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# BED REST STUDIES

# BIBLIOGRAPHY

Volume 1 of 2 Volumes

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SCIENCES COMMUNICATION DIVISION
THE GEORGE WASHINGTON UNIVERSITY MEDICAL CENTER
2001 S STREET, N.W., WASHINGTON, D.C. 20009
Telephone (202) 462-5828

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Compiled by

Thora W. Halstead and Linda Pleasant

for

Dr. Sherman P. Vinograd
Director, Biomedical Research Division
Office of Life Sciences
National Aeronautics and Space Administration

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# INTRODUCTION

This bibliography is an attempt to provide a complete and current compilation of reports and published documents resulting from bed rest studies.

References were retrieved from the computerized information systems of the Defense Documentation Center and MEDLINE. A manual search was made of Scientific and Technical Aerospace Reports, International Aerospace Abstracts, Government Reports Announcements, and Biological Abstracts.

The bibliography consists of two parts: (1) a list of the references arranged by author's names in alphabetical order and including the full publication or report citation, and (2) abstracts of each of the reports arranged in the same numerical order as the list of authors.

For convenience, the bibliography has been bound in the form of a two volume set.

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[NASA-CR-183]

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Effect of intermittent leg cuff inflation and intermittent exercise on the tilt table response after ten days bed recumbency.
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[NASA-CR-92085]

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[NASA-CR-65414]

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[NASA-CR-65422]

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[NASA-CR-114781]
*See Texas Women's University for Parts 1 and 3.

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Space Biology and Medicine 6(4):79-87.

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In: A.M. Genin and P.A. Sorokin, eds. Problems of Space Biology. Volume 13: Prolonged limitation of Mobility and its Influence on the Human Organism.
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Performance of operators during prolonged bed confinement.
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Dynamics of minute blood volume during prolonged hypokinesia as estimated by the acetylene method.
Space Biology and Medicine 5(4):71-76.

# ABSTRACTS

ACCESS. NO. 14,639

FORM: 1/ AUTHOR CARD COMPLETED

N69-14541*# Harvard Univ., Boston, Mass. Thorndike Memorial Lab.
A STUDY OF PHYSIOLOGICAL MECHANISMS AND INTER-RELATIONS BETWEEN SYSTEMIC AND REGIONAL BLOOD VOLUME, BLOOD FLOW AND ELECTROLYTE BALANCE Interim Progress Report
Walter H. Abelmann 31 Dec. 1968 8 p refs
(Grant NGR-22-007-019)
(NASA-CR-98660) Avail: CFSTI CSCL 06P

DOCUMENT SERIES & NO.: N69-14541 (NASA)

DESCRIPTORS: PHYSIOLOGY GY/8, CIRCULATORY SYSTEM R/10, CHEMICAL W/29, EXCRETORY SYSTEM R/56, FOOD DEPRIVATION GY/77, CARBOHYDRATE W/48, HUMAN BL/72, WATER W/77, DISEASE GY/40, ANIMAL BL/33, TACHYCARDIA GY/46, PRESSURE Y/28, BIOLOGICAL RHYTHM GY/21, BED-REST GY/39, EQUIPMENT GR/86, BIOINSTRUMENTATION BK/30, 1968.

ABSTRACT:

In experiments on the regulation of sodium excretion, the effects of fasting and re-feeding with carbohydrate were investigated in eight young, healthy obese volunteers who were hospitalized and maintained on a constant sodium, potassium, and water intake. The studies suggest that the natriuresis of starvation may be attributed to a decrease in distal tubular reabsorption and that the re-feeding of carbohydrate induces antinatriuresis by enhancing proximal tubular reabsorption. The relationship of valvular disease to sodium excretion is discussed briefly. Animal studies on the effects of atrial tachycardia and atrial fibrillation indicate that mean arterial pressure is a major factor in changes in tubular reabsorption of sodium associated with altered atrial rhythm. In evaluating the role of circulatory congestion, it was found that orthostatic tolerance in normal subjects was improved by expansion of plasma volume. It is also reported that cardiovascular deconditioning was not observed in patients with congestive heart failure who were treated with bed rest. Development plans for a miniature pressure transducer are mentioned. M.G.J.

