9,063	9,80	9,32	9,80	10,12	
		σ	2,152	1,691	0,789	1,560	2,234	2,035	2,132	1,560	
		m	0,963	0,756	0,353	0,408	1,017	1,823	1,236	0,711	
AST	"A"	M	11,92	11,04	11,90	11,64	13,32	12,44	11,36	11,56	
		σ	1,816	1,592	1,159	1,495	2,286	1,780	1,126	2,192	
		m	0,812	0,716	0,577	0,668	1,023	0,796	0,504	1,312	
	"B"	M	11,[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
		σ	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
		m	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

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TABLE 4.2.1.8. ACTIVITY (mU/ml) OF CREATINE PHOSPHOKINASE (CPK) IN BLOOD OF SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)				Bed rest (days)			After bed rest (days)	
			6	12	14	Mean	2	4	7	2	7
CPK	"A"	$\bar{x}$	33,86	26,54	29,22	29,873	41,44	24,28	16,76	32,51	23,12
		σ	18,320	8,106	7,705	11,893	47,223	22,281	8,581	26,1[illegible]	11,[illegible]
		m	8,193	3,625	3,445	3,071	21,1[illegible]	9,[illegible]	3,838	12,55[illegible]	4,[illegible]
	"B"	$\bar{x}$	30,74	37,64	58,24	42,207	54,80	32,78	39,13	37,[illegible]	31,[illegible]
		σ	10,233	28,684	69,839	42,483	61,369	19,081	12,393	7,[illegible]	8,[illegible]
		m	4,576	12,828	31,233	18,989	27,445	8,533	5,417	3,55[illegible]	3,[illegible]

Note: [illegible]

TABLE 4.2.1.9. ACTIVITY (mU/ml) OF ALDOLASE AND AMYLASE IN BLOOD OF SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)				Bed rest (days)			After bed rest (days)	
			6	12	14	Mean	2	4	7	1	7
Aldolase	"A"	m	2,688	2,760	2,410	2,619	1,904	3,112	2,672	[illegible]	[illegible]
		σ	1,364	1,365	0,371	1,056	0,876	3,553	0,958	[illegible]	[illegible]
		m	0,610	0,610	0,166	0,275	0,392	1,111	[illegible]	[illegible]	[illegible]
	"B"	m	1,866	2,586	2,358	2,270	3,048	2,620	1,9[illegible]	[illegible]	1,70[illegible]
		σ	0,536	0,730	0,857	0,754	1,506	1,468	0,[illegible]	[illegible]	0,[illegible]
		m	0,237	0,326	0,383	0,198	0,673	0,656	0,[illegible]	[illegible]	[illegible]
Amylase	"A"	m	161,856	207,556	205,166	216,031	244,[illegible]	2[illegible]	3[illegible]	[illegible]	[illegible]
		σ	27,634	51,468	74,626	76,745	76,619	132,[illegible]	[illegible]	[illegible]	65[illegible]
		m	13,917	40,732	33,474	21,[illegible]	34,265	59,225	53,322	[illegible]	[illegible]
	"B"	m	200,160	266,[illegible]	333,[illegible]	267,533	2[illegible]	1[illegible]	[illegible]	[illegible]	[illegible]
		σ	102,[illegible]	91,[illegible]	116,915	1[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		m	46,[illegible]	37,512	45,[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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TABLE 4.2.1.10. ACTIVITY (U/day) of AMYLASE AND UROPEPSINOGEN IN URINE OF SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)													
			I	2	3	4	5	6	7	8	9	IO	II	I2	I3	I4
Amylase	"A"	M	4,020	2,088	3,2I8	2,440	7,350	5,026	10,0I0	5,772	6,I42	8,326	4,356	6,550	I2,346	8,52[illegible]
		σ	5,539	I,I84	2,I82	I,277	2,788	4,954	4,293	4,233	4,205	4,5I3	I,38I	4,366	3,973	3,707
		m	2,670	0,529	0,976	0,57I	I,247	2,215	1,920	I,693	I,68I	2,0I8	0,6I6	I,96I	I,777	I,6[illegible]
	"B"	M	3,502	3,336	2,964	3,I00	2,002	3,766	4,630	6,I20	5,734	2,336	6,044	4,9I0	6,742	8,[illegible]
		σ	I,II7	I,759	0,988	2,232	I,2I5	I,428	2,[illegible]	5,340	5,508	0,750	4,600	2,993	3,957	3,[illegible]
		m	0,556	0,787	0,442	0,998	0,543	0,639	1,296	2,388	2,463	0,335	2,057	I,339	I,770	I,[illegible]
Uropepsinogen	"A"	M	I2,800	I0,356	I2,878	I8,432	I8,896	I6,776	II,670	II,034	I5,456	I5,2I0	8,970	22,53I	8,452	I5,[illegible]
		σ	8,803	4,I49	4,II2	8,940	8,846	7,062	5,387	3,648	5,[illegible]	9,783	3,I39	I3,667	3,387	[illegible]
		m	4,402	I,855	I,839	3,998	3,956	3,I58	2,409	I,632	2,409	4,375	I,404	6,II2	I,5I5	[illegible]
	"B"	M	I5,800	I2,I36	I8,748	20,402	I2,I46	I4,586	I4,544	I9,268	2I,[illegible]	I3,664	I5,526	I5,252	I8,[illegible]	[illegible]
		σ	8,042	5,037	I7,007	9,774	3,346	II,603	5,365	9,340	22,[illegible]	8,I5I	I2,0I9	I5,672	I4,[illegible]	[illegible]
		m	4,02I	2,253	7,[illegible]	4,37I	I,496	5,I69	2,[illegible]	4,I77	I0,0[illegible]	3,64[illegible]	5,375	7,009	6,[illegible]	[illegible]

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TABLE 4.2.1.10. CONTINUATION

Indices	Group	Significance	Before bed rest	Bed rest (days)						
			Mean for days	1	2	3	4	5	6	7
Amylase	"A"	M	6,186	6,288	7,594	6,504	3,470	2,870 x)	3,538 x)	2,[illegible]
		σ	4,386	3,805	4,789	3,893	2,867	1,723	1,859	0,[illegible]
		m	0,528	1,702	2,143	1,741	1,283	0,775	0,857	[illegible]
	"B"	M	4,557	3,774	8,720	6,390	6,046	5,456	2,274 x)	[illegible]
		σ	3,378	2,192	5,319	3,944	4,267	4,868	0,598	[illegible]
		m	0,407	0,980	2,379	1,764	1,908	2,178	0,267	[illegible]
Uropepsinogen	"A"	M	14,060	14,194	14,364	11,[illegible]	16,[illegible]	14,[illegible]	11,[illegible]	[illegible]
		σ	7,737	5,389	8,155	7,[illegible]	11,[illegible]	[illegible]	14,[illegible]	[illegible]
		m	0,931	2,401	3,647	3,[illegible]	5,[illegible]	6,[illegible]	6,475	[illegible]
	"B"	M	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		σ	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		m	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

x) - [illegible]

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TABLE 4.2.1.10. CONTINUATION

Indices	Group	Significance	After bed rest (days)										
			0	1	2	3	4	5	6	7	8	9	10
Amylase	"A"	M	4,626	5,468	5,678	7,002	7,046	5,638	6,596	5,550	6,150	5,81	4,410 [1]
		σ	3,158	4,378	1,936	3,824	3,751	4,177	3,174	2,631	0,632	2,513	0,4[illegible]
		m	1,410	1,868	0,696	1,710	1,677	1,868	1,419	1,207	2,960	1,124	0,215
	"B"		2,500 [2]	4,946	4,834	5,182 [3]	4,718	5,644	5,492	4,031	4,750	6,467	5,128
			0,69	1,633	2,322	1,884	1,250	3,804	2,940	2,401	3,[illegible]	3,6[illegible]	2,732
		m	0,277	0,730	1,039	0,839	1,918	1,702	1,314	1,101	1,[illegible]	1,6[illegible]	1,218
Uropepsinogen	"A"	M	12,158	19,406	18,702	22,508	17,256	25,980	17,686	21,782	24,882 [4]	20,782	22,908
		σ	4,302	15,477	13,268	17,714	6,163	11,141	8,[illegible]	12,716	8,838	8,641	6,523
		m	1,524	6,321	7,274	7,923	3,656	4,[illegible]	3,[illegible]	[illegible]	3,[illegible]	3,468	2,[illegible]
	"B"	M	19,348	17,640	16,794	20,816	15,334	23,108	25,772	19,457	22,572 [5]	15,312	17,208
		σ	17,070	7,984	13,350	17,723	5,362	15,716	14,363	[illegible]	[illegible]	5,988	5,137
		m	7,002	3,577	5,405	7,236	1,710	7,028	5,423	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]) [illegible]

TABLE 4.2.1.11. GLUCOSE AND LACTIC ACID LEVEL (mg%) IN BLOOD OF SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)				Bed rest (days)			After bed rest (days)	
			6	12	14	Mean	2	4	7		
Glucose	"A"	m	77,046	92,148	95,372	88,189	86,294	82,532×	83,722		
		σ	25,941	26,745	15,630	10,362	15,786				
		m	11,601	11,961	6,990	2,675	7,059				
	"B"	m	90,334	79,040	79,724	83,033	100,407×	61,226×	72,990		
		σ	9,774	10,251	7,706	10,144	11,151				
		m	4,371	4,584	3,446	2,619	5,576				
Lactic acid	"A"	m	12,186	12,756	16,762	13,901	13,382				
		σ	11,326	10,058	11,454	10,382	7,710				
		m	5,065	4,489	5,122	2,676	3,448				
	"B"	m									
		σ									
		m									

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TABLE 4.2.1.12. BLOOD PYRUVIC ACID LEVEL (mg%) IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)			Bed rest (days)				After bed rest (days)	
			6	12	14	Mean	2	4	7	2	4
Pyruvic acid	"A"	$\bar{x}$	0,220	0,780	0,424	0,475	0,678	0,288	0,486	0,312	1,
		σ	0,107	1,444	0,440	0,843	0,872	0,[illegible]	0,[illegible]	0,[illegible]	1,
		m	0,048	0,646	0,197	0,218	0,390	0,[illegible]	0,518	0,[illegible]	0,
	"B"	$\bar{x}$	0,220	0,316	0,376	0,304	1,190	0,240	0,288	0,[illegible]	0,
		σ	0,129	0,328	0,437	0,306	1,886	0,[illegible]	0,[illegible]	0,3[illegible]	0,
		m	0,058	0,146	0,195	0,078	1,060	0,085	0,088	0,[illegible]	0,[illegible]

x) - $p < 0,05$

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TABLE 4.2.1.13. BLOOD CHOLESTEROL AND TRIGLYCERIDE LEVEL (mg%) IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)				Bed rest (days)			After bed rest (days)	
			6	12	14	Mean	2	4			7
Cholesterol	"A"	M	249,000	278,400	192,800	240,067	259,400	204,800	189,000	238,000	261,[illegible]
		σ	28,116	55,145	51,597	56,077	101,279	40,900	34,287	36,188	37,9[illegible]
		m	12,574	23,767	23,075	14,479	45,293	16,518	14,873	17,[illegible]	16,[illegible]
	"B"	M	264,200	211,800	221,200	232,400	239,600	254,800	246,600	264,000	252,[illegible]
		σ	33,192	48,112	41,991	45,138	21,676	79,359	79,314	45,360	27,[illegible]
		m	14,844	21,516	18,778	11,654	9,694	35,490	35,[illegible]	20,285	12,[illegible]
Triglycerides	"A"	M	91,020	135,820	127,960	118,267	184,400	181,280	166,600	151,900	135,[illegible]
		σ	28,623	59,943	64,071	53,294	87,872	68,413	85,669	58,406	50,[illegible]
		m	12,801	26,809	28,627	13,761	56,687	29,701	37,416	13,[illegible]	11,[illegible]
	"B"	M	116,040	116,040	157,520	131,307	191,540	151,670	[illegible]	164,[illegible]	145,[illegible]
		σ	26,817	[illegible]	21,099	31,170	57,758	[illegible]	[illegible]	35,[illegible]	28,[illegible]
		m	12,000	15,414	9,570	[illegible]	25,830	[illegible]	[illegible]	15,[illegible]	[illegible]

TABLE 4.2.1.14. TOTAL LIPID (mg%) AND NONESTERIFIED FATTY ACID (NEFA) (meq/liter) LEVEL IN BLOOD OF SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)				Bed rest (days)			After bed rest (days)	
			6	12	14	Mean	2	4	7	4	7
Total lipids	"A"	M	702,600	798,400	887,400	785,467	898,800	1018,000	[illegible]	[illegible]	[illegible]
		σ	124,558	235,353	263,612	212,146	144,827	294,948	[illegible]	[illegible]	[illegible]
		m	55,704	105,253	117,891	54,776	64,769	131,908	104,943	35,[illegible]32	122,[illegible]
	"B"	M	727,200	737,400	929,400	798,000	1028,400	[illegible]	[illegible]	[illegible]	[illegible]
		σ	184,459	85,842	215,815	185,495	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		m	82,492	38,256	96,[illegible]	47,841	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NEFA	"A"	M	250,000	270,200	378,400	299,[illegible]	287,[illegible]	246,6[illegible]	217,[illegible]	363,600	[illegible]
		σ	56,527	157,001	[illegible]	128,196	71,[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		m	25,281	[illegible]	58,[illegible]	33,[illegible]	[illegible]	[illegible]	[illegible]	52,[illegible]	41,[illegible]
	"B"	M	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		σ	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		m	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE 4.2.1.15. β-LIPOPROTEIN AND PHOSPHOLIPID LEVEL (mg%) IN BLOOD OF SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)				Bed rest (days)			After bed rest (days)	
			6	12	14	Mean	2	4	[illegible]	[illegible]	
β-lipoproteins	"A"	M	557,600	546,000	620,800	581,800	616,600	542,8[illegible]	[illegible]	[illegible]	[illegible]
		σ	73,683	137,924	188,472	133,543	179,384	207,0[illegible]	[illegible]	[illegible]	[illegible]
		m	32,952	[illegible]	84,261	34,483	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	"B"	M	616,200	649,600	527,800	597,866	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		σ	70,321	[illegible]	47,552	104,914	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		m	31,448	[illegible]	18,541	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Phospholipids	"A"	M	158,800	[illegible]	172,000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		σ	24,994	26,256	36,613	28,107	32,459	37,949	46,218	47,765	62,[illegible]
		m	11,178	11,743	16,371	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	"B"	M	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		σ	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		m	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE 4.2.1.16. BLOOD LIPOPROTEIN FRACTION LEVELS (%) IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)				Bed rest (days)			After bed rest (days)	
			6	12	14	Mean	2	4	7		
α-lipoproteins	"A"	M	18,638	18,186	17,862	18,229	18,488	17,538	[illegible]		
		m	6,409	6,605	2,941	5,185	3,703	5,655	[illegible]		
		σ	2,866	2,954	1,315	1,336	1,656	2,547	[illegible]		
	"B"	M	20,472	20,082	15,620	18,725	18,552	14,282	16,950	14,[illegible]	15,[illegible]
		m	4,199	5,994	3,769	4,955	4,926	6,159	3,857	2,[illegible]	[illegible]
		σ	1,878	2,680	1,685	1,279	2,763	3,[illegible]	[illegible]	[illegible]	[illegible]
β-lipoproteins	"A"	M	45,776	48,456	44,958	46,397	45,956	[illegible]	45,682	45,[illegible]	[illegible]
		m	5,875	7,673	6,157	6,318	3,658	8,057	5,[illegible]	[illegible]	[illegible]
		m	2,622	3,452	2,754	1,611	1,[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	"B"	M	42,572	44,760	38,600	[illegible]	36,169	[illegible]	38,435	38,[illegible]	38,[illegible]
		σ	5,880	5,421	7,851	6,[illegible]	7,552	10,[illegible]	9,[illegible]	[illegible]	[illegible]
		m	2,540	2,424	3,529	1,611	3,322	4,[illegible]	3,[illegible]	3,[illegible]	3,[illegible]
Lipid residue	"A"	M	35,500	35,324	37,182	35,[illegible]	35,954	[illegible]	34,252	35,[illegible]	36,[illegible]
		σ	9,760	7,[illegible]	7,911	7,983	5,061	[illegible]	[illegible]	6,[illegible]	[illegible]
		m	4,365	3,[illegible]	3,[illegible]	2,048	2,[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	"B"	M	36,958	35,[illegible]	[illegible]	37,[illegible]	34,[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		σ	6,[illegible]	[illegible]	[illegible]	[illegible]	6,[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		m	[illegible]	[illegible]	4,[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

x) - [illegible]

TABLE 4.2.1.17. BLOOD TOTAL PROTEIN LEVEL (g%) IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Groups	Significance	Before bed rest (days)				Bed rest (days)		After bed rest (days)	
			6	12	14	Mean				
Total protein	"A"	M	6,820	7,220	6,780	6,940	7,000			
		σ	0,320	0,220	0,554	0,503				
		m	0,160	0,110	0,248					
	"B"	M	6,140							
		σ	0,207							
		m	0,093							

TABLE 4.2.1.18. BLOOD ALBUMIN AND GLOBULIN LEVEL (g%) IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)				Bed rest (days)	After bed rest (days)
						Mean		
Albumins	"A"	σ						
		m						
	"B"	σ						
		m						
Globulins	"A"	σ						
		m						
	"B"	σ						
		m						

TABLE 4.2.1.19. BLOOD GLOBULIN FRACTION LEVEL (g%) IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)				Bed rest (days)			After bed rest (days)	
			6	12	14	Mean					
Alpha-1	"A"	$\bar{x}$	0,074	0,106	0,116	0,115	0,082	[illegible]			
		σ	0,026	0,114	0,065	0,079	[illegible]	[illegible]			
		m	0,012	[illegible]	0,029	0,021	[illegible]	[illegible]	[illegible]		
	"B"	$\bar{x}$	0,106	[illegible]	0,126	[illegible]	[illegible]	[illegible]	[illegible]		
		σ	0,042	[illegible]	0,054	0,054	[illegible]	[illegible]	[illegible]		
		m	0,019	[illegible]	0,024	[illegible]	[illegible]	[illegible]			
Alpha-2	"A"	$\bar{x}$	0,242	0,216	0,184	[illegible]	0,201	[illegible]	[illegible]		
		σ	0,035	0,129	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
		m	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			
	"B"	$\bar{x}$	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
		σ	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
		m	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		

TABLE 4.2.1.19. CONTINUATION

Gamma	"A"	$\bar{x}$	0,672	0,516	0,854	0,681	0,884 x)	0,874 x)	0,752	0,584	0,580
		σ	0,125	0,151	0,127	0,190	0,171	0,150	0,070	0,086	0,096
		m	0,056	0,067	0,057	0,049	0,076	0,067	0,031	0,039	0,043
	"B"	$\bar{x}$	0,446	0,494	0,578	0,506	0,650	0,884 x)	0,870 x)	0,792 x)	0,600
		σ	0,136	0,168	0,393	0,246	0,211	0,233	0,318	0,197	0,170
		m	0,062	0,075	0,176	0,064	0,094	0,104	0,142	0,088	0,076
Beta	"A"	$\bar{x}$	0,502	0,438	0,424	0,455	0,402	0,526	0,626	0,456	0,388
		σ	0,176	0,191	0,153	0,165	0,095	0,090	0,178	0,120	0,161
		m	0,079	0,085	0,068	0,043	0,043	0,040	0,080	0,054	0,072
	"B"	$\bar{x}$	0,384	0,412	0,376	0,391	0,320	0,584	0,514	0,500	0,348
		σ	0,066	0,057	0,059	0,058	0,063	0,235	0,111	0,222	0,044
		m	0,029	0,025	0,026	0,015	0,028	0,105	0,050	0,099	0,020

x) - $p < 0,05$

TABLE 4.2.1.20. BLOOD URIC ACID AND UREA LEVELS (mg%) IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)			Mean	Bed rest (days)			After bed rest (days)	
							2	4	7	2	7
Uric acid				7,000	7,020	7,067	6,980	6,740	7,720	8,160	8,480[x]
	"A"					1,818	1,961	1,713	1,612	1,195	0,776
					0,932	0,469	0,877	0,766	0,721	0,534	0,347
	"B"				6,800	6,820	6,060	6,040	6,420	7,320	7,700
					1,875	1,938	1,416	1,620	1,894	0,942	1,573
					0,868		0,631	0,724	0,847	0,421	0,704
Urea						25,000	23,000	23,800	34,400	48,000[x]	37,200
						6,361	4,450	3,564	11,546	9,165	11,567
						1,884	1,990	1,594	5,163	4,099	5,083
	"B"						21,000	26,800	27,000	35,200[x]	29,800[x]
						1,918	2,050	2,085	7,000	3,899	3,578
							0,917	1,000	3,150	1,744	1,600

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TABLE 4.2.1.21. TOTAL BILIRUBIN AND CREATININE LEVEL (mg%) IN BLOOD OF SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)				Bed rest (days)			After bed rest (days)	
			6	12	14	Mean	2	4	7		
Total bilirubin	"A"	M	1,220	1,100	1,140	1,153	1,340	1,040	1,08	,0	,
		σ	0,164	0,235	0,270	0,217	0,378	0,288	0,19	0,	
		m	0,073	0,105	0,121	0,056	0,169	0,128	0,	0,	0,
	"B"	M	1,160	0,940	1,000	1,033	1,000	0,980	1,10	,	,
		σ	0,230	0,207	0,339	0,264	0,235	0,311	0,	0,	0,
		m	0,103	0,093	0,152	0,068	0,105	0,	0,	0,	0,
Creatinine	"A"	M	1,720	1,600	1,	1,687	1,620	1,	1,	,	,
		σ	0,337	0,385	0,40	0,360	0,455	0,451	0,	0,	0,
		m	0,169	0,172	0,	0,095	0,	0,	0,	0,	0,
	"B"	M	1,920	1,800	1,	1,487	1,	,	,	,	,
		σ	0,000	0,255	0,	0,517	0,370	0,	0,	0,	0,
		m	0,	0,114	0,	0,132	0,	0,	0,	0,	0,

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TABLE 4.2.1.22. URINE EXCRETION OF CREATININE (g/day) AND URIC ACID (mg/day) IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)										
			1	2	3	4	5	6	7	8	9	10	11
Urine creatinine	"A"	...	2,085	2,280	2,180	1,740	2,320	1,960	1,860	2,260	2,100	1,940	2,140
		σ	0,479	0,835	0,832	0,602	0,766	0,288	0,378	0,607	0,442	0,462	0,378
		m	0,239	0,373	0,732	0,269	0,343	0,129	0,169	0,271	0,197	0,206	0,169
	"B"	...	2,400	2,146	2,100	2,020	1,720	2,000	2,440	2,080	2,820	3,260	2,080
		σ	0,374	0,456	0,927	0,444	0,795	0,346	0,167	0,286	1,796	1,498	0,610
		m	0,187	0,204	0,415	0,198	0,356	0,155	0,075	0,128	0,803	0,670	0,273
Urine uric acid	"A"	...	784,000	852,000	857,200	875,000	954,200	807,600	689,000	834,000	817,800	781,800	849,800
		σ	184,208	262,169	247,881	261,348	385,873	371,087	88,442	190,585	192,102	109,370	75,301
		m	82,103	117,246	110,856	116,878	172,568	165,955	39,552	85,232	85,911	48,912	33,676
	"B"	...	674,800	655,000	872,200	598,400	778,000	505,600	818,800	632,000	926,600	756,600	665,400
		σ	402,942	376,049	521,999	315,696	229,970	259,512	369,374	287,864	823,097	279,766	319,541
		m	180,071	140,894	233,445	141,184	102,846	116,057	165,189	128,737	368,100	125,115	142,903

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TABLE 4.2.1.22. CONTINUATION

Indices	Group	Significance	Before bed rest (days)				Bed rest (days)						
			[illegible]	[illegible]	[illegible]	Mean	I	2	3	4	5	6	7
Urine creatinine	"A"	$\bar{x}$	1,740	2,000	1,820	2,03	1,560	2,260	2,520	1,900	1,740	2,580	2,160
		σ	[illegible]	[illegible]	0,540	0,540	0,434	0,770	1,069	0,406	0,391	1,310	0,527
		m	[illegible]	[illegible]	0,242	0,065	0,194	0,344	0,478	0,182	0,175	0,586	0,236
	"B"	$\bar{x}$	[illegible]	2,480	2,000	2,277	2,740	2,400	2,400	2,520	2,220	2,600	2,540
		σ	[illegible]	0,942	0,800	0,846	0,723	0,255	0,846	0,563	0,239	0,265	0,305
		m	[illegible]	0,421	0,358	0,102	0,323	0,114	0,378	0,252	0,107	0,118	0,136
Urine uric acid	"A"	$\bar{x}$	[illegible]	[illegible]	[illegible]	829,913	627,200	954,600	1024,60	752,800	759,400	914,000	1021,80
		σ	[illegible]	[illegible]	337,580	223,860	308,508	399,419	540,751	236,263	106,930	168,608	449,674
		m	[illegible]	68,979	150,961	26,950	137,969	178,626	241,831	105,660	47,820	75,404	201,100
	"B"	$\bar{x}$	[illegible]	[illegible]	[illegible]	758,014	1158,0	834,200	810,400	848,000	737,400	1075,60	734,600
		σ	[illegible]	[illegible]	[illegible]	556,555	829,500	548,084	725,812	580,104	242,749	440,668	435,697
		m	[illegible]	[illegible]	344,353	64,834	370,964	155,668	324,593	259,430	108,561	197,073	194,850

[illegible] 2 0,05

TABLE 4.2.1.22. CONTINUATION

Indices	Group	Significance	After bed rest (days)										
			0	1	2	3	4	5	6	7	8	9	10
Urine creatinine	"A"	$\bar{x}$	1,300	1,980	1,800	2,560	1,860	1,940	1,820	2,200	1,860	2,200	2,240
		σ	0,329	0,593	0,436	0,723	0,270	0,313	0,683	0,418	0,422	0,500	0,666
		m	0,147	0,265	0,195	0,323	0,121	0,140	0,306	0,187	0,189	0,224	0,298
	"B"	$\bar{x}$	1,340	1,960	2,000	2,700	2,640	1,920[x)]	2,600	2,180	2,040	2,240	2,020
		σ	0,385	0,416	0,339	0,771	0,902	0,766	0,524	0,904	0,590	0,631	0,642
		m	0,172	0,186	0,152	0,345	0,403	0,343	0,235	0,404	0,264	0,282	0,287
Urine uric acid	"A"	$\bar{x}$	636,400	908,400	876,400	1199,80[x]	923,400	1060,20	1017,60	920,200	712,800	867,800	1028,60
		σ	188,083	496,373	324,138	310,554	328,168	415,155	341,181	329,377	287,594	379,882	619,649
		m	74,275	221,985	144,959	138,884	146,761	185,663	152,581	147,302	128,616	169,888	277,115
	"B"	$\bar{x}$	640,000	740,800	1114,40	1087,40	887,600	1178,60[x]	1419,00[x]	934,600[x]	925,600[x]	777,400	784,400
		σ	404,116	400,328	826,487	808,954	280,240	1361,23	886,031	810,656	333,581	307,342	426,745
		m	180,766	178,991	369,616	361,775	125,327	608,759	396,245	273,094	149,182	137,447	190,846

x) - $p < 0,05$

TABLE 4.2.1.23. URINE EXCRETION OF UREA (g/day) IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)										
			I	2	3	4	5	6	7	8	9	I0	II
Urine urea	"A"		[illegible]	2I,580	23,400	25,240	26,I40	22,560	I8,840	22,840	20,940	20,860	2I,I00
		σ	2,9[illegible]6	3,948	7,264	5,I84	II,I20	5,I25	2,957	4,682	2,825	3,I77	2,I27
		m	I,4[illegible]3	I,766	3,249	2,3I9	4,973	2,292	I,322	2,094	I,263	I,42I	0,95I
	"B"		[illegible]	30,880	36,800	33,580	25,460	2I,I00	27,340	23,560	28,780	26,560	25,220
		σ	I,8[illegible]6	5,8I7	6,325	4,308	5,925	3,992	3,745	6,790	I7,920	5,79I	3,I40
		m	0,8[illegible]2	2,60I	3,723	I,927	2,650	I,785	I,675	3,036	8,0I4	2,590	I,404

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TABLE 4.2.1.23. CONTINUATION

Indices	Group	Significance	Before bed rest (days)			Bed rest (days)							
					Mean	I	2	3	4	5	6	7
					32,372	33,340	33,740	26,680	25,760	31,540	31,820	28,380
					5,040	7,359	6,348	9,147	6,134	10,068	11,685	5,859
					0,607	3,291	2,839	4,091	2,743	4;502	5,226	2,620
Urine urea					35,478	35,920	30,480	27,840	26,660	27,140	30,940 x	31,540 x
	"B"				7,355	11,692	8,220	8,305	8,526	3,318	3,412	6,144
					0,885	5,229	3,676	3,714	3,813	1,484	1,526	2,748

x) - $p < 0,05$

TABLE 4.2.1.23. CONTINUATION

Indices	Group	Significance	After bed rest (days)								
			2	3	4	5	6	7	8	9	I0
Urine urea	G		[illegible]	27,840	23,640	25,480	22,I40	27,920	26,960	24,840	23,540
			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	D		2,278	1,919	2,864	I,I85	2,408	3,580	2,258	I,727	3,058	2,75I
	"B"	G	[illegible]	[illegible]	[illegible]	25,320	29,040	23,620	25,760	25,220	28,940 x
			[illegible]	[illegible]	[illegible]	9,456	9,I74	I0,923	6,995	4,773	I8,37I
		D	[illegible]	[illegible]	[illegible]	4,230	4,I03	4,865	3,I28	2,I34	8,2I6

x) - $p < 0,05$

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TABLE 4.2.1.24. BLOOD IRON LEVEL (μg%) AND IRON-BINDING CAPACITY IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)			Mean	Bed rest (days)			After bed rest (days)	
							2	4	7	2	7
Iron	"A"	$\bar{x}$	[illegible]	[illegible]	142,400	137,200	114,400	102,000	136,800	87,600	109,600
		σ	[illegible]	24,898	32,168	28,373	30,113	31,654	70,521	35,338	22,064
		m	7,915	11,045	14,386	7,326	13,467	14,156	31,538	15,804	9,867
	"B"	$\bar{x}$	[illegible]	[illegible]	135,200	130,267	109,800	128,000	137,600	134,000	144,800
		σ	[illegible]	27,819	22,298	30,621	38,972	33,971	49,627	25,377	76,715
		m	[illegible]	[illegible]	9,972	7,906	17,429	15,192	22,194	11,349	34,308
Iron binding capacity	"A"	$\bar{x}$	[illegible]	[illegible]	351,600	330,667	347,200	330,200	333,600	339,200	337,600
		σ	[illegible]	[illegible]	15,327	22,168	13,537	9,124	8,771	18,742	12,686
		m	[illegible]	[illegible]	6,255	5,724	6,054	4,080	3,923	8,382	5,673
	"B"	$\bar{x}$	[illegible]	[illegible]	321,200	320,000	317,200	338,000	308,800	335,200	335,600
		σ	[illegible]	[illegible]	38,182	37,233	38,798	3,742	51,023	6,727	7,137
		m	[illegible]	[illegible]	17,525	9,613	17,351	1,673	22,818	3,008	3,192

TABLE 4.2.1.25. STATUS OF BLOOD ACID-BASE BALANCE IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)			Bed rest (days)				After bed rest (days)	
					14	Mean	2	4	7	2	7
pH				7,402	7,382	7,399	7,392	7,388	7,400	7,406	7,426[x]
		σ		0,022	0,022	0,017	0,014	0,016	0,015	0,016	0,014
		m		0,010	0,010	0,004	0,006	0,007	0,007	0,007	0,006
	"B"				7,386	7,401	7,394	7,392	7,404	7,414	7,418
		σ		0,014	0,014	0,012	0,016	0,021	0,014	0,021	0,022
		m		0,008	0,008	0,005	0,007	0,009	0,006	0,009	0,010
pCO_2 mm Hg					37,000	38,653	37,900	40,260	38,750	40,940	40,300
		σ		2,648	1,844	2,532	2,074	1,655	1,500	2,858	2,253
		m			0,755	0,654	0,527	0,740	0,750	1,278	1,008
	"B"				37,800	38,407	38,700	39,500	38,600	41,800[x]	40,100
		σ		4,650	4,424	4,070	1,718	2,346	4,393	1,956	2,702
		m			1,084	1,051	0,768	1,049	1,965	0,875	1,208

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TABLE 4.2.1.25. CONTINUATION

AB									1,621	1,150
meq/l				0,331	0,357	0,357		0,334	0,725	0,514
	"B"				23,153	21,8[illegible]X)		23,740	25,220	25,280
				1,550		1,590	1,441	2,305	0,910	1,579
				0,751	0,684	0,711	0,644	1,031	0,407	0,706
							47,340	48,525	47,280	49,580
				1,194	4,554	1,022	2,559	1,593	3,233	1,166
BB				0,534	1,364	0,457	1,073	0,796	1,446	0,522
meq/l										
				46,580	48,160	45,600X)	46,800	49,240	49,120	48,220
	"B"			1,085	3,932	1,475	4,736	3,615	4,044	0,776
				0,476	1,015	0,660	2,118	1,617	1,809	0,347
				-1,800	-0,873	-2,280	-0,800	-0,525	1,020	2,000X)
	"A"			0,469	1,107	2,339	1,151	0,690	1,698	0,840
BE				0,210	0,286	1,046	0,515	0,345	0,759	0,376
meq/l										
				-1,500	-0,513	-2,060	-0,820	0,000	0,700	1,220X)
	"B"			0,707	1,552	1,489	1,689	1,768	0,464	0,926
				0,316	0,401	0,866	0,755	0,791	0,207	0,414

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TABLE 4.2.1.25. CONTINUATION

Total CO_2 meq/l	"B"									
PO_2 meq/l										
	"B"									
SB meq/l	"B"									

Note: $x - p < 0,05$

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4.2.2. Endocrinology /129

4.2.2.1. Procedures

The status of the sympathetic-adrenal system (SAS) was evaluated according to a set of indices. Determined in blood were the concentrations of epinephrine (E), norepinephrine (NE) according to the procedure in [64], and dopamine (DA) [65]. Determined in the urine was the content of three forms of E, NE, DA, and DOPA [64], conjugated forms of E, NE, and DA [66], and also the level of catecholamine metabolites (CA), metanephrine (MN), normetanephrine (MMN) and their conjugates [67], vanillyl-mandelic (VMA) and homovanillic (HVA) acids [68]. CA fluorescence in blood was measured by the Hitachi (Japan) fluorescence spectrometer, model MPF-3.

The levels of ACTH, cortisol (C), somatotrophic hormone (STH), insulin, glucagon, thyrotropic hormone (TTH), thyroxine (T_4) triiodothyronine (T_3), parathyroid hormone (PTH), follicle-stimulating hormone (FSH), luteinizing hormone (LH), aldosterone, cyclic adenosine monophosphate (cAMP) and cyclic guanosine monophosphate (cGMP), prostaglandins (PG), pressor (F_2-alpha) and depressor (A+E) groups, and also plasma renin activity were studied in the blood of subjects.

The levels of the hormonal and biologically active compounds in blood were determined by the radioimmuno analysis method with the use of standard test-kits manufactured by Cea-Ire-Sorin, France (ACTH, aldosterone, STH), Corning, USA (TTH, T_4, T_3, insulin), Cambridge Nucleas Radiopharmaceutical Corporation USA (PTH), Byk-Mallincrodt, West Germany (FSH, LH, testosterone), Radioassay Systems Laboratories, Inc., USA (glucagon), Amersham, England (cAMP, cGMP). Plasma renin activity was expressed on the basis of angiotensin I formation by plasma incubation; angiotensin I was /130 determined by the test-kit manufactured by Clinical Assays, USA. The PG level after preliminary extraction was determined with the use of a kit produced by Clinical Assays, USA.

The aldosterone level in urine was determined by radioimmunoanalysis with the use of kits with reagents which were used to analyze the corresponding index in blood.

Radioactivity was counted on an automatic gamma-counter (model 1085, Nucleas Chicago, USA) and a liquid-scintillation system (model "Delta 300," Searle Analytic Inc., USA).

The level of total 17-ketosteroids (17-KS) was also determined in urine [69].

4.2.2.2. Results and Their Discussion

The results of experiments performed are presented in Tables 4.2.2.1.--4.2.2.11.

The blood level of hormonal and biologically active compounds in subjects during the baseline period were essentially within accepted normal limits; we should note that the blood insulin level in subjects in both groups was noticeably higher and the cAMP concentration was at its upper boundary. It must be also noted that the baseline level of hormones in blood differed with test group: thus, the ACTH, LH and T_4 concentration was significantly elevated and the TTH, and PTH levels and the value for the ratio cAMP/cGMP were significantly lower in subjects in group "B" than similar indices for group "A".

Group differences in the level of several hormonal and /131
biologically active compounds in blood in subjects during the baseline period, in all probability, may be attributed to individual responses of subjects to relative limitation in activity during this time. The higher-than-normal blood insulin concentration may be related to alimentary factors.

We should also note that indices of renin-angiotensin-aldosterone (R-A-A) indices tended to decrease at the end of the baseline period in both groups. Bed rest was accompanied by a tendency for the activity of the R-A-A system to increase in both groups; however, only plasma renin activity increased significantly on Day 4 and 7 of bed rest in subjects in group "B" beyond normal limits, as well as aldosterone excretion with urine on Day 5 of bed rest for the same subject group. During recovery, plasma renin activity, and blood and urine aldosterone level in both groups did not differ significantly from the baseline, with the exception of elevated plasma renin activity on the second day and aldosterone excretion on "0" to Day 1 in group "B" (Tables 4.2.2.1. and 4.2.2.10.). A tendency for an increase in ACTH level could be noted in subjects in group "A" on Day 2 and 7 of bed rest and during both examination periods during readaptation; in this case, ACTH level in group "B," similar to the C level in both groups, varied insignificantly (Table 4.2.2.2).

The blood LH level in group "A" subjects tended to decrease on Day 2 and 7 of bed rest; in this case, a significant decrease in this index on Day 2 and 4 of bed rest was observed in group "B" (Table 4.2.2.5.). The FSH level did not undergo any significant changes in either subject group throughout the experiment (Table 4.2.2.4.).

We should note the different direction of changes in PTH /132
levels in the experimental groups. Thus, the level of this hormone decreased gradually throughout bed rest in group "A" and was significantly lower than baseline values on Day 7 of this period, and remained reduced during readaptation, and in group "B" there was a gradual increase in PTH level toward the end of bed rest; during readaptation, the value of this index was slightly higher than baseline (Table 4.2.2.5.).

Blood insulin level in both groups on Day 4 of bed rest was significantly higher than baseline; in this case, it continued to be higher than the initial level in group "B" also on Day 7 of bed

rest; the glucagon level in group "A" subjects on Day 4 was 40% greater than baseline, whereas it did not differ from baseline in group "B" during this study period. We should emphasize that during recovery when no changes were noted in blood insulin level in both groups, the group "A" glucagon level on Day 2 after completion of bed rest decreased significantly, and on Day 7 was still lower than baseline, whereas it did not differ from the initial values for group "B" (Table 4.2.2.7).

The cGMP level in group "A" on Day 2 and 7 of bed rest was significantly higher than baseline, whereas the level of this compound in blood in group "B", similar to the cAMP concentration and the cAMP/cGMP ratio in both groups during the observation time, did not exhibit any significant changes (Table 4.2.2.8.).

We were not able to observe any significant changes in either of the experimental groups throughout observation in indices of functional activity of the thyrotropic function of the hypophysis and thyroid, and also in the level of PH pressor and depressor groups (Tables 4.2.2.3. and 4.2.2.4.).

The excretion of 17-KS with urine during the baseline /133 period was significantly higher in group "B" in comparison with that of group "A". No significant changes in the excretion of these compounds with urine were noted in either test group during bed rest or recovery (Table 4.2.2.11.).

It should be noted that we did not observe any essential statistically reliable differences in the indices studied in subjects of both groups during bed rest (BR) or during adaptation, which apparently was related to the small number of subjects in the groups and the considerable range of data.

4.2.2.3. Catecholamines

Results of the experiments performed are presented in Tables 4.2.2.12.--4.2.2.19.

The blood CA level during the baseline period (average values) in both test groups was higher than the accepted norm (Tables 4.2.2.12.--4.2.2.19.). We should note that examination on Day 9 of the baseline period revealed that the CA content was still within normal limits for both groups, whereas on Day 3 and 14 of the baseline period the CA level in blood was significantly elevated and higher than the norm in both groups.

Bed rest for subjects in group "A" was characterized by a significant decrease in the NE content on Day 4 and 7 of bed rest and DA on Day 7, whereas the E concentration did not exhibit noticeable changes throughout bed rest. The NE and DA level in blood in group "B" was significantly reduced on Day 2 and 7; in this case, the E level was significantly elevated only on Day 2 of bed rest. We

should note also the significant increase in the E/NE ratio in blood in both test groups throughout bed rest.

Recovery was accompanied by a significant increase (beyond /134 normal limits) in the NE content on Day 2 in subjects in both groups, and of DA on Day 2 and 7 in group "A" and on Day 2 in group "B". The E level in blood in both groups of subjects tended to increase on Day 2 of this period.

Thus, bed rest was characterized by a decrease in the blood CA level and an elevation of the activity of the SAS hormonal link (E/NE) in both test groups; however, these changes were more pronounced in group "B" (Table 4.2.2.12.).

Analysis of SAS activity based on CA excretion with urine demonstrated that the parameters studied during the baseline period were primarily within normal limits (Tables 4.2.2.13.--4.2.2.19.).

During hypokinesia there was a significant increase in E excretion with urine (free and bound forms) beyond normal limits in both groups. The excretion with urine of free NE forms was significantly elevated beyond normal limits on Day 1 of bed rest which was followed by its pronounced decrease, in some instances falling below normal values; in this case, the excretion of its bound forms tended to increase throughout bed rest in both groups; here, this elevation was more pronounced primarily during the first four days of bed rest and exceeded the upper normal boundary. Excretion with urine of free and conjugated forms of DA was noticeably elevated on Day 1 and 2 of bed rest with a tendency to decline at the end of hypokinesia in both groups. Excretion of DOPA with urine was significantly elevated on Days 1-2 of bed rest in subjects of only group "A".

Throughout bed rest, there was a significant (beyond normal limits) increase in the urinary excretion of free MN forms in both groups, whereas the excretion of bound MN forms exceeded the baseline on Days 1-2 of bed rest only in group "A". In this case, /135 the level of free NMN in urine was significantly (beyond normal limits) elevated in group "A" during bed rest, whereas in group "B" it was significantly elevated only on Days 4-7 of bed rest; in addition, excretion of its bound forms increased significantly on Days 1-4 of bed rest only in group "A". During bed rest, excretion with urine of HVA and VMA did not undergo significant changes in either of the experimental groups.

Thus, the results obtained demonstrate that during bed rest there is an insignificant increase in the activity of the hormonal SAS link (E/NE), which apparently demonstrated the absence of a stress reaction in subjects. The activity of the mediator SAS link during bed rest in both groups of subjects tended to decrease.

During recovery, there was a significant increase in the excretion of free E in the group "A" from "O" to Day 2, and in group "B"

from Day 1 to 2. Urinary excretion of free forms of NE was significantly elevated on Days 1-3 in both groups, whereas the urinary excretion of its conjugates did not vary significantly. The level in the urine of free DA was significantly elevated on Days 1-2, and of bound DA on Days 2-3 only in group "A". Excretion with urine of free groups of MN was significantly elevated only in group "A" on "O", Days 3-6, and of its bound forms on Days 6-9 in group "B".

For the excretion of NMN with urine, we noted a significant variation in this index only on isolated days in group "A". Excretion of VMA and HVA in both groups during recovery was at baseline levels.

Thus, during recovery the activity of the mediator SAS link /136 in group ["A"] barely varied with respect to the baseline, whereas in group "B" it was slightly elevated by Day 3 which was followed by its reduction to initial values.

Analysis of the results obtained demonstrates that the increase in blood CA concentrations in both groups on Day 12 and 14 of the baseline period (i.e., 1 and 3 days before the beginning of bed rest) demonstrates elevated activity of the hormonal SAS link, which is confirmed by the elevation in the E/NE ratio (based on blood and urine data). This demonstrates that there was an insignficantly manifested emotional reaction in subjects as the beginning of hypokinesia approached. The development of secondary emotional states during the time preceeding the beginning of the experiment has been indicated repeatedly in the literature [27,70,72].