ALEKSANDROV, A.N. and A.K. KOCHETOV. 1974.
Effect of 30-day hypokinesia in combination with LBNP training on some indices of the functional state of the cardiovascular system at rest.
Space Biology and Medicine 8(1):104-105.

Abstract: The effect of 30-day bedrest and LBNP training on the functional state of the cardiovascular system at rest was studied in two groups of test subjects. A moderate decline in tone and a delay in blood rate flow were noted in the leg vessels (mainly venules). The systolic blood volume decreased. The cardiac output at first decreased and then gradually increased, reaching the initial level by the 30th day, due to an increase in the heart rate. The changes in the EKG T wave suggested metabolic changes in the myocardium. These changes in the EKG were more distinct in test subjects who were daily subjected to LBNP training.

ANASHKIN, O.D. 1969.
Effect of hypokinesia, acceleration and reduced nutrition on the state of the blood-coagulation system in man.
Space Biology and Medicine 3(1):148-156.

pp. 89-94

*Kosmicheskaya Biologiya i Meditsina*, Vol. 3, No. 1, Moscow, 1969

Abstract: The effect of hypokinesia and reduced nutrition, as well as hypokinesia, accelerations and reduced nutrition on the coagulation system was studied in three series of experiments, each involving six test subjects. With a decrease in nutrition there were no noticeable changes in the blood coagulation system. During the course of a 15-day bedrest all the subjects exhibited a slight decrease in blood coagulation activity. During the combined effect of hypokinesia, accelerations and reduced nutrition, the changes in the coagulation system were most clearly expressed.

ASYAMOLOV, B.F., V.S. PANCHENKO, I.D. PESTOV, and M.A. TIKHONOV. 1973
Determining excess pressure on the lower part of the body ensuring prevention of orthostatic impairments.
Space Biology and Medicine 7(6):80-87.

[Article by B. F. Asyamolov, V. S. Panchenko, I. D. Pestov and M. A. Tikhonov; Moscow, Kosmicheskaya Biologiya i Meditsina, Russian, Vol 7, No 6, November-December 1973, pp 56-61, submitted 19 November 1971]

Abstract: Lower body positive pressure applied by means of an antigravity suit decreased orthostatic reactions of test subjects exposed to simulated weightlessness (18-hour water immersion, 30-day bed rest). Lower body positive pressure of 50 and 35 mm Hg proved to be effective and well tolerated whereas that of 20 mm Hg proved to be inadequate for preventing orthostatic disturbances. The greatest effect in the prevention of orthostatic disturbances was achieved by a combination of different countermeasures.

5

N73-22019 Joint Publications Research Service, Arlington, Va.
EFFECT OF PHYSICAL TRAINING AND ELECTRIC STIMULATION ON METABOLISM

I. S. Balakhovskiy, V. T. Bakhteyeva, R. V. Beleda, Ye. I. Biryukov, L. A. Vinogradova, A. I. Grigoryev, S. I. Zakharova, I. G. Diusskaya, R. K. Kiselev, and T. A. Kislovskaya Space Biol. and Med., Vol. 6, No. 4, 1972 29 Sep. 1972 p 110-116 refs
(For availability see N73-22002 13-04)

Eng transl.

Metabolic changes developing during bed rest and the possibility of preventing these changes by the use of physical exercises and electric muscle stimulation were investigated. The tested program of physical exercises and electric muscle stimulation were shown to eliminate partially unfavorable bed rest effects.

Author

A72-43921 # Effects of physical training and electric muscle stimulation on the metabolism (Vliianie fizicheskoi trenirovki i elektrostimuliatsii na obmen veshchestv). I. S. Balakhovskii, V. T. Bakhteeva, R. V. Beleda, E. I. Biriukov, L. A. Vinogradova, A. I. Grigor'ev, S. I. Zakharova, I. G. Dlusskaia, R. K. Kiselev, and T. A. Kislovskaia. *Kosmicheskaia Biologiia i Meditsina*, vol. 6, July-Aug. 1972, p. 68-72. 7 refs. In Russian.

Investigation of metabolic changes occurring during bed rest, and study of the possibility of preventing these changes by physical exercises and electric muscle stimulation. It is shown that it is possible to curb to some extent the unfavorable effects of bed rest by these means.

M.V.E.