Hypokinesia in both groups of subjects was accompanied by an insignificantly manifested activation of the hormonal SAS link, which suggests the presence of only an emotional response and not stress during this time. The decrease in the activity of the mediator SAS link, that we noted earlier during bed rest in both subject groups, agrees with previously obtained data demonstrating that in humans bed rest decreases the NE level in the body because hydrostatic blood pressure decreases when the body is in a horizontal position and afferent impulse transmission decreases [27,73,74].

In the initial stage of recovery, an emotional response typical for the beginning of the experiment was not observed in subjects in both groups [27]. The results we obtained during recovery in this experiment do not agree with previously obtained data, when /137 there were a stress response at the end of similar experiments and a pronounced elevation in the activity of the mediator SAS link in subjects, and also in cosmonauts after 7-8-day-long flights [27]. Apparently, the 7-day-long hypokinesia did not have a substantial effect and did not evoke substantial changes in SAS activity.

4.2.2.4. Abstract

In summarizing the material presented, we should note that

existence under hypokinesia conditions (clinostatic and antiorthostatic) in essence did not induce significant changes in the hormonal and metabolic status of the body in test subjects.

TABLE 4.2.2.1. ALDOSTERONE CONTENT (pg/ml) AND RENIN ACTIVITY (ng/ml/hr) IN PLASMA IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)			Bed rest (days)				After bed rest (days)	
			6	12	14	Mean	2	4	7	2	7
Renin	"A"	M	1,22	1,49	0,62	1,11	1,08	1,65	2,22	1,10	1,06
		σ	0,54	0,72	0,20	0,28	0,48	0,32	1,00	0,40	0,26
		m	0,27	0,36	0,10	0,08	0,24	0,16	0,51	0,20	0,13
	"B"	M	1,32	1,20	0,94	1,15	1,33	2,61[x)]	3,05[x)]	2,75[x)]	1,70
		σ	0,64	0,98	0,36	0,34	0,34	0,80	0,96	1,36	0,60
		m	0,32	0,49	0,18	0,09	0,17	0,40	0,48	0,68	0,30
Aldosterone	"A"	M	127,0	101,0	77,0	101,7	120,0	205,0	204,0	144,0	94,0
		σ	49,8	36,4	15,4	64,1	28,8	160,8	105,4	63,2	32,6
		m	24,9	18,2	77,0	17,1	14,4	80,4	52,7	31,6	16,3
	"B"	M	124,0	113,0	108,0	115,0	122,0	126,0	169,0	130,0	133,0
		σ	40,2	17,3	47,8	18,4	30,6	34,4	30,6	17,3	28,6
		m	20,1	8,6	23,9	4,9	15,3	17,2	15,3	8,6	14,3

x) - $p < 0,05$

[Commas in tabulated material in Tables 4.2.2.1-4.2.2.19 are equivalent to decimal points.]

TABLE 4.2.2.2. BLOOD ACTH (pg/ml) AND CORTISOL (μg%) CONTENT IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days) 6	12	14	Mean	Bed rest (days) 2	4	7	After bed rest (days) 2	7
ACTH	"A"	M	29,60	27,80	27,40	28,27•	36,20	31,60	45,10	46,20	54,20
		σ	11,95	8,89	4,72	8,41	6,94	17,95	37,58	31,39	32,15
		m	5,34	3,98	2,11	2,17	3,11	8,03	16,81	14,04	14,38
	"B"	M	55,60	52,40	55,40	54,47	56,00	49,00	52,20	48,30	51,80
		σ	22,47	38,51	34,67	30,23	42,30	33,47	27,89	36,98	42,32
		m	10,05	17,22	15,51	7,81	18,92	14,97	12,48	16,54	18,93
Corti-sol	"A"	M	12,83	12,60	12,84	12,76	12,30	11,23	14,41	12,57	14,17
		σ	4,45	4,12	1,84	3,39	5,00	3,80	5,41	4,79	5,89
		m	1,99	1,84	0,83	0,88	2,24	1,70	2,42	2,14	2,63
	"B"	M	12,31	10,33	11,34	11,33	11,29	12,32	12,99	12,19	12,97
		σ	1,25	4,38	2,93	3,02	2,89	3,43	3,45	4,76	5,21
		m	0,56	1,96	1,31	0,78	1,29	1,54	1,54	2,14	2,35

• - statistical significance of the averaged baseline for group "A" in comparison to the averaged baseline for group "B"

TABLE 4.2.2.3. BLOOD LEVEL OF THYROTROPIC HORMONE (TTH) (μU/ml) AND THYROXINE (μg%) IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)				Bed rest (days)			After bed rest (days)	
			6	12	14	Mean	2	4	7	2	7
TTH	"A"	x	3,57	3,17	2,88	3,21•	2,65	2,84	3,31	2,88	2,98
		σ	1,25	1,12	0,88	1,06	0,92	1,35	1,26	0,74	0,73
		m	0,56	0,50	0,39	0,27	0,41	0,60	0,56	0,33	0,33
	"B"	x	2,16	2,33	2,40	2,29	2,42	2,66	2,37	2,41	2,40
		σ	0,29	0,36	0,42	0,35	0,72	1,57	1,00	0,44	0,59
		m	0,12	0,16	0,19	0,09	0,32	0,70	0,45	0,20	0,26
Thyroxine	"A"	x	6,86	6,74	6,84	6,69•	6,75	7,14	7,06	7,30	6,92
		σ	0,82	0,66	0,91	0,70	0,94	0,59	0,96	0,69	0,89
		m	0,36	0,30	0,41	0,18	0,42	0,27	0,43	0,31	0,40
	"B"	x	7,06	7,34	7,04	7,25	7,78	7,34	7,22	7,46	6,78
		σ	1,09	1,04	0,65	0,96	1,19	1,22	1,16	0,52	0,68
		m	0,67	0,47	0,29	0,25	0,53	0,55	0,52	0,23	0,39

• statistical significance of the averaged baseline for group "A" in comparison to the averaged baseline for group "B"

TABLE 4.2.2.4. BLOOD LEVEL OF TRIIODOTHYRONINE (ng %) AND FOLLICLE-STIMULATING HORMONE (FSH) (μU/ml) IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)			Bed rest (days)				After bed rest (days)	
			[illegible]	[illegible]	[illegible]	Mean	2	4	7	2	7
Triiodothyronine	"A"		[illegible]	106,4	137,2	143,6	128,2	150,8	138,0	166,4[x)]	136,2
		σ	[illegible]	38,38	37,69	32,61	22,61	15,06	19,23	11,17	11,49
		m	[illegible]	17,61	16,86	8,42	10,11	6,73	8,60	4,99	5,14
	"B"		[illegible]	205,2	141,8	178,33	194,2	202,4	162,6	153,2	187,2
		σ	[illegible]	62,18	41,52	67,63	71,58	106,23	79,16	24,92	65,63
		m	[illegible]	36,75	18,57	17,46	32,01	47,51	35,40	11,15	29,35
FSH			[illegible]	3,86	3,98	3,90	3,83	3,64	3,74	3,82	3,88
		σ	[illegible]	0,56	0,75	0,56	0,55	0,51	0,35	0,51	0,36
		m	[illegible]	[illegible]	0,34	0,15	0,25	0,23	0,16	0,23	0,16
	"B"		[illegible]	[illegible]	3,79	3,87	3,84	3,67	4,01	3,66	3,46[x)]
		σ	[illegible]	[illegible]	0,91	0,87	0,86	1,15	1,42	1,35	1,11
		m	[illegible]	[illegible]	0,11	0,23	0,38	0,51	0,64	0,60	0,49

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TABLE 4.2.2.5. BLOOD LEVEL OF LUTEINIZING (LG) (μU/ml) AND PARATHYROID (PTH) (pg/ml) HORMONES IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)				Bed rest (days)			After bed rest (days)	
			6	12	14	Mean	3		1		
LH	"A"	m	6,46	6,12	6,80	6,46	6,12	6,30	6,14		
		σ	0,55	0,33	0,42	0,50	0,36	0,35	0,37		
		m	0,24	0,15	0,19	0,13	0,16	0,16	0,16		
	"B"	m	7,48	7,16	7,94	7,53	8,35 x)	8,52 x)	7,70		
		σ	1,74	0,55	1,31	1,25	0,77	0,66	0,77		
		m	0,78	0,25	0,59	0,32	0,35	0,3	0,3		
PTH	"A"	m	364,0	356,0	424,0	378,75 c					
		σ	62,05	130,74	104,51	90,52		58,78			
		m	27,78	43,3	41,21	34,71		17,74			
	"B"	m	260,0								
		σ									
		m									

x) statistical significance of the averaged baseline for group "A" in comparison to the averaged baseline for group "B"

TABLE 4.2.2.6. BLOOD LEVEL OF SOMATOTROPIC HORMONE (STH) (ng/ml) IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)				Bed rest (days)			After bed rest (days)	
			6	12	14	Mean	2	4	7	2	7
STH	"A"	M	I,70	I,68	I,55	I,64	I,69	I,63	I,50	I,5	
		σ	0,29	0,46	0,44	0,38	0,24	0,59	0,22	0,I	0,45
		m	0,I3	0,2I	0,I9	0,I0	0,II	0,26	0,09	0,08	0,20
	"B"	M	2,I2	3,25	I,90	2,43	I,99	I,86	I,84	2,I8	I,75
		σ	0,68	3,22	0,38	I,88	0,52	0,39	0,09	0,56	0,35
		m	0,30	1,44	0,I7	0,48	0,23	0,I8	0,04	0,25	0,I6

x) - $p < 0,05$

TABLE 4.2.2.7. BLOOD LEVEL OF INSULIN (μU/ml) AND GLUCAGON (pg/ml) IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)				Bed rest (days)			After bed rest (days)	
			6	12	14	Mean	2	4	7	1	7
Insulin	"A"	M	30,94	30,96	30,54	30,61	33,80	38,80 x)	37,50	35,14	33,40
		σ	5,64	6,65	5,71	5,65	I,20	I,64	6,97	5,37	3,43
		m	2,52	3,06	2,56	I,46	0,54	0.73	3,12	2,40	I,54
	"B"	M	24,36	28,20	26,92	26,49	28,90	36,40	33,60 x)	30,00	30,02
		σ	7,18	3,35	4,34	5,104	7,63	8,38	4,09	5,3	5,13
		m	3,2	1,49	I,94	I,32	3,4I	3,75	I,83	2,41	4,76
Glucagon	"A"	M	85,[illegible]	117,40	97,40	I00,28	98,40	140,20	134,20	41,00 x)	88,40
		σ	52,53	35,02	52,35	46,16	28,89	66,01	55,42	26,75	22,57
		m	23,49	16,01	23,41	19,89	10,[illegible]	23,69	24,78	11,96	8,[illegible]
	"B"	M	98,83	88,[illegible]	103,8[illegible]	93,[illegible]	[illegible]	145,[illegible]	74,[illegible]	[illegible]	76,[illegible]
		σ	75,[illegible]	[illegible]	[illegible]	50,[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		m	[illegible]	[illegible]	32,0[illegible]	19,[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

x) [illegible]

TABLE 4.2.2.8. BLOOD LEVEL OF cAMP (pmole/ml) AND cGMP (pmole/ml) IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)				Bed rest (days)		After bed rest (days)		
			6	12	14	Mean	2	4	7	2	7
cAMP	"A"	M	27,60	28,20	33,20	29,67	31,40	33,60	35,60	36,20	31,2
		σ	2,07	3,77	9,91	6,33	11,55	13,03	12,99	13,03	10,71
		m	0,93	1,68	4,43	1,64	5,16	5,83	5,81	5,83	4,79
	"B"	M	16,60	30,40	30,20	26,40	27,60	25,60	30,00	32,80	37,40
		σ	6,62	20,99	16,08	15,65	13,41	13,24	19,65	19,02	20,53
		m	2,96	9,39	7,19	4,04	5,99	5,92	8,79	8,50	9,18
cGMP	"A"	M	4,05	5,60	5,95	5,20	4,10 x	5,30	4,15 x	3,95	4,05
		σ	1,26	2,47	1,87	1,98	0,68	3,36	0,91	1,26	1,14
		m	0,57	1,10	0,83	0,51	0,39	1,50	0,41	0,57	0,51
	"B"	M	5,45	7,40	7,75	6,87	7,60	6,50	7,10	6,90	7,40
		σ	1,42	2,65	2,78	2,43	5,15	2,22	3,68	2,69	1,84
		m	0,63	1,19	1,24	0,63	2,30	0,99	1,65	1,21	0,82
cAMP/cGMP	"A"	M	7,46	6,30	6,58	6,76 x	7,80	6,60	8,68	9,56	7,96
		σ	2,61	3,42	4,14	3,23	3,17	4,92	2,95	3,26	4,43
		m	1,17	1,53	1,85	0,84	1,42	2,19	1,32	1,46	1,98
	"B"	M	3,58	4,00	3,90	3,83	5,82	4,40	5,14	5,20	5,20
		σ	1,33	1,86	1,45	1,46	5,19	2,60	3,12	2,49	2,64
		m	0,59	0,83	0,65	0,38	2,32	1,16	1,39	1,12	1,16

x) – $p < 0,05$

TABLE 4.2.2.9. BLOOD PROSTAGLANDIN LEVEL (PG) (ng/ml) IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)				Bed rest (days)			After bed rest (days)	
			6	12	1	Mean	2	4	7	2	7
GA+E	"A"	M	1,22	1,72	1,18	1,37	1,63	1,30	1,46	1,11	1,39
		σ	0,201	0,48	0,48	0,46	0,30	0,59	0,43	0,43	0,37
		m	0,09	0,22	0,21	0,12	0,13	0,26	0,19	0,19	0,16
	"B"	M	1,75	1,86	1,6112	1,74	1,59	1,78	1,56	1,30*	1,45
		σ	0,38	0,59	0,32	0,42	0,66	0,34	0,21	0,14	0,28
		m	0,17	0,26	0,14	0,11	0,29	0,17	0,09	0,06	0,12
$GF_2\alpha$	"A"	M	0,96	0,94	0,97	0,96	1,05	0,87	0,91	0,78	1,02
		σ	0,56	0,35	0,44	0,43	0,24	0,23	0,17	0,13	0,1
		m	0,262	0,15	0,20	0,11	0,11	0,10	0,07	0,06	0,05
	"B"	M	1,05	1,30	1,21	1,19	1,31	1,05	1,08	1,1	1,05
		σ	0,35	0,42	0,43	0,40	0,32	0,43	0,46	0,3	0,28
		m	0,17	0,19	0,19	0,10	0,07	0,19	0,22	0,1	0,1
$GF_2-\alpha$ GA+E	"A"	M	0,76	0,87	0,97	0,77	0,63	0,75	0,66	0,80	0,7
		σ	0,40	0,28	0,60	0,44	0,19	0,21	0,17	0,26	0,2
		m	0,17	0,13	0,22	0,11	0,08	0,11	0,07	0,11	0,09
	"B"	M	0,63	0,73	0,79	0,71	0,53	0,55	0,72	0,82	0,77
		σ	0,28	0,22	0,38	0,21	0,46	0,21	0,36	0,38	0,3
		m	0,13	0,1	0,15	0,11	0,12	0,1	0,15	0,15	0,13

TABLE 4.2.2.10. URINE ALDOSTERONE EXCRETION (μg/day) IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)														
			I	2	3	4	5	6	7	8	9	I0	II	I2	I3	I4	Mean
Aldosterone	"A"	M	2I,5	I5,4	2I,8	20,5	25,I	20,7	I6,I	I7,4	23,8	I6,8	I5,6	2I,6	I8,4	I6,6	I9,4
		σ	8,0	8,4	8,0	2,4	7,6	7,2	5,0	5,8	3,8	3,0	3,4	8,4	5,4	8,6	6,6
		m	4,0	4,2	4,0	I,2	3,8	3,6	2,5	2,9	I,9	I,5	I,7	4,2	2,7	4,3	0,8
	"B"	M	I9,8	24,6	I6,4	I8,2	20,4	I4,4	I8,4	I7,6	I6,8	25,6	25,4	I7,8	I8,0	I2,8	I9,1
		σ	5,8	5,6	5,0	8,0	7,2	4,4	4,2	5,8	6,6	I9,2	3,0	2,4	I,2	4,4	6,8
		m	2,9	2,8	2,5	4,0	3,6	2,2	2,I	2,9	3,3	9,6	I,5	I,2	0,6	2,2	0,9

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TABLE 4.2.2.10. CONTINUATION

Indices	Group	Significance	Bed rest (days)						
			1	2	3	4	5	6	7
Aldosterone	"A"	M	10,8	17,4	17,8	22,4	22,6	23,0	28,0
		σ	5,0	5,8	6,2	1,6	7,6	11,4	10,0
		m	2,5	2,9	3,1	0,8	3,8	5,7	5,0
	"B"	M	16,4	21,6	22,8	20,8	25,2[x]	21,8	21,8
		σ	5,0	2,2	8,0	8,0	5,4	6,2	2,4
		m	2,5	1,1	4,0	4,0	2,7	3,1	1,2

		After bed rest (days)											
Aldosterone	"A"	M	27,0	21,3	11,6	15,0	18,8	21,3	24,3	21,5	17,8	22,5	15,0	10,5	9,5
		σ	9,6	0,2	0,2	5,4	4,8	7,6	6,2	5,4	3,4	9,6	6,2	6,2	2,6
		m	4,8	0,1	2,7	2,3	2,1	3,8	3,1	2,[illegible]	1,7	4,8	0,1	0,1	0,3
	"B"	M	30,2[x]	27,4[x]	19,8	18,5	19,8	15,0	17,0	16,0	19,6	14,8	19,6	12,8	11,[illegible]
		σ	3,8	4,6	9,2	4,4	3,0	2,6	0,8	7,6	3,0	2,6	4,2	2,4	2,[illegible]
		m	1,9	2,3	4,6	2,2	1,5	1,3	0,4	3,8	1,5	1,3	2,1	[illegible]	2,2

Note: x - p<0,05

TABLE 4.2.2.11. URINE EXCRETION OF 17-KETOSTEROIDS (17-KS) (mg/day) IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days) I	2	3	4	5	6	7	8	9	I0	II	I2	I3	I4	Mean
17-KS	"A"	M	8,49	II,52	I0,I2	I2,00	9,93	II,89	8,78	I0,97	I0,02	9,50	8,25	7,84	I0,07	6,87	9,73
		σ	2,82	2,78	3,8I	3,23	4,97	5,59	I,47	3,60	3,76	2,55	I,78	2,47	2,52	2,73	3,36
		m	I,63	I,24	I,7I	I,45	2,22	2,50	0,66	I,6I	I,68	I,I4	0,79	I,II	I,I3	I,22	0,40
	"B"	M	I2,04	II,99	I2,04	II,I8	II,77	7,94	I2,72	II,00	I2,03	I4,I8	II,39	II,65	II,68	9,6I	II,71
		σ	0,44	2,75	4,I4	4,52	5,64	I,69	4,39	2,33	3,42	4,33	4,I9	4,39	3,5I	4,08	3,75
		m	0,22	I,23	I,3I	2,02	2,82	0,76	I,96	I,04	I,53	I,96	I,87	I,97	I,57	I,82	0,45

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TABLE 4.2.2.11. CONTINUATION

Indices	Group	Significance	Bed rest (days)						
			I	2	3	4	5	6	7
		M	8,7I	I2,92	II,87	I2,55	I3,59	I4,96	I4,29
	"A"	σ	3,90	I,44	2,80	3,04	4,67	3,75	4,27
17-KS		m	I,75	0,64	I,25	I,36	2,09	I,68	I,9I
		M	I3,27	I5,24	II,02	II,75	I3,I8	I5,3I	I4,02
	"B"	σ	7,II	3,79	2,92	3,95	4,02	5,I4	5,38
		m	3,I8	I,69	I,3I	I,77	I,79	2,30	2,40

		After bed rest (days)										
		0	I	2	3	4	5	6	7	8	9	I0
	M	9,26	9,30	8,58	9,92	8,45	9,67	8,76	I0,97	9,I7	II,53	8,4[illegible]
"A"	σ	I,86	I,98	2,43	2,63	0,77	2,89	2,04	4,28	2,56	5,47	2,3I
17-KS	m	0,83	0,88	I,09	I,I7	0,34	I,30	0,9I	I,9I	I,I5	2,45	I,0[illegible]
	M	II,09	I[illegible],39	9,4	II,7I	I0,5I	II,I8	I2,24	9,0[illegible]	9,80	9,I2	II,3[illegible]
"B"	σ	2,7I	4,[illegible]7	4,28	5,34	5,23	5,85	3,79	4,04	2,I8	I,20	3,[illegible]3
	m	I,2[illegible]	2,09	2,I4	2,39	2,34	2,6[illegible]	I,69	I,[illegible]	0,9[illegible]	0,54	I,[illegible]7

TABLE 4.2.2.12. BLOOD CATECHOLAMINE LEVEL (μg/liter) IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)				Bed rest (days)			After bed rest (days)	
			6	12	14	Mean	2	4	7	2	7
Epinephrine	"A"	M	0,47	0,81	1,48	0,919	1,11	1,08	0,98	1,30	0,91
		σ	0,07	0,12	0,41	0,49	0,23	0,17	0,22	0,44	0,25
		m	0,03	0,05	0,18	0,13	0,10	0,08	0,10	0,20	0,11
	"B"	M	0,45	1,19	1,53	1,06	1,37 x	1,18	0,98	1,38	0,71
		σ	0,11	0,14	0,19	0,49	0,18	0,17	0,24	0,34	0,12
		m	0,05	0,06	0,09	0,13	0,08	0,08	0,11	0,15	0,05
Norepinephrine	"A"	M	0,80	1,35	2,01	1,39	1,42	1,07 x	0,89 x	2,24 x	1,32
		σ	0,07	0,34	0,19	0,56	0,29	0,12	0,16	0,55	0,45
		m	0,03	0,15	0,09	0,14	0,13	0,05	0,07	0,25	0,19
	"B"	M	1,00	1,46	2,02	1,49	1,59	0,95 x	0,70 x	2,19 x	1,2
		σ	0,19	0,32	0,31	0,51	0,22	0,14	0,16	0,39	0,2
		m	0,09	0,15	0,14	0,13	0,10	0,07	0,08	0,18	0,2

x) - p < 0,05

TABLE 4.2.2.12. CONTINUATION

Dopamine	"A"	M	0,73	0,87	I,84	I,I5	I,02	0,93	0,80 x	I,83 x	0,80 x
		σ	0,07	0,I7	0,57	0,60	0,2I	0,23	0,25	0,I6	0,II
		m	0,03	0,07	0,26	0,I6	0,09	0,I0	0,II	0,07	0,05
	"B"	M	0,73	0,90	I,86	I,I7	I,03	0,75 x	0,62 x	2,06 x	I,34
		σ	0,09	0,28	0,63	0,63	0,28	0,22	0,I9	0,33	0,53
		m	0,04	0,I3	0,28	0,I6	0,I3	0,I0	0,09	0,I5	0,24
Epinephrine/ Norepinephrine	"A"	M	0,58	0,64	0,74	0,66	0,82	I,02 x	I,I4 x	0,66	0,8I
		σ	0,06	0,22	0,22	0,I8	0,26	0,I6	0,37	0,42	0,44
		m	0,03	0,I0	0,I0	0,05	0,I2	0,07	0,I6	0,I9	0,20
	"B"	M	0,47	0,84	0,77	0,69	0,87 x	I,60 x	I,4I x	0,68	0,64
		σ	0,I4	0,II	0,I2	0,20	0,06	0,27	0,28	0,I0	0,I8
		m	0,06	0,05	0,06	0,05	0,03	0,I2	0,I3	0,05	0,0[illegible]

x) - $p < 0,05$

TABLE 4.2.2.13. URINE EXCRETION (μg/day) OF FREE AND BOUND EPINEPHRINE (E) FORMS IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days) I	2	3	4	5	6	7	8	9	I0	II
E_{free}	"A"	M	I4,233	II,620	I0,940	9,856	9,596	I0,044	9,0[illegible]	I0,226	I0,856	II,4[illegible]	II,0I4
		σ	I,274	2,334	2,209	2,I54	2,4I8	4,055	2,[illegible]43	2,3I[illegible]	3,I56	3,63[illegible]	3,07I
		m	0,736	I,044	0,[illegible]88	0,963	I,08I	I,8I3	I,27I	I,036	I,4II	I,627	I,373
	"B"	M	I2,225	II,[illegible]96	I0,82I	II,I84	II,460	I2,I20	II,920	I0,774	II,080	II,962	I2,6[illegible]
		σ	2,784	2,74[illegible]	2,899	3,I86	2,627	2,052	2,909	3,090	3,39[illegible]	2,732	2,72[illegible]
		m	I,[illegible]82	I,229	0,9I7	I,425	I,I75	I,I86	I,30I	I,382	I,5I9	I,366	I,2I6
E_{bound}	"A"	M	23,000	26,[illegible]00	2[illegible],880	30,020	33,340	34,400	35,[illegible]40	38,400	39,I60	39,[illegible]00	38,[illegible]
		σ	2,080	3,I44	4,4I8	4,452	5,787	5,[illegible]84	4,[illegible]74	4,[illegible]07	4,300	5,0I6	3,[illegible]
		m	I,I73	I,[illegible]96	I,976	I,93I	2,58[illegible]	2,[illegible]97	2,[illegible]	I,792	I,923	2,243	I,[illegible]
	"B"	M	26,775	27,[illegible]00	2[illegible],680	27,860	3I,240	3I,700	32,[illegible]40	38,300	36,360	38,225	39,64[illegible]
		σ	4,089	2,027	3,376	2,692	3,666	3,I[illegible]5	5,759	8,577	8,4[illegible]6	7,048	8,60[illegible]
		m	2,044	0,9[illegible]7	I,068	I,204	I,639	I,42[illegible]	2,[illegible]75	3,836	3,764	3,524	3,[illegible]77

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TABLE 4.2.2.13. CONTINUATION

Indices	Group	Significance	Before bed rest (days) I2	I3	I4	Mean	Bed rest (days) I	2	3	4	5	6	7
E_{free}	"A"	M	I3,I80	I6,920	23,680	I2,272	26,000x	23,820x	20,000x	23,720x	23,780x	2I,I20	I7,3[illegible]
		σ	3,325	I,686	3,655	4,560	2,763	6,279	3,59[illegible]	5,903	8,082	8,235	6,83[illegible]
		m	I,487	0,754	I,635	0,549	I,236	2,808	I,6[illegible]0	2,640	3,6I4	3,683	3,05[illegible]
	"B"	M	I3,680	I5,400	I9,460	I2,632	25,I20x	25,860x	24,[illegible]40x	I8,[illegible]80	I7,720	I4,[illegible]0	I2,[illegible]
		σ	3,35I	3,563	4,I43	3,647	7,383	5,257	4,248	3,602	3,48I	2,872	3,0[illegible]
		m	I,498	I,593	I,853	0,442	3,302	2,35I	I,900	I,6II	I,557	I,284	I,365
E_{bound}	"A"	M	37,760	37,640	45,680	35,223	4I,340	48,580	42,880	40,420	40,900	38,060	37,[illegible]
		σ	3,307	2,044	8,075	6,954	I0,638	I0,535	5,593	3,394	I0,97I	6,808	7,[illegible]
		m	I,479	0,9I4	3,6II	0,837	4,757	4,7II	2,50I	I,5I8	4,906	3,045	3,[illegible]
	"B"	M	38,620	38,240	49,240	34,597	56,460x	52,040x	5I,740	44,320	47,220x	39,[illegible]60	42,[illegible]
		σ	6,965	5,559	5,974	8,I06	5,803	7,I75	I5,236	7,[illegible]85	6,369	5,[illegible]32	5,[illegible]
		m	3,II5	2,486	2,672	0,983	2,595	3,209	6,8I4	3,[illegible]26	2,848	2,[illegible]54	2,5[illegible]

x) - $p < 0,05$

TABLE 4.2.2.13. CONTINUATION

Indices	Group	Significance	After bed rest (days)										
			0	I	2	3	4	5	6	7	8	9	I0
E_{free}	"A"	M	22,500x	26,580x	20,840x	I7,240	I4,880	I3,960	I0,744	I2,043	9,800	I0,800	9,940
		σ	6,520	5,379	2,I97	3,II9	2,985	2,466	2,734	4,8I0	I,655	I,24I	I,2I9
		m	2,938	2,406	0,983	I,395	I,335	I,I03	I,223	2,I77	0,740	0,555	0,545
	"B"	M	I5,720	24,700x	23,600x	I9,500	I8,700	I7,840	I7,540	I3,720	I2,I92	II,030	II,I62
		σ	3,273	6,472	4,856	5,420	4,49I	4,295	2,534	3,052	4,I90	4,573	3,587
		m	I,464	2,894	2,I72	2,424	I,9I9	I,92I	I,I33	I,365	I,874	2,045	I,604
E_{bound}	"A"	M	40,I80	39,580	40,720	4I,620	38,880	33,580	32,260	34,633	30,I40	29,860	30,2[illegible]
		σ	II,755	I0,249	4,640	I0,I70	6,78I	4,663	5,I05	3,894	7,I09	5,08I	5,7I5
		m	5,257	4,584	2,075	4,548	3,033	2,085	2,283	2,248	3,I79	2,2[illegible]	2,55[illegible]
	"B"	M	40,I00	43,000	3I,I20	32,200	32,980	30,240	32,900	3I,980	3I,880	35,580	29,2[illegible]
		σ	3,992	5,720	7,960	7,359	7,405	8,239	I0,072	5,I4I	5,738	4,005	3,3[illegible]
		m	I,785	2,558	3,560	3,29I	3,3I2	3,685	4,504	2,239	2,566	I,7[illegible]	[illegible]

x) - $p < 0,05$

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TABLE 4.2.2.14. URINE EXCRETION (μg/day) OF FREE AND BOUND FORMS OF NOREPINEPHRINE (NE) IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)										
			I	2	3	4	5	6	7	8	9	I0	II
NE_{free}	"A"	$\bar{x}$	25,I33	29,0I0	28,780	28,260	28,I80	27,200	25,0[illegible]	26,580	27,080	27,980	28,540
		σ	2,I22	4,723	2,054	I,389	0,589	0,579	2,II2	4,00I	4,645	5,424	5,4I3
		m	I,225	2,II2	0,9I8	0,62I	0,263	0,259	0,94[illegible]	I,789	2,0[illegible]	2,426	2,42I
	"B"	$\bar{x}$	29,360	30,640	29,7I0	30,740	3I,I00	29,080	26,620	26,280	26,940	25,375	26,340
		σ	I,446	3,9I2	3,452	4,060	5,422	3,325	2,273	4,I73	2,46I	I,6[illegible]	3,[illegible]
		m	0,723	I,749	I,09[illegible]	2,084	2,425	I,487	I,0I7	I,866	I,I0I	0,[illegible]	I,[illegible]
NE_{bound}	"A"	$\bar{x}$	37,960	38,480	40,0[illegible]0	42,I80	4I,I20	42,220	44,9[illegible]	44,[illegible]0	44,600	4[illegible],[illegible]0	45,[illegible]6
		σ	4,94[illegible]	3,402	5,[illegible]4	8,976	5,423	5,200	6,783	6,2[illegible]	6,0[illegible]	5,[illegible]	5,[illegible]
		m	2,857	I,52I	2,3I9	4,0I4	2,425	2,325	3,034	2,79[illegible]	2,689	2,[illegible]	2,[illegible]
	"B"	$\bar{x}$	39,I00	38,4[illegible]0	39,[illegible]0	39,700	40,220	38,980	4[illegible],I80	4I,440	40,440	39,425	4I,[illegible]
		σ	3,562	2,54[illegible]	4,02[illegible]	3,337	2,422	3,372	2,780	3,I66	2,996	4,I25	2,[illegible]
		m	I,78[illegible]	I,[illegible]	[illegible],8[illegible]	I,492	1,083	I,0[illegible]	1,24[illegible]	I,4I[illegible]	I,335	2,068	I,[illegible]

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TABLE 4.2.2.14. CONTINUATION

Indices	Group	Significance	Before bed rest (days) I2	I3	I4	Mean	Bed rest (days) 1	2	3	4	5	6	7
NE_{free}	"A"	M	28,460	30,980	45,040	29,242	47,320*	36,980	27,740	21,360*	19,680*	16,840*	16,840*
		σ	4,640	3,394	9,567	6,167	7,639	10,205	4,390	3,635	3,277	2,736	3,039
		m	2,075	1,518	4,265	0,742	3,416	4,564	1,963	1,626	1,465	1,223	1,359
	"B"	M	26,240	30,640	46,960	30,625	52,680*	39,880	29,320	23,620	21,320*	16,480*	16,480*
		σ	4,659	7,408	4,727	6,430	20,243	6,796	2,595	3,869	3,741	5,151	5,013
		m	2,083	3,313	2,114	0,780	9,053	3,039	1,167	1,730	1,673	2,304	2,258
NE_{bound}	"A"	M	42,680	42,080	48,780	42,769	51,920	54,060	54,300*	52,860	45,880	42,080	40,780
		σ	3,810	1,977	4,408	5,476	8,343	8,880	6,648	10,087	6,596	7,736	8,153
		m	1,704	0,884	1,933	0,659	3,731	3,971	2,973	4,484	2,951	3,459	4,019
	"B"	M	40,540	41,180	51,640	40,965	58,180	55,620*	59,640	56,300	49,580	45,840	45,820
		σ	4,525	2,941	5,743	4,383	16,840	5,494	18,037	14,833	11,140	7,531	6,935
		m	2,024	1,315	2,569	0,532	7,531	2,457	8,064	6,636	4,982	3,368	3,092

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TABLE 4.2.2.14. CONTINUATION

Indices	Group	Significance	After bed rest (days) 0	1	2	3	4	5	6	7	8	9	10
Ne_{free}	"A"	M	29,760	48,180x	48,480x	41,340	34,360	32,320	29,100	25,080	26,500	27,320	29,5[illegible]
		σ	7,372	4,294	4,198	6,600	9,990	7,872	2,482	2,511	2,597	2,799	3,03[illegible]
		m	3,297	1,920	1,876	2,952	4,468	3,520	1,103	1,480	1,162	1,252	1,35[illegible]
	"B"	M	26,600	47,340x	52,420x	48,720x	37,640	34,800	29,360	27,320	26,420	25,400	2[illegible]
		σ	6,594	5,534	6,[illegible]10	2,799	6,758	6,170	4,622	2,924	4,188	3,730	3,45[illegible]
		m	2,949	2,475	2,974	1,252	3,022	2,762	2,067	1,308	1,873	1,669	1,54[illegible]
NE_{bound}	"A"	M	43,460	40,440	43,560	45,380	42,400	42,680	39,820	37,500	36,[illegible]00	34,500	39,[illegible]x
		σ	10,099	11,419	10,245	7,814	10,194	10,106	7,823	6,511	4,1[illegible]	2,544	2,408
		m	4,516	5,107	4,[illegible]72	3,494	4,559	4,530	3,49[illegible]	2,759	1,[illegible]	1,138	1,0[illegible]
	"B"	M	40,200	36,660	39,660	35,540	39,080	38,580	39,120x	40,120	39,460	40,440	42,0[illegible]
		σ	6,355	9,233	7,[illegible]93	11,581	6,608	3,2[illegible]	2,749	4,[illegible]79	4,462	1,553	2,3[illegible]
		m	2,842	4,1[illegible]3	3,[illegible]53	5,179	2,955	1,43[illegible]	1,23[illegible]	2,12[illegible]	1,995	0,695	1,08[illegible]

x) - $p < 0,05$

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TABLE 4.2.2.15. URINE EXCRETION (μg/day) OF FREE AND BOUND FORMS OF DOPAMINE (DA) IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days) I	2	3	4	5	6	7	8	9	10	11
DA_{free}	"A"	M	246,000	263,000	264,080	259,400	260,140	242,020	239,100	214,000	243,640	253,260	251,20
		σ	18,193	21,045	21,652	24,256	29,982	27,403	35,264	34,605	39,003	32,132	32,53
		m	10,504	9,412	9,683	10,848	13,408	12,255	15,771	15,476	17,443	14,140	14,551
	"B"	M	292,750	289,200	278,540	273,360	267,400	277,440	273,080	271,800	269,300	2 ,280	2 ,98
		σ	51,136	57,482	46,619	59,587	58,137	67,085	64,698	67,650	59,796	66,166	61,51
		m	25,569	29,207	14,742	26,648	26,000	29,906	28,983	30,257	26,742	3 ,093	2 ,57
DA_{bound}	"A"	M	430,000	437,420	436,760	433,860	428,[illegible]	422,500	422,540	425,860	424,320	42 ,300	4 ,0
		σ	6,245	9,290	8,[illegible]76	11,984	7,896	12,288	19,506	14,593	10,641	16,[illegible]85	21,87
		m	3,606	4,193	3,899	5,359	3,531	5,473	8,724	6,526	4,759	7,[illegible]29	13,04
	"B"	M	433,500	437,500	436,060	442,000	444,400	440,400	437,200	438,640	441,120	43 ,950	42 ,9
		σ	7,569	12,634	10,405	10,416	13,930	17,886	26,[illegible]61	27,003	25,062	39,[illegible]26	24,08
		m	3,[illegible]45	5,[illegible]11	3,796	4,658	6,230	7,999	11,[illegible]05	12,027	10,314	15,[illegible]70	10,7

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TABLE 4.2.2.15. CONTINUATION

Indices	Group	Signifi-cance	Before bed rest (days) I2	I3	I4	Mean	Bed rest (days) I	2	3	4	5	6	7
		M	275,820	283,680	421,040	268,694	470,440×	385,200×	293,400	251,760	230,840	214,720	208,
	"A"	σ	40,023	71,868	17,815	54,554	72,945	73,946	60,970	76,493	71,824	75,665	71,
		m	17,899	32,141	7,967	6,568	32,622	33,071	27,267	34,209	32,121	33,838	32,0
DA_{free}		M	263,920	285,400	400,320	281,685	422,540×	341,200×	305,420	278,480	248,860	219,780	231,400
	"B"	σ	79,953	74,863	24,498	66,399	47,556	20,875	62,053	70,384	73,491	52,378	67,818
		m	35,756	33,480	10,956	8,052	21,268	9,335	27,751	31,477	32,868	23,121	30,337
		M	425,280	428,240	511,300	433,737	503,000	517,380	464,040	430,300	388,000	374,920	386,700
	"A"	σ	32,099	30,740	93,969	35,809	64,004	74,616	70,915	78,802	42,607	33,386	50,1
		m	14,346	13,751	42,034	4,311	28,623	33,369	31,714	35,241	19,054	14,931	22,5
DA_{bound}		M	439,380	446,440	489,660	443,003	535,860	507,460	488,820	466,040	447,840	436,840	433,
	"B"	σ	21,070	15,123	22,858	23,190	38,490	36,710	56,050	41,370	55,556	72,665	68,9
		m	9,396	6,763	10,223	2,812	17,213	17,312	25,061	18,494	24,845	32,49	27,6

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TABLE 4.2.2.15. CONTINUATION

Indices	Group	Significance	After bed rest (days) 0	I	2	3	4	5	6	7	8	9	I0
DA_{free}	"A"	M	298,920	387,460*	372,460*	336,060	300,540	29I,760	270,740	260,267	250,820	244,780	265,620
		σ	I07,5I5	3I,I68	5I,94I	46,69I	59,352	49,940	I8,5I3	I8,045	34,269	34,365	42,992
		m	48,082	I3,939	23,229	20,88I	26,543	22,334	8,279	I0,4I8	I5,325	I5,368	I9,224
	"B"	M	256,080	290,000	358,300	353,200	330,460	280,980	262,000	225,640	225,820	23I,740	24I,260
		σ	I38,5I0	I45,484	I05,258	80,083	70,370	60,709	40,4II	39,72I	4I,330	49,267	57,450
		m	6I,944	65,063	47,073	35,8I4	3I,470	27,I77	2I,650	I7,764	I8,497	22,033	I4,791
DA_{bound}	"A"	M	423,200	47I,400	5I2,240	493,200	472,700	456,200	443,800	448,667	45I,000	448,440	47[illegible],600
		σ	25,26I	[illegible],686	30,508	24,583	42,435	45,I86	32,398	38,506	56,457	30,I32	I[illegible],I3I
		m	II,29[illegible]	[illegible],849	I3,0[illegible]	I5,466	I8,97[illegible]	20,20[illegible]	I4,48[illegible]	22,260	I6,2[illegible]	I3,[illegible]75	8,[illegible]
	"B"	M	455,6[illegible]	547,600	49[illegible],840	473,400	46I,660	447,600	444,200	435,300	347,650	43[illegible],940	47[illegible],760
		σ	58,8[illegible]	I4[illegible],344	77,I59	54,360	53,444	40,I22	42,6[illegible]	39,4[illegible]	I95,454	26,70I	2I,2[illegible]
		m	26,3[illegible]	6[illegible],5[illegible]	34,507	24,3I0	23,90I	2I,[illegible]68	I9,05[illegible]	I7,652	82,4I0	II,34I	9,49[illegible]

x) - p < 0,0[illegible]

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TABLE 4.2.2.16. URINE DOPA EXCRETION (μg/day) IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)										
			I	2	3	4	5	6	7	8	9	I0	II
DOPA	"A"	M	32,267	33,920	33,980	33,840	32,600	33,460	30,860	30,960	3I,960	32,500	33,360
		σ	4,750	6,I26	5,482	8,8II	6,I27	3,680	4,347	6,843	6,406	5,852	6,268
		m	2,742	2,740	2,45I	3,940	2,740	I,646	I,944	3,060	2,865	2,6I7	2,803
	"B"	M	3I,075	33,380	33,3I0	35,000	37,I60	39,360	42,I40	38,320	35,900	33,575	3I,060
		σ	4,I00	4,I22	5,254	5,778	7,II8	9,I96	II,I98	7,583	4,7I6	4,44I	7,395
		m	2,050	I,843	I,66I	2,584	3,I83	4,II3	5,008	3,39I	2,I09	2,220	3,307

TABLE 4.2.2.16. CONTINUATION

Indices	Group	Significance	Before bed rest (days) I2	I3	I4	Mean	Bed rest (days) 1	2	3	4	5	6	7
DOPA	"A"	M	35,060	37,460	5I,940	34,687	49,560	50,860	39,480	35,620	32,460	29,900	3I,260
		σ	6,379	6,730	I8,649	8,650	9,I63	9,075	6,455	I,220	3,309	6,875	5,826
		m	2,853	3,0I0	8,340	I,04I	4,098	4,059	2,887	0,545	I,480	3,075	2,605
	"B"	M	32,680	33,300	38,500	35,379	43,000	38,040	3I,800	29,540	29,360	30,320	32,I20
		σ	4,725	5,236	7,594	6,866	6,452	8,787	7,242	6,458	4,225	3,400	5,379
		m	2,II3	2,342	3,396	0,833	2,886	3,929	3,239	2,888	I,889	I,520	2,406

Indices	Group		After bed rest (days) 0	1	2	3	4	5	6	7	8	9	10
DOPA	"A"	M	30,260	38,400	44,920	4I,420	42,480	40,580	37,I60	33,600	35,500	3I,060	32,I40
		σ	8,074	9,532	9,097	I3,429	8,479	7,625	4,676	2,889	4,346	4,326	3,909
		m	3,6TI	4,263	4,068	6,006	3,792	3,4I0	2,09I	I,656	I,943	I,935	I,748
	"B"	M	30,620	46,I80	40,160	37,700	36,900	37,340	36,540	35,860	34,800	33,820	34,500
		σ	6,I9I	I2,936	7,304	I0,3I5	9,002	8,958	7,745	7,533	4,432	4,925	4,277
		m	2,769	5,8I2	3,267	4,6I3	4,026	4,006	3,464	3,369	I,982	2,202	I,9I3

Note: x - $p \leq 0,05$.

TABLE 4.2.2.17. URINE EXCRETION (μg/day) OF FREE AND BOUND FORMS OF METANEPHRINE (MN) IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days) 1	2	3	4	5	6	7	8	9	10	11
MN_{free}	"A"	M	140,467	135,360	136,240	128,960	138,380	141,840	152,500	151,160	150,580	151,280	151,9[illegible]
		σ	15,083	22,094	13,564	22,373	12,806	14,711	23,256	18,092	14,690	17,504	19,107
		m	8,706	9,881	6,066	10,005	5,727	6,579	10,400	8,091	6,570	7,828	8,545
	"B"	M	151,325	149,020	140,400	143,600	144,220	143,980	148,620	151,500	169,160	160,100	160,89[illegible]
		σ	17,393	19,801	18,450	21,144	17,72[illegible]	15,695	13,461	5,703	24,092	13,373	11,58[illegible]
		m	8,695	8,855	5,834	9,458	7,920	7 019	6,020	2,553	10,774	6,686	5,16[illegible]
MN_{bound}	"A"	M	118,667	117,920	116,880	114,840	119,100	115,280	116,740	116,320	113,720	119,520	124,[illegible]
		σ	6,253	10,792	7,933	7,499	3,729	12,883	13,802	10,487	7,162	8,144	16,[illegible]
		m	3,610	4,826	3,550	3,354	1,668	5,762	6,173	4,690	3,203	3,642	[illegible]
	"B"	M	114,[illegible]	112,[illegible]	114,780	113,660	114,520	112,560	109,940	114,400	119,220	114,575	[illegible]
		σ	13,084	6,79[illegible]	9,933	7,213	7,159	13,123	14,423	10,368	7,866	20,884	11,[illegible]
		m	6,532	3,03[illegible]	3,160	3,226	3,202	5,869	6,450	4,64[illegible]	3,518	10,442	5,2[illegible]

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TABLE 4.2.2.17. CONTINUATION

Indices	Group	Significance	Before bed rest (days) I2	I3	I4	Mean	Bed rest (days) I	2	3	4	5	6	7
MN_{free}	"A"	M	I53,820	I62,460	I83,400	I48,3I6	I98,000*	2I5,600*	2I6,I00*	209,800*	2I3,880*	2II,980*	204,640*
		σ	I9,II5	I3,694	29,433	2I,66I	26,382	23,850	28,246	26,067	I9,579	28,58I	30,680
		m	8,549	6,I24	I3,I63	2,608	II,798	I0,666	I2,622	II,657	8,756	I2,782	I3,72I
	"B"	M	I6I,240	I63,980	I79,680	I55,II4	206,600*	2I2,800*	2I6,600*	2II,800*	2I6,270*	I9I,920	I[illegible]
		σ	I3,468	I0,272	4,640	I8,I0I	9,I0I	I5,400	22,0I9	26,9I6	30,630	2I,852	27,2[illegible]
		m	6,023	4,594	2,075	2,I95	4,070	6,887	9,847	I2,037	I3,698	9,773	I2,I[illegible]
MN_{bound}	"A"	M	I22,720	I28,300	I5I,000	I20,900	I62,800*	I55,600*	I40,780	I24,980	I20,I80	I08,440	9[illegible]
		σ	I8,604	I7,978	20,037	I4,65I	I7,065	I8,690	28,943	36,850	3I,26[illegible]	34,I05	3[illegible]
		m	8,320	8,040	8,96I	I,764	7,632	8,358	I2,944	I6,480	I3,9[illegible]	I5,252	I6,[illegible]
	"B"	M	I22,400	I27,340	I26,420	II7,52I	I30,300	I32,280	I22,320	II5,040	II4,900	II8,460	I[illegible]
		σ	I6,937	I4,070	I5,968	I2,684	I7,698	I9,4I9	33,222	29,470	26,684	32,478	3[illegible]
		m	7,575	6,293	7,I4I	I,536	7,9I5	8,685	I4,852	I3,I79	II,920	I4,525	I[illegible]

TABLE 4.2.2.17. CONTINUATION

Indices	Group	Significance	After bed rest (days) 0	1	2	3	4	5	6	7	8	9	10
MN free	"A"	M	197,660	184,840	174,820	203,360*	200,540*	196,830*	194,480*	231,833	183,220	167,560	160,760
		σ	33,036	48,070	39,435	23,872	10,481	18,551	29,050	56,251	44,471	20,307	18,628
		m	14,774	19,261	17,636	10,676	4,687	8,296	12,981	32,476	19,886	9,108	8,337
	"B"	M	175,760	166,360	183,700	139,800	151,020	140,460	130,940	155,820	144,900	150,020	157,440
		σ	38,335	24,735	40,715	45,257	44,790	45,497	44,873	37,343	30,806	32,258	28,[illegible]
		m	17,157	11,062	18,208	20,250	20,031	20,347	20,068	16,700	13,776	14,457	11,[illegible]
MN bound		M	106,350	119,600	129,580	129,440	131,700	131,180	138,460	155,735	125,[illegible]	120,[illegible]	115,[illegible]
		σ	35,020	44,371	31,597	29,456	28,245	34,972	41,194	41,404	21,[illegible]	12,[illegible]	11,[illegible]
		m	15,108	19,843	16,[illegible]	13,173	12,631	15,640	18,423	23,935	9,443	10,[illegible]	4,[illegible]
	"B"	M	107,260	110,080	114,080	109,260	111,640	108,500	95,660*	92,240*	99,[illegible]*	97,[illegible]*	104,[illegible]
		σ	35,109	23,655	21,261	29,632	21,754	18,107	14,838	4,804	8,[illegible]12	13,[illegible]	13,[illegible]
		m	15,[illegible]	10,579	9,[illegible]	13,252	9,729	8,[illegible]	6,633	2,149	3,[illegible]	5,[illegible]	6,[illegible]

Note: * - $p < 0.05$

TABLE 4.2.2.18. URINE EXCRETION (μg/day) OF FREE AND BOUND FORMS OF NORMETANEPHRINE (NMN) IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)										
			I	2	3	4	5	6	7	8	9	I0	II
NMN_{free}	"A"	M	II6,I00	II0,080	III,700	I09,860	I09,480	I07,520	I09,640	I04,940	III,800	II3,900	II4,8
		σ	3,297	I0,606	7,573	4,7I9	6,842	6,997	7,652	I3,I76	7,590	I0,932	I2,
		m	I,903	4,743	3,36?	2,III	3,060	3,I29	3,422	5,893	3,395	4,889	5,5I4
	"B"	M	8I,450	I06,460	I0?,6I0	I0?,900	I06,640	II0,080	II0,2?0	III,240	I22,300	II9,?00	II?,3?
		σ	4I,726	I8,289	8,?54	9,287	8,794	8,II6	I0,052	I8,473	I9,365	I0,?87	I2,32?
		m	20,863	6,838	2,?0?	4,I53	3,933	3,630	4,496	8,26I	8,600	5,I??	5,4??
NMN_{bound}	"A"	M	?7,I6?	?8,520	?8,I80	?6,880	?8,300	8I,620	8I,940	85,380	86,?00	8?,?00	8?,?00
		σ	0,9??	5,I0I	4,99?	4,942	5,346	4,593	2,930	4,385	?,5??	8,?00	8,?00
		m	0,5??	2,59?	2,233	2,2I0	2,39I	2,054	I,3I0	I,9?I	2,92?	4,?00	3,?00
	"B"	M	8I,?2?	8I,9?0	?8,6?0	80,080	8I,360	82,420	86,060	?3,68?	94,?60	I0?,?00	93,?00
		σ	9,0?4	6,I?5	5,3?3	5,36?	?,6?6	9,362	9,?32	I0,I3?	I2,30I	8,2??	6,0??
		m	4,5??	3,0?5	I,?02	2,400	3,4?3	4,I??	4,I8?	4,I32	5,5?5	4,?I3	2,?0?

TABLE 4.2.2.18. CONTINUATION

Indices	Group	Significance	Before bed rest (days)				Bed rest (days)						
			I2	I3	I4	Mean	I	2	3	4	5	6	7
NMN free	"A"	M	II6,880	II5,740	I37,800	II3,363	I53,640*	I59,200*	I65,080	I6I,600*	I68,500*	I66,040*	I5I,8
		σ	I0,993	I2,567	I9,228	I2,I54	23,460	3I,800	44,930	35,746	25,843	I7,235	20,4
		m	4,9I6	5,620	8,599	I,463	I0,492	I4,22I	20,09	I5,986	II,557	7,708	9,I2
	"B"	M	II5,720	II9,240	I2	III,488	I36,400	I38,040	I39,3	I42,860*	I49,200*		
		σ	I5,844	I2,I33	I	I7,367	I7,I26	22,542	25,6	I2,2	8,08	2	I3,0
		m	7,086		5,3	2,059	7,659	I0,08I	II,48	5,4	3,6I	II,54I	5,8
NMN bound	"A"	M	9I,000	98,960	II0,I80	86,269	I23,620*	I2I,300*	II8,0	I08,2	I06,8		I0
		σ	9,425	9,I87	I9,2	II,805	II,734	8,029	II,032	I0,3	I5,4	,25	I7,1
		m	4,2I5	4,I08	8,	I,42I	5,248	3,59I	5,I93	7,49	8,0	,597	2,9
	"B"	M	92,540	97,980	I0	89,I72	I08,600	II8,	II3,3	II5,56	I03,	I06,640	I03,
		σ	5,I72	7,I06	I2,	II,326	26,907	23,	23,6I	24,74	2	I7,468	I5,
		m	2,48	3,205	5,6	I,374	I2,069	I0,686	I0,5	II,	I	,I72	7,0

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TABLE 4.2.2.18. CONTINUATION

Indices	Group	Significance	After bed rest (days) 0	1	2	3	4	5	6	7	8	9	10
NMN_{free}	"A"	M	147,000	144,980	141,120*	131,280	128,780	120,920	105,560	95,357	104,540	103,780	101,3
		σ	23,884	28,582	18,016	21,805	18,244	13,815	16,626	22,195	11,139	7,563	4,90
		m	10,681	12,782	8,057	9,751	8,159	6,178	7,435	12,809	4,981	3,382	2,219
	"B"	M	150,000	120,420	138,100	147,880*	145,840*	135,760*	122,440	116,600	105,320	104,200	96,7
		σ	36,896	26,845	27,984	24,673	13,349	6,198	18,415	24,589	18,365	14,382	12,0
		m	16,501	12,960	12,515	11,034	5,970	2,768	8,231	10,993	8,213	6,432	5,3
NMN_{bound}	"A"	M	103,320	108,460	109,400	120,920*	105,920	102,180	90,000	91,433	89,520	87,220	87,4
		σ	13,563	29,394	23,351	10,370	20,694	21,079	17,461	20,618	18,364	14,082	8,2
		m	6,065	13,145	10,443	4,638	9,251	9,422	7,810	11,951	8,213	7,617	3,7
	"B"	M	92,200	101,880	109,420	109,860	105,680	97,960	128,440	105,800	93,760	93,160	86,0
		σ	10,300	19,093	18,073	19,811	13,840	26,659	31,669	21,201	24,075	13,599	8,4
		m	7,299	8,539	8,082	8,860	6,189	11,922	14,176	9,491	10,287	6,082	3,7

Note: * - $p < 0.05$

TABLE 4.2.2.19. URINE EXCRETION (μg/day) OF VANILLYL MANDELIC (VMA) AND HOMOVANILLIC (HVA) ACIDS IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)										
			I	2	3	4	5	6	7	8	9	I0	I1
VMA	"A"	X	3,367	3,492	3,472	3,536	3,534	3,536	3,528	3,520	3,502	3,502	3,510
		σ	0,I04	0,220	0,I95	0,233	0,228	0,229	0,239	0,24I	0,2I4	0,220	0,254
		m	0,060	0,098	0,08[illegible]	0,I04	0,I02	0,I03	0,I07	0,I08	0,096	0,098	0,[illegible]
	"B"	X	3,740	3,736	3,622	3,600	3,584	3,578	3,570	3,580	3,562	3,547	3,530
		σ	0,325	0,287	0,2[illegible]3	0,6I5	0,6I4	0,6II	0,580	0,580	0,56I	0,659	0,5[illegible]
		m	0,I62	0,I29	0,09[illegible]	0,275	0,275	0,273	0,259	0,260	0,250	0,330	0,2[illegible]6
HVA	"A"	X	2,287	2,302	2,3I6	2,344	2,350	2,368	2,4I8	2,400	2,40[illegible]	2,[illegible]02	2,[illegible]3
		σ	0,242	0,280	0,2I9	0,I86	0,I70	0,I76	0,I82	0,I9I	0,I[illegible]9	0,[illegible]52	0,[illegible]3
		m	0,I[illegible]3	0,I25	0,05[illegible]	0,083	0,076	0,079	0,08I	0,086	0,0[illegible]4	0,[illegible]03	0,[illegible]63
	"B"	X	2,[illegible]3	2,456	2,393	2,402	2,4I4	2,494	2,450	2,432	2,474	2,447	2,5[illegible]7
		σ	0,3[illegible]4	0,3[illegible]6	0,2[illegible]4	0,307	0,270	0,2I7	0,255	0,252	0,252	0,[illegible]39	0,2[illegible]3
		m	0,I[illegible]0	0,I[illegible]3	0,0[illegible]8	0,I37	0,I2I	0,[illegible]42	0,II4	0,I04	0,I06	0,[illegible]19	0,[illegible]I7

TABLE 4.2.2.19. CONTINUATION

Indices	Group	Significance	After bed rest (days)										
			0	I	2	3	4	5	6	7	8	9	I0
VMA	"A"	M	3,752	3,978	3,956	3,862	3,762	3,65[illegible]	3,590	3,683	3,508	3,536	3,502
		σ	0,306	0,399	0,252	0,353	0,3I4	0,293	0,236	0,I70	0,I8I	0,I50	0,II6
		m	0,I37	0,I78	0,II3	0,I58	0,I4I	0,I3I	0,I06	0,076	0,08I	0,067	0,05[illegible]
	"B"	M	3,706	3,992	4,004	3,854	3,794	3,730	3,654	3,654	3,628	3,694	3,60[illegible]
		σ	0,823	0,622	0,603	0,635	0,623	0,580	0,626	0,6[illegible]	0,58[illegible]	0,5[illegible]	0,[illegible]
		m	0,369	0,278	0,270	0,284	0,279	0,259	0,280	0,2[illegible]	0,26I	0,237	0,[illegible]
HVA	"A"	M	2,760	2,956	3,0I4	2,760	2,682	2,616	2,574	2,6[illegible]	2,550	2,652	3,[illegible]
		σ	0,654	0,696	0,630	0,35I	0,34I	0,274	0,28[illegible]	0,I[illegible]	0,2I8	0,2[illegible]	0,[illegible]
		m	0,293	0,3II	0,2I0	0,I57	0,I53	0,I22	0,II[illegible]	0,0[illegible]	0,098	0,II[illegible]	0,[illegible]
	"B"	M	2,7I6	2,7I0	2,636	2,402	2,444	2,470	2,420	2,3[illegible]	2,400	2,4I0	2,4[illegible]
		σ	0,4I3	0,4[illegible]	0,5[illegible]	0,449	0,50[illegible]	0,477	0,4[illegible]	0,4[illegible]	0,38I	0,[illegible]	0,3[illegible]
		m	0,[illegible]	0,2[illegible]	0,2[illegible]	0,20I	0,22[illegible]	0,2I3	0,[illegible]	0,20[illegible]	0,I7I	0,[illegible]	0,I[illegible]

TABLE 4.2.2.19. CONTINUATION

Indices	Group	Significance	Before bed rest (days)				Bed rest (days)						
			I2	I3	I4	Mean	1	2	3	4	5	6	
VMA	"A"	M	3,454	3,502	3,632	3,515	4,076	3,994	3,992	3,852	3,766	3,690	3,6[illegible]
		σ	0,309	0,305	0,303	0,227	0,377	0,339	0,416	0,314	0,393	0,309	0,2[illegible]
		m	0,136	0,136	0,135	0,027	0,168	0,152	0,186	0,140	0,175	0,[illegible]	0,[illegible]
	"B"	M	3,539	3,532	3,924	3,627	4,280	4,070	3,974	3,824	3,672	3,[illegible]	3,[illegible]
		σ	0,589	0,574	0,[illegible]	0,522	0,789	0,654	0,629	0,[illegible]	0,623	0,[illegible]	0,[illegible]
		m	0,263	0,257	0,35[illegible]	0,0[illegible]	0,353	0,293	0,282	0,284	0,279	0,[illegible]	0,[illegible]
HVA	"A"	M	2,418	2,442	2,7[illegible]	2,40[illegible]	2,950	2,926	2,859	2,782	2,693	2,[illegible]	2,[illegible]
		σ	0,203	0,2[illegible]	0,713	0,276	0,[illegible]30	0,[illegible]35	0,[illegible]01	0,[illegible]	0,593	0,[illegible]	0,[illegible]
		m	0,091	0,10[illegible]	0,3[illegible]	0,0[illegible]	0,376	0,[illegible]05	0,[illegible]	0,[illegible]	0,[illegible]	0,[illegible]	0,[illegible]
	"B"	M	2,522	2,4[illegible]	2,60[illegible]	2,478	2,724	2,72[illegible]	2,6[illegible]	2,[illegible]	2,602	2,726	2,[illegible]
		σ	0,177	0,22[illegible]	0,306	0,246	0,3I4	0,318	0,222	0,[illegible]	0,328	0,[illegible]	0,[illegible]
		m	0,08[illegible]	0,10[illegible]	0,137	0,050	0,1[illegible]0	0,[illegible]42	0,[illegible]	0,[illegible]	0,[illegible]47	0,[illegible]	0,[illegible]

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4.3. Water-Salt Metabolism /181

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4.3.1. Fluid and Electrolyte Analysis

This investigation was conducted to study aspects of water-salt metabolism adaptation to bed rest. The problems studied included:

the study of the effect of body position on the bed on the rate of adaptation and dynamics of water-salt metabolism indices during hypokinesia;

clarification of the role of individual characteristics of subjects in the development of changes in the water-salt balance.

4.3.1.1. Literature Review

At present, extensive information has been accumulated on adaptation of physiological body systems during flight in our country after the successful completion of a series of long-term spaceflights lasting from 30 to 175 days. Generally accepted is the point of view of researchers in both countries that functional changes in the body during flights of various lengths are determined by different factors. If during long-term flights the major symptoms are metabolic disturbances, then, in short flights, hemodynamic changes predominate that are related to the redistribution of fluids. In this case, changes generally occur in water-salt metabolism, appearing in the losses of body fluids and electrolytes [1-5].

Comparison of data on water-salt metabolism during the first 7 days of flight obtained by us and our American colleagues on the spacecraft Soyuz-9, Gemini-7, Apollo-16, and Skylab, and of /182 water and electrolyte excretion dynamics in terrestrial experiments during antiorthostatic hypokinesia demonstrated basic similarities in the development of changes in water-salt metabolism under these conditions [6-11].

The first days of flight, similar to existence under experimental hypokinesia in bed, are accompanied by typical changes in hemodynamics in response to changes in hydrostatic gradient of blood pressure and the resultant increase in central blood volume. The turning on of cardio-renal regulation mechanisms results in hormonal shifts. This results in changes in renal blood circulation, decrease in water and electrolyte reabsorption in renal tubules, and development of water-salt diuresis. All these factors result in the decrease in plasma volume, an increase in blood serum osmotic concentration, imbalance of electrolytes, shifts, in pH, and several other changes [12-15].

Thus, bed rest with exposure to the earth's gravity is a suitable model for reproducing several physiological effects of weightlessness, and specifically, changes in water-salt metabolism and renal function. This has been repeatedly confirmed by our investigations. Thus, in water and salt loading tests that we widely used to study renal functions, identical conclusions were obtained on the changes in osmo- and ionoregulation during flight and terrestrial experiments of various durations [4,16-18]. Investigations with the use of antiorthostatic hypokinesia, which have the advantages, in addition to those listed above of simplicity and ease of operation, make it possible to obtain data on the sequence of the development of adaptations at various experimental stages.

The joint Soviet-American experiments undoubtedly made it possible to improve some procedures used by investigators in both countries and to bring together our points of view on the elaboration of the causes and the pathogenesis of changes in human body functions, including water-salt metabolism, during spaceflight and in terrestrial model experiments. /183

4.3.1.2. Experimental Procedures

Urine electrolyte excretion was determined in experiments with careful estimation of their intake on a background of maintained microclimate parameters.

During the first days as in-patients, the subjects received standard rations, consisting of three meals of food similar in salt composition, but with certain diversity in the daily menu. To determine the food moisture content and its mineral composition, the food products were homogenized, dried to a constant weight (to determine fluid content in the ration), and then combusted and mineralized. The quantity of minerals entering with the food daily, comprised on the average (in meq): sodium, 174±25 (160-190); potassium, 63±2; calcium, 42±7 (30-60); and magnesium, 27±0.6. Throughout the experiment, the amount of water consumed was not limited, but was strictly monitored by measuring the amount of water drunk and by checking the records kept by the subjects themselves. Subjects were weighed daily in the morning on an empty stomach to determine indirectly extrarenal fluid loss.

Both in the ration mineralizers and in the collected urine, sodium and potassium concentrations were determined by flame photometry, calcium and magnesium by atomic absorption, urine chlorides by titrometry, urine osmolarity by cryoscopy, and urine specific gravity was determined at 20°C with the use of a urometer.

Water intake was measured in ml/day. In addition, in /184 consideration of the significant spread in body weight among the test subjects (from 65 to 85 kg), the amount of water drunk was estimated in ml/kg of body weight to obtain more comparable data.

TABLE 4.3.1. CONCENTRATION OF PRIMARY ELECTROLYTES (in meq/liter), IONIZED CALCIUM (meq/liter) AND BLOOD OSMOLARITY (mosm/liter) IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days)				Mean	Bed rest (days)			After bed rest (days)	
			6	12	14			2	4	7	2	7
1	2	3	4	5	6	7	8	9	10	11	12
Sodium	"A"		143 2,1 0,9	142 3,6 1,6	142 1,9 0,8	142 2,5 0,5	140,0 3,5 1,6	142 0,8 0,4	140 3,4 1,5	142 2,2 1,0	141 2,3 1,0
	"B"		142 1,1 0,49	141 2,2 1,0	141 1,5 0,7	141 1,9 0,8	139 3,7 1,7	143 3,0 1,4	145[x] 3,3 1,5	142 1,3 0,6	141 1,7 0,8
Potassium	"A"		4,49 0,14 0,06	4,38 0,12 0,05	4,39 0,14 0,06	4,35 0,14 0,06	4,36 1,11 0,05	4,17 0,21 0,09	4,14 0,23 0,10	[illegible]	[illegible]
	"B"		4,15 0,21 0,09	4,20 0,17 0,08	4,22 0,21 0,09	4,20 0,18 0,08	4,21 0,15 0,07	4,03 0,18 0,08	4,07 0,26 0,12	[illegible]	[illegible]
Total calcium	"A"		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	"B"		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[Commas in tabulated material in Tables 4.3.1--4.3.13 and Tables 4.4.1--4.4.3 are equivalent to decimal points.]

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TABLE 4.3.1. CONTINUATION

I	2	3	4	5	6	7	8	9	IO	II	I2
Ionized calcium	"A"	M	I,06 0,05 0,02	I,08 0,04 0,02	I,07 0,03 0,02	I,07 0,04 0,0I	I,07 0,03 0,0I	I,I0 0,05 0,02	I,I5 0,06 0,03	I,08 0,03 0,02	I,06 0,02 0,0I
	"B"	M	I,05 0,04 0,02	I,06 0,04 0,02	I,05 0,03 0,0I	I,05 0,03 0,0I	I,06 0,06 0,03	I,08 0,06 0,03	I,09 0,I0 0,04	I,09 0,06 0,03	I,05 0,[illegible] 0,[illegible]
Magnesium	"A"	M	2,II 0,I4 0,06	2,04 0,II 0,05	2,07 0,I5 0,06	2,07 0,I2 0,03	2,04 0,09 0,04	2,07 0,04 0,02	2,I4 0,09 0,04	2,20 0,I5 0,05	2,09 0,[illegible] 0,[illegible]
	"B"	M	I,97 0,I7 0,08	I,97 0,I4 0,06	2,00 0,I4 0,06	I,98 0,I4 0,04	I,95 0,I3 0,06	I,97 0,I4 0,06	2,06 0,I2 0,05	2,09 0,[illegible] 0,[illegible]	2,0[illegible] 0,I3 0,0[illegible]
Chlorine	"A"	M	I06 3,I I,4	I02 3,3 I,4	I02 3,7 I,6	I02 3,I 0,8	I00 4,8 2,2	I02 I,82 0,8I	I03 [illegible] 3,2	[illegible] [illegible]	[illegible] 3,[illegible]
	"B"	M	I02 2,7 I,2	I0[illegible] 3,3 I,5	I0I 2,9 I,3	I0I 2,7 0,7	99 4,6 2,I	I00 3,4 I,5	I04 3,6 I,I	[illegible] 2,[illegible] I,[illegible]	[illegible] 2,4 I,[illegible]
Osmolarity	"A"	M	29I 4,2 I,6	292 5,0 2,2	292 3,8 I,7	292 4,I I,0	29I 4,5 I,9	292 I,9 0,8	29[illegible]X 4,4 I,9	2[illegible] 2,[illegible] I,[illegible]	2[illegible] 2,[illegible] I,3
	"B"	M	[illegible] [illegible] [illegible]	2[illegible] [illegible] [illegible]	29[illegible] 2,I [illegible]	2[illegible] 2,I 0,[illegible]	29[illegible] 2,5 I,I	2[illegible] [illegible] [illegible]	[illegible] 3,[illegible]	2[illegible] [illegible]	[illegible] [illegible]

Note: X — [illegible] in comparison with baseline

Estimations were based on the amount of so-called "total" water, representing the sum of beverages in the ration, the water content of products (ration moisture), and any additional drinking water consumed by the subjects.

Both the absolute values for water and electrolyte intake with food and their excretion with urine and the percent of excretion of the substances studied with respect to their intake were analyzed mathematically.

4.3.1.3. Results and Discussion

4.3.1.3.1. Blood Serum Electrolyte Concentration

Specific individual characteristics of blood electrolyte content were determined during the baseline period [Supplement "B," Sections 4.3.1 and 4.3.2]. However, changes in the ion concentration and osmolarity for each of three determinations for the baseline were minimal for the same subject. Differences in serum osmotic concentrations during this period were slightly higher only in subjects Zh and P and comprised 8 and 9 mosm/liter, respectively. A slight variability in the total calcium blood level was noted in subject S, and in potassium in subject Se. To study blood ion concentration dynamics during the experiment, data obtained from three measurements during bed rest, were combined and average baseline values were estimated for all parameters studied (Table 4.3.1).

No significant changes in ion concentration and blood osmolarity were revealed during or after bed rest (Table 4.3.1).

There was a tendency for blood potassium to decrease in several subjects on Days 4 and 7 of BR. However, according to group averages, these changes in comparison with the baseline were not signi- /187
ficant (Table 4.3.1.).

There was an increase in blood sodium and osmotically active substances concentration on Day 7 of BR in subjects of both groups. In this case, only changes in the osmotically active substance level were statistically significant ($P<0.05$) in group "A", and sodium concentration and osmolarity increased in group "B" ($P<0.05$).

4.3.1.3.2. Intake and Urine Excretion of Fluids

During the baseline period, the amount of fluids consumed during the day was the same for both groups. Based on kg of weight of the subjects, the value for water intake was slightly higher for the subjects than we usually observe for individuals of this age group on a standard diet.

TABLE 4.3.2. WATER INTAKE IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (mean)	Bed rest (days) I	2	3	4	5	6	7
Water intake ml/24-hr	"A"	M	2430	I698^{XX}	I737^{XX}	I722^{XX}	I745^{XX}	I862^{XX}	I904	I600^{XX}
		σ	I57	282	242	382	258	338	456	I60
		m	70	I25	I08	I70	II5	I48	204	7I
	"B"	M	2442	I739^{XX}	2I3I	2060	I860^{XX}	I936	2000	I940
		σ	256	350	530	260	342	277	4I2	487
		m	II4	I56	237	II6	I54	I24	I93	2I8
Water intake ml/kg	"A"	M	32,0	23,4^{X}	23,8^{XX}	23,5	24,0^{X}	25,8	26,2	22,0
		σ	4,8	6,0	3,6	6,6	5,3	6,I	7,9	3,6
		m	2,2	2,7	I,6	2,96	2,4	2,7	3,5	I,6
	"B"	M	30,0	2I,6^{XX}	26,5	26,4	23,0^{XX}	24,0	24,8	24,6
		σ	3,4	5,0	6,6	4,4	4,3	3,7	4,4	5,5
		m	I,8	2,2	2,9	2,0	I,9	I,7	I,9	2,4

Note: x - p<0,05, xx - p<0,01 in comparison with baseline

TABLE 4.3.2. CONTINUATION
WATER INTAKE IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	After bed rest (days) 0	I	3	4	5	6	7	8	9	I0
Water intake ml/24 hr	"A"	M	I946	2I54	I880	2II2	I9I8	2064	2I38	2420	26I3	2242
		♂	222	I25	I46	235	27I	3I6	38I	745	363	270
		m	99	56	65	I05	I2I	I4I	I70	333	I62	I2I
	"B"	M	2024	2250	2I48	2068	2I22	I934	I992	2086	2292	2154
		♂	28I	404	339	375	428	27I	365	480	322	446
		m	I26	I80	I78	I68	I9I	I2I	I63	2I5	I44	200
Water intake ml/kg	"A"	M	26,8	29,3	25,6	29,I	26,3	28,5	29,6	33,8	36,I	30,9
		♂	4,5	I,5	I,9	4,7	4,4	6,5	7,6	I2,9	7,3	5,I
		m	2,0	0,7	0,8	2,I	2,0	2,9	3,4	5,8	3,3	2,3
	"B"	M	25,5	28,3	27,0	27,4	26,6	24,3	25,I	26,3	28,8	27,4
		♂	4,7	5,5	5,8	5,I	5,5	3,6	4,7	6,2	4,3	7,7
		m	2,I	2,5	2,6	2,6	2,4	I,6	2,I	2,8	I,9	3,5

There was a decrease in the amount of water consumed, which was more apparent in test group "A", from the first to the last day of bed rest. Based on kg of weight, we established that on the average during hypokinesia the value for water intake was approximately the same for both groups and comprised 24.1±0.52 and 24.5±0.67 ml for test group "A" and "B," respectively, and was statistically lower than the baseline (Table 4.3.2).

During recovery, water intake on Day 0 was maintained at the same level as during hypokinesia. On the other days, water intake by subjects increased slightly, but did not reach baseline values (Table 4.3.2, continuation).

The value for diuresis during the baseline period in both groups of subjects differed significantly ($P<0.05$). After conversion to kg of weight, this difference became insignificant.

No noticeable changes in diuresis values were observed during BR. A significant increase in diuresis occurred on Days 2 and 5 /190 only in group "A" subjects. In group "B" subjects, there was a considerable individual spread in the quantity of urine excreted for all bed rest days (Table 4.3.3.).

Comparison of the values for urine output with water intake reveals a significant increase in fluid excretion by kidneys during the first two days of BR in both groups of subjects; in this case, this was apparent to a greater extent in group "A" subjects (Table 4.3.4).

During the recovery period on Day 0 diuresis increased by a significant value in both groups in comparison with diuresis during BR. At the end of the observation, the diuresis value approximately corresponded to baseline values (Table 4.3.3).

4.3.1.3.3. Excretion of Electrolytes and Osmotically Active Substances

4.3.1.3.3.1. Sodium and Chlorides

Regardless of the standard intake of sodium in the food ration during the baseline period, significant variations were noted in renal sodium excretion both for each subject and as an average for the group. Satisfactory stabilization in excretion occurred only in the last few days before the beginning of hypokinesia.

During BR, natriuresis in group "A" subjects increased significantly from Day 2 to 5, and during the last two days of BR its amount did not exceed the baseline value (Table 4.3.5).

There was a significant increase in urine sodium throughout hypokinesia in group "B" subjects. A significant difference between groups ($P<0.05$) was noted only during the first days of BR and was

TABLE 4.3.3. EXCRETION OF FLUIDS BY KIDNEYS IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (mean)	Bed rest (days)							After bed rest (days)
				1	2	3	4	5	6	7	0[XXX]
Diuresis ml/24 h	"A"	M	720	800	1000[XX]	950	950	1123[XX]	1229	984	669
		σ	58	80	148	338	214	310	520	240	105
		m	26	36	66	153	96	137	232	108	62
	"B"	M	935	1248	1127	1090	928	954	1004	1260	667
		σ	105	429	214	290	178	133	288	509	102
		m	47	192	96	148	80	60	128	227	68
Diuresis ml/kg	"A"	M	9,7	10,9	13,7[XX]	13,1	13,1	15,4[XX]	17,0	13,6	9,2
		σ	1,0	1,2	2,6	5,4	4,0	4,7	6,1	4,3	1,9
		m	0,4	0,5	1,2	2,4	1,8	2,1	3,7	1,9	0,9
	"B"	M	11,3	15,6	14,0	14,0	11,8	12,0	12,4	15,7	8,7
		σ	3,2	6,1	3,8	5,8	5,4	2,1	3,0	6,1	2,1
		m	1,5	2,7	1,7	2,6	2,4	1,0	1,3	2,7	1,0

Note: [illegible] in comparison with baseline

[illegible] diuresis from the time of shift to vertical position

TABLE 4.3.3. CONTINUATION

EXCRETION OF FLUIDS BY KIDNEYS IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	After bed rest (days) 0	I	3	4	5	6	7	8	9	I0
Diuresis ml/24 h	"A"	M	775	874	970	768	970	863	I024	678	980	8I2
		σ	I09	I30	242	60	I89	I44	453	57	398	22I
		m	49	58	I08	27	85	72	203	29	I99	II0
	"B"	M	85C	930	I056	II08	III0	992	I029	960	900	I066
		σ	I9I	25I	440	575	365	3I2	265	28I	I44	678
		m	85	II2	I97	257	2II	I39	I32	I26	72	303
Diuresis ml/kg	"A"	M	I0,6	I2,0	I3,2	I0,6	I3,3	II,8	I3,8	9,5	I3,2	II,3
		σ	I,7	2,4	3,2	I,3	2,5	2,I	5,3	0,8	4,3	2,3
		m	0,8	I,I	I,4	0,6	I,I	I,0	2,4	0,4	2,2	I,I
	"B"	M	I0,8	II,8	I3,3	I4,0	I4,3	I2,5	I3,0	I2,I	II,4	-
		σ	2,9	4,2	5,8	7,6	5,6	3,8	4,0	3,8	I,9	-
		m	I,3	I,9	2,6	3,8	3,2	I,7	2,0	1,7	I,0	-

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TABLE 4.3.4. URINE EXCRETION OF FLUIDS WITH RESPECT TO WATER INTAKE (in%) IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Group	Significance	Before bed rest (mean)	Bed rest (days) 1	2	3	4	5	6	7
"A"	M	30	47^{XX}	58^{XX}	55^{XX}	54^{XX}	60^{XX}	64^{XX}	62^{XX}
	δ	3,7	I0,4	2,4	9,6	6,9	I4,6	I0,3	8,0
	m	I,7	4,7	I,I	4,3	3,I	6,5	4,6	4,0
"B"	M	39	72^{XX}	5[illegible]^{X}	53	50	50	52	65^{XX}
	δ	5,2	I9,5	I[illegible],7	I5,4	I8,0	7,7	II,8	I7,4
	m	2,4	8,7	4,7	6,9	8,I	3,4	5,3	7,8

Note: x - $p < 0,05$ xx - $p < 0,0I$ in comparison with baseline

TABLE 4.3.5. RENAL EXCRETION OF SODIUM, CHLORINE (in meq/24 hr) AND OSMOTICALLY ACTIVE SUBSTANCES (in mosm/24 hr) AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (mean)	Bed rest (days) I	2	3	4	5	6	7
Sodium	"A"	M	I44	I75	253^{XX}	$I82^{X}$	$I80^{X}$	$I76^{X}$	I74	I44
		δ	I3	3?	46	29	29	I5	39	I8
		m	6	I4	2I	I3	I3	7	I7	8
	"B"	M	I36	239^{XX}	$23I^{XX}$	$I88^{X}$	$I63^{X}$	$I66^{XX}$	I52	$I76^{XX}$
		δ	II	46	34	42	26	I4	23	29
		m	4	20	I5	I9	I2	6	I0	I3
Chlorine	"A"	M	I25	I53	227^{XX}	$2II^{XX}$	$I72^{XX}$	226^{XX}	209	$I67^{XX}$
		δ	27	22	3I	66	39	88	62	29
		m	5	I0	I4	29	I8	39	37	I3
	"B"	M	I40	200^{X}	208^{XX}	210^{XX}	$I8I^{XX}$	$I76^{XX}$	I8I	206^{XX}
		δ	9	55	33	63	86	I8	58	40
		m	4	25	I5	28	38	8	26	I8
Osmotically active substances	"A"	M	86I	880	$II54^{XX}$	I027	953	I035	I03I	954
		δ	95	I30	I49	228	I20	II5	84	43
		m	I6	58	67	I02	60	5I	38	I9
	"B"	M	923	I007	$II78^{XX}$	993	965	965	I0II	I03[illegible]
		δ	I50	I28	223	253	I42	75	I47	2[illegible]
		m	26	52	I09	II3	64	33	66	[illegible]

Note: X - $p<0,05$ XX - $p<0,01$ in comparison with baseline

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TABLE 4.3.5. CONTINUATION
RENAL EXCRETION OF SODIUM, CHLORINE (in meq/24 hr) AND OSMOTICALLY ACTIVE SUBSTANCES (in mosm/24 hr) AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	After bed rest (days) 0	I	3	4	5	6	7	8	9	I0
Sodium	"A"	M	I05^{XX}	II6	I80	I43	I77	I63	I54	I24	I65	I46
		δ	I7	29	39	I4	I9	25	42	I4	33	6
		m	8	I3	I8	6	9	I3	I9	7	I9	3
	"B"	M	I08^{XX}	II4^{XX}	I52	I38	I46	I56	209	I45	I54	[illegible]
		δ	33	7	55	69	36	38	42	56	I4	78
		m	I5	3	25	3I	2I	I7	2I	25	7	3[illegible]
Chlorine	"A"	M	I42^{XX}	I57	I93	I42	I65	I63	I65	I34	[illegible]	I36
		δ	26	28	40	I7	20	26	35	22	59	26
		m	I2	I2	I8	8	9	I3	I6	II	26	[illegible]
	"B"	M	I47	I48	I85	I5I	I6I	I60	I78	I57	I57	I6[illegible]
		δ	2I	3I	64	63	44	37	23	52	8	7[illegible]
		m	9	I4	28	30	26	I6	II	23	4	[illegible]
Osmotically active substances	"A"	M	835	8I0	974	925	935	930	977	776	[illegible]	[illegible]
		δ	I3[illegible]	II4	I66	63	67	I37	I2I	7[illegible]	[illegible]	[illegible]
		m	59	5I	7[illegible]	3I	30	6I	54	3[illegible]	[illegible]	3
	"B"	M	[illegible]	825	973	[illegible]	[illegible]	[illegible]	[illegible]I	[illegible]	[illegible]	[illegible]
		δ	[illegible]	66	22[illegible]	[illegible]	[illegible]	I37	22	[illegible]	[illegible]	[illegible]
		m	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6I	65	[illegible]	[illegible]	[illegible]

Note: [illegible] ^{XX} - $p < [illegible]$ in comparison with baseline

more pronounced in group "B" subjects. During Day 0 of the recovery period, sodium retention was observed in subjects of both groups. Thereafter, values for sodium excretion corresponded to baseline values. Dynamics of chloride excretion throughout the experiment corresponded to sodium excretion. /196

4.3.1.3.3.2. Potassium

No specific aspects were noted in potassium excretion. Throughout the observation period, its renal excretion was uniform with minor individual characteristics. Its excretion was significantly elevated in group "A" subjects at the end of the experiment (Table 4.3.6).

4.3.1.3.3.3. Calcium

There were no group differences on the average daily calcium excretion during the baseline period. Both groups contained subjects with low calcium excretion. We should specifically point out subjects in group "B", namely P, T, and A, in whom calcium excretion differed significantly from other subjects in this group (7.9±0.94 meq/24 hr, in comparison with 11.8±0.7).

During BR, urine calcium increased significantly in group "A" subjects on the second day during a maximum elevation in diuresis natriuresis; this last shift in calcium excretion was fixed on Day 7 of BR (Table 4.3.6).

No significant changes in the calcium quantity in urine were determined for the group as a whole for group "B." The reason for this was the fact that in two subjects (P and T), who were characterized by low calcium excretion during the baseline period, there were no changes in its quantity in urine throughout BR. For the three other subjects, the significant increase in urine calcium coincided with the increase in sodium excretion.

4.3.1.3.3.4. Magnesium

Urine magnesium level varied insignificantly for both groups throughout BR (Table 4.3.6). Its somewhat atypical relationship to calcium is apparently determined by the diet characteristics.

4.3.1.3.3.5. Osmotically Active Substances /199

Urine osmotic concentration during the baseline period was the same for subjects in both groups. During hypokinesia considerable individual variation was noted, which leveled off group differences. A significant elevation in osmotic concentration was observed for both groups on Day 2 of BR (Table 4.3.5).

TABLE 4.3.6. RENAL EXCRETION OF POTASSIUM, CALCIUM, AND MAGNESIUM (in meq/24 hr) AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (mean)	Bed rest (days) 1	2	3	4	5	6	7
Potassium	"A"	M	53	40,8^{x}	57,0	50,6	57,0	58,4	52,0	62,0^{xx}
		σ	4,7	II,0	II,9	I2,5	I0,7	I2,5	20,5	3,3
		m	2,3	5,0	5,3	5,6	4,8	5,6	9,2	I,5
	"B"	M	50,0	48,6	60,8	56,0	60,0	56,6	50,4	55,8
		σ	5,0	II,9	II,5	I5,7	9,7	5,5	I3,8	II,I
		m	2,0	5,3	5,I	7,0	4,3	2,4	6,2	4,9
Calcium	"A"	M	9,9	8,3	I4,6^{xx}	II,3	II,I	I2,5	II,9	I4,3^{xx}
		σ	I,7	2,2	2,8	3,4	3,3	2,9	3,5	I,9
		m	0,7	I,0	I,3	I,5	I,5	I,3	I,6	0,8
	"B"	M	9,5	I0,9	I3,2	9,7	8,7	I2,0	II,8	I3,8
		σ	2,2	4,5	6,3	3,4	2,2	4,8	5,2	3,8
		m	I,0	2,0	2,8	I,5	I,0	2,I	2,3	I,7
Magnesium	"A"	M	8,2	8,I	I2,5^{x}	8,6	8,6	I0,3	8,9	I0,0
		σ	I,5	0,7	3,I	I,5	I,5	I,3	3,3	2,0
		m	0,6	0,3	I,4	0,7	0,7	0,6	I,5	0,9
	"B"	M	8,0	9,2	I0,7	I0,7	I0,9	II,0	9,5	I0,4
		σ	I,7	I,0	3,7	2,8	2,8	I,6	I,8	3,2
		m	0,7	0,4	I,6	I,2	I,3	0,7	0,8	I,2

Note: x - $p < 0,05$ xx - $p < 0,01$ in comparison with baseline

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TABLE 4.3.6. CONTINUATION
RENAL EXCRETION OF POTASSIUM, CALCIUM, AND MAGNESIUM (in meq/24 hr) AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	After bed rest (days) 0	I	3	4	5	6	7	8	9	I0
Potassium	"A"	M	62,8	49,6	53,4	47,0	46,4	50,5	56,0	5I,8	57,3	45,8
		σ	II,4	I2,0	6,4	II,I	8,9	I4,8	I8,0	3,9	3,2	I2,I
		m	5,7	5,3	2,9	5,0	4,0	7,4	8,0	I,9	I,6	6,0
	"B"	M	53,4	46,0	46,8	40,2	44,0	44,2	50,8	49,4	52,8	55,2
		σ	I2,0	4,7	8,2	5,9	3,5	7,2	9,4	7,0	I4,4	I8,9
		m	5,4	2,I	3,7	2,6	2,0	3,2	4,7	3,I	7,2	8,4
Calcium	"A"	M	8,9	9,5	I0,7	8,6	9,6	9,7	9,4	9,7	II,I	8,7
		σ	0,5	2,3	2,3	2,9	I,5	2,I	I,4	I,0	3,6	3,0
		m	0,3	I,0	I,0	I,3	0,7	I,I	0,6	0,5	I,8	I,5
	"B"	M	II,2	I8,6	I5,I	I2,9	II,I	I0,I	I2,6	I2,3	I2,2	I2,0
		σ	I,5	II,2	5,6	8,5	4,2	2,8	4,3	9,I	5,0	6,7
		m	0,7	5,0	2,5	3,8	2,4	I,3	2,2	4,I	2,5	3,0
Magnesium	"A"	M	9,3	8,2	9,0	8,2	II,4	9,I	9,3	9,3	I0,9	9,6
		σ	2,0	2,0	I,3	I,3	5,2	I,9	2,5	I,0	2,3	I,5
		m	I,0	0,9	0,6	0,6	2,3	I,0	I,I	0,5	I,I	0,8
	"B"	M	II,9	II,5	I0,I	I0,7	II,7	I0,7	II,5	8,5	I0,6	I0,9
		σ	3,7	I,6	3,I	3,3	4,9	2,9	2,3	I,8	2,4	4,9
		m	I,7	0,7	I,4	I,5	2,8	I,3	I,I	0,8	I,2	2,2

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4.3.1.4. Discussion of Results

Investigators in the field of space biology have repeatedly observed that during the first few days of BR, in response to the increase in central blood volume, typical changes occur in total and renal hemodynamics, accompanying the elimination of fluid from the body.

The viewpoint has been raised that during weightlessness this is apparently determined by the suppression of thirst center activity and also by the development of diuresis, whereas during antiorthostatic hypokinesia "relative polyuria" develops, i.e., stable diuresis on a background of reduction in the amount of fluid intake.

In this experiment to analyze the actual material, we encountered difficulties in obtaining data because of the great diversity related, as we suspect, to individual characteristics of the subjects and the small number of subjects in the groups. Actually, in comparing data on water intake with the diuresis values on the average for BR with baseline values, we noted the following: in both groups, some subjects significantly reduced water intake and essentially did not alter diuresis, and in others there was a slightly lower reduction in water intake, but, on the other hand, diuresis increased almost 10-fold.

Thus, apparently, both types of adaptation to BR are possible, due to a decrease in fluid intake by suppression of thirst /200 center activity, and also to the development of diuresis. This can explain the not very manifest changes during the first days of BR in diuresis and water intake. In this experiment, both groups contain subjects with differing adaptive responses.

It has been suggested earlier that the type of diuresis developing depends to a great extent on body hydration level. Thus, water diuresis develops in well hydrated subjects and osmotic diuresis in poorly hydrated subjects. However, none of the authors, including us, in using the term "hydration level," gave it a physiological definition. In this experiment, we attempted to find the most suitable index to characterize water-salt status.

Comparison of values for diuresis and water intake in subjects with various adaptive responses (Table 4.3.7) during BR (subgroup 1 and 2) revealed that during the baseline period these indices did not differ significantly. The only index for which differences were noted was the daily excretion of sodium and its urine concentration. Thus, in the first subgroup with the most subjects (80% of the total number), who were characterized during BR primarily by a reduction in water intake and in whom diuresis essentially did not develop, during the baseline period 117±7.2 meq of sodium was excreted by the kidneys the concentration of which in the urine was 135±14 meq/liter. In the other subgroup, these indices were 140±5.5 meq and 194±14 meq/liter,

TABLE 4.3.7. URINE EXCRETION OF SODIUM (meq/24 hr) AND ITS CONCENTRATION (meq/liter) AND ALSO WATER INTAKE (ml/kg) AND DIURESIS (ml/kg) ON THE AVERAGE BEFORE BED REST AND THROUGHOUT BED REST

Group	Significance	Before bed rest				Bed rest			
		sodium		water intake	diuresis	sodium		water intake	diuresis
		meq/24 hr	meq/24 l	ml/kg	ml/kg	meq/24 hr	meq/24 l	ml/kg	ml/kg
"A"	M	II7	I35	30,6	II,7	I84	203	22,6	I2,0
	σ	I3,2	24,0	2,9	3,0	I5,8	24,0	3,9	3,3
	m	7,2	I4,0	I,5	I,5	8,5	II,4	I,9	I,6
"B"	M	I40	I94	33,0	I0,3	I87	I68	26,6	I5,0
	σ	I2,0	26,0	5,I	0,28	7,8	I2,0	I,8	2,3
	m	5,5	I4,0	2,2	0,2	3,0	5,4	I,0	I,3

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respectively.

Consequently, with the identical intake of sodium with food, its excretion by kidneys differed for these subgroups. Nonetheless, in both subgroups during BR moderate sodium and water deficiency developed. We could suggest that the decrease in /202 sodium and water excretion after completion of bed rest was related to the necessity of retaining fluid and salt in the body to maintain an optimal water-salt status. During BR, this group of subjects produced urine with a high sodium concentration. Regardless of the fact that each experimental group contained subjects with different adaptation responses, high natriuresis developed during the first days in group "B" which is definitely a reflection of volume regulation characteristics determined by the experimental conditions.

The reduction in body hydration level in subjects had an effect both on serum sodium concentration and on osmolarity. Thus, there was an increase in these indices in both groups on Day 7 of BR with group-related differences, since osmolarity increased only in group "B".

On Day 0 from the time of vertical position and shift to the limited motor activity regime, the following was noted for both groups of subjects: significant fluid and sodium retention both in comparison with BR and with baseline. This response may be regarded as a suitable response necessary for compensating fluid and sodium deficiency occurring during BR.

With consideration of the type of recovery in weight after BR, we can suggest that 0.6 and 0.75 liters of body weight were lost due to fluids in groups "A" and "B"; accordingly, sodium excretion by kidneys during BR surpassed by 14-16% sodium entering with food. In analyzing the weight dynamics of subjects during BR, a significant weight loss in group "A" was noted only for S, and on the whole changes for the group comprised 0.4 kg; in group "B" weight loss was much more significant and comprised on the average 1.5 kg.

During the first few days after BR, there was an approximately equal fluid retention in both groups, which had an effect on increase in weight on the average by 0.6 kg and 0.75 kg in groups "A" and "B", respectively. /203

The absence of manifest weight dynamics during BR in group "A" is apparently related to diet characteristics. We can suggest that for subjects with a lower body weight (for group "A" the weight of subjects on the average was almost 8 kg less than for group "B") the food ration with the calorie content of 2500 kCal was adequate and they did not lose tissue mass; this ration was insufficient for subjects in group "B".

Calcium excretion dynamics differed in its great diversity for individual values. Our experience demonstrated that after analyzing

data on the calcium quantity excreted by kidneys, comparison with baseline values is necessary for each subject. In this case, significant elevation in calcium excretion on Days 2-3 of BR were successfully established. This can be related absolutely to changes in metabolic regulation, since metabolic changes in calcium occur at later stages. Confirmation of this is the stability in the ionized calcium level in blood serum.

Potassium metabolism is subject to similar individual characteristics. Thus, in some subjects in both groups there was a significant elevation in its excretion, and in some of them there was a significant decrease. This is apparently closely related to individual adaptive responses to BR.

4.3.1.5. Summary /204

Thus, fluid and salt excretion by kidneys increases during BR. These phenomena develop more rapidly when the body is in an anti-orthostatic position.

Group differences cannot be found for many indices, although some shifts in blood electrolyte concentrations and osmotic concentration are more pronounced in group "B" subjects. The great individual diversity and the low number of subjects per group do not make it possible in many instances to discuss regular differences between groups. The changes noted in water-salt metabolism are primarily determined by shifts in metabolic regulation and in shifts in hemocirculatory and neuroendocrine homeostasis typical for BR.

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4.3.2. Water Loading Test /207

Tests were performed to study the characteristics of osmo- and ionoregulating functions of the kidneys in healthy individuals after a 7-day bed rest in a horizontal or antiorthostatic position.

4.3.2.1. Literature Review

The water test which increases requirements for target organs and systems and evaluates their reserve capacities makes it possible to detect latent disorders in water-salt metabolism and is widely used in diagnosing various diseases, primarily in the kidneys and hypothalamo-adrenal system. Since one of the reasons for the reduction in fluid and electrolyte excretion after spaceflight may be variations in renal activity or in the state of their regulatory systems, it is suitable to evaluate their functional activity with the use of this test.

The first study of this type was undertaken on crew members of the spacecraft "Voskhod" [1]. In this case, after the flight a reduction in renal capacity to rapidly excrete fluid after the water loading was detected. The small number of observations did not make it possible for the authors to reach a conclusion on the significance of these changes; in this regard, this test was used in the subsequent flights.

A decrease in fluid and electrolyte excretion by kidneys, an increase in osmotic urine concentration, and a decrease in the excretion of osmotically free water during maximum diuresis were noted in most cosmonauts after flights ranging from 2 to 30 days [2-5]. An increase in sodium and calcium excretion was also noted in some cosmonauts in addition to a reduction in fluid excretion [6,7]. The disturbances observed in the relationship between natriuretic and hydrouretic renal functions may have been caused by the fact that after spaceflight, when the hemodynamics are still not /208 stabilized, the body does not react adequately to the administration of an excess amount of water [7]. To identify further mechanisms responsible for these changes, similar investigations were performed in experiments with exposure to hypokinesia and immersion. In this case, both after completion of spaceflights and also in model experiments, excretion of fluids, sodium, and calcium decreased after the water test and the clearance of osmotically free water during maximum diuresis also decreased [8-10]. In this case, these changes were not isolated during hypokinesia, but were noticed only after its completion. Since the value for glomerular filtration did not differ from the initial value, the shifts observed in ion and water excretion, according to some authors, were determined not by decrease in filtration load but by changes in their transport in tubules.

After a 5-day antiorthostatic hypokinesia, water and ion retention after the water test was also noted. However, no significant differences in the expression of changes as a function of the angle

of inclination of the head of the bed (from 0° to -12°) were noted [11]. After a more prolonged 30-day antiorthostatic hypokinesia (-6°), the reduction in fluid, sodium, and potassium excretion by kidneys after the water test was slightly greater, than if the subjects were kept in a position close to horizontal (-2°) or with the head of the bed elevated (+6°) [12]. According to the authors, these differences may have been caused by hemodynamics characteristics, including the redistribution of fluid in the body.

It has been suggested [12] on the basis of analysis of postflight and experimental data that changes observed after the water test are not due to disturbances in renal activity, but to characteristics to osmo- and volume regulation under these conditions. /209 An increase in water reabsorption in renal tubules after spaceflight and experiments on hypokinesia is the result of incomplete suppression after the water loading of ADH secretion, the production of which is elevated under these conditions [5,13]. The metabolism regulation system in humans during and after spaceflight, bed rest, and immersion remains highly sensitive and the kidneys by altering fluid and sodium transport mantain effectively or restore the metabolism of the intravascular bed suitable for these conditions [12].

4.3.2.2. Procedures

The test was executed according to standard procedure [14] in the morning on an empty stomach after water deprivation during the night. After venous blood has been sampled, the bladder has been emptied, and the subjects have been weighed, subjects drink distilled water at the rate of 20 ml per kg of body weight after 10-15 minutes. Fractional collection of urine after the water loading was performed for 4 hours: during the first 3 hours after 30-minute intervals (6 urine samples), and then at 1-hour intervals (7 urine samples). In addition, the urine collected during the night and collected for the rest of the day after the water test is analyzed. This collection of specimens makes it possible to obtain information on the initial level of excretion of the substance studied, the value of their maximum excretion rate with urine after the water loading, and the total quantity of these substances excreted during the water test period, and also to evaluate their excretion dynamics throughout those days on which this study was performed.

During the entire test time, subjects are confined to bed in a horizontal position and get up only to empty their bladder at times specified by the investigation procedure. The subjects were /210 not allowed to eat, drink, or smoke during the 4 hours of the test period. A specimen of 5 ml of venous blood was taken 90 minutes before and after the water loading.

Sodium, potassium, calcium, magnesium, creatinine, and osmotically active substance concentrations were determined in all blood and urine specimens. The procedures for analyzing these substances has been described above (Section 4.3.1). In addition, the 17-HCS

content was determined in the urine by the Silber Porter method after enzymatic hydrolysis with the use of beta-glucuronidase [15].

The following indices were analyzed to evaluate experimental results:

concentration of substances analyzed in urine and blood;
values for diuresis and the rate of excretion of the substances analyzed in each test period;
excretion of the substances indicated for each test period and as a total for the 4-hr test, and also for the day on which the study was performed;
clearance of the substances studied;
value for reabsorption of osmotically free water.

It was assumed in estimating clearances that the concentrations of the substances studied in blood in the urine fractions I, V, VI, and VII corresponded to their values before the test, and urine fractions II, III, and IV to their values when blood was sampled 90 minutes (fraction III) after loading.

In addition, several other indices were used to evaluate the functional state of the kidneys before and after maximum diuresis: filtration charge of the substances, their concentration index, absolute and relative value for sodium reabsorption, and others. Conventional physiological concepts and formulas were used for this purpose [16-20].

4.3.2.3. Experimental Results and Their Evaluation /211

Diuresis increased after the water loading in all subjects during the baseline period.

In this case, the highest values for fluid excretion rate were found 60 to 120 minutes after loading (urine fractions III-IV). During this time, tests for minute diuresis increased 15-20-fold relative to initial values, and reached 12-13 ml/min. Thereafter, the value for diuresis decreased, but even four hours after the water loading it remained higher than during the night and was higher than its average daily level. Separate data are presented in Supplement "B" (Section 4.3.2).

Urine electrolyte concentration decreased progressively with an increase in diuresis, and generally, reached minimum values during its maximum (Table 4.3.8). Regardless of the fact that at the peak of diuresis electrolyte concentration was the lowest, their excretion rate even increased slightly in comparison with values for the night period (Table 4.3.9).

Electrolyte concentration in serum collected 90 minutes after loading, did not differ significantly from values obtained before the test. The analysis of serum made it possible to detect a significant decrease only in sodium concentration and in osmolarity in both

groups of subjects (Table 4.3.10). Apparently, this was one of the basic factors for the significant changes in renal osmoregulation function during the water test.

Urine osmotic concentration decreased progressively immediately after loading and in reaching minimum values at the height of water diuresis was almost 15-fold less than its night level. The index of urine osmotic concentration after the water loading decreased and reached a minimum of 60-120 minutes after loading. Values for /212 osmolar clearance and urine excretion rate for osmotically active substances during maximum diuresis were also significantly higher ($p<0.05$) than during the night before loading (Supplement "B," Section 4.3.2).

In addition to the increase in diuresis and decrease in urine osmolarity, the most significant changes during the water test were observed in the value of osmotically free water clearance which increased gradually and reached a maximum at the peak of water diuresis (Table 4.3.11) and was approximately 10 ml/min for all subjects (Supplement "B", Section 4.3.2). Consequently, consumption of an excess amount of water by healthy humans increases the body fluid volume and decreases the concentration of osmotically active substances in it, which, in turn, turns on several reflex mechanisms responsible for inhibition of ADH and limitation of water reabsorption in distal nephron sections [17].

In addition to these specific adaptive mechanisms, a series of reflex actions involving the mucosa of the upper digestive tract sections and also internal organ receptors aid the body in rapidly reestablishing the lost osmotic equilibrium of its internal medium by excreting hypoosmotic urine [18].

Serum osmolarity increases as excess water is eliminated from the body which restores ADH level and the permeability of the distal nephron section and collecting du for water. Therefore, urine osmolarity increased gradually until the end of the test and generally surpassed serum osmotic concentration. The value for osmotically free water clearance in this case again became negative (Supplement "B," Section 4.3.2).

Integral indices reflecting the status of the water- /218 salt metabolism and renal functions after water loading include excretion of fluids, electrolytes, and creatinine throughout the test. The amount of substances excreted th urine over the 4-hour test is presented in Table 4.3.12 and in Supplement "B" (Section 4.3.2).

On Day 2 after BR, excretion of fluids, sodium, potassium, calcium, magnesium, osmotically active substances, and 17-HCS by the kidneys 4 hours after the water loading remained almost at baseline levels. No significant group differences were noted in the values for these indices. Creatinine excretion in most subjects in both groups during the water test after BR was higher than before the

TABLE 4.3.8. ELECTROLYTE (meq/liter) AND CREATININE CONCENTRATION (mg/liter) DURING MAXIMUM DIURESIS AFTER WATER LOADING IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Significance	Before bed rest group		After bed rest group	
		"A"	"B"	"A"	"B"
Sodium	M	9,60	7,90	9,28	8,70
	σ	I,89	I,27	2,38	2,20
	m	0,82	0,55	I,I9	0,88
Potassium	M	4,90	4,72	4,78	3,84
	σ	0,62	0,28	I,I3	0,97
	m	0,27	0,I2	0,57	0,41
Calcium	M	0,66	0,48	0,53	0,50
	σ	0,39	0,09	0,I3	0,10
	m	0,I7	0,04	0,06	0,05
Magnesium	M	0,36	0,40	0,4I	0,43
	σ	0,I4	0,07	0,25	0,I0
	m	0,06	0,03	0,II	0,04
Creatinine	M	0,II	0,I2	0,I4	0,I5
	σ	0,02	0,02	0,02	0,04
	m	0,0I	0,0I	0,0I	0,02

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TABLE 4.3.9. RATE OF ELECTROLYTE (μeq/min), CREATININE (mg/min), AND 17-HCS (μg/min) EXCRETION DURING MAXIMUM DIURESIS AFTER WATER LOADING AT VARIOUS EXPERIMENTAL STAGES

Indices	Significance	Before bed rest group		After bed rest group	
		"A"	"B"	"A"	"B"
Sodium	M	I33,0	I07,8	I25,8	[illegible]
	σ	30.2	24,4	29,2	I3,3
	m	I3,I	I0,6	I4,6	[illegible]
Potassium	M	67,29	63,58	64,62	[illegible]
	σ	4,53	3,I5	I3,68	[illegible]
	m	I,97	I,37	6,84	[illegible]
Calcium	M	8,84	6,4I	7,I7	[illegible]
	σ	3,29	0,83	I,30	[illegible]
	m	2,20	0,36	0,95	[illegible]
Magnesium	M	4,9	5,4	5,3	[illegible]
	σ	I,7	0,8	2,8	[illegible]
	m	0,7	0,4	I,2	[illegible]
Creatinine	M	I,5I	I,56	I,66[X]	[illegible]
	σ	0,2I	0,28	0,24	[illegible]
	m	0,09	0,I2	0,II	[illegible]
17-HCS	M	I6,4	I7,I	I5,7	I8,4
	σ	3,4	2,8	2,3	[illegible]
	m	I,5	I,2	I,0	2,9

Note: X – $p < 0,05$ in comparison with baseline

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TABLE 4.3.10. ELECTROLYTE CONCENTRATION (meq/liter) AND OSMOTIC CONCENTRATION (mosm/liter) IN SERUM OF SUBJECTS DURING THE WATER LOADING TEST AT VARIOUS EXPERIMENTAL STAGES

Indices		Before bed rest				After bed rest			
		Before loading		After loading		Before loading		After loading	
		group		group		group		group	
		"A"	"B"	"A"	"B"	"A"	"B"	"A"	"B"
Sodium	M	143	142	139^{X}	139^{X}	143	143	142	[illegible]^{X}
	σ	2,2	1,2	0,92	1,1	2,2	1,4	2,3	1,6
	m	0,9	0,5	0,4	0,5	1,0	0,6	1,3	0,7
Potassium	M	4,43	4,18	4,37	4,29	4,35	4,19	4,42	4,32
	σ	0,14	0,21	0,25	0,35	0,18	0,28	0,29	0,21
	m	0,06	0,09	0,11	0,15	0,08	0,12	0,21	0,12
Calcium	M	4,67	4,61	4,68	4,64	4,59	4,83	4,73	4,62
	σ	0,21	0,14	0,16	0,09	0,16	0,21	0,28	0,27
	m	0,09	0,06	0,07	0,04	0,07	0,09	0,08	0,07
Magnesium	M	2,11	1,97	2,12	2,02	2,20	2,03	2,14	2,15
	σ	0,14	0,18	0,14	0,09	0,12	0,07	0,13	0,14
	m	0,06	0,08	0,06	0,04	0,05	0,03	0,05	0,06
Chlorine	M	103	102	101	100	103	103	103	102
	σ	3,2	2,8	1,6	1,6	2,8	2,5	1,8	3,1
	m	1,4	1,2	0,7	0,7	1,2	1,1	0,8	1,3
Osmotic concentration	M	291	289	284^{X}	280^{X}	290	289	288^{X}	287
	σ	4,1	1,4	2,1	3,45	2,5	5,1	3,1	3,1
	m	1,8	0,6	0,9	1,5	1,1	2,2	0,9	1,3

Note: X – $p < 0,05$ in comparison with baseline

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TABLE 4.3.11. CLEARANCE VALUES FOR THE SUBSTANCES STUDIED (ml/min) BEFORE WATER LOADING (I) AND DURING MAXIMUM DIURESIS (II) IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices		Before bed rest group				After bed rest group			
		"A"		"B"		"A"		"B"	
		I	II	I	II	I	II	I	II
Sodium clearance	M	0,50	0,97	0,45	0,75	0,5I	0,9[illegible]	[illegible]	[illegible]
	δ	0,I6	0,2I	0,22	0,09	0,I3	0,9[illegible]	[illegible]	[illegible]
	m	0,07	0,09	0,I0	0,0I	0,06	0,I0	[illegible]	[illegible]
Potassium clearance	M	6,08	I5,8I	7,56	I3,64	7,5	I4,67	[illegible]	[illegible]
	δ	I,6I	I,28	4,05	I,88	2,08	3,04	[illegible]	[illegible]
	m	0,72	0,57	I,8I	0,84	I,0I	I,52	[illegible]	[illegible]
Calcium clearance	M	0,99	I,92	I,66	I,50	I,67	I,55	[illegible]	[illegible]
	δ	0,53	I,23	I,22	0,28	0,75	0,40	[illegible]	[illegible]
	m	0,24	0,55	0,55	0,I8	0,34	0,I8	[illegible]	[illegible]
Magnesium clearance	M	I,34	2,38	2,97	2,8I	I,87	2,52	[illegible]	[illegible]
	δ	0,49	0,57	2,23	0,49	0,70	I,[illegible]	[illegible]	[illegible]
	m	0,22	0,26	I,00	0,22	0,3I	0,6I	[illegible]	[illegible]
Creatinine clearance	M	77	I04	I04	I04	94	I[illegible]	[illegible]	[illegible]
	δ	9,I	I8,6	I7,0	I9,0	24,3	I8,7	[illegible]	[illegible]
	m	4,I	8,3	7,6	8,5	I0,9	8,3	[illegible]	[illegible]
Osmotically free water clearance	M	I,02	I0,03	I,I8	9,I0	I,32	I0,I3	[illegible]	[illegible]
	δ	0,26	I,58	0,39	I,08	0,36	I,80	[illegible]	[illegible]
	m	0,I2	0,70	0,I7	0,48	0,I6	0,80	[illegible]	[illegible]

Note: x - $p < 0,05$

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TABLE 4.3.12. EXCRETION OF SUBSTANCES AFTER A 4-HOUR WATER TEST AT VARIOUS EXPERIMENTAL STAGES

Indices	Significance	Before bed rest group "A"	Before bed rest group "B"	After bed rest group "A"	After bed rest group "B"
Fluid loss (ml)	M	I326	I395	I436	I3[illegible]3
	σ	30I	I25	3I2	40I
	m	I35	55	I40	I89
Water loss to intake (%)	M	89,0	87,0	99,0	86,0
	σ	I8,6	I0,2	23,6	20,3
	m	8,I	4,5	I0,3	I2,6
Sodium (meq)	M	29,0	24,4	30,2	22,6
	σ	5,2	3,2	5,8	3,9
	m	2,3	I,4	2,9	I,8
Potassium (meq)	M	I3,98	I4,I6	I5,04	I3,4
	σ	I,07	I,22	4,60	I,7
	m	0,48	0,55	2,00	0,8
Calcium (meq)	M	I,78	I,94	I,97	2,I4
	σ	0,49	0,I7	0,47	0,8[illegible]
	m	0,22	0,08	0,2I	0,[illegible]
Magnesium (meq)	M	I,26	I,57	I,22	I,[illegible]
	σ	0,32	0,25	0,39	[illegible]
	m	0,I4	0,II	0,I3	[illegible]
Creatinine (mg)	M	376	433	430[x]	[illegible]
	σ	26	55	3I	[illegible]
	m	II	25	I4	[illegible]
17-HCS (mg)	M	2,9	3,3	2,6	3,[illegible]
	σ	0,7	0,5	0,5	0,[illegible]
	m	0,3	0,2	0,2	0,[illegible]

Note: x - $p < 0,05$ in comparison with baseline

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experimental period (Supplement "B," Section 4.3.2).

In addition to general patterns, we must note several individual features (Supplement "B," Section 4.3.2).

No statistically reliable differences in the diuresis dynamics during the loading test in comparison with baseline were noted on Day 2 after BR in both groups of test subjects. Since electrolyte and 17-HCS concentration on Day 2 after BR did not differ significantly from initial values (Table 4.3.8), their excretion rates during the test were almost the same as during the baseline period (Table 4.3.9). Only creatinine excretion rate was higher in subjects in both groups than during BR, which was most clearly evident during maximum diuresis (Table 4.3.9). Sodium and potassium clearance during maximum diuresis in the water test, as during the baseline period, was significantly higher than in the night urine fractions. No statistically significant group differences were noted in the period studied (Table 4.3.11). There was a significant decrease in sodium clearance in 24-hr urine collected after the water test on Day 2 after completion of bed rest in comparison with /219 similar data obtained during the baseline period. It was higher than baseline only in subject T.

Creatinine clearance during maximum diuresis during BR, as during the baseline period, was higher ($p<0.05$) than before loading (Table 4.3.10).

There were no significant shifts in comparison with baseline also in variations in serum ion concentrations. However, if in group "A" the sodium concentration reduction 90 minutes after loading was not statistically significant, in group "B" it was significant (Table 4.3.10).

4.3.2.4. Abstract

Thus, no significant differences in osmo- and ionoregulating activity of kidneys between subjects in group "A" and "B" were noted during the water test 2 days after BR or in comparison with the baseline period, with the exception of an increase in glomerular filtration rate. In experiments that we conducted earlier, on similar activity, the water test was conducted the day after BR, i.e., a day earlier than in this experiment. Retention of fluids, electrolytes, and osmotically active substances was noted as a result of changes in osmoregulation retained at this time. The absence of changes in indices for renal activity in this experiment apparently is not so much due to the limited duration of the experimental period as to the condition that the test was performed 2 days after completion of bed rest, when toning of the volume-regulation system was no longer noted.

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4.3.3. Analysis of Body Fluids /222

Among the many urgent problems in space physiology that need to be solved, the most important is the study of body hydration status during exposure to extreme factors, since the functions of all vitally important body systems depend to a great extent on the fluid balance status.

Study of these problems has always been emphasized in the medical sections of national space programs in the USSR and USA. However, at present concepts on water metabolism both in cosmonauts and in subjects in terrestrial model experiments are still hypothetical.

4.3.3.1. Literature Review

American investigators have made a great contribution to the study of fluid metabolism in astronauts during flight. Information was obtained with the use of radioindication during flights of differing durations on the effect of spaceflight factors on blood volume and its components and total water and extracellular fluid content [1,2,etc.]. The most comprehensive information was obtained during flights in the orbital station Skylab, where the fluid balance status in the body was comprehensively studied [3,etc.].

Unfortunately, these unique results did not make it possible to reach complete and definitive conclusions on the quantitative aspects of changes in body hydration status. This above all is related to the small number of observations, pronounced individual variability in parameters studied, differing conditions, and durations of spaceflights, abundance of preventive measures, the flight manifestations of changes observed that often did not go beyond experimental errors, etc.

These circumstances prompted Soviet and American investi- /223
gators to broaden investigations in this direction in terrestrial model experiments on bed rest. With the use of radioisotope research methods, it was possible to amplify and supplement information obtained during spaceflights.

Fluid volumes in experiments performed varied over a broad range: from total absence of changes to pronounced shifts, However, in most cases, investigators noted a decrease in blood, plasma, and red cell mass volume [5-9,etc.]. Information on changes in total water and its extracellular and intracellular fractions is very limited and contradictory. Most investigators recorded basic changes generally during Days 1-3 of bed rest. Thereafter, there was a stabilization in shifts with a tendency for normalization [5-9,etc.].

4.3.3.2. Experimental Procedures

With the use of radioactive isotopes in subjects, the following

body fluid volumes were determined in experiments: total body water, extracellular fluid, plasma, and red cell mass. In addition, intracellular and interstitial fluid volumes were calculated.

Total body water (TBW) was measured with the use of tritiated water by conventional procedure [10] with some modifications. Subjects received 25 μCi tritiated water per os; this level of activity adjusted to a volume of 1 liter was used for the standard. After 24 hr 0.25 ml samples were taken from the total 24-hr urine which were subjected to radiometry without distillation on a /224 liquid scintillation spectrometer Mark II, Searle, after their suitable treatment. TBW was estimated from a standard dilution formula with consideration of 24-hr diuresis.

Extracellular fluid volume (EFV) was estimated by dilution with exogenous stable bromine and its determination in urine with the use of radioisotope fluorescence radiometric analysis [11] as modified in [12].

The baseline bromine content was determined in 2 ml of plasma. Subjects received 45 ml of a NaBr solution (10%) per os on an empty stomach; 24 hr after this blood samples were collected to obtain two parallel 2 ml plasma samples. Daily urine samples were collected concomitantly to determine the quantity of excreted bromine. EFV was calculated from a conventional dilution formula to determine bromine excreted with urine. Bromine solution and the tritiated water were administered in one "cocktail."

Plasma volume (PV) was determined following conventional procedures [13,14]. Administered intravenously was 0.5 ml of 2 μCi human serum albumin labeled with ^{129}I-gamma. After 20 minutes, a blood sample was taken from the vein of the opposite arm from which the plasma sample was obtained by centrifugation. Plasma radiometry (double) was performed for 20 min in a Gamma Well Counter. Computations were made with the use of standard formulas [13,14].

The erythrocyte mass volume was determined with the use of erythrocytes labeled with ^{51}Cr by conventional procedure [15] with modifications in [16]. Blood specimens were collected from the cubital vein in two test tubes; the anticoagulant 7B was added in a 1:4 ratio. The blood was centrifuged for 10 min at 1500 rpm and the supernatent was removed. Then, added to the precipitate /225 was 50 μCi $Na^{51}CrO_4$ and the mixture was adjusted to 10 ml in each test tube with an isotonic solution. Incubation lasted 30 min at 38°C with intermittent mixing (five times over 30 min). Label incorporation was 50-60%. After incubation, labeled erythrocytes were washed twice with the isotonic solution and centrifuged at 1000 rpm for 15 min. Then, the erythrocyte mass was resuspended in the isotonic solution, the volume was adjusted to 5 ml and reinjected intravenously. Before injection of labeled erythrocytes, the syringe was examined by radiometry. After 20 min, whole blood was taken from the vein of the other hand for subsequent radiometry. Computations were made with conventional formulas.

Blood volume (BV) was determined from whole blood on a Picker hemoliter.

In addition, BV was determined by the following computations:

from the total plasma and erythrocyte volumes;
from plasma volume and hematocrit;
from erythrocyte volume and hematocrit.

Blood volumes obtained by the methods indicated differed by not more than 2%. Average BV indices are given in the reports.

Hematocrit was determined by two methods: conventional with centrifugation and electronic. Data obtained made it possible to carry out an additional mutual monitoring of blood, plasma, and erythrocyte volumes.

Volunteers were examined according to the schedule: for 9 days of a control (baseline) period and for 7 days of bed rest (BR). After mutual agreement, an additional series of studies of fluids was performed on the 9th day of the recovery period (RP). The purpose of this study at this late RP was not only to establish the recovery of the hydration status, but also to delineate in addition the initial norm for fluid content in volunteers and their individual characteristics. /226

The need for carrying out this examination was caused by the circumstances that water intake was slightly reduced during the baseline period in some of the subjects, which could have affected to some extent the parameters studied. In addition, the baseline examination was carried out under unusually hot weather conditions.

4.3.3.3. Results and Discussion

As the investigations demonstrated (Table 4.3.13), the levels of the fluids studied in all subjects during the baseline period were within the range of norms for the age group for healthy individuals (Supplement "B," Table 8.4.3.3.1).

Data obtained are presented with respect to relative body weight, since on the one hand the subjects' weight was one of the criteria for forming the experimental groups and on the other, it varied during hypokinesia. In addition, the average weight index for subjects in "B" was higher than for group "A" by 7.5 kg.

As is evident from Table 4.3.13, the total water content in the body in subjects varied over a small range, reaching a maximum difference of 94 ml/kg.

A relatively low water content was recorded in subject K (group "A") and P (group "B"). The total water content was relatively high (624-682 ml/kg) in four subjects; in this case,

three of these were in group "B" and slightly affected the homogeneity of the group on the basis of the index studied. Regardless of the indicated individual differences, average group values for total water content were very similar, and their standard deviation in groups did not exceed 2.5%-4% of the average value levels. /227

Individual variations in extracellular fluid content (Supplement "B," Table 8.4.3.3.2) were slightly higher. However, with respect to group distribution individual differences were compensated and average group values were very similar.

The simultaneous determination of the content of these fluids in subjects made it possible not only to obtain a more complete picture of their content in the body but also to study their relationships, including their redistribution.

Especially informative in the study of body water metabolism is the study of extracellular fluid and its components. As is well known, vascular and interstitial fluid is the most mobile medium and undergoes the most extensive changes with exposure to extreme factors.

Plasma volume varies according to body metabolic requirements and interstitial fluid actively participates in maintaining this function. Body capacity to adapt to a constantly changing environment is determined to a great extent by this relationship.

For this reason, the study of metabolism of the fluids indicated requires an unavoidable complex approach. Investigation of the content of one extracellular fluid may not be informative. For example, the situation is possible when significant redistributions of intravascular and interstitial fluids occur and the intercellular volume remains unaltered. On the other hand, /228 study of plasma metabolism alone does not indicate the status of the interstitial component of extracellular fluid and, primarily, their interaction. In our opinion, this is one of the reasons for the contradictory data in the literature on body fluid dynamics during hypokinesia.

However, analysis of the interaction of body fluids and primarily the extracellular sector with respect to weight is justified when body weight varies insignificantly.

This is related to the fact that weight does not reflect body structure and does not take into account the different level of water content in tissues.

In our opinion, if body weight changes noticeably, extra- and intracellular fluid volumes and their relationship should be regarded with respect to total water and vascular and interstitial fluids with respect to extracellular fluid volume. The tables (Supplement "B," Tables 8.4.3.3.1-8.4.3.3.3) present these

relationships. This presentation of data made it possible to exclude essentially the effect of body weight dynamics on the volumes studied.

Combination of the determination of total body water and extracellular fluid made it possible to obtain by estimations a description on the intracellular fluid level (Table 4.3.13, Supplement "B," Table 8.4.3.3.3).

Starting values for red cell mass in subjects during the baseline period were within norms for the age group for healthy individuals.

Examination of subjects on Day 7 of bed rest did not reveal the development of statistically significant changes in either of the experimental groups. However, a specific trend in shifts /229 was noted for several indices. There was a tendency for the total water content to decrease in all volunteers in the group with a horizontal bed rest position (Table 4.3.13). For group "B" the total water changed in different directions. The changes evaluated were more pronounced, if one takes into account that the fluid volumes presented in the report were referred to body weight, which decreased during hypokinesia in almost all volunteers.

More pronounced changes were recorded in extracellular fluid (EFV). Observed in both groups was an approximately equal decrease in EFV; in this case, the basic changes occurred due to interstitial fluid (Supplement "B," Table 8.4.3.3.4). It is necessary to note that after the decrease in total water in the body, due to the interstitial component during bed rest, distribution of fluids in both groups maintains its previous relationship (Supplement "B," Tables 8.4.3.3.7-8.4.3.3.10). An exception was vascular fluid: in group "A" it tended to decrease and in group "B" to increase slightly (Table 8.4.3.3.6). In other words, a 7-day bed rest slightly decreased body hydration level, but did not alter fluid relationships.

A slight tendency was noted for red cell mass to decrease in both groups and was more apparent in the group with the anti-orthostatic bed rest. However, the changes were not significant.

Examination of subjects on Day 9 of recovery demonstrated that shifts noted on Day 7 of bed rest reversed and returned primarily to their initial level (Fig. 4.3.3.1) and were even slightly /230 higher. (Supplement "B," Tables 8.4.3.3.1-8.4.3.3.10). Such recovery dynamics demonstrate rather convincingly that changes in the hydration status in volunteers were functional and were determined by the 7-day bed rest.

Thus, having completed the complex study of the hydration status in subjects during a 7-bed rest in horizontal and anti-orthostatic body positions, we did not find statistically significant changes in fluids.

C-3

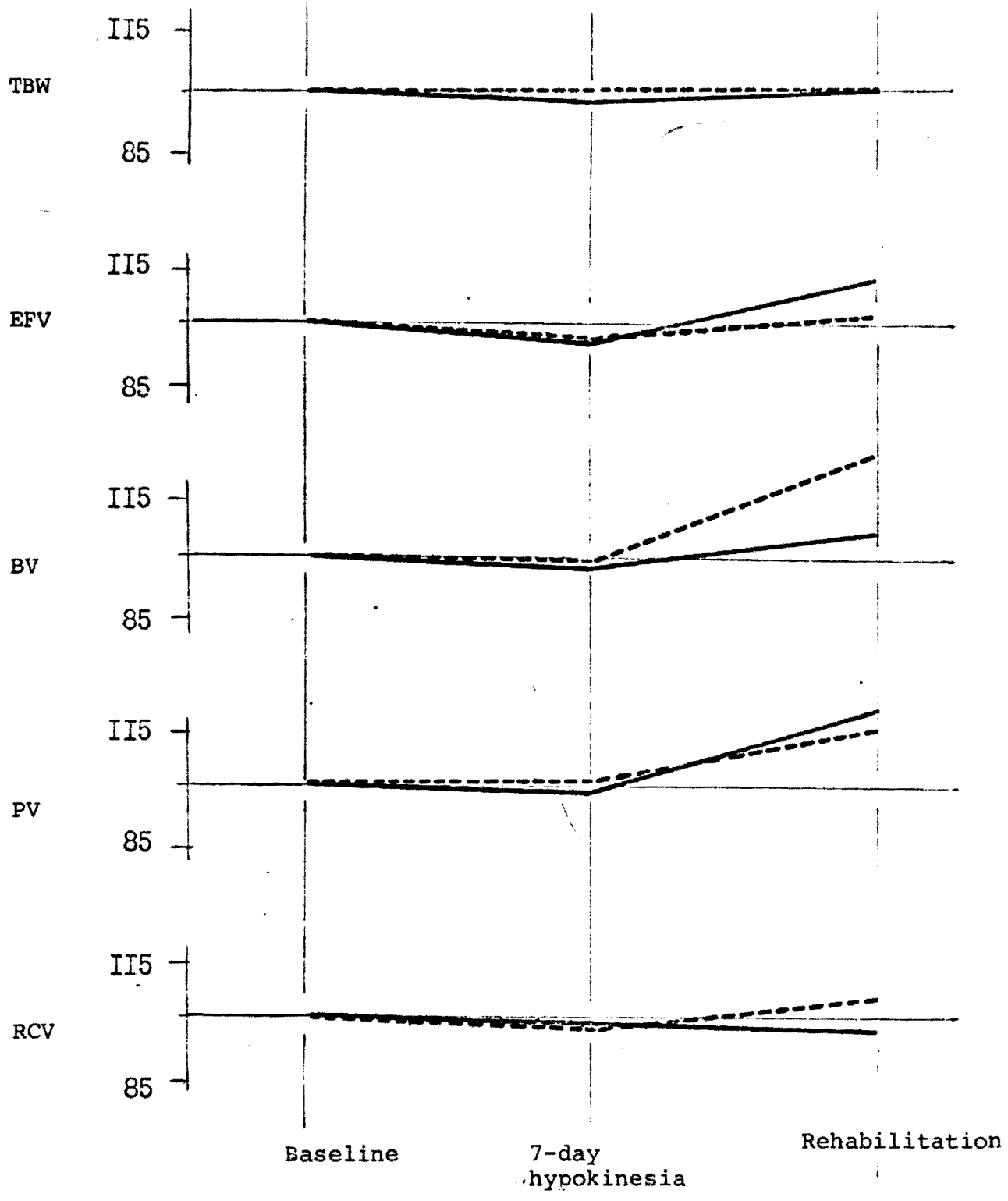

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Fig. 4.3 3.1. Fluid, blood and red cell mass dynamics in subjects at various experimental stages (in % of baseline)

The shifts noted above were tendencies, totally typical for similar experiments. Analysis of the results obtained, the conditions of the experiment, and also literature data demonstrated that the absence of significant changes may be explained by several factors:

the low number of experimental groups and noticeable individual variability in subject's response to bed rest;
characteristics of water intake in subjects during the baseline period;
age-related characteristics and the relatively sedentary lifestyle of the subjects;
nonuniformity (in weight) of experimental groups;
insufficient dynamics of examination of subjects during the baseline period.

The absence of significant differences between experimental groups in our opinion could be the result of insufficient dynamics in the observations during bed rest. /232
According to existing experience and literature data [5-7,etc.], basic changes in body fluids generally occur during the first three days of bed rest and thereafter tend to normalize. We should also not exclude that in this experiment changes could have developed in a similar way. In this respect, apparently it will be advisable in the future to examine subjects at an earlier period of bed rest.

With regard to the evaluation of the variants of bed rest regimes evaluated for simulating hemodynamic effects of the weightlessness, we prefer antiorthostatic hypokinesia. Using radioisotope methods, we had earlier studied indices of central, peripheral, and organ hemodynamics and also blood distribution in the bed rest variants indicated. Apparently, one of the basic hemodynamic phenomena of weightlessness can be simulated during antiorthostasis, namely, the more pronounced redistribution of blood from the lower to the upper half of the body [17,18].

With further development of scientific cooperation, it will be advisable in addition to the study of fluids, to also study more extensively hemodynamic parameters, including by radioisotope techniques. We consider this approach most productive.

4.3.3.4. Abstract /233

Examination on Day 7 of bed rest did not reveal statistically significant changes in comparison with baseline in any of the experimental groups. We could only observe a tendency for total water to decrease in subjects in group "A", a decrease in extracellular fluid volume in both groups, and a slight tendency for red cell mass to decrease in group "B."

absolute increase in the neutrophil count, the mechanisms for which during hypokinesia are not yet clear.

TABLE 4.3.13. FLUID AND BLOOD VOLUMES (ml/kg) IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Experimental period (days)		
			Before BR 9	BR 7	After BR 9
Total water volume	"A"	M	624,6	592,6	6I3,0
		6	25,2	29,9	3I,7
		m	II,2	I3,4	I4,2
	"B"	M	629,4	633,0	624,6
		6	34,9	30,I	29,3
		m	I5,6	I3,4	I3,1
Extracellular fluid volume	"A"	M	229,5	2I9,3	253,3
		6	22,I	22,7	43,0
		m	9,9	I0,2	I9,2
	"B"	M	228,6	22I,5	229,4
		6	I6,4	7,3	I5,5
		m	7,3	3,3	6,9
Intracelluar fluid volume	"A"	M	395,I	373,3	354,7
		6	30,0	30,6	5I,8
		m	I3,4	I7,7	23,2
	"B"	M	400 ,8	4II,5	385,2
		6	36,I	3I,7	33,8
		m	I6,I	I4,2	I6,3
Interstitial fluid volume	"A"	M	I90,8	I8I,7	2I3,5
		6	I8,6	27,6	45,3
		m	8,3	I2,3	20,5
	"B"	M	I9I,9	I84,3	I87,3
		6	I5,9	8,8	I8,9
		m	7,I	3,9	7,3

TABLE 4.3.13. CONTINUATION

Indices	Group	Significance	Experimental period (days)		
			Before BR 9	BR 7	After BR 9
Blood volume	"A"	M	67,9	66,0	72,6
		σ	II,3	9,5	I2,9
		m	5,0	4,2	5,6
	"B"	M	64,I	64,2	7I,2
		σ	6,8	3,3	3,3
		m	3,I	I,5	2,8
Plasma volume	" A"	M	38,6	37,6	44,8
		σ	5,8	8,8	8,I
		m	2,6	3,9	3,6
	"B"	M	36,7	37,2	4I,9
		σ	3,4	I,8	4,8
		m	I,5	0,79	2,0
Erythrocyte volume	"A"	M	28,5	28,I	27,7
		σ	4,6	5,2	5,3
		m	2,I	2,3	2,4
	"B"	M	27,4	26,3	29,I
		σ	3,5	2,0	4,0
		m	I,6	0,9	I,9

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4.4 Hematology /238

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4.4.1. Literature Review

Numerous researchers have demonstrated that a strict bed rest in healthy individuals results in a noticeable decrease in blood and plasma volumes [1,2], which is reflected in hemoconcentration values. Thus, even during the first two days of bed rest, there was an increase in hemoglobin level and the hematocrit value [3]. There are sufficiently convincing data on a reduction in red cell mass [1,2] and total hemoglobin mass, particularly evident with an antiorthostatic body position [4,5]. However, the elevation in hemoconcentration should not be explained only by the loss of plasma. It is fully evident that during prolonged motion limitation erythropoietic bone marrow activity changes. This is indicated by significant deviations in reticulocyte level in peripheral blood and changes in plama erythropoietin and erythropoiesis inhibitor ratios [6,7]. Similar effects related to hemopoietic disturbances during hypokinesia were found in experiments on dogs [8,9] and mice [10,11].

4.4.2. Procedures

Blood was obtained by venipuncture in all subjects from 7 to 7:30 in the morning. EDTA was used as the preservative. We studied: erythrocyte sedimentation rate (ESR) by the conventional method on a Panchenkov unit, erythrocyte count and hemoglobin level on the Lars Ljungberg 202 celloscope, hematocrit by centrifugation in micropipettes, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and the mean hemoglobin concentration (MHC) by calculation using the formulas: /239

$$MCV = \frac{\text{hematocrit}}{\text{erythrocytes (million)}}\ \mu m^3, \quad MCH = \frac{\text{hemoglobin (g\%) . 10}}{\text{erythrocytes (million)}}\ pg,$$

$$MHC = \frac{\text{hemoglobin (g\%) . 100}}{\text{hematocrit}},$$

leukocyte count by counting in a Goryaev chamber under a microscope, thrombocyte count and leukocyte formula by counting on smears stained according to Pappenheim, reticulocyte count and reticulocytogram by microscopy of smears prepared after a two-hour maintenance in a hermetically sealed test tube with an equal quantity of blood and a 1% brilliant cresyl blue solution in a physiological solution. Hematological analyses were performed at the following times: 9, 3, and 1 day before bed rest (Day 6, 12 and 14 of the baseline period, respectively), on Day 2, 4, and 7 of bed rest, and on Day 2 and 7 after completion of bed rest.

4.4.3. Results of Experiments and Discussion

Erythrocyte sedimentation rate (ESR) throughout the observation period and as an average for both groups varied within the range from 4.2±0.5 to 6.6±0.9 mm/hr (Table 4.4.1). The maximum values recorded for this index were 10-11 mm/hr and were found in Se on

Day 9 before bed rest, in S on Day 2 of hypokinesia, and in A on Day 2 after completion of bed rest.

Blood leukocyte count for test group "A" (0°) remained at the starting baseline level almost throughout bed rest (Table 4.4.1). Only in S on Day 2 of hypokinesia did the leukocyte count increase to $11.9 \cdot 10^3$ per mm^3, which had an effect on the average value for this index for group "A." In all subjects in group "B" (-6°) during bed rest the leukocyte count increased approximately by $1 \cdot 10^3$ and on Day 4 differed significantly from the averaged baseline. We /240 should note that at first the groups were not equal in this index and the lower (however, not significant) leukocyte count in group "A" was maintained throughout the observation period.

Analysis of the qualitative blood leukocyte fraction composition demonstrated that the shift to hypokinesia, regardless of body position during bed rest, was accompanied by an increase in the blood neutrophil count, both with respect to absolute and relative values (Tables 4.4.1 and 4.4.2). During this time, differences from average values for baseline were significant for both groups. The lymphocyte count during hypokinesia was slightly reduced with respect to relative values and remained stable with respect to absolute values (Tables 4.4.1 and 4.4.2).

Literature data on the effect of hypokinesia on blood leukocyte composition are very limited. There are reports that on Day 0 after a 28-day bed rest the blood leukocyte count increased significantly by approximately 2000 per mm^3; in this case, the T and B-lymphocyte count varied within normal limits [12]. The neutrophil reaction that we observed requires further study.

Blood thrombocyte count dynamics was characterized by relatively sharp variations during bed rest, and is especially pronounced in subjects in group "A" (Table 4.4.1).

More pronounced shifts were detected in the erythron system. As early as Day 4 of hypokinesia, there was an elevation in the hemoglobin content, erythrocyte hemoglobin saturation, and the hematocrit values in subjects of both groups (Table 4.4.1). Here, with an antiorthostatic body position (group "B"), this elevation was more pronounced and on Days 4 and 7 of bed rest was statistically significant in comparison with the averaged baseline. In /241 comparing the two experimental variants according to the Student test, statistically significant differences were detected only on Day 7 of hypokinesia in the hematocrit value. Apparently, the basic reason for such a low significance for differences between the two experimental variants is the small number of subjects per group.

The effect of hemoconcentration elevation that we observed at the end of the first week of the strict bed rest agrees with literature data [1-4]. According to these data [1,2,etc.], the red cell mass volume decreased during hypokinesia. However, more significantly, plasma volume reduction in this case hides this decrease.

Apparently, in this respect, the erythrocyte count per mm^3 of blood during bed rest remained stable (Table 4.4.1), and only after bed rest, evidently because of the sharp elevation in plasma volume, the erythrocyte concentration decreased significantly in both experimental groups. During this time, the hemoglobin level and hematocrit value also decreased significantly.

However, hematological effects during strictly limited mobility cannot be explained only by the loss of blood and particularly plasma. It is known that the major pathogenetic factor during hypokinesia and particularly the antiorthostatic variant is blood redistribution in the body during the first few days of bed rest. The changes in blood circulation in the kidneys and spleen occurring during this time alter the oxygen supply of these organs and at the same time affect the mechanism of erythropoietin production and the spleen hemolytic factor, which apparently, in the final analysis, alters bone marrow erythropoietic activity [13-15]. On Day 8 of strict bed rest erythropoiesis inhibitors were found in plasma with a decrease in erythropoietin activity [6]. A transition at this /242 time to normal motor activity, which occurred in this experiment, increased the requirements for oxygen transport system and as a result, erythropoietic activity of bone marrow increases. This is demonstrated by the statistically signficant reticulocytosis in subjects in both groups found on Day 7 after termination of bed rest (Table 4.4.1). The blood reticulocyte count increased to 11.6±1.2 and 12.8±1.9% in comparison with 7.1±0.7 and 6.5±0.7% during the baseline period (average data) in test groups "A" and "B," respectively.

Analysis of the reticulocytogram demonstrated that cells of maturity stage 4 (isolated granular skeins) and 5 (isolated grains) predominant in blood and comprise a total of 83.8 and 84.5% for group "A" and group "B," respectively. During hypokinesia the maturation curves shift to the left, i.e., to earlier stages: 2 (granulation in the form of knots or clumps) and 3 (a dense granular network), and the number of more mature cells decreases. It may be suggested that at this time erythroid cell maturation accelerates (Table 4.4.3).

4.4.4. Abstract

A strict bed rest for 7 days resulted in a pronounced elevation in hemoconcentration, evident in the increase in hemoglobin level, hematocrit value, and erythrocyte hemoglobin saturation. A transition to normal motor activity was accompanied by a reduction in erythrocyte concentration per mm^3 of blood, hemoglobin level, hematocrit value, and an increase in reticulocyte count. The last phenomenon demonstrates apparently that the 7-day hypokinesia decreases the functional level of the erythropoietic system. /243 Changes in hemoconcentrations were more apparent during the antiorthostatic variant of hypokinesia; however, because of the low number of subjects per group, they were statistically insignificant in most cases. During hypokinesia, there was a relative and

TABLE 4.4.1. HEMOGRAM INDICES IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before BR (days)			BR (days)			After BR (days)		
			6	I2	I4	M	2	4	7	2	7
I	2	3	4	5	6	7	8	9	I0	II	I2
ESR (mm/hr)	"A"	M	5,2	4,2	4,4	4,6	5,4	5,0	3,8	5,8	5,2
		σ	3,4	I,I	2,I	2,3	3,I	2,5	I,3	2,2	0,8
		m	I,5	0,5	0,9	0,6	I,4	I,I	0,6	I,0	0,4
	"B"	M	4,6	4,6	5,2	4,8	4,4	6,6	4,4	5,6	6,0
		σ	0,89	2,07	0,8	I,3	0,9	2,I	I,I	2,7	I,2
		m	0,4	0,9	0,4	0,3	0,4	0,9	0,5	I,2	0,5
Leukocytes (thousand/mm^3)	"A"	M	5,85	5,I7	6,I2	5,7I	6,97	6,28	6,II	6,02	5,58
		σ	I,6	0,26	I,85	I,36	3,02[x]	I,7I	I,88	I,34	I,29
		m	0,70	0,I2	0,83	0,35	I,35	0,76	0,84	0,60	0,58
	"B"	M	7,II	7,I6	6,50	6,92	7,72	7,98	7,22	7,43	6,76
		σ	I,32	0,45	0,64	0,88	I,30	0,94[x]	0,70	I,I9	I,93
		m	0,59	0,20	0,29	0,23	0,58	0,42	0,3I	0,54	0,66
Neutrophils (thousand/mm^3)	"A"	M	2,66	2,29	2,7I	2,56	3,22	4,73	3,2I	3,00	2,45
		σ	I,I	0,32	0,89	0,78	I,88[x]	I,36[x]	I,3I[x]	I,02	0,7I
		m	0,47	0,I4	0,40	0,20	0,84	0,09	0,58	0,46	0,32
	"B"	M	3,55	4,00	3,20	3,58	4,62	4,63	3,96	3,73	3,12
		σ	0,42	0,57	0,55	0,97	I,22[x]	0,90[x]	0,82	0,94	0,89
		m	0,67	0,26	0,25	0,25	0,54	0,40	0,37	0,42	0,3[illegible]

TABLE 4.4.1. CONTINUATION

I	2	3	4	5	6	7	8	9	I0	II	I2
Lympho-cytes (thousand/mm^3)	"A"	M	2,7I	2,5I	3,II	2,78	3,I8	2,46	2,43	2,46	2,66
		σ	0,8[illegible]	0,52	I,I8	0,84	I,23	0,73	0,63	0,46	0,88
		m	0,34	0,23	0,53	0,22	0,55	0,33	0,28	0,20	0,39
	"B"	M	3,2I	2,66	2,78	2,88	2,45	3,24	2,4[illegible]	2,80	2,93
		σ	I,50	0,2I	0,43	0,52	0,45	0,76	0,57	0,6I	I,I8
		m	0,32	0,09	0,I9	0,I3	0,20	0,34	0,26	0,27	0,53
Thrombo-cytes (thousand/mm^3)	"A"	M	224,5	2I7,0	I79,5	207,0	I63,8	258,9	206,2	I76,5	I93,4
		σ	32,7	35,0	36,7	38,2	30,2[illegible]	66,6[illegible]	28,9	39,7	60,5
		m	I4,6	I5,6	I6,4	9,9	I3,5	29,8	I2,9	I7,8	27,I
	"B"	M	237,2	25I,2	265,2	25I,2	225,2	272,6	I92,9	2[illegible]3,8	2[illegible]
		σ	70,9	6I,7	90,6	69,5	68,6	69,5	52,9	8[illegible],0	3[illegible]
		m	35,4	28,9	45,3	I9,3	30,7	3I,I	23,6	37,6	I7,[illegible]
Erythro-cytes (million/mm^3)	"A"	M	4,74	4,59	4,52	4,62	4,58	4,73	4,66	3,98[illegible]	3,9[illegible]
		σ	0,28	0,27	0,I9	0,25	0,26	0,20	0,22	0,I3[illegible]	0,I[illegible]
		m	0,I3	0,I2	0,09	0,07	0,II	0,09	0,I0	0,06	0,0[illegible]
	"B"	M	4,73	4,62	4,56	4,64	4,62	4,78	4,79	4,3[illegible]	[illegible]
		σ	0,22	0,27	0,I2	0,28	0,06	0,33	I,I9	0,2[illegible]	[illegible]
		m	0,I9	0,I[illegible]	0,05	0,07	0,03	0,I6	0,08	0,I[illegible]	[illegible]

TABLE 4.4.1. CONTINUATION

1	2	3	4	5	6	7	8	9	10	11	12
Hemoglobin (g%)	"A"	M	I4,76	I5,06	I4,36	I4,73	I4,42	I5,33	I5,24	I3,56	I3,76
		σ	I,08	I,20	0,59	0,97	0,82	I,0I	0,78	I,09[X]	0,92[X]
		m	0,48	0,54	0,27	0,25	0,39	0,50	0,35	0,49	0,4I
	"B"	M	I5,02	I4,76	I4,68	I4,82	I4,94	I5,94	I5,94	I4,28	I3,78
		σ	I,74	0,45	0,36	0,99	0,44	I,I6[X]	0,22[X]	0,47	0,93[X]
		m	0,78	0,20	0,I6	0,26	0,20	0,52	0,I0	0,2I	0,42
Hematocrit (U)	"A"	M	43,2	43,0	4I,2	42,5	42,2	44,0	43,6	39,8	4I,2
		σ	I,9	I,9	2,2	2,I	I,3	2,4[X]	I,3	I,5	I,9[X]
		m	0,9	0,8	I,0	0,5	0,6	I,I	0,6	0,7	0,86
	"B"	M	[illegible]	43,6	43,2	43,6	43,4	45,0	46,8	4I,6	42,4
		σ	I,[illegible]	I,8	I,8	I,7	I,7	I,9[X]	I,9[X]	I,3[X]	I,I
		m	0,[illegible]	0,8	0,8	0,4	0,8	0,84	0,9	0,6	0,5
Mean erythrocyte volume (μm^3)	"A"	M	9I,2	93,9	9I,I	92,I	92,5	92,9	94,4	I00,I	I04,2
		σ	4,I	2,8	3,8	3,6	3,5	3,0	2,2	3,8	5,0
		m	I,8	I,3	I,7	0,9	I,6	I,3	I,0	I,7	2,3
	"B"	M	93,2	93,3	94,7	93,7	93,9	94,7	97,8	95,7	98,4
		σ	4,9	2,I	4,5	3,8	3,4	6,6	7,3	3,6	2,4
		m	2,2	0,9	2,0	I,0	I,5	2,9	3,3	I,6	I,I

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TABLE 4.4.1. CONTINUATION

I	2	3	4	5	6	7	8	9	I0	II	I2
Mean hemoglobin per erythrocyte (pg)	"A"	M	3I,2	32,8	3I,8	3I,9	3I,5	32,5	32,7	34,0	34,9
		σ	I,3	I,0	0,5	I,I	0,7	0,7	0,6	2,2x	I,9x
		m	0,6	0,4	0,2	0,3	0,3	0,4	0,3	I,0	0,8
	"B"	M	3I,7	32,0	32,2	32,0	32,3	33,4	33,3	32,9	32,0
		σ	I,9	2,0	0,6	I,5	0,6	I,3x	I,7x	2,0	2,I
		m	0,9	0,9	0,3	0,4	0,3	0,6	0,7	0,9	0,9
Mean hemoglobin concentration (%)	"A"	M	34,0	35,0	34,8	34,6	34,I	34,9	35,0	3I,I	33,5
		σ	2,0	I,8	I,2	I,6	I,3	I,5	I,I	I,8	3,3
		m	0,9	0,8	0,5	0,4	0,6	0,8	0,5	0,7	I,5
	"B"	M	34,0	33,9	34,I	34,0	34,5	35,5	34,I	3I,3	32,5x
		σ	2,9	I,8	I,4	2,0	I,3	2,2x	I,3	0,9	2,0
		m	I,3	0,8	0,6	0,5	0,6	I,0	0,6	0,4	0,9
Reticulocytes (0/00)	"A"	M	9,2	7,4	4,6x	7,I	5,4x	7,8	6,4	8,2	II,6
		σ	I,9	I,3	2,4	2,7	2,5	3,0	3,8	4,4	6,0x
		m	0,9	0,6	I,I	0,7	I,I	I,4	I,7	2,0	2,7
	"B"	M	8,6	6,4	4,6	6,5	4,8	6,8	8,4	8,8x	I2,0
		σ	2,I	2,8	2,2	2,8	2,0	3,7	2,4	2,7x	4,2
		m	0,9	I,2	I,0	0,7	0,9	I,7	I,I	I,2	I,9

Note: x - p<0,05

TABLE 4.4.2. LEUKOCYTE FORMULA (%) IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before bed rest (days) 6	12	14	M	Bed rest (days) 2	4	7	After bed rest (days) 2	7
I	2	3	4	5	6	7	8	9	10	11	12
Basophils	"A"	M	0,3	0,5	0,1	0,3	0,6	1,5	0,9	0,4	0,8
		σ	0,4	0,5	0,2	0,4	0,4	0,3x	0,9	0,5	0,8
		m	0,2	0,2	0,1	0,1	1,2	0,3	0,4	0,3	0,3
	"B"	M	0,4	0,4	0,2	0,3	0,8x	0,1	0,6	0,8	0,8
		σ	0,4	0,4	0,4	0,4	0,8x	0,2	0,9	0,9	1,0
		m	0,2	0,2	0,2	0,1	0,3	0,1	0,4	0,4	0,4
Eosinophils	"A"	M	1,6	3,3	2,4	2,4	2,1	2,6	1,9	2,5	3,2
		σ	0,9	2,7	1,0	1,8	1,3	0,7	0,7	2,5	1,3
		m	0,4	1,2	0,4	0,5	0,6	0,7	0,3	1,1	0,6
	"B"	M	1,3	3,5	4,3	3,0	3,9	3,7	4,8x	5,4x	3,8
		σ	1,8	2,0	1,9	2,2	1,7	1,6	2,3x	1,4x	1,8
		m	0,8	0,9	0,9	0,6	0,8	0,7	1,0	0,6	0,8
Band neutrophils	"A"	M	3,1	2,3	2,7	2,7	3,0	2,2	3,0	2,4	3,3
		σ	1,9	1,4	0,7	1,4	1,7	0,8	1,2	1,1	2,8
		m	0,8	0,6	0,3	0,4	0,8	0,7	0,5	0,5	1,2
	"B"	M	3,0	4,6	2,6	3,5	3,7	3,6	4,4	2,[illegible]	2,9
		σ	2,1	[illegible]	1,1	1,8	1,9	2,3	1,8	1,[illegible]	2,3
		m	1,0	0,7	0,5	0,5	0,9	1,0	0,8	0,[illegible]	[illegible]

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TABLE 4.4.2. CONTINUATION

I	2	3	4	5	6	7	8	9	I0	II	I2
Segmented neutrophils	"A"	M	42,I	42,2	4I,6	4I,9	42,I	49,5	48,4	46,6[X]	40,3
		σ	8,7	5,9	6,4	6,6	8,5	4,I[X]	7,8[X]	7,5	5,0
		m	3,9	2,6	2,9	I,7	3,8	4,I	0,5	3,3	2,2
	"B"	M	46,8	50,9	46,4	48,0	55,6	54,2[X]	50,0	47,0	47,0
		σ	II,6	6,4	6,2	8,I	I0,4[X]	6,9	8,8	6,I	5,2
		m	5,2	2,8	2,8	2,I	4,6	3,I	3,9	2,7	2,7
Lympho-cytes	"A"	M	47,2	47,9	50,5	48,5	46,4	39,8[X]	40,3[X]	4I,5[X]	47,5
		σ	9,8	7,8	6,5	7,7	5,6	3,6	4,I	6,9	8,9
		m	4,4	3,5	2,9	2,0	2,5	3,6	I,8	3,I	4,4
	"B"	M	45,9	37,3	42,7	42,0	32,I[X]	38,6	34,I[X]	37,8	37,8
		σ	I2,4	4,3	4,4	8,2	6,9	4,6	7,4	6,2	6,8
		m	5,5	I,9	2,0	2,I	3,I	2,I	3,3	2,8	2,8
Mono-cytes	"A"	M	5,7	3,6	3,I	4,I	3,8	4,4	5,5	6,8	4,9
		σ	I,8	I,I	I,5	I,8	2,4	0,8	2,5	3,8	2,9
		m	0,8	0,5	0,7	0,5	I,I	0,8	I,I	I,7	I,3
	"B"	M	2,6	3,2	3,7	3,2	3,8	3,0	6,I	6,I[X]	5,6
		σ	I,I	I,3	2,0	I,5	I,8	I,9	2,I	2,2	3,3
		m	0,5	0,6	0,9	0,4	0,8	0,9	0,9	I,0	I,5

Note: x - [illegible]0,05

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TABLE 4.4.3. RETICULOCYTOGRAM (%) IN SUBJECTS AT VARIOUS EXPERIMENTAL STAGES

Indices	Group	Significance	Before BR (days) 6	12	14	M	BR (days) 2	4	7	After BR (days) 2	7
I	2	3	4	5	6	7	8	9	10	11	12
Stage of maturity I	"A"	M	0	0	0	0	0	0	0	0	0
		б	0	0	0	0	0	0	0	0	0
		m	0	0	0	0	0	0	0	0	0
	"B"	M	0	0	0	0	0	0	0	0	0
		б	0	0	0	0	0	0	0	0	0
		m	0	0	0	0	0	0	0	0	0
Stage of maturity 2	"A"	M	5,2	0,4	4,0	3,2	II,3	6,0	6,4	0,8	2,4
		б	5,6	0,9	2,4	3,9	8,3	5,3	2,2	I,I	2,6
		m	2,5	0,4	I,I	I,0	4,8	3,I	I,0	0,5	I,6
	"B"	M	2,4	2,0	2,0	2,I	0,8	0	4,4	I,6	2,0
		б	2,6	3,5	2,4	2,7	I,I	0	4,6	I,7	2,0
		m	I,2	I,5	I,0	0,7	0,5	0	2,0	0,7	0,9

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TABLE 4.4.3. CONTINUATION

I	2	3	4	5	6	7	8	9	I0	II	I2
Stage of maturity	3	"A" M	I6,0	5,6	I7,2	I2,9	3I,3	29,3	2I,2	8,8	I2,4
		"A" σ	I8,4	4,3	I2,8	I3,3	2I,0	8,I	I2,3	6,I	I0,9
		"A" m	8,2	I,9	5,7	3,4	I2,I	4,7	5,5	2,3	4,9
		"B" M	6,8	I2,0	2I,2	I3,3	5,6	7,2	I6,2	I4,0	20,8
		"B" σ	2,7	II,3	I4,7	II,8	4,9	I0,7	I2,I	I2,9	I3,6
		"B" m	I,2	5,0	6,6	3,0	2,2	4,8	5,4	5,8	6,I
	4	"A" M	58,0	70,0	59,6	62,5	37,3	38,0	53,6	70,4	6I,2
		"A" σ	25,I	7,3	I7,3	I7,6	3I,6	5,3	I7,7	5,2	20,7
		"A" m	II,2	3,3	7,7	4,6	I8,3	3,I	8,0	2,3	9,3
		"B" M	76,0	67,2	56,4	66,5	64,4	65,6	46,8	63,2	6I,2
		"B" σ	6,6	2I,5	I8,9	I7,6	I8,8	I6,I	I8,I	I9,I	I7,0
		"B" m	3,0	9,4	8,5	4,5	8,4	7,2	8,I	8,5	7,6
	5	"A" M	20,8	24,0	I9,2	2I,3	2I,3	26,7	I8,8	20,0	24,0
		"A" σ	6,I	9,3	I0,4	8,4	5,0	I,2	6,3	9,4	8,2
		"A" m	2,7	4,I	4,6	2,2	2,9	0,7	2,8	4,2	3,7
		"B" M	I4,8	I8,8	20,4	I8,0	28,8	26,8	32,4	2I,2	I6,0
		"B" σ	4,I	7,6	I2,2	8,4	I9,9	I0,5	7,8	6,9	2,8
		"B" m	I,9	3,4	5,5	2,2	8,9	4,7	3,5	3,I	I,3

Note: $\lambda - \rho = 0,05$

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5.0. Investigation of the Cardio-Vascular System

Condition of the Cardio-Vascular System at Rest

Electrocardiographic and echocardiographic investigations.

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The results of medical treatment of astronauts testify that one of the possible consequences of the unfavorable influence of weightlessness on the cardio-vascular system of the human being is the development of disturbances in the heart activity. This was especially indicated by the disturbance, noted many times during and after flights, of the heart contraction rhythm, the change in the bioelectric activity of the myocardium, change in the phase structure of the heart contraction, reduction of the heart size, the manifestation of symptoms of impaired contractile function of the myocardium during functional loads, and the lowering of the reserve capabilities of the heart. Although the currently noticed alterations in the heart activity of astronauts are of a functional nature, their development deserves serious attention, especially in connection with the prolongation of flights and the increase in the age group of the participating astronauts, i.e. this considerably raises the probability for the development of more pronounced and clinically significant disturbances [1-4].

In connection with the above, experimental research directed at studying the features of heart activity for a healthy person at various stages of circulatory system adaptation to the conditions of simulated weightlessness have recently acquired great importance. This work is an essential prerequisite for determining the most effective means and methods of preventing cardio-vascular disorders in conditions of actual space flight.

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The principal task of this section of the work was the study of the influence of a 7-day hypokinesia in bedrest conditions, which is one of the practicable and most often employed weightlessness models, on the bioelectric myocardial activity and on the volumes and contractile function of the heart. Moreover, a study was made as to how greatly the observed shifts were indebted to the overfilling of the upper body vessels with blood, which is characteristic for weightlessness. For this purpose, a comparative analysis was made for the dynamics of the studied cardiologic indices of two groups of subjects, being in the horizontal (group A) or the antiorthostatic (group B) body positions during hypokinesia.

5.1.1. Electrocardiography

An electrocardiographic examination of the subjects was done by means of the 8-channel "Mingograf-81" electrocardiograph (Sweden) at an amplification 1 mv = 10 mm. The ECG recording was done in the supine position; the subjects of group B were examined in the antiorthostatic position during the bedrest. Twelve clinical

discharges were recorded: 3 standard (I, II, III), 3 amplified (ayR, ayL, ayF) from the extremities, and 6 thoracic (V_1 - V_6). The placement of the electrodes and the interpretation and analysis of the ECG were done in conformity with generally-accepted principles and methods [5-9]. For the entire bedrest period, the well-being of the subjects was completely satisfactory. No complaints were made for uncomfortable feelings or pain in the heart region.

In both the background and the hypokinesia periods, during the examination at rest, the rhythm of heart contractions was regular, sinusoidal, with a moderate respiratory arythmia.

During the hypokinesia, a certain reduction in the heart contraction frequency was noted, the length of the PQ, QRS, and QRST intervals being almost unchanged and corresponding to the length of interval R-R. The deviation of the real values of the interval QRST and of the systolic index (SI) from the required values did not exceed 0.04 sec and 5%, respectively. /256

A slight reduction in the amplitude of the deflections T during the hypokinesia was not attended by the development of symptoms that accompany a disturbance in the bioelectric activity of the myocardium. There was no lowering of the interval ST relative to the isoelectric line and no deformation of the segment ST. (Supplement B tables 8.5.1.1 and 8.5.1.2).

The obtained data wholly confirms the fact that the remaining of the subjects in hypokinetic conditions with horizontal and antiorthostatic positions of the body did not lead to the development of ECG changes indicative of metabolic disturbance or interference with myocardial blood supply. No significant difference was noted in the dynamics of the studied ECG indices for the subjects of groups A and B. The discovered tendency for lowering of the deflection amplitude T was apparently due to a certain change in the position of the heart in the rib cage as a result of the adaptation of the subjects' cardio-vascular system to the conditions of reduced motor activity.

5.1.2. Echocardiography

The echocardiographic examination of the subjects was done on the "Echovue-80C" echocardiograph of the Picker Company (USA). The echocardiogram (M-mode) and the electrocardiogram (2-pole chest discharge) were recorded synchronously on paper tape sensitive to ultraviolet rays (1895 type, Kodak company). For all the investigations the same ultrasonic sensor with 13 mm diameter (frequency 2.25 MHz) was used.

The ultrasonic sensor was placed at the level between the fourth and fifth ribs at the left side of the chest. After obtaining an image of the mitral valve (figure 5.1.1, position A), under visual control by oscilloscope the ultrasonic beam was moved in the direction toward the apex cordis until a good-quality /257

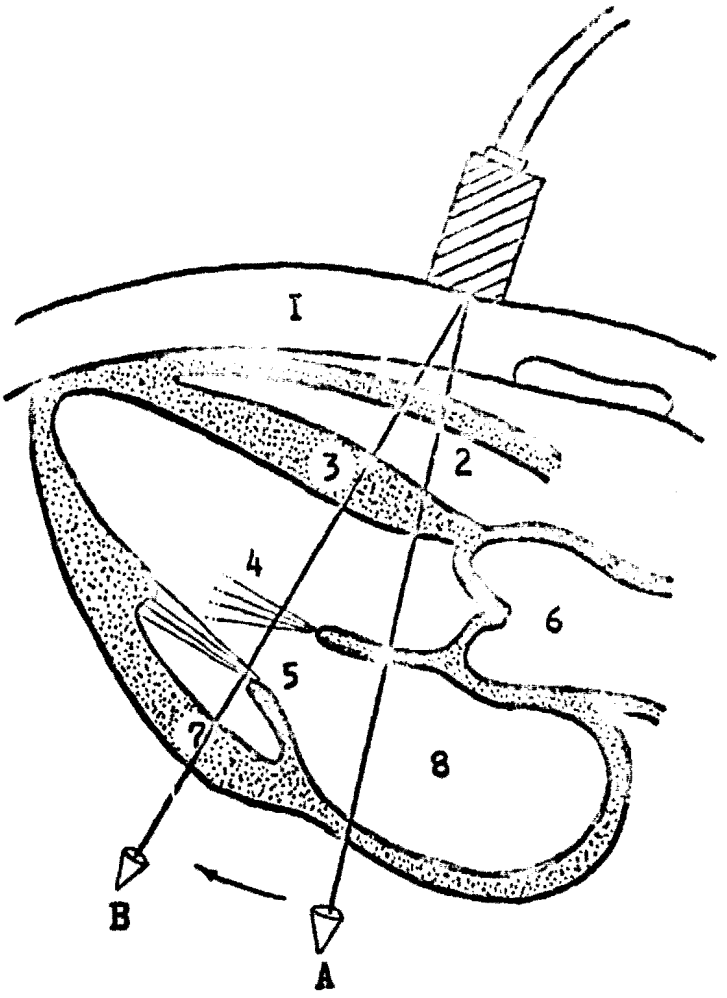

Fig. 5.1.1. Scheme for recording the echocardiogram (after Feigenbaum 11,12). Key: 1 - thorax, 2 - right ventricle, 3 - interventricular septum, 4 - left ventricle, 5 - mitral valve, 6 - right auricle, 7 - rear wall of the left ventricle, 8 - left auricle.

echogram was obtained of the interventricular septum and the rear wall of the left ventricle at the level of the mitral valve chordae (figure 5.1.1, position B). Thus, in the examination of the subjects, even when carrying out the NPLB test, the ultrasonic sensor was positioned in relation to reference points within the heart.

In the examination at rest, before and after hypokinesia, the subjects were in the horizontal position. During the bedrest, group A was in the horizontal position, group B was at an angle of -6°.

Since it was established, in the course of a preliminary examination, that it was not possible to record an echocardiogram for all the subjects in the supine position, commencing with P-13 all the investigations at rest were done with the subjects on their left side, that is, by a 30-40° turn about the "longitudinal axis of the body." This enabled the obtaining of echograms of the left heart ventricle, suitable for interpretation, from all the subjects.

The interpretation of the echocardiograms was done by the procedure described in a number of Soviet and foreign publications. The systolic size of the left ventricle chamber was determined at the point of maximum deflection for the echogram of the interventricular septum, while the diastolic size was determined at the level of projection of the ECG R deflection [10-15].

The following echocardiographic indices are presented in the report:

- The diameter of the left ventricle in systole (SD, cm);
- Diameter of the left ventricle in diastole (DD, cm); /259
- The volume of the left ventricle in systole (SV, ml);
- The volume of the left ventricle in diastole (DV, ml);
- The stroke volume of the heart (St.V., ml);
- The minute volume of the blood circulation (MVC, l/min);
- The discharge fraction (DF, %).

Furthermore, the following reference indices were calculated by formulas (14,16,17):

- SV (ml) = $7.0/(2.4 \cdot SD) \cdot SD^3$
- DV (ml) = $7.0/(2.4 \cdot DD) \cdot DD^3$
- St.V. (ml) = DV - SV
- MVC (l/min) = St.V.·FHC·0.001
- DF (%) = St.V./DV · 100.

The findings were subjected to statistical processing (cf. section 3.5). As can be seen from the data presented in table 5.1.1 (graphs 3-5), prior to hypokinesia the mean values of the echocardiographic indices for both groups of subjects were within the bounds of physiological fluctuations and corresponded to persons of this particular age group and level of general physical development. For two of them (A-ov, P-ov), relatively large values of DV, SV, and St.V. were recorded, but since these subjects were assigned to

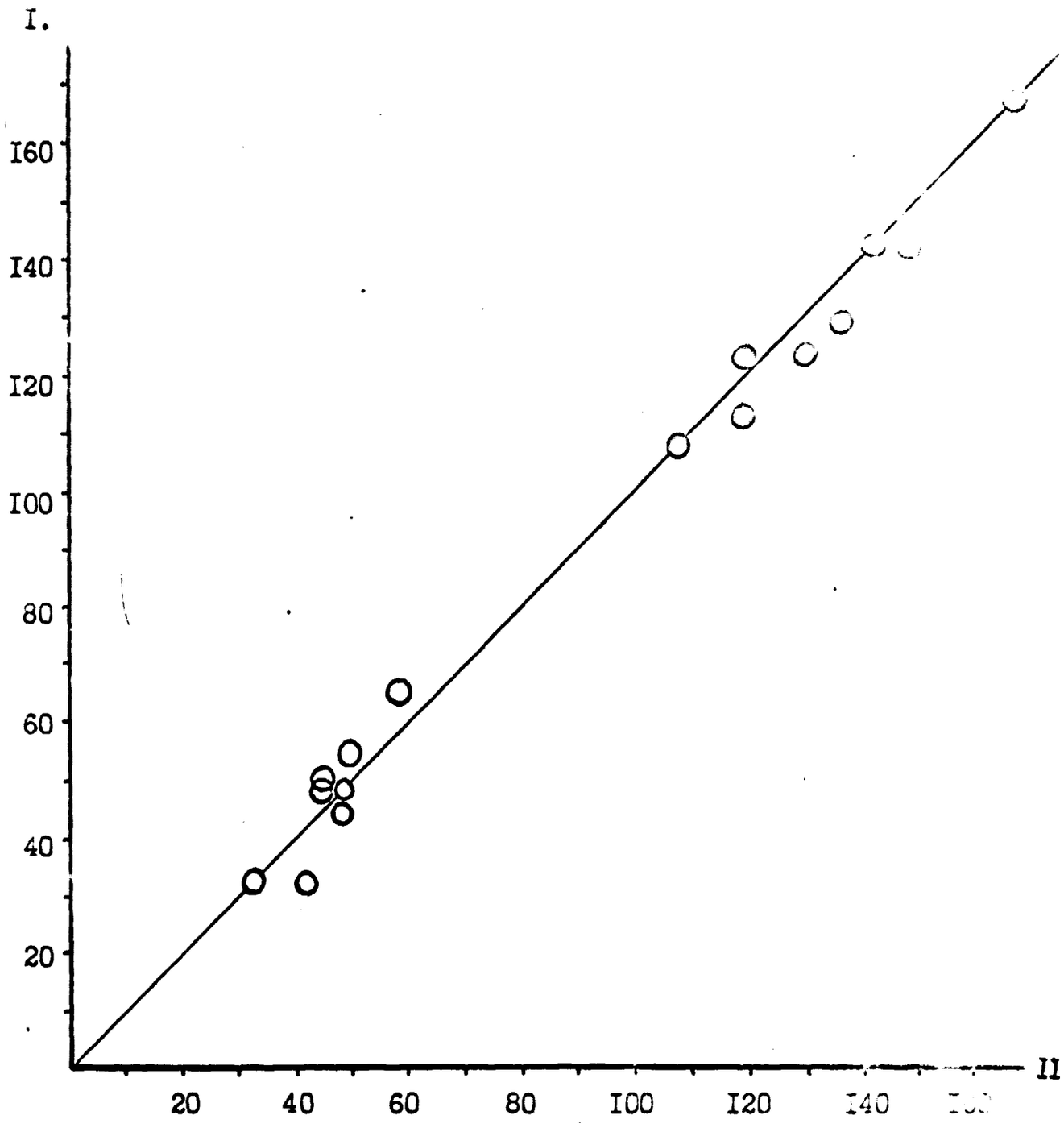

Fig. 5.1.2. The magnitude of DV and SV for the subjects of group A and B during a repeated examination prior to hypokinesia.

Key: I - examination on day 13 prior to hypokinesia, II - examination on day 14 prior to hypokinesia, O - DV, ● - SV.

Table 5.1.1.

Dynamics of the echocardiographic indices for the subjects of groups A and B during the experiment (at rest)

Index	Group	Values	before BR		BR (days)				after BR (days)			
			I3	I4	mean	a	b	c	2	4	0	5
1	2	3	4	5	6	7	8	9	I0	II	I2	I3
DV (ml)	"A"	M	I37	I35	I36	I30	I28	I27	I24	I2I	II8	I34
		σ	23	27	25	2I	2I	I5	22	I8	I7	23
		±m	I0	I3	8	I0	9	7	I0	8	7	I0
	"B"	M	I35	I3I	I33	I4I	I4I	I47	I44	I46	I33	I34
		σ	2I	I0	I6	22	25	20	I8	20	23	I9
		±m	9	5	5	I0	II	9	8	9	I0	8
SV (ml)	"A"	M	47	46	47	47	46	46	45	44	40	48
		σ	I2	II	II	I0	9	9	I0	9	8	I3
		±m	5	5	4	4	4	4	4	4	4	6
	"B"	M	49	45	47	57	57	56	55	56	47	44
		σ	II	4	9	I2	I0		7	9	II	I2
		±m	5	2	3	6			3	4	5	5
St.V. (ml)	"A"	M	9I	89	90	83		8I	79	77	76	86
		σ	I4	I6	I5	I2	I3	I2	I5	I3	I2	II
		±m	6	7	5	6	6	5	7	6	5	5
	"B"	M	86	86	86	84	84	9I	89	89	85	90
		σ	I	6	9	I2	I7	II	I3	I2	I3	

Table 5.1.1.
(Cont'd)

			4	5	6	7	8	9	I0	II	I2	I3
FHC (beats/min)	"A"	M	62	67	64	56	60	59	59	57	69	6I
		σ	8	9	8	7	8	8	I0	7	I5	8
		$\pm m$	3	5	3	3	3	4	5	3	7	4
	"B"	M	69	63	66	60	64	64	60	59	68	79
		σ	8	I3	I0	9	8	5	8	I0	I0	II
		$\pm m$	3	7	3	4	3	2	4	4	5	5
MVC (l)	"A"	M	5,7	6,0	5,8	4,6	5,0	4,8	4,7	4,4	5,4	5,3
		σ	I,3	I,6	I,4	I,I	I,3	I,I	I,3	I,0	I,4	I,2
		$\pm m$	0,6	0,8	0,5	0,4	0,6	0,5	0,6	0,5	0,6	0,5
	"B"	M	5,9	5,3	5,7	5,0	5,3	5,8	5,3	5,2	5,8	7,0
		σ	I,1	0,8	I,0	0,7	0,6	0,3	I,I	0,9	I,I	0,5
		$\pm m$	0,5	0,4	0,3	0,3	0,3	0,2	0,5	0,4	0,5	0,2
DF (%)	"A"	M	66	66	66	64	64	64	64	64	66	65
		σ	5	4	4	4	2	6	5	5	4	4
		$\pm m$	2	2	I	I	I	3	2	2	2	2
	"B"	M	64	66	65	60	59	62	62	6I	65	68
		σ	4	I	3	5	4	2	2	2	3	5
		$\pm m$	2	I	I	2	2	I	I	I	I	3

Key: a - 3 hours hypokinesia, b - 6 hours hypokinesia, c - 9 hours hypokinesia

N.B. Commas in the tabulated material are to be understood as decimal points.

different groups, on the average groups A and B were rather uniform prior to the experiment.

The data in figure 5.1.2 testifies to a certain individual scattering of SV and (especially) DV values before the bedrest. This figure represents the individual values of the SV (white circles) and DV (black dots), recorded during an examination on the thirteenth day of the background period and, two days later, in bedrest conditions 2-2.5 hours after the transition. In the /263
period from the first to the fourth day of bedrest, a tendency to gradual diminution of DV, SV, and St.V. (on the average by 11%, 6%, and 14%, respectively) was noted in the subjects of group A (cf. table 5.1.1). At the same time, there was a certain lowering of the FHC (on the average by 11%), which led to a consequent lowering of the MVC (on the average by 24%).

In this same period of observations, the direction of the change in DV, SV, and St.V. was opposite for the subjects of group B. At the fourth day of hypokinesia, the sizes of these indices were larger by 10%, 19%, and 3% on the average than those in the background period. In connection with this, by the fourth day of bedrest, the size of the MVC was reduced by an average of 7% on the whole.

In the examination on day "0" after the termination of the bedrest (cf. table 5.1.1, graph 2), i.e. within 7 days after the beginning of bedrest, a reduction in DV and SV was noted in both groups relative to the magnitudes registered on the fourth day of bedrest, while at the same time the MVC increased almost to the initial level. Before this time, the magnitudes of DV, SV, and St.V. for the subjects of group A were on the average less by 13%, 15%, and 15%, while for group B they were practically the same as before the bedrest.

The above dynamics for the echocardiographic indices on day "0", in our opinion, was to a considerable extent due to the fact that this examination was carried out immediately before the beginning of the LBNP test, which was accompanied by the development of a characteristic preparatory ("prestart") reaction of the cardiovascular system, one of the symptoms of which was an increase in the frequency of heart contractions. The latter, naturally, /264
may be the immediate cause for the reduction in the heart volumes and the increase in the MVC.

However, for the subjects of group B, the reduction in DV and SV on day "0" of the recuperation period may also be associated with decrease in return of venous blood to the heart, since immediately prior to this examination (prior to the LBNP test) the subjects had been moved from the antiorthostatic to the horizontal position. In connection with the above, on day "0" of the recuperation period, 2-2.5 hours before the scheduled investigation, we carried out an additional (facultative) investigation on the subjects of group B (in the ward), while preserving the antiorthostatic

position stipulated by the experimental conditions. The results of this investigation showed that the tendency to increase of heart volumes (table 5.1.1, graphs 5-10), discovered in the subjects of group B in the first four days of hypokinesia, was retained for the duration of all 7 days of bedrest. During this examination, the magnitudes of DV, SV, St.V., FHC, and MVC were practically the same as on the fourth day of bedrest: 145 ml, 55 ml, 90 ml, 61 beats/min, and 5.4 l/min. Thus, the results of the additional examination support the hypothesis that the above-mentioned reduction in the heart volumes and increase in the MVC during the examination prior to the LBNP test on day "0" of the recuperation period was due, not to the length of hypokinesia, but to the change in the examination conditions.

For the subjects of group B, after the transition from the antiorthostatic to the horizontal position prior to the NPLB test (the second examination on day "0"), the greatest decrease in DV and SV was noted alongside a comparatively more pronounced increase in the frequency of heart contractions. This, as well as the /265
fact that similar changes on day "0" were found in the subjects of group A, testifies that the principal cause of these changes was the increase in the FHC, and not the relative decrease in the flow of venous blood to the heart, which is possible in these conditions. However, it is not possible to entirely exclude the possibility for the influence of hemodynamic shifts on the heart volumes in the transfer of the subjects from the antiorthostatic to the horizontal position, the moreso since, in the given situation, the increase in the FHC may be secondary, as one of the methods of maintaining an adequate MVC in the case of a pronounced decrease in the stroke volume. It is possible that this was precisely the case for, e.g., subject T-n in whom, as a response to the transfer from the antiorthostatic to the horizontal position, the St.V. decreased from 93 ml to 78 ml (i.e. by 16%); due to the increase in the HFC from 48 to 57 beats/min, the size of the minute volume of circulation hardly changed at all.

It should be noted that the dynamics of the above-presented indices was not accompanied by a substantial change in the size of the DF or by the appearance of other symptoms for the disturbance of the contractile function of the myocardium. A restoration of the mean values of the echocardiographic parameters, registered at rest, to almost the initial level was already noted in the examination of subjects of both groups on the fifth day after the termination of bedrest.

Thus, an analysis of the findings showed that the 7-day stay in conditions of hypokinesia was not attended by the development of clinically significant changes in the heart activity. The shifts noted during the examination at rest were moderately expressed, of a functional nature, and were remedied in a brief period following the experiment. /266

The presence of a difference in the direction of the heart volume change for the subjects of group A and B is of certain interest.

The slight reduction in DV, SV, St.V., and HFC for the subjects in the horizontal position during hypokinesia, in our opinion, is a regular adaptive reaction, directed at maintaining an adequate (relatively lesser) minute volume of blood circulation in conditions of lowered muscular activity and motor activity. One of the probable causes of the heart volume reduction in the subjects of group A may also be the reduction of the volume of circulating blood, which occurred for them (section 4.3.3) and had been noted earlier in similar experiments [18-20]. The tendency toward increase in DV and SV, noted in the subjects of group B, in the antiorthostatic position during hypokinesia, was apparently associated with a slight overload of the heart as a result of the redistribution of blood to the vessels of the upper body half, characteristic for this experimental model of weightlessness [19,20].

In conclusion it must be noted that, on the basis of the obtained material, it is difficult to make a judgment as to the general regularities of the heart volume change and the alteration of the myocardial contractile function in the studied experimental conditions. This is largely due to the relatively small number of subjects in each of the experimental groups and to the significant individual variations in both the initial magnitudes of the echocardiographic indices and in their dynamics during hypokinesia. The latter is apparently due to the short duration of the hypokinesia, during which the phase of stable adaptation of the circulatory system to the studied experimental conditions has not yet set in.

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5.1.3. Plethysmography.

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5.1.3.1. Survey of the Literature

There is a belief that the lowering of the orthostatic stability in conditions of restricted muscular activity is associated with a lowering of the tonus of the arterial [1,2 etc.] or venous [3-7 etc.] vessels.

However, convincing data have not yet been obtained for the increased extensibility of the vascular channel and the lowering of the tonus of the arterial vessels during restricted muscular activity.

Investigations [8,9] have shown that, after a prolonged stay in conditions of water immersion, in a chair (in the position of "average physiological rest"), and in conditions of bedrest up to 120 days in length, the extensibility of the vascular bed of the lower extremities does not change remarkably, while the tonus of the arterial vessels even increases.

Other researchers [10,11] have come to a similar conclusion as to the absence of a lowering of the vascular tonus in astronauts after space flight. According to certain data [12], the tonus of the vessels of the lower extremities even surpassed the initial level in astronauts following flight.

A significant (almost 5 times) increase in the capacity of the vascular channel has been noted during space flight [13]. The importance of the question as to the state of the vascular channel to explain the mechanisms of de-training of the cardio-vascular system in conditions of restricted muscular activity and weightlessness has motivated the present investigations.

This experiment employed the procedure of occlusion plethysmography, which has become common in estimating the volume rate of blood flow and the extensibility of the vascular channel [14-17 etc.]. /270

5.1.3.2 The Procedure

The plethysmography was carried out in the morning in conditions similar to the basic metabolism two days prior to the beginning of bedrest, on the second, fourth, and sixth day of bedrest, and on the zero, fifth, and tenth day after its termination.

Mercury sensors of the Whytney type were used for the plethysmography. The sensors were applied to the forearm, 3 cm below the elbow joint, and on the portion of the calf with the largest perimeter. The occlusion was produced by sleeves applied to the arm and thigh. A special device enabled the pressure in these sleeves to be raised to 50 mm mercury in 2-3 seconds. The

occlusion lasted until the curve reached a plateau.

The following indices were analyzed:

5.1.3.2.1. The initial level of the plethysmogram for 2-3 min duration.

5.1.3.2.2. The index of the volume rate of blood flow, which was determined by the slope of the curve in the first five seconds (the rapid component of the volume increase). The volume rate of blood flow was expressed in ml/min per 100 ml of tissue.

5.1.3.2.3. The amplitude of the curve from the level of the plethysmogram at rest to the establishment of a plateau during occlusion. This magnitude is regarded as an index for the extensibility of the venous channel.

5.1.3.2.4. The rate of volume increase of the extremities from the moment of a 30-second occlusion until the curve reaches a plateau, with conversion for a 1 minute time period (the slow component of the volume increase). It is considered that this index primarily reflects the ratio of the filtration and reabsorption relationships between the intravascular and extravascular fluid, although it is not possible to totally eliminate the influence of elasticity changes in the vascular walls [18]. /271

5.1.3.2.5. The extent of restoration of the volume in the extremity within 30 seconds after cessation of venous occlusion.

Furthermore, each time before beginning the plethysmography, a centimeter tape was used to measure the perimeters of the forearm with a spacing of 3 cm and the perimeters of the lower leg with a spacing of 6 cm, as well as the length of the extremities. Afterwards, the volumes of the forearm and lower leg were calculated. The measurement levels were marked with paint prior to the bedrest and, as a rule, preserved for the entire length of the experiment.

The measurement was done by the same experimenter. An exception is the measurements of the forearm perimeters on the fifth and tenth days and of the lower leg perimeters on the tenth day following the conclusion of bedrest, which were made by a different experimenter.

5.1.3.3. Results of the Investigations

5.1.3.3.1. The Volume of the Limbs

Group A differed from group B by a somewhat lesser volume of the forearm (by 160 ml) and lower leg (by 260 ml).

In bedrest conditions, the volume of the forearm varied insignificantly and uncertainly ($r < 0.05$). The volume of the lower leg was lowered by an average of 4.4% for the subjects of group A and by 6.6% for those of group B or, respectively, by 106 ± 7.6 and 169 ± 36.4 ml. However, due to the large individual variations in this index and the small number of observations, the difference in the mean values of the lower leg volume before and during the bedrest in the subjects of both groups was not reliable (table 5.1.2).

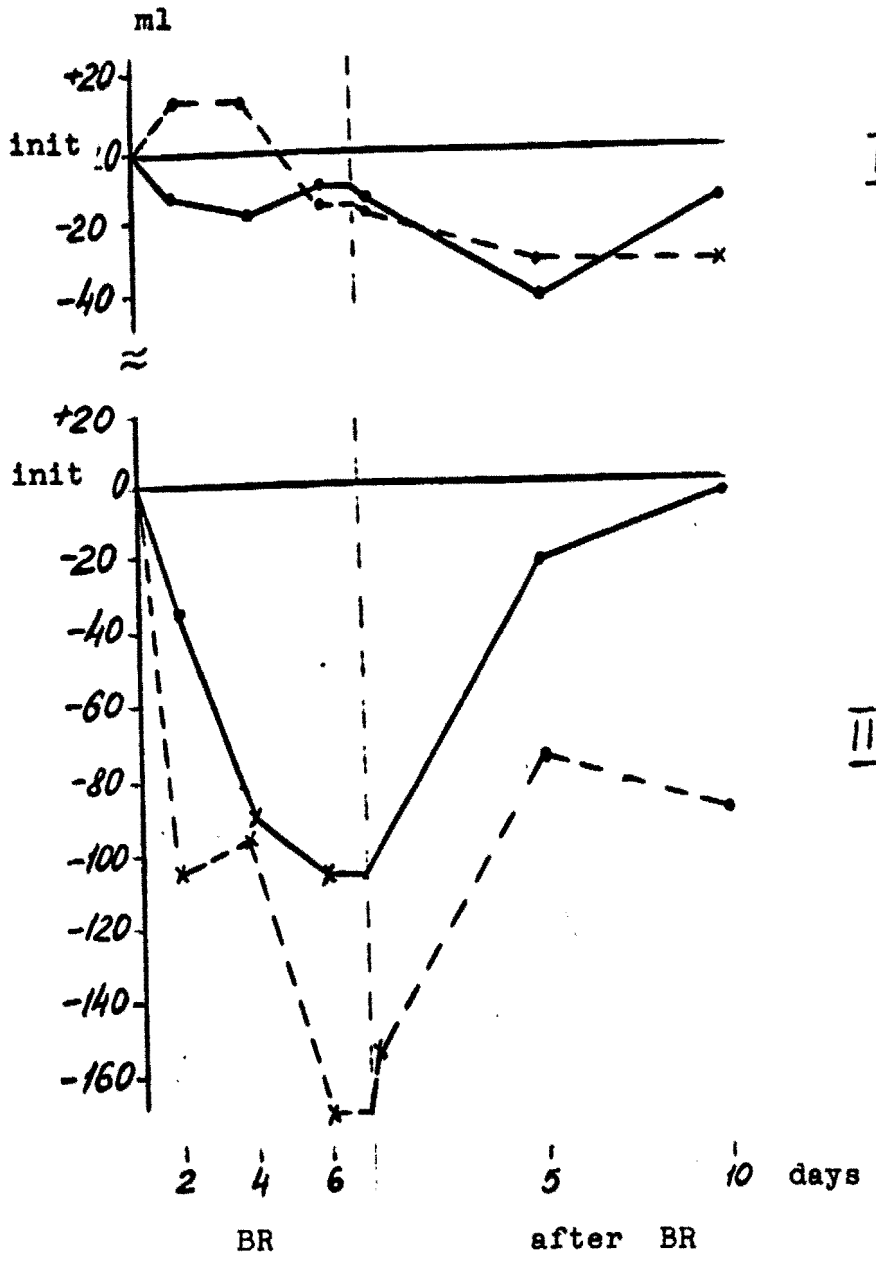

Fig. 5.1.3. The change in the volume (ml) of the forearm (I) and lower leg (II) after BR (relative to the amount prior to BR).

Key: ——— group A, - - - - group B, x = reliable changes relative to the amount prior to BR ($r < 0.05$).

Table 5.1.2.

Volume of the forearm and lower leg (ml) for the subjects at various stages of the experiment.

Index	Group	Values	before BR mean	BR (days) 2	BR (days) 4	BR (days) 6	after BR (days) 0	after BR (days) 5	after BR (days) 10
forearm	"A"	M	1025,8	1015,3	1010,4	1019,5	1008,1	987,8	1013,9
		σ	109,2	106,9	88,5	91,1	87,6	84,3	83,3
		m	48,8	47,8	39,6	40,8	39,2	37,7	37,3
	"B"	M	1183,0	1203,3	1185,7	1162,6	1168,9	1163,5	1150,8
		σ	92,4	103,5	118,8	110,2	114,8	108,5	101,4
		m	41,3	46,3	53,1	49,3	51,3	48,5	45,4
lower leg	"A"	M	2415,9	2343,8	2332,2	2309,4	2300,1	2398,0	2412,2
		σ	236,3	265,3	253,2	231,8	224,4	217,2	269,0
		m	105,7	118,6	113,2	103,6	100,4	97,1	120,3
	"B"	M	2677,4	2578,2	2588,5	2508,3	2534,6	2602,8	2609,6
		σ	268,5	245,8	263,4	226,9	265,4	241,6	306,4
		m	120,1	109,9	117,8	101,5	118,7	108,0	137,0

Key: BR = bedrest

N.B. Commas in the tabulated material are to be understood as decimal points.

An analysis of the individual data showed that the volume of the forearm was reduced in three subjects, did not change for another, and increased for another in group A. /273

In group B, the forearm volume increased for 3 subjects, did not change for another, and was reduced for another, i.e., a certain tendency was noted for oppositely-directed changes in groups A and B.

The averaged values for the difference in the lower leg volume before and during the bedrest revealed a reliable lowering of this index in bedrest conditions. The lowering was reliable on the fourth and sixth days of bedrest, and also on the zero day after bedrest ($r < 0.05$). For the subjects of group B, the reduction in the lower leg volume was more pronounced (figure 5.1.3). However, the differences between the groups were not reliable.

On the fifth and tenth day following bedrest, the lower leg volume did not differ from the initial values prior to bedrest. The forearm volume on these days was lower than the initial values which, apparently, is explained by an artefact produced by the fact that the measurements were made by a different experimenter. The lowering of the lower leg volume in both groups of subjects by the end of bedrest was similar to the changes observed on the fifth day of space flight in the astronauts of the "Skylab" spaceship [13].

5.1.3.3.2. The Volume Rate of the Blood Flow

Prior to bedrest, the volume rate of the blood flow in the forearm was somewhat higher for the subjects in group A as opposed to group B, although these differences were not reliable. The volume rate of blood flow in the lower leg was essentially the same for the subjects of both groups.

In bedrest conditions, the volume rate of blood flow in the forearm and lower leg of the group A subjects was gradually lowered and by the sixth day of bedrest was almost two times lower than the initial value before bedrest. For the subjects of group B, the volume rate of blood flow was also lowered, but more slowly and to a lesser extent than in group A. The changes in the subjects /275
of this group were not reliable (table 5.1.3, figure 5.1.4). A reliable lowering of the rate of blood flow in the forearm was only noted on the zero day after bedrest. The magnitude of the volume rate of blood flow in the subjects of this group was also restored within 10 days after bedrest.

Thus, on the basis of the obtained data, it may be presumed that, for subjects in bedrest conditions in a horizontal position, the amount of blood flowing to the extremities is reduced. These facts correspond to the data as to the depression of metabolic processes in conditions with restricted muscular activity.

Table 5.1.3.

Volume Rate of Blood Flow (ml/100 ml tissue/min) in the Forearm and Lower Leg of the Subjects at Various Stages of the Experiment.

Index	Group	Values	before BR (days) Mean	BR (days) 2	BR (days) 4	BR (days) 6	after BR (days) 0	after BR (days) 5	after BR (days) 10
forearm	"A"	M	6,993	5,4	3,785[x]	3,360[x]	4,080	3,960	7,320
		σ	3,634	4,I35	2,902	I,565	3,I58	I,972	2,560
		m	I,625	I,849	I,298	0,7	I,4I2	0,882	I,I45
	"B"	M	6,3	6,00	5,64	4,233	2,I60[x]	5,520	7,592
		σ	3,436	I,643	2,I88	0,952	0,9I0	5,272	5,207
		m	I,537	0,735	0,98	0,426	0,407	2,358	2,329
lower leg	"A"	M	2,43I	2,208	0,656[x]	I,408[x]	I,536[x]	2,256	2,35I
		σ	0,565	0,429	0,260	0,9I0	0,526	0,322	0,597
		m	0,253	0,I92	0,II6	0,407	0,235	0,I44	0,267
	"B"	M	2,480	2,4	I,770	2,080	2,040	3,728	3,945
		σ	I,073	0,849	0,565	0,460	0,684	I,I78	I,636
		m	0,480	0,379	0,253	0,206	0,306	0,527	0,732

Key: BR = bedrest, x = reliable differences from the background ($r < 0.05$).

N.B. Commas in tabulated material are to be understood as decimal points.

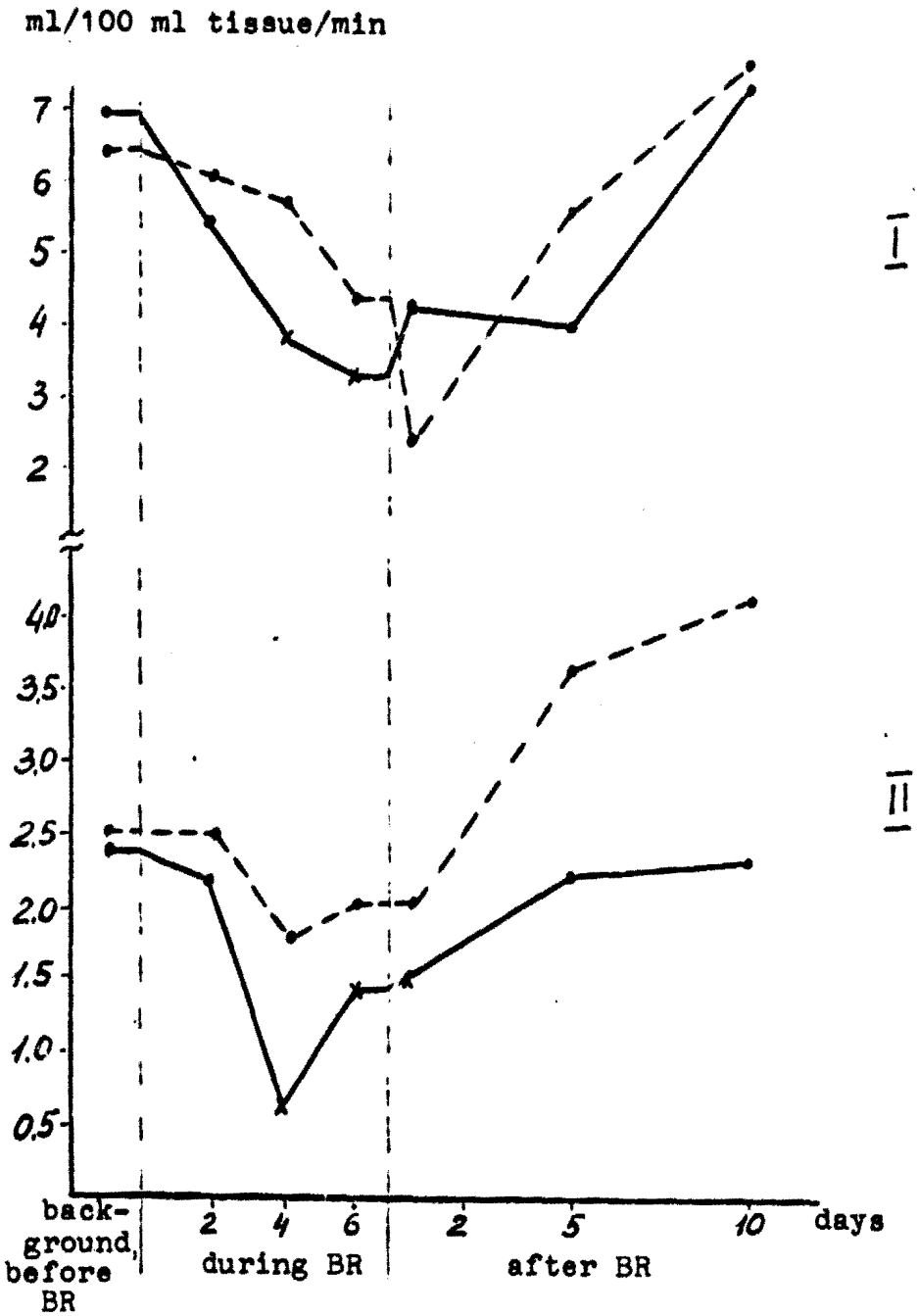

Fig. 5.1.4. Volume rate of blood flow (ml/100 ml tissue/min) in the forearm (I) and lower leg (II) at various stages of the experiment.

Key: ——— Group A, - - - - Group B, x = reliable differences from the background ($r<0.05$).

Table 5.1.4.

Size of Volume Increase in the Forearm and Lower Leg of the Subjects (ml/100 ml tissue) upon occlusion (50 mm Hg) of the Veins in the Arm & Leg.

Index	Group	Values	before BR (days)	BR (days)			after BR (days)		
			Mean	2	4	6	0	5	I0
forearm	"A"	M	I,704	I,490	I,422	I,770	I,500	I,500	I,660
		б	0,525	0,332	0,503	0,3I5	0,524	0,6I2	0,5I8
		m	0,235	0,I49	0,225	0,I4I	0,235	0,274	0,232
	"B"	M	I,790	I,870	I,820	I,5I8	I,540	I,I80	I,6I3
		б	0,230	0,363	0,35I	0,625	0,4I6	0,356	0,63I
		m	0,I03	0,I62	0,I57	0,279	0,I86	0,I59	0,282
lower leg	"A"	M	2,080	I,220x	I,I50x	I,380x	I,220x	I,260x	I,656
		б	0,642	0,327	0,328	0,257	0,370	0,503	0,532
		m	0,287	0,I46	0,I47	0,II6	0,I66	0,225	0,238
	"B"	M	I,873	I,600	I,555	I,5I3	I,2I7	I,940	I,9I8
		б	0,777	0,837	0,735	0,48I	0,653	0,537	0,708
		m	0,347	0,374	0,329	0,2I5	0,284	0,240	0,3I7

Key: BR = bedrest, x = reliable differences as compared to the background before bedrest.

N.B. Commas in the tabulated material are to be understood as decimal points.

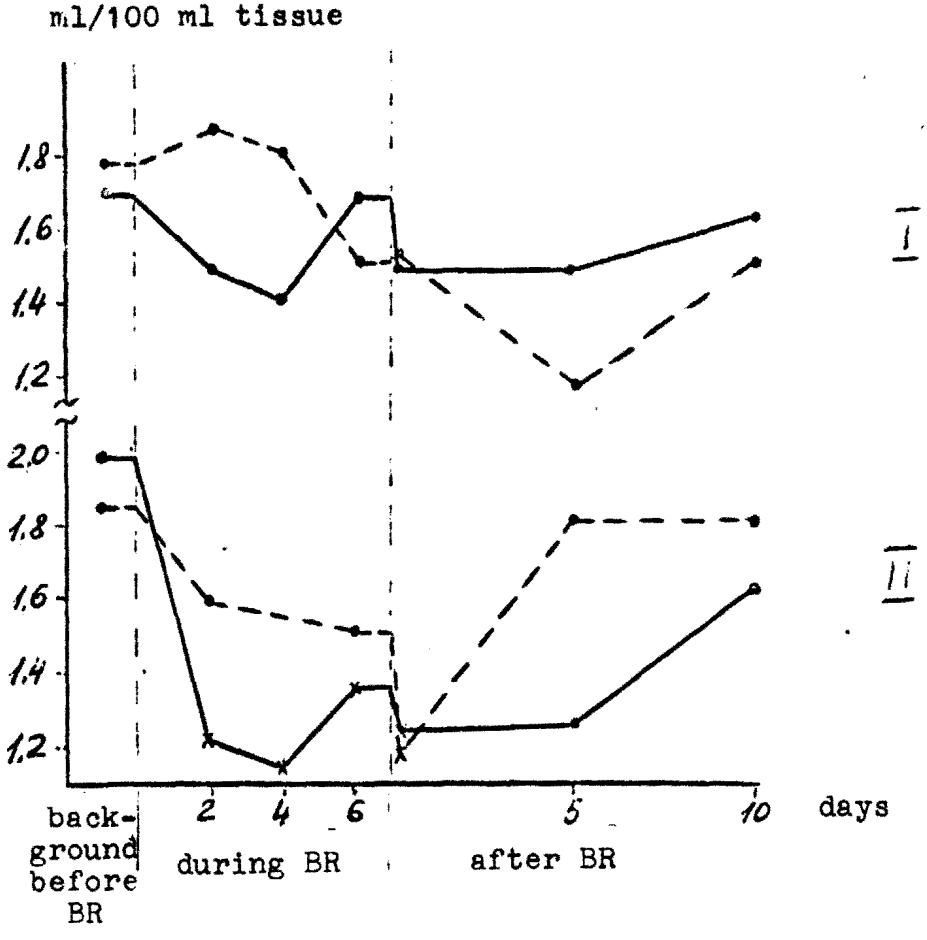

Fig. 5.1.5. Size of the volume increase in the forearm (I) and lower leg (II) of the subjects (in ml/100 ml tissue) upon occlusion of the veins in the arm and leg (50 mm mercury).

Key: ——— Group A, - - - - Group B, x = reliable differences from the background before BR ($r<0.05$).

5.1.3.3.3. The Increase in the Limb Volume During Occlusion of Veins

During occlusion of the veins in the arm and leg, the volume of the forearm and lower leg increased until the curve was stabilized at a new level, on the average by 1.7-1.8 and 1.9-2.0 ml/100 ml tissue, respectively. No substantial differences were revealed between the subjects of groups A and B for the volume increase in the forearm and lower leg prior to bedrest. In bedrest conditions and after its conclusion, the size of the volume increase in the forearm for the subjects of both groups was reliably no different than the background values (table 5.1.4). The size of the volume increase in the lower leg in bedrest conditions was reliably lower in the subjects of group A and unreliably lower ($r \lesssim 0.05$) in the subjects of group B (figure 5.1.5).

On the day of transition to the ambulatory regimen, a reliable lowering in the size of volume increase in the lower leg was noted in the subjects of both groups. An analysis of the data of both the average and the individual values of the volume increase in the lower leg did not reveal reliable differences in this index between the subjects of both groups during and after bedrest.

Thus, these investigations showed that, during and after bedrest, the volume increase in the lower leg upon occlusion of the veins in the leg is lowered. One of the most probable causes of this lowering may be the reduction in the capacity of the venous channel in conditions of restricted mobility. /280

5.1.3.3.4. The Slow Component of the Limb Volume Increase

The slow increase in the limb volume during impeded venous drainage is an indirect index for the relationship between the processes of vascular fluid filtration and extravascular fluid reabsorption.

In bedrest conditions, this index is reliably lowered, beginning on the fourth day, only for the subjects of group A in the region of the lower leg. In the other cases, the changes were not reliable. For the subjects of group B, a certain tendency was noted for the increase in this index of the plethysmogram in the area of the lower leg in bedrest conditions.

Consequently, in group A a reduction in the filtration processes was observed, while in group B, on the contrary, a tendency to their increase.

This data is in good agreement with that obtained by a number of authors on the reduction in the number of perfused capillaries in conditions of restricted muscular activity [19,20]. The reduction in the number of perfused capillaries is an adaptive reaction that restricts the passage of fluid from the vascular channel to the space between the tissues.

5.1.3.3.5. The Restoration of the Limb Volume after the Termination of Occlusion

After the termination of occlusion, i.e. the release of pressure in the clamping sleeve to the atmospheric pressure, the volume of the forearm and lower leg is sharply reduced. As a rule, within thirty /281
seconds after the termination of occlusion, the volume is restored to the level prior to occlusion, or even lower than this in a number of cases. No differences were noted in the degree of restoration of limb volume during and after bedrest as compared to the data prior to bedrest.

5.1.3.4. Discussion of the Results

Thus, the investigations revealed a lowering of the lower leg volume and of the volume rate of blood flow for the lower leg and forearm in bedrest conditions, as well as a reduction in the capacity of the lower leg vascular channel upon occlusion of the veins in the leg. The changes in the lower leg volume were more pronounced for the subjects in the antiorthostatic position, while the lowering of the volume rate of blood flow and the capacity of the lower leg vascular channel was more significant for the subjects in the horizontal position. However, the differences in dynamics of the above-mentioned indices between the groups were not reliable ($r < 0.05$). The forearm volume and the extensibility of its vessels upon occlusion of the veins in the arm in conditions of both horizontal and antiorthostatic position varied unreliably. There was a tendency toward certain discrepancies in the values of the forearm volume between groups A and B in bedrest conditions and for the indices that may characterize the processes of filtration and reabsorption in the capillary bed of the lower leg. In group B, a tendency was noted for increase in the forearm volume and the filtration processes in the lower leg, while in group A the forearm volume did not change and the filtration processes in the lower leg were retarded.

In conditions of restricted muscular activity, the vascular channel of the lower extremities underwent the greatest changes: the flow of blood to the legs was lowered, the capacity of the vascular channel was reduced, and the exchange of intravascular and extravascular fluid was altered in the direction of lowering the intensity of filtration processes from the vascular channel during occlusion of the veins in the leg. /282

One may not regard these changes of state in the vascular channel of the lower extremities as the consequence of a mechanical redistribution of the blood in connection with the change in the posture. Since they developed gradually and became reliable only from the fourth day of bedrest, it is likely they are of an adaptive nature, caused by adaptation to the lowering of muscular activity.

The absence of reliable differences in the change of state of the vascular channel between the subjects of group A and B may be

due to the small number of observations, in consequence of which the reliability was not developed. Or, the nature of the changes and the state of the vascular channel in the subjects of both groups are similar in direction and magnitude and, consequently, there are in general no differences.

From the physiological point of view one may suppose that there are likely to be changes in the condition of the human vascular channel during prolonged stay in the horizontal or the antiorthostatic position. It may be supposed that the less pronounced or even the oppositely-directed dynamics of change in the condition of the vascular channel in the antiorthostatic position, as compared to the horizontal position, is a specific factor of the physiological effect of the antiorthostatic posture.

A number of authors [21-24] have established that the size of the intravascular, and more specifically of the transmural pressure plays an important role in the regulation of the vascular tonus. Beginning with this data, the peculiarities of blood circulation in the antiorthostatic position may be represented in the following manner. In the antiorthostatic position, the hydrostatic pressure in the vessels of the lower extremities is lowered and, as a consequence, the transmural pressure is reduced, which causes a /283
lowering of the basal tonus of the arterial vessels, being a compensatory reaction that facilitates the flow of blood to the lower extremities. As a result, in the antiorthostatic position, on the one hand, the tonus of the lower limb vessels is raised in connection with the adaptation to restricted muscular activity and the volume rate of blood flow is reduced. On the other hand, the antiorthostatic position may be accompanied by an expansion of the arterial vessels in connection with the lowering of their basal tonus, the blood flow increasing. The total result of the interaction of these processes is a less pronounced lowering of the volume rate of blood flow in the lower leg in the antiorthostatic position than in the horizontal position.

For the subjects of group B, the tonus of the large vessels of the lower leg was raised to a lesser extent in bedrest conditions, which may also be explained as the effect of interaction between the lowered transmural pressure in the veins of the lower limbs and the restricted muscular activity. In the antiorthostatic position, the venous pressure in the veins of the lower limbs is reduced, the drainage of blood from the legs is intensified [25,26], and also the pressure between the tissues is apparently reduced. All of these processes cause a lowering of the tonus of the larger vessels. At the same time, the restricted muscular activity, as was observed in the subjects of group A, is accompanied by a raising of the tonus of the larger vessels in the lower leg. As a result of the interaction of these effects, the lowered tonus of the larger vessels in subjects of group B was less significantly pronounced.

However, since no reliable differences were obtained for the change in state of the vascular channel between subjects of group A

and B, it is appropriate to increase the number of observations in order to make definitive conclusions as to the presence of absence of differences in the physiological effects of the investigated models. /284

5.1.3.5. Summary

These investigations showed that, in bedrest conditions, the vascular channel of the lower extremities underwent the greatest changes: the volume rate of blood flow was reduced, the capacity of the vascular channel was lowered, and the intensity of filtration processes from the vascular channel of the lower leg was reduced upon occlusion of the veins in the thigh. However, in conditions of antiorthostatic posture, these changes were less pronounced and not reliable ($r < 0.05$). In bedrest conditions, a lowering of the lower leg volume was also observed, being more pronounced in the subjects of group B. On the other hand, the changes in the volume and main parameters of the plethysmograms for the forearm region were not reliable in bedrest conditions. A comparative analysis of all the plethysmographic indices in the dynamics did not reveal reliable differences between the groups in the horizontal and in the antiorthostatic positions.

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5.2. The Functional Test With Lower Body Negative Pressure (LBNP)

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5.2.1. The General Hemodynamics

The LBNP test (lower body negative pressure) was carried out in order to determine the influence of experimental horizontal and antiorthostatic hypokinesia on the endurance of reduced venous reflux. This test was also used to evaluate the regulatory function of the circulatory system during simulation of postural action.

5.2.1.1. Survey of the Literature

It has been observed more than once that, as a result of a stay in bedrest conditions with restricted motor activity or in conditions of space flight, an impairment of the postural regulation of the blood circulation occurs, particularly expressed in the lowering of the endurance in the orthostatic test [1-17].

During brief flights, to estimate the total effect of the negative influence of weightlessness and of preventive measures, a comparison of the results from pre-flight and post-flight orthostatic tests will suffice. As the length of the stay in weightlessness conditions increase aboard the orbital stations of the Salyut and Skylab types, for individual correction of the preventive measures it became necessary to evaluate the regulatory function of the circulatory system directly in flight where, naturally, the orthostatic test cannot be carried out. For this reason, researchers were attracted to two analogues of this test: the Valsalva manuever and LBNP. A number of works have revealed that the reaction of the organism to the LBNP test under a vacuum of 50 mm mercury corresponds to the orthostatic test. Consequently, /289 on the basis of test results with LBNP, it is possible to predict the state of the organism's orthostatic stability [18-21].

The phenomenology of the changes occurring in weightlessness had previously been studied in ground conditions with the subjects remaining in the horizontal position in bed [1-5, 7-13, 16-17]. Investigators later went on to model the individual elements of weightlessness in the orthostatic position [22].

The purpose of this section of the report is a comparative evaluation of the change in the human reaction to LBNP during a 7-day period of hypokinesia in the horizontal and the antiorthostatic positions of the body.

5.2.1.2. The Procedure

The test was carried out by means of a prophylactic vacuum suit

(PVS), which was placed on the lower half of the body and made airtight at the level of the waist. During the rarefaction, a support was created on the soles of the subject's feet. After the donning of the suit and the fixation of electrodes, the subject lay at rest on his back for not less than five minutes (the initial condition). Afterwards, a rarefaction was created: 25 mm mercury - 2 min; 35 mm mercury - 3 min; 40 mm mercury - 5 min; 50 mm mercury - 5 min. After this, the pressure was equalized to the atmospheric and the subject continued to lie in the same position for 5 minutes (recuperation).

Five minutes before the beginning of rarefaction, the pulse frequency and arterial pressure began to be recorded every minute. This continued until five minutes after the equalization of the pressure to the atmospheric. /290

The test was always carried out at the same time of day at previously determined periods: twice in the background period (before the bedrest), as well as on the zero, fifth, and tenth day after the bedrest. Only for subject P-iy, due to his toothache, was the last test shifted to the thirteenth day. In all, 50 LBNP tests were carried out.

In the quantitative analysis of the reaction to LBNP, the main foundation was a comparison of the initial level to the segments of worst condition of the subject (the greatest pulse frequency and the least pulse arterial pressure). As had been agreed upon previously, the main attention was devoted to the increase in pulse frequency and to the lowering of the pulse arterial pressure.

To estimate the influence of experimental factors, test results obtained after hypokinesia were compared with a second background-period investigation.

5.2.1.3. The Results and An Appraisal

During the background period, all of the subjects in group A and four of group B had a good endurance of both LBNP treatments in all the conditions of rarefaction. Only one subject (P-iy) developed a precollaptoid condition (4 min. 50 sec., vacuum 50 mm mercury) during the first investigation. He passed the second LBNP treatment of the background period satisfactorily.

The reaction of the pulse frequency and arterial pressure of all the subjects corresponded with that for those of similar age and conditioning. The general hemodynamic indices for the subjects of both groups were nearly the same. The values of the heart contraction frequency were somewhat larger by group average, and those of the pulse arterial pressure somewhat lower, for the subjects of group B in the initial condition. However, the /291 difference was not considerable (table 5.2.1).

Table 5.2.1.

Pulse Frequency (beats/min) and Pulse Arterial Pressure (mm mercury) at Rest and during Action of LBNP.

Index	Group		before bedrest			after bedrest (days) 0			5			10		
			Rest	LBNP50		Rest	LBNP-50		Rest	LBNP-50		Rest	LBNP-50	
				Δ	%		Δ	%		Δ	%		Δ	%
pulse frequency	"A"	M	65,0	26	40	67	43	66	65	26	40	69	24	37
		6	I2,II	6,7	5,8	I4,65	I2,3	22	II,I3	6,2	7,9	I3,22	5,6	I3,6
		M	5,42	3,04	2,63	6,55	5,59	I0	4,98	2,8I	3,59	5,9I	2,54	6,I
	"B"	M	70	29	42	68	46	68	76	34	45	76	27	37
		6	9,06	I2,2	I8,I	8,44	I3,6	I6,9	8,86	II,3	I7,4	I3,33	7,0	I6,(
		M	4,05	5,54	8,22	3,78	6,I8	7,68	3,96	5,I3	7,90	5,96	3,I8	7,2
pulse pressure	"A"	M	4I	I9	47	44	30	68	38	I6	4I	42	23	53
		6	8,94	4,2	7,9	4,I5	6,6	II,8	6,7I	6,6	I0,6	6,7I	8,4	I4,9
		I	4,00	I,9	3,59	I,86	3,0	5,36	3,0	3,0	4,8I	3,0	3,8I	6,77
	"B"	M	37	I8	47	46	20	46	45	2I	48	43	I9	44
		6	5,70	7,2	I7,0	9,62	7,9	I3,9	II,72	4,2	9,6	I2,04	6,6	9,2
		M	2,55	3,27	7,72	4,30	3,59	6,3I	5,24	I,90	4,36	5,39	3,0	4,I8

N.B. Commas in the tabulated material are to be understood as decimal points.

Upon termination of bedrest, the general circulatory indices prior to the rarefaction became practically identical for both groups, thus leveling off the minor discrepancy that had been noted in the background examinations. One would anticipate a quickening of the pulse in group A and its slowing in group B. This was in fact observed, although the pulse frequency on the average in each group was in all 2 beats/min. It is not precluded that this was associated with the fact that the measurements were done in the morning, before the subjects had undergone the load tests. Furthermore, they were in the horizontal position, which implied a slight orthostasis (+6°) for group B, capable of producing a quickening of the heart contractions.

In all the subjects, there was a lowering of LBNP endurance. For certain of them, this was manifested in the impairment of subjective sensations, a feeling of weakness, sweating, dizziness, the sensation of heat, etc. The reaction of the circulatory system to the action of LBNP was intensified: the heart contraction frequency, its increment, and the depression of the pulse arterial pressure all increased during rarefaction, while the pulse arterial pressure was reduced to a greater extent than prior to hypokinesia. It is interesting to note that, in this period, a tendency (R = 0.1) toward a greater change in the pulse arterial pressure was observed in group A. The discrepancy was associated with a greater lowering of the systolic arterial pressure during the vacuum. In group A, it was lowered from 121±1.0 mm mercury in the initial condition to 101±4.0 mm mercury during the vacuum; whereas in group B the respective amounts were 122±5.28 and 113±4.0 mm mercury. The diastolic arterial pressure in both groups underwent an almost identical change. In group A, it rose from 77±2.59 to 87±2.55 mm mercury, in group B from 76±5.57 to 87±3.74 mm mercury. /293

The investigations on the fifth and tenth day from the termination of bedrest revealed a significant improvement in the endurance of the NPLB test both in the subjective feelings and in the data characterizing the general hemodynamics. While a precollaptoid condition did develop on the fifth day in subject P-iy No. 3 (4 min. 40 sec., 50 mm mercury), a similar effect had been observed in him during the background investigation, as already mentioned. For the majority of subjects, the initial level of the blood circulation reaction was restored. It is interesting to note that, in group A, the reduction of the pulse arterial pressure was more significant than in group B on day "0". By day 5 of the recuperation period, it became less than during the background, and by day 10 of the recuperation it again exceeded the background reaction. It is possible that this phenomenon is associated with a wave-like restoration in the postural regulation of the blood circulation [6].

It is not precluded that, once the number of observations is increased by combining the data of the USSR and the USA, it will be possible to obtain statistically reliable discrepancies for those cases in which, in the individual experiments, the result was unreliable. For example, the statistically unreliable difference in

the change in pulse arterial pressure on day "0" between groups A and B may become reliable. For this reason, we have stressed the statistically unreliable discrepancies.

5.2.2. Echocardiography

5.2.2.1. The Procedure

The procedure of the echocardiographical investigations has been described in detail in section 5.1.2. To this it is necessary /294
to add that, prior to the LBNP tests, the subjects of both groups were placed in the horizontal supine position. These examination conditions were chosen in accordance with the preliminary agreement in order to insure the comparability of the findings with the data of the American researchers and the results of previous work. For the above-mentioned reasons, and also due to the displacement of the heart during LBNP (especially in a vacuum greater than 35 mm mercury), an echocardiogram suitable for interpretation could only be recorded during the test for 7 of the 10 subjects: 4 from group A and 3 from group B. Due to the small number of investigations in each of the groups, this material was not subjected to statistical processing.

5.2.2.2. The Results and An Appraisal

As can be seen from the data in table 5.2.2, the resistance of the subjects to the action of LBNP was entirely satisfactory prior to hypokinesia; nonetheless, the reaction was rather pronounced. By the fifth minute of LBNB at -50 mm mercury, the frequency of heart contractions increased by an average of 42% in the subjects of group A and 36% in group B. The sizes of the diastolic (DV), systolic (SV) and stroke (St.V.) volumes of the heart were reduced by 38%, 28%, and 43%, and by 28%, 31%, and 28%, respectively.

In the examination immediately following bedrest (day "0" of the RP), an intensified reaction of the cardio-vascular system to the action of the identical magnitudes of LBNP was noted in the subjects of both groups. This was indicated, in particular, by a slightly more pronounced FHC (on the average by 70% and 52%). The increase in the degree of change in the DV, SV, and St.V. was less pronounced.

Both before and immediately after hypokinesia, the change in /295
the minute volume of circulation (MVC) and the discharge fraction (DF) on the average was much more insignificant for the subjects of both groups (table 5.2.2).

During the examination on the fifth day of the recuperation period, the degree of change in the majority of recorded parameters was practically the same as prior to hypokinesia. The only peculiarity in the reaction of the cardio-vascular system of the subjects in group B on the fifth day following bedrest was a somewhat greater decrease in the MVC (by 17% on the average), than

Table 5.2.2.

Dynamics of Echocardiographic Indices during the LBNP Test (-50 mm mercury, 5 min) at Various Periods of the Experiment.

Index	Group	before bedrest	after bedrest (days)			
			0		5	
		rest	rest	LBNP	rest	LBNP
diastolic volume (ml)	"A"	I38	I22	7I	I28	84
	"B"	I32	I27	84	I33	83
systolic volume (ml)	"A"	46	45	[illegible]	44	28
	"B"	47	40	27	43	3I
stroke volume (ml)	"A"	87	82	52	88	56
	"B"	9I	82	44	85	53
frequency of heart contractions (beats/min)	"A"	67	67	I02	79	I04
	"B"	66	66	II2	65	92
minute volume of circulation (l/min)	"A"	5,8	5,5	[illegible],2	6,9	5,7
	"B"	6,[illegible]	5,4	5,0	5,6	5,I
discharge fraction (%)	"A"	6[illegible]	65	62	67	67
	"B"	66	68	62	67	63

N.B. Commas in the tabulated material are to be understood as decimal points.

during the preceding investigations. However, this was largely due to the relatively larger size of this index prior to the beginning of the test.

Thus the data of the echocardiographic investigation testify that, at all stages of the experiment, the compensatory-adaptive capabilities of the cardio-vascular system of the subjects remained at a rather high level. The observed changes in the heart volumes, as well as the changes in the stroke and minute volumes of blood circulation and in the discharge fraction, were moderately expressed and corresponded to the redistribution of blood to the vessels of the lower body half, characteristic for such a functional load, and to the increase in the frequency of heart contractions [33].

5.2.3. Plethysmographic Investigations

5.2.3.1. Survey of the Literature

The study of the redistribution of blood filling for various organs during LBNP tests is important to clarify the mechanisms for the lowering of resistance to this test. The works of a number of authors have been devoted to this question [24-27]. Despite the nonidentical conditions and the various methods of investigation, the findings all point in the same direction. It was established that, during LBNP, the volume of the lower leg increases in dependence on the degree of rarefaction in the vacuum suit [28-31]. /297

The volume rate of blood flow in the forearm during a rarefaction in the vacuum suit of 20-60 mm mercury is lowered within limits of 17-43% [25-26] or greater [32].

There have been much less investigations for the dynamics of the limb volume (especially the legs) during LBNP in conditions with restricted mobility. In the works devoted to this question, the existing point of view as to the dependence of the lowering of orthostatic stability and resistance to LBNP on the size of blood deposition in the lower extremities is not confirmed. In particular, after a 9-day bedrest, despite the lowering of resistance to LBNP, no major changes were noted for the increase in blood filling of the legs during LBNP [33].

There is almost no data as to the redistribution of the blood filling of the upper and lower extremities during NPLB in connection with a stay in conditions of antiorthostatic hypokinesia. The insufficient attention to this question was a motive for carrying out the present investigations.

5.2.3.2. The Procedure

The plethysmographic sensors, the position of their application, and the occlusion procedure have been described in section 5.1.3.

The plethysmogram was continuously recorded during the LBNP test. Furthermore, on the fifth, fourth, and second minute before the test, during the test at a vacuum of 25 mm mercury for 2 minutes, 35 mm mercury for 2 minutes, 40 mm mercury for 2 and 4 minutes, 50 mm mercury for 2 and 4 minutes, and on the first, second, fourth, and fifth minute after the test, the volume rate of blood flow was determined by the method of venous occlusion of the veins in the shoulder.

5.2.3.3. The Results and An Appraisal /298

The volume of the forearm during LBNP did not change significantly either before or after bedrest. The observed variations were not reliable ($r < 0.05$) and were basically determined on various days by the individual reactions of different subjects (table 5.2.3, 5.2.4, figure 5.2.1).

In all cases, the change in the lower leg volume depended on the degree of rarefaction in the vacuum suit; the greater the negative pressure, the more pronounced the effect. Thus, for 2 days prior to bedrest, the increase in the volume of the right lower leg during a vacuum of 25 mm mercury attained 2 ml/100 ml tissue, at 35 mm mercury it was 2.7±0.4 ml/100 ml tissue, at 40 mm mercury it was 3.3±0.2 ml/100 ml tissue, and at 50 mm mercury it was 3.8±0.3 ml/100 ml tissue. The absolute increment in the lower leg volume was equal to 50, 72.5, 95, and 105 ml respectively for the above vacuum conditions. Upon termination of the LBNP, the volume of the lower leg sharply dropped, but a return to the level prior to the test did not occur until 5 minutes.

After bedrest, reliable changes were not noted in the increment of lower leg volume during LBNP or in the degree of its restoration following the treatment (tables 5.2.5, 5.2.6, figure 5.2.2). Nor were there established any differences in the reaction of volume increase for the lower leg and forearm or in their restoration during the LBNP test for the subjects of group A and group B.

In studying the volume rate of blood flow prior to bedrest, a dependence was detected between the degree of rarefaction in the vacuum suit and the lowering of the volume rate of blood flow. In particular, for a vacuum of 35 and 50 mm mercury, the volume rate of blood flow was reduced from 13 to 31% respectively. However, this reduction was not reliable in all instances and, for the most part, there was no reliability for small vacua in the suit (-25 mm mercury). This, apparently, was due to the slightness of the reaction, the small number of observations, and the wide scatter. On day "0" and /305 5 of the recuperation period, the indices for the volume rate of blood flow of the forearm during the background investigations prior to the LBNP test, and also during the plethysmographic investigations in conditions similar to the basic metabolism, were reliably lower than the data prior to bedrest ($r < 0.05$). The lower blood flow in the forearm on these days after bedrest was retained for all vacuum conditions in the suit, although this discrepancy with the data prior

Table 5.2.3.

Forearm Volume (ml) and its Change (ml/100 ml tissue) during LBNP before and after Bedrest.

measurement period	Group	values	initial volume (ml)	lowering of pressure in suit: 25 MM	35 MM	40 MM	50 MM	0	0	0
				minutes of measurement: 2	2	4	4	30 sec	I	5
before BR	"A"	M	I025,8	0,I75	-0,060	0,400	0,875	-0,400	0,340	- 0,I80
		σ	I09,2	0,299	0,404	0,560	0,377	0,552	0,225	0,550
		m	48,8	0,I49	D,I8I	0,280	0,I89	0,247	0,503	0,246
	"B"	M	II83,0	0,040	0,280	0,060	0,220	0,0	0,0	0,I00
		σ	92,4	0,207	0,638	0,477	0,779	0,548	0,2I2	0,224
		m	4I,3	0,093	0,285	0,2I4	0,348	0,274	0,095	0,I
day 0	"A"	M	I008,I	0,425	0,425	0,740	0,760	0,340	0,300	0,I80
		σ	87,6	0,532	0,802	I,I84	I,I59	0,835	I,084	I,028
		m	39,2	0,266	0,40I	0,530	0,5I8	0,374	0,485	0,460
	"B"	M	II68,9	-0,I80	0,060	-0,480	-0,240	-0,I80	-0,533	-0,220
		σ	II4,8	0,460	0,650	I,303	I,626	I,050	I,I85	I,094
		m	5I,3	0,206	0,29I	0,583	0,727	0,469	0,684	0,469

N.B. Commas in tabulated material are to be understood as decimal points.

Table 5.2.4.

Forearm Volume (ml) and its Change (ml/100 ml tissue) during LBNP after Bedrest.

measurement period	Group	values	initial volume (ml)	lowering of pressure in suit: 25 MM	35 MM	40 MM	50 MM	0	0	0
				minutes of measurement: 2	2	4	4	30 sec	I	5
5 th day	"A"	M	987,8	0,I60	-0,I60	0,025	-0,I33	0,500	0,050	-0,500
		σ	84,3	0,378	0,568	0,907	I,405	0,I4I	0,2I2	0,72I
		m	37,7	0,I69	0,254	0,453	0,8II	0,I00	0,I50	0,4I6
	"B"	M	II63,5	-0,I40	-0,200	-0,060	-0,I40	-0,060	0,025	-0,I00
		σ	I08,5	0,26I	0,200	0,344	0,4I6	0,297	0,206	0,453
		m	48,5	0,II7	0,089	0,I54	0,I86	0,I33	0,I03	0,202
I0 th day	"A"	M	I0I3,9	-0,200	-0,260	0,460	-0,500	-0,500	-0,300	-0,300
		σ	83,3	0,I5I	0,24I	0,24I	0,274	0,38I	0,I00	0,I4I
		m	37,3	0,07I	0,I08	0,I08	0,I22	0,I70	0,058	0,070
	"B"	M	II50,8	0,200	0,I60	0,520	0,340	0,225	0,275	0,909
		σ	I0I,4	0,300	0,2I9	I,36I	I,60I	I,3I8	I,284	2,II8
		m	45,4	0,I34	0,098	0,609	0,7I6	0,659	0,642	I,059

N.B. Commas in the tabulated material are to be understood as decimal points.

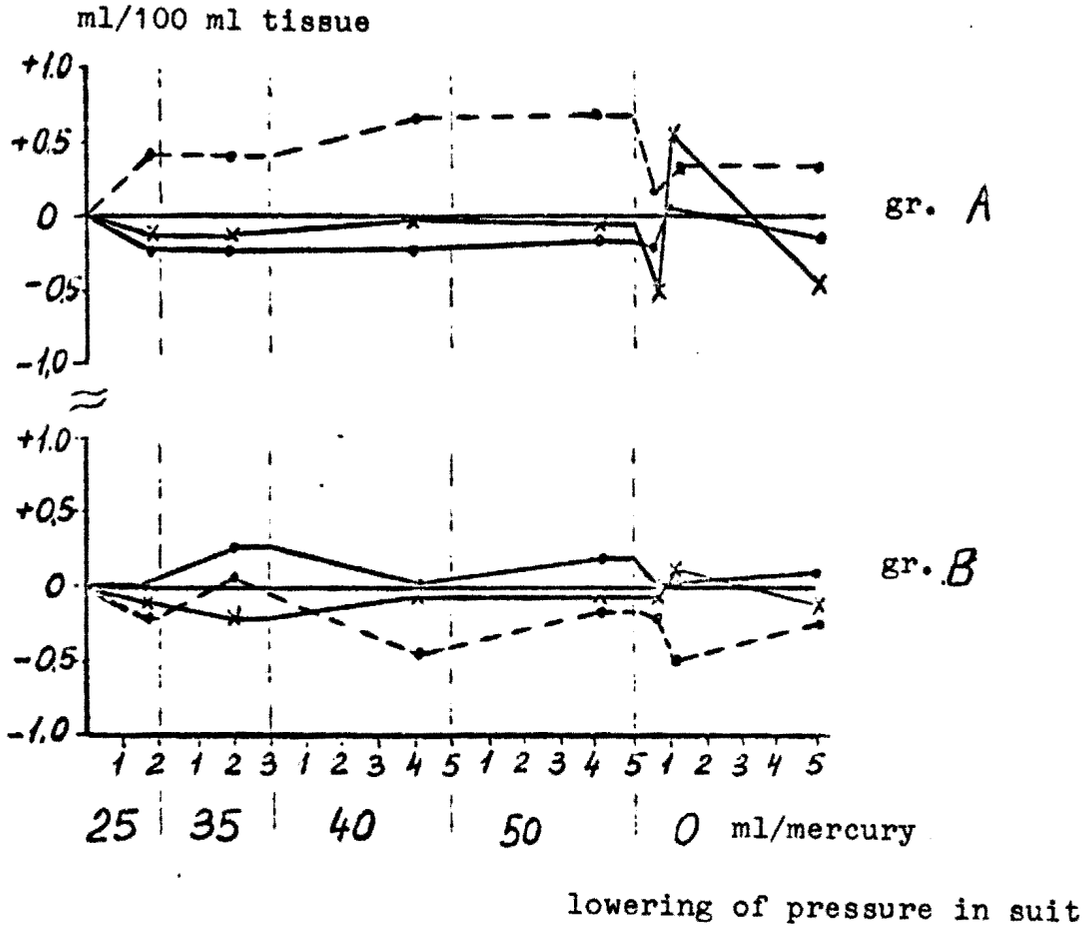

Fig. 5.2.1. Change in the Forearm Volume during LBNP (ml/100 ml tissue) for the Subjects at Various Stages of the Experiment.

Key: ——— before bedrest, - - - - - day 0 after bedrest, x = day 5 after bedrest.

Table 5.2.5.

Lower Leg Volume (ml) and its Change (ml/100 ml tissue) during LBNP before and after Bedrest.

measurement period	Group	values	lower leg vol. (ml) (init)	lowering of pressure in suit: 25 MM	35 MM	40 MM	50 MM	0	0	0
				minutes of measurement: 2	2	4	4	30 sec	I	5
before BR	"A"	M	24I5,9	I,960	2,720	3,320	3,840	I,480	I,I40	0,940
		♂	236,3	0,780	0,887	0,487	0,627	0,363	0,3I3	0,397
		m	I05,7	0,349	0,397	0,2I8	0,280	0,I62	0,I40	0,I78
	"B"	M	2677,4	I,620	2,680	3,220	4,I20	I,520	0,900	0,720
		♂	268,5	0,482	0,936	I,I92	I,472	I,099	0,863	0,80I
		m	I20,I	0,2I5	0,4I9	0,533	0,658	0,49I	0,386	0,358
day 0	"A"	M	2300,I	I,660	2,420	3,220	4,440	I,960	I,000	0,640
		♂	224,4	0,I95	0,2I7	0,427	0,635	0,695	0,436	0,35I
		m	I00,3	0,087	0,097	0,I9I	0,284	0,3II	0,I95	0,I57
	"B"	M	2534,6	2,020	2,740	3,720	4,760	I,760	0,900	0,720
		♂	265,4	I,I58	I,0I4	0,795	0,945	0,4I5	0,224	0,42I
		m	II8,7	0,5I8	2,453	0,356	0,423	0,I85	0,I00	0,I88

N.B. Commas in the tabulated material are to be understood as decimal points.

Table 5.2.6.

Lower Leg Volume (ml) and its Change (ml/100 ml tissue) during LBNP after Bedrest

measurement period	Group	values	lower leg vol. in ml (init)	lowering of pressure in suit: 25 MM	35 MM	40 MM	50 MM	0	0	0
				minutes of measurement: 2	2	4	4	30 sec	I	5
5th day	"A"	M	2398,0	2,040	2,800	3,460	4,I40	I,760	I,040	0,860
		♂	2I7,2	0,92I	0,970	I,220	I,II3	0,623	0,669	0,3I9
		m	97,I	0,4I2	0,434	0,546	0,498	0,279	0,299	0,7I3
	"B"	M	2602,8	2,080	2,860	3,520	4,360	I,400	0,860	0,620
		♂	24I,6	0,642	0,888	0,944	I,004	0,600	0,537	0,492
		m	I08,0	0,287	0,397	0,442	0,449	0,268	0,240	0,220
I0 th day	"A"	M	24I2,2	2,240	3,I60	3,780	4,600	I,640	I,I60	0,820
		♂	269,0	0,5I8	0,856	0,820	0,73I	0,456	0,860	0,867
		m	I20,3	0,232	0,383	0,367	0,327	0,204	0,392	0,388
	"B"	M	2609,6	2,500	3,I50	3,700	4,400	I,525	I,I50	I,000
		♂	306,4	0,503	0,854	0,93I	I,I43	I,I35	I,320	I,275
		m	I37,0	0,252	0,427	0,465	0,572	0,568	0,660	0,638

N.B. Commas in tabulated material are to be understood as decimal points.

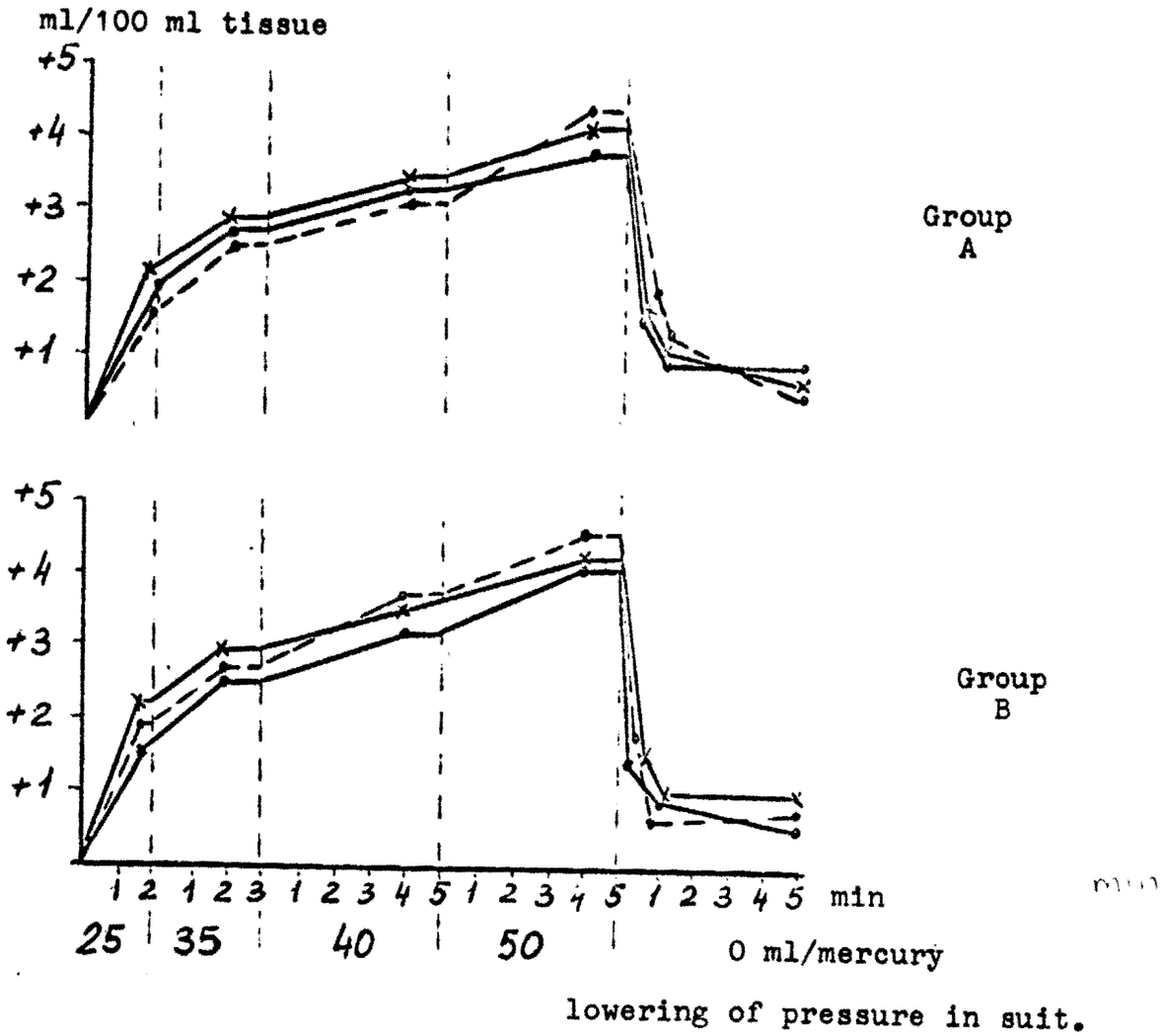

Fig. 5.2.2. Change in Lower Leg Volume during LBNP (ml/100 ml tissue) for the Subjects at Various Stages of the Experiment.

Key: ——— before bedrest, - - - - - day 0 after bedrest, x = day 5 after bedrest.

to bedrest was not statistically reliable in the majority of cases.

Thus, the findings did not disclose substantial changes in the amount of blood accumulation in the lower limbs during the LBNP test after bedrest, despite a pejoration of the general hemodynamic reaction. Nor were there established any changes in the amount of blood deposition during LBNP in dependence on the bedrest conditions: the horizontal position or the position with upper end of the bed lowered.

In analyzing the resulting material, one may interpret the data in two ways. Either the bedrest conditions do not significantly alter the capacity of the vascular channel during LBNP, or the insufficient number of observations does not permit the discovery of regular changes in the reaction. The authors believe that the former is more probable; i.e., in conditions of a 7-day hypokinesia, the capacity of the vascular channel of the legs does not increase in response to LBNP and, consequently, the amount of blood deposited in the legs does not vary after a stay in bed.

The lowering of the volume rate of blood flow of the forearm following bedrest and prior to the LBNP test is discussed in section 5.1.3.

5.2.4. Summary /306

Thus, the LBNP test produced characteristic (for this functional load) changes in the frequency of heart contractions, the arterial pressure, the heart volumes, the stroke volume of the circulation, and the discharge fraction. The plethysmographic investigations also revealed an increase in the blood filling of the lower leg.

During the LBNP test following hypokinesia, the observed increase in the increment of the heart contraction frequency and the decrease in the pulse arterial pressure testify to a certain lowering of the compensatory-adaptive capabilities of the circulatory system of the subjects. The echocardiographic data indicate that the lowering of resistance to LBNP did not involve a disturbance of the contractile function of the myocardium. The plethysmographic investigations did not disclose a substantial change in the capacity of the vascular channel of the lower extremities during this test.

No substantial difference in endurance of the tests was found for the subjects in the horizontal and the antiorthostatic positions during hypokinesia.

Further investigations with an increase in the length of the experiments and in the number of observations are necessary in order to resolve the question as to the mechanisms of the observed pejoration of the regulatory capacities of the cardio-vascular system, as well as to establish the presence or absence of regular alterations in dependence on the bedrest conditions (stay in the horizontal or the antiorthostatic position).

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5.3. The Test with Physical Load /311

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The reduced capacity of the human organism for physical labor has been studied more than once after space flights and model experiments [1-7]. Beyond a dependence on the test procedure (sit-ups, step-rises, or exercise on a bicycle ergometer), the investigators remarked a considerable increase in the pulse frequency (PF), the minute volume of respiration (MVR), and, in several cases, the gas exchange. The arterial pressure indices, as a rule, rose. In the recuperation period after the exercise, the normalization of the studied parameters of the cardio-respiratory system was delayed [1-5].

The existence of these changes points to a deconditioning of the cardio-vascular system and a lowering of the physical efficiency of the human being. However, since the functional tests were as a rule carried out in the seated position on the bicycle ergometer, two factors may conduce to the pejoration of the functional capacities of the astronauts and test subjects:

- the lowering of the level of motor activity, leading to a deconditioning of the mechanisms responsible for stability of the organism to physical work;

- the adaptation of the human organism to altered hemodynamic conditions, in connection with the absence (in weightlessness) or the considerable lowering (in model experiments) of the hydrostatic pressure in the fluid medium of the organism, leading to an impaired withstanding of the vertical position.

A clarification of the role of each factor is naturally not /312
only of theoretic interest, but also of practical significance for the specialists of aerospace medicine in resolving questions on the use of preventive measures in weightlessness.

Tests with physical loads, carried out in the lying and seated positions, were used to study:

- the features of the reaction of the subjects' cardio-respiratory system to a standard exercise of 750 kgm/min after a 7-day stay in conditions of clinostatic (group A) and antiorthostatic (group B) hypokinesia in bed;

- the role of the orthostatic effect in the reaction of the subjects' organism to a standard physical load in the lying and seated positions before and after hypokinesia.

The Procedure

The test with a graduated physical load was carried out in two positions: the supine position and seated on a bicycle ergometer

(the Godart company). The investigations were done in the first half of the day, 20-25 minutes after the LBNP test. In the event of a poor endurance to the latter test, the time for the beginning of the physical load test was delayed for 40-45 minutes. The subject was adapted to the laboratory conditions for 10-15 minutes, in the course of which time sensors were fastened to the body to record the ECG, and the equipment was also tuned. Afterwards the subject assumed the initial position on a special table for loading in the supine position. For 7-10 minutes, the initial parameters of blood circulation and respiration at rest were recorded and, after this, the subject turned the pedals of a bicycle ergometer for 5 minutes at a speed of 65±5 rev/min and developed a force of 750 kgm/min. Upon conclusion of the work, there was a 10-minute recuperation period. The tests in the seated position were carried out in the same sequence (table 5.3.1). /313

According to the investigation program, the oxygen consumption and the evolution of carbon dioxide (V_{O_2}, V_{CO_2}) were continuously recorded at all stages of the test (at rest, during work, and in the recuperation period) on the automatic gas analyzer "Spirolit" (company Junkalor, GDR). The MVR was determined by dry gas portions. To calculate the pulse frequency, the ECG was recorded at taps DS. The percent content of CO_2 in the alveolar gas and the respiration frequency were calculated by capnogram from the "Capnograph" instrument (company Godart).

The gas exchange values (V_{O_2} and V_{CO_2}) led to the standard conditions, STRD, while the MVR led to VTRS. The background data was formed by the results of investigations carried out two days prior to the beginning of bedrest.

Table 5.3.1.
Schedule for the Physical Load Tests on the Bicycle Ergometer

Time	Test Conditions	Position
10-15 min.	Adaptation to experimental environment	Supine
7-10 min.	Recording of indices at rest	
5 min.	Exercise at 750 kgm/min.	
10 min.	Recuperation	
5 min.	Adaptation to experimental environment	Seated
7-10 min.	Recording of initial indices at rest	
5 min.	Exercise at 750 kgm/min.	
10 min.	Recuperation	

NOTE: Each test was administered to the subjects twice prior to bedrest (on day 2 and 13) and 3 times after bedrest (on days 0, 5, and 10).

Results of the Investigation /314

5.3.1. The Load in the Supine Position

Prior to bedrest, no substantial differences in any of the analyzed parameters was noted between groups A and B during the test with physical load (tables 5.3.2.-5.3.9.). An exception was the V_{O_2} at rest (table 5.3.2), but this difference was leveled off after a conversion for oxygen consumption per kilogram of body weight (table 5.3.4). During the recuperation period, the investigated parameters of the gas exchange and the external respiration were essentially no different from those obtained at rest. The pulse frequency, on the other hand, was not fully restored and was (in 10 min) 23.9% and 13.8% higher than the resting level in groups A and B respectively (table 5.3.5).

On day 0 after bedrest, the pulse frequency at the fifth minute of load increased from 128 to 135 beats/min, or 5.4% in group A, and from 124 to 132 beats/min, or 6.4% in group B (table 5.3.5). On the fifth and tenth minutes of recuperation, a complete normalization of the pulse frequency was observed in group B, whereas this did not occur in group A. The pulse frequency in this group exceeded the background values by 8.3% and 7.5%, respectively.

The arterial pressure (systolic and diastolic) on day 0 after bedrest was larger at rest and prior to the physical load test than it was during the test carried out prior to bedrest (tables 5.3.8, 5.3.9). During the physical load, these values also exceeded the results of tests prior to bedrest. Thus, the increment in the systolic pressure in group B was 23 mm mercury, while in group A it was 4 mm mercury in all. On the fifth and tenth minutes after the physical load, a retarded restoration of these parameters was observed.

The values of the gas exchange (V_{O_2} and V_{CO_2}) and of the external respiration (MVR, FR) were rather close to the results of tests prior to bedrest. /323

During the investigation on the fifth and tenth day after bedrest, a clear tendency for the normalization of the pulse reaction to physical load is observed. Nonetheless, while in group A the pulse frequency was practically identical to the background, in group B these differences were 7.9% and 7.8% (on day 5 and 10). These differences between the groups were also retained in the recuperation period after the loads. During the later investigation (on day 10), the pulse frequency on minute 10 of the recuperation period exceeded the background values by 8.2%. The gas exchange and external respiration indices recorded on days 5-10 after bedrest differed only slightly from the background values.

Thus, the most pronounced differences between groups A and B

Table 5.3.2.

Consumption of O_2 by subjects when carrying out physical load test in supine position at various periods of the experiment, in ml/min.

Group	Indices	before bedrest				after bedrest (days) "0"				5				I0			
		AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}
"A"	M	290	I754	383	322	30I	I732	379	32I	3II	I735	354	3II	307	I734	393	336
	$\sigma \pm$	27,6	I76,8	38,8	I8,5	I8,8	68,0	4I,9	5I,9	I4,9	II5,6	22,4	32,5	5I,2	I05,2	6I,0	73,8
	$m \pm$	I2,3	79,I	I7,4	8,3	8,4	30,4	I8,7	23,2	6,7	5I,7	I0,0	I4,5	22,9	47,0	27,3	33,0
"B"	M	36I	I847	428	376	358	I806	4I5	303	360	I844	432	376	359	I82I	455	374
	$\sigma \pm$	22,0	I33,9	36,3	40,7	73,4	I47,6	42,7	44,I	33,7	2I8,9	43,		2,0	38,9	34,4	44,9
	$m \pm$	9,9	60,0	I6,2	I8,2	32,8	66,0	I9,0	I9,7	I5,0	97,9	I9		4,3	I7,4	I5,4	20,0

Key: AR = at rest (average data)
PL = physical load (5 min)
R_5 = recuperation (5 min)
R_{10} = recuperation (10 min)

N.B. Commas in the tabulated material are to be understood as decimal points.

Table 5.3.3.

Exhalation of CO_2 (ml/min) by subjects when carrying out physical load test in supine position at various periods of the experiment.

Group	Indices	before bedrest				after bedrest (days) 0				5				10			
		AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}
"A"	M	229	I536	328	255	270	I654	37I	249	267	I60I	354	248	264	I588	350	270
	$\sigma \pm$	33,4	22I,6	39,8	20,8	32,I	85,9	28,7	75,4	24,4	III,2	20,2	20,4	55,9	I38,3	37,9	43,5
	$m \pm$	I4,9	99,I	I7,8	9,3	I4,4	38,4	I2,8	33,7	I0,9	49,7	9,0	9,I	25,0	6I,8	I6,9	I9,5
"B"	M	279	I383	377	270	3I0	I688	4II	246	293	I769	42I	3I9	290	I670	42I	320
	$\sigma \pm$	40,3	345,0	I08,0	8I,0	76,3	I4I,7	48,4	60,7	40,2	I9I,3	96,9	60,7	53,9	I72,0	96,9	39,9
	$m \pm$	I8,0	I54,3	48,3	36,2	34,I	63,4	2I,6	I3,7	I7,9	85,5	43,3	27,I	24,I	76,9	43,3	I7,9

Symbols are the same as in table 5.3.2.

N.B. Commas in the tabulated material are to be understood as decimal points.

Table 5.3.4.

Consumption of O_2 by subjects per unit of body weight (ml/kg/min) when carrying out physical load test in supine position at various periods of the experiment.

Group	Indices	before bedrest				after bedrest (days) 0				5				10			
		AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}
"A"	M	3,9	23,9	5,3	4,4	4,I	23,7	5,2	4,4	4,2	23,7	4,8	4,2	4,2	23,8	5,4	4,6
	$\sigma \pm$	0,6	3,8	0,9	0,4	0,3	I,8	0,5	0,8	0,3	2,3	0,4	0,4	0,8	2,7	I,2	0,9
	$m \pm$	0,2	I,7	0,4	0,2	0,I	0,8	0,2	0,4	0,I	I,0	0,2	0,2	0,3	I,2	0,5	0,4
"B"	M	4,4	22,8	5,2	4,6	4,4	22,2	5,2	4,4	4,4	22,5	5,2	3,7	4,5	22,9	5,4	4,7
	$\sigma \pm$	0,3	2,3	0,4	0,5	0,3	2,2	0,5	0,3	0,8	I,0	0,4	0;5	0,3	I,9	0,5	0,3
	$m \pm$	0,2	I,0	0,2	0,2	0,2	I,I	0,2	0,2	0,3	0,4	0,2	0,2	0,I	0,9	0,2	0,I

Symbols are the same as in table 5.3.2.

N.B. Commas in the tabulated material are to be understood as decimal points.

Table 5.3.5.

Frequency of heart contractions (beats/min) for the subjects when carrying out the physical load test in the supine position at various periods of the experiment.

Group	Indices	before bedrest				after bedrest (days) 0				5				10			
		AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}
"A"	M	65	I28	82	80	7I	I35	88	86	62	I3I	83	76	68	I3I	83	8I
	$\sigma \pm$	I0,6	9,8	I4,6	I5,8	I9,0	I8,5	I9,5	I8,3	9,6	II,5	I7,3	9,7	I3,2	II,I	I5,0	I4,5
	$m \pm$	4,7	4,4	6,5	7,I	8;5	8,3	8,7	8,2	4,3	5,2	8,6	4,3	5,9	4,9	6,7	6,5
"B"	M	72	I24	83	82	69	I32	84	79	72	I34	90	86	77	I33	90	89
	$\sigma \pm$	8,6	I0,0	II,7	II,9	II,3	I4,4	II,8	I3,6	II,7	I4,8	7,6	8,5	II,I	I0,7	9,9	7,6
	$m \pm$	3,8	4,5	5,2	5,3	5,0	6,4	5,3	6,I	5,2	6,6	3,4	3,8	4,9	4,9	4,4	3,4

Symbols are the same as in table 5.3.2.

N.B. Commas in the tabulated material are to be understood as decimal points.

Table 5.3.6.

Minute volume of respiration (l/min) for the subjects when carrying out the physical load test in the supine position at various periods of the experiment.

Group	Indices	before bedrest				after bedrest (days) 0				5				IO			
		AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}
"A"	M	9	43	I2	II	9	46	I3	IO	9	45	I2	9	IO	43	I2	IO
	$\sigma \pm$	I,3	5,2	2,I	3,2	I,6	4,4	I,9	I,4	I,3	7,5	2,3	I,7	3,2	6,5	2,7	3,6
	$m \pm$	0,6	2,3	0,9	I,4	0,7	I,9	0,8	0,7	0,6	3,3	I,0	0,8	I,4	2,9	I,2	I,6
"B"	M	8	34	IO	7	IO	50	I3	II	IO	49	I5	II	IO	47	I5	II
	$\sigma \pm$	5,7	II,6	6,4	4,6	2,4	2,4	I,4	I,9	2,0	3,7	I,4	I,9	I,3	4,2	3,3	I,8
	$m \pm$	2,8	2,3	3,2	2,3	I,I	I,I	0,6	0,9	0,9	I,6	0,6	0,9	0,6	I,9	I,5	0,8

Symbols are the same as in Table 5.3.2.

N.B. Commas in the tabulated material are to be understood as decimal points.

Table 5.3.7.

Respiration frequency (in min) for the subjects when carrying out the physical load test in the supine position at various periods of the experiment.

Group	In-dices	before bedrest				after bedrest (days) 0				5				I0			
		AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}
	M	I0	2I	II	II	II	I9	I2	I4	I0	I9	II	II	II	20	II	I2
"A"	$\sigma \pm$	3,4	3,8	5,4	6,2	4,3	4,6	4,6	5,I	3,7	4,0	4,9	5,2	4,9	4,5	5,9	5,I
	$m \pm$	I,5	I,7	2,4	2,8	I,9	2,0	2,I	2,3	I,7	I,8	2,2	2,3	2,2	2,0	2,6	2,3
	M	I3	23	I3	I2	I2	23	I5	I3	I3	22	I4	I4	I3	2I	I6	I5
"B"	$\sigma \pm$	I,3	4,I	3,2	3,8	I,8	3,4	2,9	3,I	I,5	2,7	2,4	2,7	3,0	I,3	I,5	4,4
	$m \pm$	0,6	I,8	I,4	I,7	0,8	I,5	I,3	I,5	0,7	I,2	I,I	I,2	I,3	0,6	0,7	2,0

Symbols are the same as in Table 5.3.2.

N.B. Commas in the tabulated material are to be understood as decimal points.

Table 5.3.8.

Arterial systolic pressure (mm mercury) of the subjects when carrying out the physical load test in the supine position at various periods of the experiment.

Group	Indices	before bedrest				after bedrest (days) 0				5				10			
		AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}
	M	I44	I80	I22	II5	I22	I84	I3I	II8	II9	I87	I25	II8	II4	I75	I23	II2
"A"	σ ±	6,6	I2,2	9,I	7,9	2,3	I0,8	4,2	2,7	4,2	I2,0	5,0	4,5	6,5	I8,7	II,5	6,7
	m ±	2,9	5,5	4,I	3,5	I,0	4,8	I,9	I,2	I,9	5,4	2,2	2,0	2,9	8,4	5,I	3,0
	M	I20	I70	I28	I2I	I25	I93	I3I	I20	I25	I85	I30	I23	I28	I9I	I3I	I22
"B"	σ ±	5,6	20,6	I2,6	8,9	I4,5	I5,0	7,4	I0,0	I0,4	26,4	II,2	8,4	9,2	23,6	I0,8	I2,5
	m ±	2,5	9,2	5,6	4,0	6,5	II,6	3,3	4,5	4,6	II,8	5,0	3,7	4,I	I0,5	4,8	5,6

Symbols are the same as in Table 5.3.2.

N.B. Commas in the tabulated material are to be understood as decimal points.

were noted in the period after bedrest. These consisted in a more pronounced increase in the systolic pressure in the subjects of group B after loading, and a retarded restoration of the pulse reaction on days 5 and 10.

5.3.2. The Load in the Seated Position

In the background period, the V_{O_2} and V_{CO_2} at rest were higher for the subjects of group B than for those of group A (tables 5.3.10-5.3.11). Upon calculating for the kilograms of body weight, this difference was insignificant (table 5.3.12), as for the case of the supine position. The pulse frequency in this period was higher (table 5.3.13) while the systolic pressure was lower than that of group A, differing considerably from the data obtained in the supine position (table 5.3.16). These changes, in our opinion, were of a compensatory nature and involved a somewhat worse initial orthostatic stability for the subjects of group B. During the /330
exercise on the bicycle ergometer, the differences between the groups were smoothed out. The gas exchange and external respiration indices were practically normalized by minute 10 of the restoration period, while the pulse frequency somewhat exceeded the level recorded at rest.

During the investigation on days 0, 5, and 10 after bedrest, the gas exchange and the external respiration indices at rest, under load, and in the recuperation period after load varied within the limits of the background values (table 5.3.1, 5.3.11, 5.3.14, 5.3.15). No major difference was found between the groups.

In comparing the pulse frequency values, obtained after bedrest, with the investigations prior to bedrest, the most obvious changes were observed only on day 0. Even at rest, the pulse frequency for the subjects of group A increased by 9.3%, and in group B by 8.5%. On the fifth minute of exercise in group A, it rose to 154 beats/min, and in group B it attained 152 beats/min, or, it was higher than the background value by 15.6% and 12.9% respectively. The systolic arterial pressure increased slightly in both groups, while the diastolic pressure varied within the limits of the background values (tables 5.3.16, 5.3.17). During the recuperation period following the load, a tendency was noticed for retarded normalization of the analyzed cardio-vascular indices. The pulse frequency on minute 10 of recuperation in group A was higher than the initial (at rest) by 12.8%, and in group B by 6.9%.

On days 5 and 10 after bedrest, the pulse reaction of the subjects in both groups gradually approached the values obtained prior to bedrest and displayed a tendency to a more rapid normalization in group A.

Thus, even prior to bedrest, there were certain differences between the groups in the state of rest. In the seated position on the bicycle ergometer, the V_{O_2}, V_{CO_2}, and the pulse frequency were higher in the subjects of group B, while the systolic pressure was lower. During physical exercise, these /333

Table 5.3.10.

Consumption of O_2 (ml/min) by subjects when carrying out the physical load test in the seated position at various periods of the experiment.

Group	Indices	before bedrest				after bedrest (days) 0				5				10	0		
		AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}
"A"	M	313	1753	360	316	350	1792	396	335	311	1896	377	338	329	1822	405	346
	$\sigma \pm$	28,3	184,1	44,9	39,3	47,7	110,5	74,8	65,7	13,5	97,9	32,5	31,0	51,5	87,1	28,4	54,3
	$m \pm$	12,7	82,3	20,1	17,6	21,3	49,4	33,5	29,4	6,1	43,8	14,6	13,9	23,1	38,9	12,7	24,8
"B"	M	382	1857	429	3569	370	1772	452	388	369	1885	434	385	355	1833	452	372
	$\sigma \pm$	73,5	198,1	59,2	61,1	51,3	59,2	45,9	32,5	45,9	219,5	48,1	75,5	54,9	49,4	19,8	50,7
	$m \pm$	32,9	88,6	26,5	27,0	22,9	26,5	20,5	14,5	22,9	109,7	24,1	37,7	24,6	22,1	8,8	22,7

Symbols are the same as in Table 5.3.2.

N.B. Commas in the tabulated material are to be understood as decimal points.

Table 5.3.11.

Exhalation of CO_2 (ml/min) by the subjects when carrying out the physical load test in the seated position at various periods of the experiment.

Group	Indices	before bedrest				after bedrest (days) 0				5				10			
		AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}
"A"	M	244	1494	299	256	273	I6I2	347	279	244	I704	3I7	260	293	I586	348	3I6
	σ ±	42,4	278,6	37,3	49,7	32,7	I3I,7	92,3	70,7	30,9	I00,8	24,5	I5,4	4I,7	6I,4	34,6	I7,7
	m ±	I8,9	I24,6	I6,7	22,2	I4,6	58,9	4I,3	3I,6	I3,8	45,I	I0,9	6,9	I8,6	27,5	I5,5	7,9
"B"	M	27I	I478	337	274	302	I674	4II	320	28I	I697	377	3I3	288	I627	384	305
	σ ±	57,I	279,7	89,6	64,2	56,0	69,2	65,6	22,5	45,6	I67,6	75,4	57,9	43,7	67,I	I9,9	24,7
	m ±	25,5	I25,I	40,0	28,7	25,I	30,9	29,3	I0,I	22,8	83,8	37,7	28,9	I9,5	30,0	8,9	II,0

Symbols are the same as in Table 5.3.2.

N.B. Commas in the tabulated material are to be understood as decimal points.

Table 5.3.12.

Consumption of O_2 by subjects per unit of body weight (ml/kg/min) when performing the physical load test in the seated position at various periods of the experiment.

Group	Indices	before bedrest				after bedrest (days) 0				5				IO			
		AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}
"A"	M	4,3	23,9	4,9	4,3	4,8	24,5	5,4	4,5	4,2	25,9	5,I	4,6	4,5	25,I	5,6	4,7
	σ ±	0,7	3,9	0,6	0,6	0,4	I,I	0,7	0,7	0,3	2,3	0,2	0,5	0,6	3,I	0,8	0,9
	m ±	0,3	I,7	0,3	0,3	0,2	0,5	0,3	0,3	0,I	I,0	0,I	0,2	0,3	I,4	0,4	0,4
"B"	M	4,7	23,5	5,3	4,4	4,6	23,0	5,6	4,8	4,6	23,7	5,5	4,8	4,4	23,0	5,7	4,6
	σ ±	0,8	3,9	0,7	0,7	0,5	2,0	0,6	0,5	0,5	2,2	0,5	0,9	0,5	I,7	0,2	0,5
	m ±	0,4	I,7	0,3	0,3	0,2	0,9	0,3	0,2	0,2	I,I	0,2	0,4	0,2	0,7	0,I	0,2

Symbols are the same as in Table 5.3.2.

N.B. Commas in the tabulated material are to be understood as decimal points.

Table 5.3.13.

Frequency of heart contractions (beats/min) for the subjects when performing the physical load ɜst in the seated position at various periods of the experiment.

Group	Indices	before bedrest				after bedrest (days)											
						0				5				I0			
		$\overline{AR}$	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}
	M	90	I38	94	92	98	I54	II3	III	84	I4I	96	96	92	I44	96	95
"A"	$\sigma \pm$	I7,7	I7,6	2I,0	I9,0	2I,8	I7,8	I5,4	I7,I	I2,I	II,9	I4,2	I5,4	I5,6	I0,8	I8,3	I6,8
	$m \pm$	7,	',8	9,4	8,5	9,7	8,0	6,9	7,6	5,4	5,3	6,3	6,9	7,0	4,8	9,I	7,5
	M	94	I35	98	99	I02	I52	I06	I08	93	I4I	I00	I00	97	I44	I03	I03
"B"	$\sigma \pm$	5,9	9,6	8,4	9,6	9,7	9,6	I4,9	II,0	7,7	I4,0	I0,6	I0,5	5,6	9,6	6,8	9,I
	$m \pm$	2,6	4,3	3,8	4,3	4,3	4,3	6,6	4,9	3,8	7,0	5,3	5,3	2,5	4,8	3,0	4,I

Symbols are the same as in Table 5.3.2.

N.B. Commas in the tabulated material are to be understood as decimal points.

Table 5.3.14.

Minute volume of respiration (l/min) for the subjects when performing the physical load test in the seated position at various periods of the experiment.

Group	Indices	before bedrest				after bedrest (days) 0				5				10			
		AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}
"A"	M	I0	4I	I0	I0	I0	46	I3	I2	9	45	II	I0	II	44	I2	II
	σ ±	I,9	6,53	I,9	2,4	I,7	8,5	2,8	2,2	I,3	6,2	2,I	I,5	4,4	5,9	I,7	I,9
	m ±	0,87	2,9	0,85	I,I	0,8	4,0	I,3	I,0	0,6	2,8	0,9	0,7	I,9	2,6	0,8	0,8
"B"	M	I2	47	I4	I3	I3	5I	I5	I3	I0	46	I4	I2	II	47	I5	I3
	σ ±	2,34	5,43	2,0	I,2	2,I	I0,3	3,5	I,8	I,I	4,I	2,7	I,0	I,4	3,7	I,7	2,2
	m ±	I,05	2,43	0,9	0,5	I,0	4,6	I,6	0,8	0,5	2,I	I,3	0,5	0,6	I,6	0,8	0,9

Symbols are the same as in Table 5.3.2.

N.B. Commas in the tabulated material are to be understood as decimal points.

Table 5.3.15.

Respiration frequency (per min) of subjects when performing the physical load test in the seated position at various periods of the experiment.

Group	Indices	before bedrest				after bedrest (days) 0				5				10			
		AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}
"A"	M	II	I7	I2	I2	II	I8	II	I0	I0	I8	II	II	II	20	I2	I3
	$\sigma \pm$	2,7	4,I	4,9	3,3	3,I	3,9	3,I	2,5	4,2	3,5	4,3	4,7	3,9	3,I	5,3	4,6
	$m \pm$	I,2	I,8	2,2	I,5	I,4	I,7	I,4	I,I	I,9	I,6	I,9	2,I	I,7	I,4	2,4	2,I
"B"	M	I3	2I	I5	I4	I3	23	I6	I4	I4	2I	I5	I5	I3	20	I5	I4
	$\sigma \pm$	I,9	2,7	I,9	3,4	2,3	3,7	3,6	4,4	I,4	I,7	2,2	I,3	3,I	I,3	3,I	3,2
	$m \pm$	0,8	I,2	0,8	I,5	I,0	I,7	I,6	I,9	0,7	0,9	I,I	0,6	I,4	0,6	I,4	I,4

Symbols are the same as in Table 5.3.2.

N.B. Commas in the tabulated material are to be understood as decimal points.

Table 5.3.16.

Arterial systolic pressure (mm mercury) for the subjects when performing the physical load test in the seated position at various periods of the experiment.

Group	Indices	before bedrest				after bedrest (days) 0				5				10			
		AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}
"A"	M	II0	I67	I20	II3	II5	I7I	I26	II8	II7	I65	I23	II8	II6	I78	I22	II8
	$\sigma \pm$	9,6	I9,6	9,4	I0,4	I3,9	26,6	8,9	I3,0	I2,2	23,8	I0,4	8,7	II,2	2I,4	8,4	8,4
	$m \pm$	4,3	8,7	4,2	4,6	6,2	II,8	4,0	5,8	6,I	II,9	5,2	4,3	5,0	9,6	3,7	3,7
"B"	M	I09	I60	I07	I06	II2	I68	II6	II5	I09	I65	I08	I09	II2	I73	II6	II0
	$\sigma \pm$	9,0	I8,4	I3,5	6,5	6,I	I8,2	II,9	7,9	6,9	I0,6	9,7	I0,8	3,2	23,I	8,2	I0,6
	$m \pm$	4,0	8,2	6,0	2,9	2,7	8,2	5,3	3,5	3,I	4,7	4,4	4,8	I,4	I0,3	3,7	4,7

Symbols are the same as in Table 5.3.2.

N.B. Commas in the tabulated material are to be understood as decimal points.

Table 5.3.17.

Arterial diastolic pressure (mm mercury) of the subjects when performing the physical load test in the seated position at various periods of the experiment.

Group	Indices	before bedrest				after bedrest (days) 0				5				10			
		AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}
	M	78	80	75	72	85	84	79	82	78	80	73	78	76	76	74	75
"A"	$\sigma \pm$	4,7	7,6	9,3	7,6	6,5	8,2	8,2	7,6	6,I	I2,7	I0,4	9,7	6,5	I5,I	6,5	5,0
	$m \pm$	2,I	3,2	4,2	3,4	2,9	3,7	3,7	3,4	2,7	5,7	4,6	4,4	2,9	6,8	2,9	2,2
	M	77	74	8I	80	87	78	86	87	83	78	76	80	8I	79	79	82
"Б	$\sigma \pm$	8,I	I4,7	8,2	5,0	I0,7	I4,0	II,4	7,6	9,3	II,9	I0,3	7,I	6,9	I7,I	9,6	7,6
	$m \pm$	3,6	6,6	3,7	2,2	4,8	6,2	5,I	3,4	4,6	5,9	5,2	3,5	3,I	7,6	4,3	3,4

Symbols are the same as in Table 5.3.2.

N.B. Commas in the tabulated material are to be understood as decimal points.

differences were almost unnoticeable.

During the load, the increment in the pulse frequency values (the difference in pulse frequency values between the load and rest) in group B approached the upper limit of significance ($m = 2.77$). The pulse normalization during the recuperation period also occurred more slowly than in group A.

The somewhat more pronounced changes in the cardio-vascular system of the group B subjects during the tests in the seated position after bedrest were apparently due to a greater deconditioning of the compensatory mechanisms that are responsible for an adequate flow of blood to the heart in the vertical position.

5.3.3. A Comparison of the Loads in the Supine and Seated Positions

The above analysis for the reaction of the cardio-respiratory system of the subjects in groups A and B during graduated loads in the supine and seated positions did not reveal major differences between the groups. There were only isolated symptoms that suggest a 7-day stay at an angle of -6° causes a slightly more pronounced reaction from the cardio-vascular system during exercise in the seated position and delays the pulse normalization process during the recuperation period after exercise in both the seated and the supine positions.

Therefore, in our opinion, there is full justification for uniting the groups and comparing the reaction of the cardio-respiratory system during physical load tests for 10 subjects in dependence on the body position: supine or seated.

An analysis of the obtained material showed that, in the seated position at rest, the pulse frequency was considerably higher than in the supine position during all the investigations. This difference was somewhat reduced during physical exercise, yet it attained 10 beats/min and increased even more at the fifth and tenth minutes of recuperation (table 5.3.21). On day 0 after /334
the bedrest, the pulse frequency during exercise in the seated posture was higher by 20 beats/min or 14.2% than in the supine posture. These differences were also reliable with reference to the background ($R < 0.05$). On days 5 and 10 of the recuperation period, the pulse reaction to the test was gradually normalized. Nonetheless, the mentioned relations between the pulse frequency in the supine and seated postures were retained (table 5.3.21).

With respect to the gas exchange and the external respiration, in contrast to the changes in the pulse reaction, no differences of any sort were discovered for the tests in the supine and seated positions (tables 5.3.18-5.3.23).

The systolic pressure was higher in the supine position, the diastolic in the seated position (tables 5.3.24-5.3.25). The investigation results confirmed the belief that the position of the

Table 5.3.18.

Consumption of O_2 (ml/min) by subjects of both groups (A & B) when performing the physical load test at various periods of the experiment.

Position	Indices	before bedrest				after bedrest (days) 0				5				10			
		AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}
supine	M	325	I800	405	349	329	I769	397	3I2	335	I789	394	344	333	I777	424	355
	$\sigma \pm$	44,2	I55,7	42,6	4I,I	58,5	II5,3	44,I	46,4	35,7	I74,8	52,2	46,4	48,8	87,6	56,9	6I,0
	$m \pm$	I3,9	49,2	I3,5	I2,9	I8,5	36,5	I3,9	I4,7	II,3	55,3	I6,5	I4,7	I5,4	27,7	I7,9	I9,3
seated	M	348	I825	394	337	360	I8I6	424	36I	337	I89I	402	359	342	I827	428	359
	$\sigma \pm$	63,9	204,8	6I,4	52,9	47,9	82,5	65,6	56,4	42,6	I5I,3	47,9	56,9	52,I	66,9	33,9	5I,3
	$m \pm$	20,2	64,8	I9,4	I6,7	I5,2	26,I	20,8	I7,8	I4,2	50,4	I5,9	I8,9	I6,5	2I,2	I0,7	I6,2

Symbols are the same as in Table 5.3.2.

N.B. Commas in the tabulated material are to be understood as decimal points.

Table 5.3.19.

Exhalation of CO_2 (ml/min) by subjects of both groups (A & B) when performing the physical load test at various periods of the experiment.

Position	Indices	before bedrest				after bedrest (days) 0				5				10			
		AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}
supine	M	254	I460	352	262	290	I67I	39I	248	280	I685	406	283	277	I629	386	295
	$\sigma \pm$	43,7	285,4	8I,I	56,3	59,I	II2,0	43,0	54,3	34,I	I72,I	72,3	56,7	53,6	I53,3	78,9	47,3
	$m \pm$	I3,8	90,3	25,7	I7,8	I8,7	35,4	I3,6	I7,2	20,8	54,4	22,8	I7,9	I6,9	48,5	24,9	I4,9
seated	M	258	I486	3I8	265	287	I643	379	299	26I	I70I	343	283	29I	I606	366	3II
	$\sigma \pm$	49,6	263,4	67,8	54,9	45,9	I04,5	82,7	53,9	40,6	I24,9	58,6	46,4	40,4	64,5	32,8	20,9
	$m \pm$	I5,7	83,3	2I,4	I7,4	I4,5	33,0	26,I	I7,0	I3,5	4I,7	I9,5	I5,5	I2,8	20,4	I0,4	6,6

Symbols are the same as in Table 5.3.2.

N.B. Commas in the tabulated material are to be understood as decimal points.

Table 5.3.20.

Consumption of O_2 per unit of body weight (ml/kg/min) by the subjects of both groups (A & B) when performing the physical load test at various periods of the experiment.

Position	Indices	before bedrest				after bedrest (days) 0				5				10			
		AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}
supine	M	4,2	23,4	5,3	4,5	4,3	23,2	5,2	4,I	4,4	23,3	5,I	4,5	4,4	23,3	5,6	4,6
	$\sigma \pm$	0,5	3,0	0,7	0,4	0,6	I,5	0,4	0,7	0,3	2,I	0,5	0,4	0,6	2,I	0,9	0,7
	$m \pm$	0,2	I,0	0,2	0,I	0,2	0,5	0,I	0,2	0,I	0,7	0,2	0,I	0,2	0,7	0,3	0,2
seated	M	4,5	23,7	5,I	4,4	4,7	23,8	5,5	4,7	4,5	24,8	5,3	4,7	4,5	24,0	5,6	4,7
	$\sigma \pm$	0,8	3,7	0,7	0,6	0,4	I,7	0,6	0,6	0,4	2,4	0,4	0,7	0,6	2,6	0,6	0,7
	$m \pm$	0,2	I,2	0,2	0,2	0,I	0,5	0,2	0,2	0,I	0,8	0,I	0,2	0,2	0,8	0,2	0,2

Symbols are the same as in Table 5.3.2.

N.B. Commas in the tabulated material are to be understood as decimal points.

Table 5.3.21.

Frequency of heart contractions (beats/min) for the subjects of both groups (A & B) when performing the physical load test at various periods of the experiment.

Position	Indices	before bedrest				after bedrest (days) 0				5				10			
		AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}
supine	M	68	I26	83	8I	70	I34	86	83	67	I33	87	8I	72	I32	87	85
	$\sigma \pm$	9,8	9,6	I2,5	I3,3	I4,8	I5,7	I5,4	I5,6	II,4	I2,5	I2,3	I0,I	I2,5	I0,3	I2,6	II,6
	$m \pm$	3,I	3,0	4,0	4,2	4,7	5,0	4,9	4,9	3,6	3,9	4,I	3,2	3,9	3,3	3,9	3,7
seated	M	92	I37	96	95	I00	I53	I09	I09	88	I4I	98	98	94	I44	99	99
	$\sigma \pm$	I2,6	I3,4	I5,2	I5,I	I6,0	I3,6	I4,7	I3,6	I0,8	I2,0	I2,I	I2,8	II,2	9,6	I2,7	I3,4
	$m \pm$	4,0	4,2	4,8	4,6	5,I	4,3	4,7	4,3	3,6	4,0	4,0	4,3	3,6	3,2	4,2	4,3

Symbols are the same as in Table 5.3.2.

N.B. Commas in the tabulated material are to be understood as decimal points.

Table 5.3.22.

Minute volume of respiratcn (l/min) for the subjects of both groups (A & B) when performing the physical load test at various periods of the experiment.

Position	Indices	before bedrest				after bedrest (days) 0				5				IO			
		AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}
supine	M	IO	43	I3	II	9	48	I3	IO	IO	46	I3	IO	IO	45	I3	I2
	$\sigma \pm$	I,8	5,I	2,3	2,7	2,I	3,8	I,6	I,6	I,7	5,9	2,4	I,8	2,3	5,5	3,2	2,4
	$m \pm$	0,6	I,7	0,8	0,9	0,7	I,2	0,5	0,5	0,5	I,9	0,8	0,6	0,7	I,7	I,0	0,8
seated	M	II	44	I2	II	II	49	I4	I3	IO	45	I2	II	II	46	I3	I2
	$\sigma \pm$	2,4	6,4	2,5	2,4	2,3	9,3	3,I	I,9	I,3	5,I	2,6	I,6	3,I	4,9	2,I	2,I
	$m \pm$	0,8	2,0	0,8	0,8	0,7	2,9	I,0	0,6	0,4	I,7	0,9	0,5	I,0	I,6	0,7	0,7

Symbols are the same as in Table 5.3.2.

N.B. Commas in the tabulated material are to be understood as decimal points.

Table 5.3.23.

Respiration frequency (per min) for the subjects of both groups (A & B) when performing the physical load test at various periods of the experiment.

Position	Indices	before bedrest				after bedrest (days) 0				5				10			
		AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}
supine	M	I2	22	I2	I2	I2	2I	I3	I4	I2	2I	I3	I2	I2	20	I4	I4
	$\sigma \pm$	2,8	3,9	4,3	4,9	3,2	4,4	3,9	4,I	3,2	3,5	4,0	4,2	3,9	3,2	4,8	4,9
	$m \pm$	0,9	I,2	I,4	I,5	I,0	I,4	I,2	I,3	I,0	I,I	I,3	I,3	I,2	I,0	I,5	I,5
seated	M	I2	I9	I3	I3	I2	2I	I3	I2	I2	I9	I3	I2	I2	20	I4	I3
	$\sigma \pm$	2,3	3	3,9	3,4	2,9	4,3	3,9	3,8	3,6	3,0	4,0	3,9	3,4	2,3	4,5	3,8
	$m \pm$	0,7	1,2	I,2	I,I	0,9	I,3	I,2	I,2	I,2	I,0	I,3	I,3	I,I	0,7	I,4	I,2

Symbols are the same as in Table 5.3.2.

N.B. Commas in the tabulated material are to be understood as decimal points.

Table 5.3.24.

Arterial systolic pressure (mm mercury) for the subjects of both groups (A & B) when performing the physical load test at various periods of the experiment.

Position	Indices	before bedrest				after bedrest (days) 0				5				10			
		AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}
supine	M	II7	I75	I25	II8	I23	I89	I3I	II9	I22	I86	I28	I2I	I2I	I83	I27	II7
	$\sigma \pm$	6,6	I6,8	I0,8	8,6	9,9	I9,3	5,7	7,0	8,3	I9,4	8,6	6,I	I0,4	2I,8	II,4	I0,9
	$m \pm$	2,I	5,3	3,4	2,7	3,I	6,I	I,8	2,2	2,6	6,I	2,7	2,2	3,3	6,9	3,6	3,4
seated	M	II0	I64	II4	II0	II4	I70	I2I	II7	II3	I74	II4	II3	II4	I76	II9	II4
	$\sigma \pm$	8,8	I8,3	I2,9	9,0	I0,2	2I,5	II,3	I0,3	9,7	I9,5	I2,I	I0,3	8,I	2I,I	8,4	9,9
	$m \pm$	2,8	5,8	4,I	2,8	3,2	6,8	3,6	3,3	3,2	6,4	4,0	3,5	2,6	6,7	2,7	3,I

Symbols are the same as in Table 5.3.2.

N.B. Commas in the tabulated material are to be understood as decimal points.

Table 5.3.25.

Arterial diastolic pressure (mm mercury) for the subjects of both groups (A & B) when performing the physical load test at various periods of the experiment.

Position	Indices	before bedrest				after bedrest (days) 0				5				10			
		AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}	AR	PL	R_5	R_{10}
supine	M	76	85	7I	74	82	93	75	8I	8I	86	73	77	77	87	7I	77
	$\sigma \pm$	5,2	8,3	8,6	6,7	6,6	9,2	8,0	5,7	6,2	8,4	7,5	8,9	8,3	9,5	9,9	9,5
	$m \pm$	I,7	2,6	2,7	2,I	2,I	2,9	2,5	I,8	2,0	2,7	2,4	2,8	2,6	3,0	3,2	3,0
seated	M	78	77	78	76	86	8I	83	85	80	79	74	79	79	78	77	79
	$\sigma \pm$	6,3	II,5	8,9	7,4	8,5	II,3	I0,I	7,6	7,6	II,7	9,8	8,2	6,9	I5,3	8,2	7,I
	$m \pm$	2,0	3,6	2,8	2,3	2,7	3,6	3,2	2,4	2,5	3,9	3,3	2,7	2,2	4,8	2,6	2,2

Symbols are the same as in Table 5.3.2.

N.B. Commas in the tabulated material are to be understood as decimal points.

body when performing work has the greatest significance in the above-mentioned peculiarities for the reaction of the cardio-respiratory system of the subjects in groups A and B during the physical load tests, in addition to the factors due to their stay at various angles in bed. Symptoms for deconditioning of the cardio-vascular system, vaguely expressed during load in the supine position were manifested more distinctly during exercise in the seated position.

5.3.4. Conclusion

The results from the investigations of the cardio-vascular and respiratory systems of the subjects in groups A and B during the physical exercise tests again confirmed the data that the cardio-vascular system itself is most susceptible to the influence of weightlessness and the conditions of its modeling, e.g. by means of bedrest [4,5]. /343

It should be noted, however, that the alterations were less pronounced during the tests in the supine position. Differences between the groups appeared only in a greater increase of the systolic pressure during work (group B) and a delayed normalization of the pulse frequency in the recuperation period after bedrest.

The most substantial differences with respect to the cardio-vascular system were found in both groups during exercise in the seated position. In group B, a more significant increment in the pulse frequency and a retardation of its restoration were noted. In both groups, the reaction to the seated test was more pronounced than that for the supine test. Statistically reliable differences were observed on day 0 following the bedrest.

The gas exchange and external respiration indices changed insignificantly during the supine and seated tests. Large individual variations of the indices under load were responsible for the insufficient information content. Maximum work tests may be valuable in this respect [2,3,8,9].

One of the characteristic symptoms of cardio-vascular deconditioning, noted in the subjects after bedrest, was an increment in the pulse frequency for standard work in the seated position, being higher than before the bedrest [4-6]. Similar data had been obtained by us during pre-flight and post-flight examinations of Soviet astronauts, having completed orbital flights from 2 to 18 days aboard the Soyuz spacecraft [5].

The American investigators, in examining the third crew of the Skylab orbital station, detected an increase in the pulse frequency and a considerable lowering of the stroke volume in the astronauts when exercising in the seated position. They tend to regard the more pronounced redistribution of blood in the vertical position and the lowering of the vascular tonus as the main cause of these cha ·s [10]. /344

Our data does not permit an unequivocal conclusion as to the nature of the observed changes. We may only assume that one of the causes of the changes noted in the cardio-vascular system's reaction to physical load following bedrest may be the less perfect interaction of the mechanisms that provide for an adequate flow of blood to the heart during exercise in the vertical position.

5.3.5. Summary

Thus, a 7-day stay in conditions of hypokinesia in bed produced a deterioration in the response of the cardio-vascular system to the test with physical work. The changes in the gas exchange and external respiration were minor. The most pronounced symptoms of deconditioning were the increase in the pulse frequency during work, its slow normalization, and an increase in the systolic pressure, all manifested under load in the seated position.

The position of the subjects in the course of the hypokinesia at various angles in bed did not exert a major influence on the adaptation of the cardio-respiratory system to physical work. In group B, during exercise in the seated posture, a more significant increment in the pulse frequency and its retarded normalization during the recuperation period were noted. One of the possible causes for the observed disorders of the cardio-vascular system in the period after bedrest may be the orthostatic instability due to adaptation to conditions of hypokinesia and to a lower hydrostatic pressure of the fluids in the organism.

6.0. Preliminary Conclusion /347

Before, during, and after the bedrest, the general health and well-being of all the subjects in both groups was entirely satisfactory.

During bedrest in the antiorthostatic position, the subjects perceived a more pronounced sensation of blood rush and a feeling of heaviness in the head, blockage of the nose, and a more or less impeded nose breathing, than did the subjects in the horizontal position. An intumescence of the face and injection of the vessels of the sclera and conjunctiva were observed. Individual subjects experienced a feeling of "enlargement" and "heaviness" in the region of the epididymal sinuses of the nose, a "cotton" blockage of the ears, hoarseness of voice, pain in the back, and a chill in the legs. Daily measurement of the main vital physiological indices during the bedrest indicated that, for the subjects of group A, the slowing of the heart contraction rhythm was more pronounced, while for the subjects of group B the lowering of the systolic and diastolic arterial pressure was more pronounced.

In the bedrest period, individual changes were detected in the general biochemical and hormonal indices of the human organism in stress conditions, as well as characteristic alterations in the

water-salt metabolism and the kidney function, most clearly manifested in an elevated excretion of fluids and salts by the kidneys. The latter were more pronounced for the subjects of group B. An analysis of the fluids of the organism by means of radioisotopic methods revealed a slight lowering of the hydration status of the subjects and a tendency toward reduction of the erythrocyte mass for the subjects of both groups. The hematological investigations revealed a definite raising of the hemoconcentration, expressed in the increase in hemoglobin content, the hematocrit value, and the hemoglobin saturation of the erythrocytes, more pronounced for the subjects of group B. /348

The investigation of the cardio-vascular system at rest, including electrocardiographic investigations, did not reveal major changes or a difference in the dynamics of the ECG-indices for the subjects of groups A and B during bedrest. The observed tendency to decreased amplitude of the T spikes was apparently due to a slight change in the position of the heart within the rib cage as a result of adaptation of the cardio-vascular system to conditions of hypokinesia. The echocardiographic investigations carried out during bedrest revealed, in the subjects of group A, a tendency to the gradual lowering of the diastolic, systolic, and stroke volumes and a slight reduction of the heart contraction frequency, which led to a significant reduction of the minute volume of blood circulation. For the subjects of group B, on the contrary, there was observed an increase in the diastolic, systolic, and stroke volumes of the heart, along with an insignificant reduction of the minute volume of circulation.

The plethysmographic investigations revealed that, in bedrest conditions, the vascular channel of the lower extremities was subject to the greatest changes: the volume rate of blood flow was lowered, the capacity of the vascular channel was reduced, and the intensity of filtration processes from the vascular channel of the lower leg was lowered during occlusion of the veins in the leg; the volume of the lower leg was reduced, being more pronounced in the subjects of group B.

At the termination of bedrest (day "0"), the subjects experienced a general weakness and dizziness in standing up. The face and neck /349 were pale, and acrocyanosis of the extremities was observed. By the end of the day, pains appeared in the muscles of the back and especially of the legs. Later on, the changes gradually decreased and practically disappeared by day 2-3 for the subjects of group A and day 3-4 for those of group B in the recuperation period. At the conclusion of bedrest, the body weight had been reduced by 0.7 kg for the subjects of group A and 1.7 kg for those of group B.

The LBNP test after the conclusion of the hypokinesia period revealed in all the subjects a more pronounced increase in the frequency of heart contractions and decrease in the pulse arterial pressure than that prior to bedrest. This indicates a slight lowering of the compensatory-adaptive capabilities of the circulatory system

of the subjects. The echocardiographic data did not reveal disturbances in the contractile function of the myocardium, nor did the plethysmographic investigations reveal a major change in the capacity of the vascular channel in the lower extremities. We were not able to find a reliable difference in resistance to the tests between the subjects of groups A and B.

The test with graduated physical load on a bicycle ergometer, carried out after bedrest, revealed a deterioration in the response of the cardio-respiratory system, less pronounced under load in the supine position and more pronounced under load in the seated position, especially for the subjects of group B.

Thus, the investigation results permit a tentative conclusion that statistically significant differences in regard to the majority of the investigated parameters were not found between the two groups of subjects. Furthermore, with regard to clinical symptoms and individual physiological shifts, antiorthostatic hypokinesia more adequately reproduces those reactions that are noted in the human as a result of space flight, than does a bedrest regimen in the horizontal position. In conclusion, it should /350
again be emphasized that the investigations have enabled a standardization of the conditions for conducting experiments with hypokinesia and a unification of the procedure for clinico-physiological and laboratory investigations, the order of administering the individual tests and the recording of medical information, and the methods of mathematical processing, analysis, and representation of the data. This will serve as a good foundation for future cooperation between the USSR and the USA in the area of space biology and medicine and will be of scientific and practical importance.

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31. Kozyrevskaya, G. I. - 4.3.1, 4.3.2.
32. Kolchina, Ye. V. - 4.2.2.
33. Kondrasheva, N. V. - 3.2.
34. Kochetkova, A. N. - 3.3.

35. Krupina, T. N. - 3.1.
36. Krylov, K. P. - 3.1.
37. Kuz'min, M. P. - 3.1.
38. Kuz'mishcheva, Ye. P. - 4.3.3.
39. Kurkina, L. M. - 4.2.1.
40. Kushnerev, A. Ya. - 4.3.3.
41. Lobachik, V. I. - 4.3.3.
42. Lysenko, G. V. - 4.1, 4.2.1.
43. Lyubarskaya, I. I. - 4.2.1.
44. Manin, A. P. - 3.1.
45. Machinskiy, G. V. - 3.1, 5.3.
46. Mikhaylov, V. M. - 2.0, 3.1, 3.2, 6.0. (Operations Chief)
47. Mikhaylovskiy, G. P. - 3.1.
48. Morukov, B. V. - 4.3.1, 4.3.2.
49. Moskovkina, N. N. - 4.3.1.
50. Nazin, A. N. - 3.2, 3.4.
51. Noskov, V. B. - 4.3.1, 4.3.2.
52. Pavlova, E. A. - 4.2.2.
53. Panferova, N. Ye. - 5.1.3, 5.2.3.
54. Petrova, V. N. - 4.3.3.
55. Pometov, Yu. D. - 5.3.
56. Popova, I. A. - 4.2.1.
57. Pushko, R. S. - 3.3.
58. Rustamyan, L. A. - 3.5, 5.1.3, 5.2.3, Supplement B.
59. Savilov, A. A. - 5.1.1, 5.1.2, 5.2.2.
60. Skukina, I. S. - 4.3.1.
61. Tigranyan, R. A. - 4.1, 4.2.
62. Tolmacheva, M. Ya., 3.1, 3.4.
63. Ul'yanova, I. Ya. - 3.3.
64. Ushakov, A. S. - 3.3.
65. Fisenko, N. R. - 3.1.
66. Tsyganova, N. I. - 3.1.

7.2. List of Abbreviations.

Group A - subjects reposing in horizontal position during bedrest.

Group B - subjects reposing in antiorthostatic position during bedrest.

AOH - antiorthostatic hypokinesia

AP - arterial pressure

BP - background period

BR - bedrest

CVS - cardiovascular system

DAP - diastolic arterial pressure

DV - diastolic volume

ECG - electrocardiogram

FHC - frequency of heart contractions

GPL - graduated physical load

M - arithmetic mean

Max. - maximum value of an index

Min. - minimum value of an index

MVC - minute volume of circulation

LBNP - lower body negative pressure

PAP - pulse arterial pressure

PF - pulse frequency

R - reliability

RP - recuperation period (after bedrest)

SAP - systolic arterial pressure

SF - space flight

SS - spaceship

St.V. - stroke volume

SV - systolic volume

V_{CO_2} - exhalation of carbon dioxide

V_{O_2} - consumption of oxygen

m - mean arithmetic error

σ - mean square variation

SUPPLEMENT B

Table

Investigation Results from Controlled Blood Samples.

Index	Specimen	
	USSR	USA
I. Sodium (meq/l)	I42	I40
2. Potassium (meq/l)	4.4	4.3
3. Calcium (meq/l)	5.I	5.3
4. Magnesium (meq/l)	2.0	I.9
5. Chlorine (meq/l)	I02	I00
6. Inorg. Phosphorus (mg%)	4.4	3.8
7. Total Protein (g%)	7.2	7.2
8. Creatinine (mg%)	0.9	0.7
9. Hydrocortisone (mg%)	9.2	8.2
I0. Aldosterone (pg/ml)	95.0	82.0

Note: The above indices in the blood serum were determined by methods indicated in the relevant sections of the report.

Table 8.3.2.1.

Level of motor activity (No. of steps per day) for the subjects of Group A prior to bedrest.

Subjects	before bedrest (days)													
	-I	-2	-3	-4	-5	-6	-7	-8	-9	-I0	-II	-I2	-I3	-I4
2	4600	3500	4330	4I00	4600	2200	3900	3700	2I00	3900	4I00	3500	2200	3600
4	4800	3600	4200	4000	4700	2300	3800	3I00	2400	3700	4200	3400	2I00	3500
6	5000	4I00	4I00	3200	4700	3200	3500	4I00	2800	3400	3300	3600	4I00	3600
8	3800	2800	4I00	3200	4I00	3800	4900	3700	3300	4300	4200	4I00	3300	3300
I0	5I00	[illegible]	4I00	2I00	2600	2000	3800	5000	3900	4I00	3I00	4300	2000	2800
M	4600	3460	4I66	3320	4I40	2300	3800	3920	2900	3880	3780	3780	2740	3360

Table 8.3.2.2.

Level of motor activity (No. of steps per day) for the subjects of Group B prior to bedrest.

Subjects	before bedrest (days)													
	-I	-2	-3	-4	-5	-6	-7	-8	-9	-I0	-II	-I2	-I3	-I4
I	4700	3I00	5000	4I00	3700	2000	4000	3300	2300	4I00	3000	2800	2200	3000
3	4400	2I00	4400	4700	3I00	2000	4I00	3900	2800	2900	4000	3800	2200	3200
5	4I00	2700	4400	4300	3700	2200	3700	3800	2300	4I00	3900	3700	I900	4000
7	5200	3000	4400	3700	3800	2700	3I00	3200	2400	3I00	3400	2800	2800	3200
9	4700	2900	5000	3700	4000	2900	3I00	3400	2400	3500	3700	3400	2400	3400
M	4620	2760	4640	4I00	3660	2360	3600	3520	24I0	3540	3600	3300	2300	3360

Table t 3.2.3.

Level of motor activity (No. of steps per day)
for the subjects of Group A after bedrest.

Subject	after bedrest (days)													
	0	I	2	3	4	5	6	7	8	9	I0	II	I2	I3
2	II00	2200	2200	3500	4330	3200	4600	3900	4600	4700	3I00	4330	4200	4600
4	I400	2500	2I00	3600	4200	3I00	4700	3700	4800	4900	3200	4200	3900	4800
6	I800	2900	3I00	4I00	4I00	3I00	4700	3400	5000	4800	3I00	4300	3800	5000
8	2300	2400	3300	3800	4I00	3300	4I00	3800	3800	4800	2800	4200	4I00	4800
I0	I900	2900	3000	3600	4200	3000	3600	3I00	5I00	4700	2300	4200	4300	5I00
M	I700	2580	2740	3720	4I86	3I40	4340	3580	4660	4780	2900	4246	4060	4860

Table 8.3.2.4.

Level of motor activity (No. of steps per day)
for the subjects of Group B after bedrest.

Subject	after bedrest (days)													
	0	I	2	3	4	5	6	7	8	9	I0	II	I2	I3
I	I300	2300	2400	3600	4900	3200	4700	3I00	4700	4300	2I00	4000	4200	4700
3	I800	2800	2300	3400	4400	32004300		2900	4400	4600	2200	4400	3800	4900
5	I300	2300	2I00	3800	4500	2900	4700	3I00	4I00	4400	2700	4300	3900	4400
7	I400	2400	2800	3700	4400	3500	4800	3I00	5200	4200	2800	4200	4100	5000
9	I400	2400	2400	3600	4800	3400	4600	2500	4700	4600	2900	4700	4200	4700
M	I440	2440	2400	3620	4600	3240	4620	2940	4620	4420	2540	4320	4040	4740

Table 8.4.3.3.1.

Volume of total water in the subjects at various periods of the experiment (ml/kg).

No.	Group	Subjects	periods of the experiment (days) before bedrest 9	bedrest 7	after bedrest 9
I.		S-ev	630,0	6I2,0	639,0
2.		S-ov	6I0,0	578,0	635,0
3.	"A"	P-ov	659,0	602,0	620,0
4.		Sh-ov	632,0	623,0	6II,0
5.		K-ko	592,0	548,0	560,0
		M	624,6	592,6	6I3,0
		σ	25,2	29,9	3I,7
		m	II,2	I3,4	I4,2
I.		A-ev	627,0	59I,0	597,0
2.		P-iy	588,0	6II,0	620,0
3.	"B"	T-in	682,0	655,0	652,0
4.		Zh-ov	6I2,0	653,0	598,0
5.		L-iy	638,0	655,0	687,0
		M	629,4	633,0	631,6
		σ	34,9	30,I	2[illegible]
		m	I5,6	I3,4	[illegible]

N.B. Commas in the tabulated material are to be understood as decimal points.

Table 8.4.3.3.2.

Volume of extra-cellular fluid for the subjects at various periods of the experiment (ml/kg).

No.	Group	Subjects	periods of the experiment (days)		
			before bedrest 9	bedrest 7	after bedrest 9
I.		S-ev	248,7	244,2	296,3
2.		S-ov	I93,6	I89,2	208,9
3.	"A"	P-ov	238,2	22I,7	305,9
4.		Sh-ov	224,0	204,4	222,8
5.		K-ko	243,I	237,I	257,6
		M	229,5	2I9,3	258,3
		σ	22,I	22,7	43,0
		m	9,9	I0,2	I9,2
I.		A-ev	252,I	2I7,2	226,I
2.		P-iy	223,5	230,3	253,2
3.	"B"	T-in	234,9	228,7	230,9
4.		Zh-ov	225,I	2I6,I	226,6
5.		L-iy	207,4	2I5,2	2I0,4
		M	228,6	22I,5	229,4
		σ	I6,4	7,3	I5,5
		m_1	7,3	3,3	6,9

N.B. Commas in the tabulated material are to be understood as decimal points.

Table 8.4.3.3.3.

Volume of intracellular fluid for the subjects at various periods of the experiment (ml/kg).

No.	Group	Subject	periods of the experiment (days)		
			before bedrest 9	bedrest 7	after bedrest 9
I.		S-ev	38I,3	367,8	342,7
2.		S-ov	4I6,4	388,8	426,I
3.	"A"	P-ov	420,8	380,3	3I4,I
4.		Sh-ov	408,0	4I8,6	388,2
5.		K-ko	348,9	3I0,9	302,4
		M	395,I	373,3	354,7
		σ	30,0	39,6	5I,8
		m	I3,4	I7,7	23,2
I.		A-ev	374,9	373,8	370,9
2.		P-iy	364,5	380,7	368,6
3.	"Б"	T-in	447,I	426,3	42I,I
4.		Zh-ov	386,9	436,8	368,4
5.		L-iy	430,6	439,8	446,6
		M	400,8	4II,5	395,2
		σ	36,I	3I,7	36,5
		m	I6,I	I4,2	I6,3

N.B. Commas in the tabulated material are to be understood as decimal points.

Table 8.4.3.3.4.

Volumes of interstitial fluid for the subjects at various periods of the experiment (ml/kg).

No.	Group	Subject	periods of the experiment (days)		
			before bedrest 9	bedrest 7	after bedrest 9
I.		S-ev	206,4	207,5	249,9
2.		S-ov	I62,2	I53,7	I68,0
3.	"A"	P-ov	204,7	I87,6	272,I
4.		Sh-ov	I82,4	I5I,9	I75,6
5.		K-ko	I98,5	207,7	20I,8
		M	I90,8	I8I,7	2I8,5
		6 m	I8,6	27,7	45,8
			8,3	I2,3	20,5
I.		A-ev	2I7,2	I78,8	I88,7
2.		P-iy	I83,2	I93,2	206,I
3.	"B"	T-in	I95,6	I9[illegible],5	I9I,I
4.		Zh-ov	I88,I	I78,8	I87,4
5.		L-iy	I75,5	I76,5	I8I,7
		M	I9I,9	I84,3	I87,8
		6 m	I5,9	8,8	I6,9
			7,I	3,9	7,6

N.B. Commas in the tabulated material are to be understood as decimal points.

Table 8.4.3.3.5.

Volume of blood in the subjects at various periods of the experiment (ml/kg).

No.	Group	Subject	periods of the experiment (days) before bedrest 9	bedrest 7	after bedrest 9
I.		S-ev	73,I	66,0	74,8
2.		S-ov	56,9	63,I	64,8
3.	"A"	P-ov	58,I	58,2	57,6
4.		Sh-ov	67,4	82,2	73,7
5.		K-ko	84,2	60,5	92,I
		M	67,9	66,0	72,6
		6	II,3	9,5	I2,9
		m	5,0	4,2	5,6
I.		A-ev	59,4	6I,4	62,7
2.		P-iy	7I,9	63,5	75,5
3.	"Б"	T-in	70,I	6I,I	76,0
4.		Zh-ov	63,0	66,2	66,0
5.		L-iy	56,0	68,9	75,6
		M	64,I	64,2	7I,2
		6	6,8	3,3	6,3
		m	3,I	I,5	2,8

N.B. Commas in the tabulated material are to be understood as decimal points.

Table 8.4.3.3.6.

Volume of plasma in the subjects at various periods of the experiment (ml/kg).

No.	Group	Subject	periods of the experiment (days) before bedrest 9	bedrest 7	after bedrest 9
I.	"A"	S-ev	42,2	36,7	46,4
2.		S-ov	3I,4	35,5	40,9
3.		P-ov	33,5	34,I	33,8
4.		Sh-ov	4I,6	52,5	47,2
5.		K-ko	44,6	29,4	55,8
		M	38,6	37,6	44,8
		6	5,8	8,8	8,I
		m	2,6	3,9	3,6
I.	"Б"	A-ev	34,9	38,4	37,4
2.		P-iy	40,3	37,0	44,2
3.		T-in	39,3	34,2	39,8
4.		Zh-ov	37,0	37,6	39,2
5.		L-iy	3I,9	38,6	48,7
		M	36,7	37,2	4I,9
		6	3,4	I,8	4,8
		m	I,5	0,8	2,0

N.B. Commas in the tabulated material are to be understood as decimal points.

Table 8.4.3.3.7.'.

Volume of erythrocyte mass for the subjects at various periods of the experiment (ml/kg).

No.	Group	Subject	periods of the experiment (days) before bedrest 9	bedrest 7	after bedrest 9
I.		S-ev	30,8	27,9	28,6
2.		S-ov	25,4	24,I	23,7
3.	"A"	P-ov	24,7	22,8	23,4
4.		Sh-ov	26,2	29,7	26,3
5.		K-ko	35,6	36,0	36,4
		M	28,5	28,I	27,7
		6	4,6	5,2	5,3
		m	2,I	2,3	2,4
I.		A-ev	24,6	23,4	25,5
2.		P-iy	3I,5	26,I	30,3
3.	"Б"	T-in	30,7	25,5	33,0
4.		Zh-ov	25,9	27,5	26,4
5.		L-iy	24,I	28,8	27,3
		M	27,4	26,3	29,I
		6	3,5	2,0	4,3
		m	I,6	0,9	1,9

N.B. Commas in the tabulated material are to be understood as decimal points.

Table 8.4.3.3.8.

Relation of the Fluid Volumes (in %) for the Subjects on Day 9 Following Bedrest.

Group	Subjects	! EFV/TBW	! IFV/TBW	!! IF/EFV	!! FV/EFV
"A"	S-ev	46,4	53,6	84,3	I5,6
	S-ov	32,9	67,I	80,4	I9,6
	P-ov	49,3	50,7	88,9	II,0
	Sh-ov	36,5	63,5	78,8	2I,2
	K-ko	46,0	54,0	78,3	2I,7
	M	42,I	57,9	82,6	I7,3
"B"	A-ev	37,8	62,I	83,4	I6,5
	P-iy	40,7	59,2	8I,4	I7,4
	T-in	35,4	64;6	82,8	I7,2
	Zh-ov	38,I	6I,9	82,7	I7,3
	L-iy	32,0	68,0	76,8	23,I
	M	36,7	63,3	8I,8	I8,3

Note: symbols given in text.

N.B. Commas in the tabulated material are to be understood as decimal points.
IFV - intracellular fluid volume; IF - interstitial fluid

Table 8.4.3.3.9.

Relation of the Fluid Volumes (in %) for the Subjects on Day 9 of a Control Period.

Group	Subjects	EFV/TBW	IFV/TBW	IF/EFV	PV/EFV
"A"	S-ev	39,5	60,5	83,0	I6,9
	S-ov	3I,7	68,3	83,8	I6,2
	P-ov	36,I	63,8	85,9	I4,I
	Sh-ov	35,4	64,5	8I,4	I8,6
	K-ko	4I,4	58,8	8I,6	I8,3
	M	36,7	63,2	83,I	I6,8
"B"	A-ev	40,2	59,8	86,I	I3,8
	P-iy	34,4	65,5	83,3	I6,7
	T-in	38,0	62,0	82,0	I8,0
	Zh-ov	36,8	63,2	82,6	I6,4
	L-iy	32,5	67,5	84,6	I5,4
	M	36,3	63,7	83,9	I6,0

Note: symbols given in text. N.B. Commas in the tabulated material are to be understood as decimal points.

Table 8.4.3.3.10.

Relation of the Fluid Volumes (in %) for the Subjects on Day 7 of the Bedrest Period.

Group	Subjects	EFV/TBW	IFV/TBW	IF/EFV	FV/EFV
"A"	S-ev	39,9	60,I	85,0	I5,0
	S-ov	32,7	67,3	8I,2	I8,8
	P-ov	36,8	63,2	84,6	I5,4
	Sh-ov	32,8	67,2	74,3	25,7
	K-ko	43.3	56,7	87,6	I2,4
	M	37,0	,0	82,8	I7,I
"B"	A-ev	36,7	[illegible],2	8I,9	I7,7
	P-iy	37,7	62,3	83,9	I6,I
	T-in	34,9	65,I	85,0	I4,9
	Zh-ov	33,I	66,9	82,6	I7,4
	L-iy	32,8	67,I	82,0	I7,9
	M	35,0	65,0	83,2	I6,7

Note: symbols given in text. N.B. Commas in the tabul. ed material are to be understood as decimal points.

Table 8.5.1.1.

ECG Indices for the Subjects of Group A at Rest at Various Periods of the Experiment.

Index	before BR (days)			BR (days)			after BR
	P13	P14	P(av)	I	2	4	0
R-R (sec)	I,0I	0,9I	0,95	0,99	I,I6	I,I2	I,0
PHC (beats/min)	60	66	63	6I	52	54	5
PQ (sec)	0,I8	0,I8	0,I8	0,I9	0,I8	0,I8	0,I
QRS (sec)	0,08	0,08	0,08	0,08	0,08	0,08	0,0
$QRST_4$ (sec)	0,39	0,39	0,39	0,40	0,42	0,4I	0,.
$QRST_9$ (sec)	0,37	0,35	0,36	0,37	0,39	0,39	0,.
Δ QRST (sec)	+0,02	+0,04	+0,03	+0,03	+0,03	+0,02	+0,0
SI_r (%)	38	42	40	40	36	38	3
SI_{rq} (%)	37	38	37	37	34	34	3
SI (%)	I	4	3	3	2	2	
T_I (mv)	0,23	0,28	0,26	0,20	0,27	0,20	0,.
T_{II} (mv)	0,26	0,28	0,27	0,27	0,3I	0,29	0
T_{III} (mv)	0,04	0,05	0,05	0,I0	0,05	0,II	0,.
T ayR (mv)	-0,23	-0,29	-0,26	-0,24	-0,25	-0,26	-0,
T ayL (mv)	0,I2	0,09	0,II	0,06	0,I0	0,08	0,
T ayF (mv)	0,I4	0,I7	0,I6	0,I7	0,I6	0,I6	0,
T_{yI} (mv)	0,09	0,I2	0,II	0,06	0,I0	0,I0	0
T_{y2} (mv)	0,50	0,5I	0,5I	0,5I	0,68	0,60	0,.
T_{y3} (mv)	0,82	0,63	0,73	0,77	0,87	0,89	0
T_{y4} (mv)	0,84	0,82	0,83	0,80	0,9I	0,80	0
T_{y5} (mv)	0,36	0,39	0,37	0,36	0,45	0,38	0,
T_{y6} (mv)	0,26	0,28	0,27	0,22	0,30	0,26	0,

Key: a - actual value and SI

p - proper value and SI

- difference between real and required values and SI

Table 8.5.1.2.

ECG Indices for the Subjects of Group B at Rest at Various Periods of the Experiment.

Index	before BR (days)			BR (days)			after BR
	P13	P14	P(av)	I	2	4	0
R-R (sec)	0,99	I,0I	I,00	I,0I	I,08	I,06	I,I4
FHC (beat/min)	6I	60	60	6I	56	57	53
PQ (sec)	0,I6	0,I7	0,I7	0,I7	0,I7	0,I6	0,I7
QRS (sec)	0,08	0,08	0,08	0,08	0,08	0,08	0,09
$QRST_h$ (sec)	0,4I	0,40	0,4I	0,39	0,4I	0,4I	0,4I
$QRST_q$ (sec)	0,37	0,37	0,37	0,37	0,38	0,38	0,39
$\Delta QRST$ (sec)	+0,04	+0,03	+0,04	+0,02	+0,03	+0,03	+0,02
SI_r (%)	42	39	4I	39	38	39	36
SI_{rq} (%)	37	36	37	37	35	36	34
SI (%)	+5	+3	+4	+2	+3	+3	+2
T_I (mv)	0,20	0,20	0,20	0,20	0,20	0,19	0,I4
T_{II} (mv)	0,22	9,29	0,25	0,26	0,29	0,25	0,I8
T_{III} (mv)	0,02	0,II	0,07	0,03	0,I2	0,I0	0,07
TayR (mv)	-0,24	-0,2I	-0,23	-0,22	-0,23	-0,23	-0,I5
TayL (mv)	0,07	0,04	0,06	0,06	0,05	0,06	0,04
TayF (mv)	0,I3	0,20	0,I7	0,I8	0,I8	0,I7	0,I3
T_{yI} (mv)	0,06	0,06	0,06	0,0I	0,07	0,II	0,I0
T_{y2} (mv)	0,42	0,32	0,37	0,29	0,33	0,48	0,44
T_{y3} (mv)	0,64	0,59	0,62	0,60	0,66	0,72	0,58
T_{y4} (mv)	0,66	0,70	0,68	0,69	0,78	0,64	0,59
T_{y5} (mv)	0,28	0,33	0,3I	0,29	0,38	0,26	0,24
T_{y6} (mv)	0,I9	0,28	0,24	0,22	0,28	0,23	0,I7

Note: key is the same as in Table 8.5.1.1.

N.B. Commas in the tabulated material are to be understood as decimal points.