14,259

6

A69-11334 *
CARDIOVASCULAR CHANGES DURING TILT AND LEG NEGATIVE PRESSURE TESTS.
Stephen J. Bartok, Loren D. Carlson, and Richard F. Walters
(California, University, School of Medicine, Davis, Calif.).
Aerospace Medicine, vol. 39, Nov. 1968, p. 1157-1162. 7 refs.
Grant No. NGR-05-004-026.

DOCUMENT SERIES & NO.: A69-11334-IAA

DESCRIPTORS: BEDREST GY/39, CIRCULATORY SYSTEM R/10, EXTREMITIES R/28, HUMAN BL/72, MEASURE P/3, PRESSURE Y/28, STRESS GY/76, TILTING GR/37. EXERCISE GR/61, PHYSIOLOGY GY/8 1968.

ABSTRACT:

Description of an experiment in which eight students were studied before and after nine days of supervised bedrest using 15 min at 70° tilt, followed by 15 min of negative pressure (up to 30 mm Hg) applied to the left leg as the testing stresses for measuring cardiovascular change. Values recorded included heart rate, blood pressure, and relative changes in leg volume using mercury in silastic strain gauges at the greatest calf circumference. The maximal increase in heart rate during tilt was approximately 40% higher at 0 and 2.5 hr post-bedrest than pre-bedrest. The diastolic pressure following bedrest tended to be higher pretilt and increased more during tilt, resulting in higher mean pressure and narrowed pulse pressures. The negative pressure tests showed changes in heart rate and blood pressure similar to the tilt tests, but to a lesser degree. Leg volume increases were greater following bedrest. M. G.

FOR 14258 SEE 13611

BEARD, D.A., and J.D. GATTS. 1968.
The Effect of Using the Gravitational Acceleration Simulation Suit (GASS) in Preventing Deconditioning Effects of Weightlessness.
In: Preprints of the 1968 Annual Scientific Meeting, Aerospace Medical Association, Bal Harbour, Florida. p. 107-108.

It is generally recognized that the weightless state, as associated with space flights, can adversely affect the physiological state of man and his ability to adapt to this new environment. Since the real effects of prolonged exposure to weightlessness will have to await actual exposure to this condition, simple bed rest has become a substitute in simulating, to some extent, the "deconditioning" effects found during the short orbital flights. Physiological data gathered from these tests indicate profound changes in the cardiovascular system, metabolic effects, and, to some degree, hematopoietic effects.

Physiological deconditioning as evidenced in prolonged bed rest studies results in decreased plasma and total blood volumes, less active bone marrow with decreased erythrocytes, and a gradual increase in resting and working heart rates. The decrease or absence of the stimulus of weight-bearing or compression forces appears to alter the normal osteoblastic and osteoclastic equilibrium of the body resulting in an inadequate calcium and phosphorus reabsorption (or increased excretion).

CONCLUSION AND DISCUSSION

The acceptability of wearing the device during the three-week bed rest period was in accordance with predicted performance and experimental test programs performed on smaller groups. After the initial uncomfortable feeling during the first two or three days, the subjects were able to don the device and maintain the loads for the entire compression periods without discomfort.

Some physiological data was gathered during the study which is presented by other researchers and, although not conclusive, it does indicate more than sufficient justification for undertaking additional studies using larger groups and an experimental design which avoids cumulative effects.

Clinical observations of the subjects using the device, which are difficult to express in terms of data, were, undoubtedly, the most encouraging results. The subjects were able to resume normal routines at once with no apparent dizziness, vertigo, or cool sweat (indicative of normal bed rest studies). Even though the occulsion cuffs were not used, there was a smaller decline in plasma volumes during the period in which the devices were used and a significant maintenance of pulse pressure during tilts. Creatine excretion was significantly lower with use of the devices, as was the urinary excretion of 17-ketosteroids.

The absence of the symptoms of postural degradation with subjects using the GASS device and the significant earlier return to normal of impaired physiological functions after becoming ambulatory shows that the GASS device not only provides a technique, through the medium of muscular tension on periosteal surfaces, to study effects of osteoblastic activity during immobilization as related to a weightlessness analog, but also provides an encouraging method by which some of the anticipated physiological deconditioning effects of weightlessness may be diminished or possibly prevented.

The dramatic comparison of the two experimental bed rest periods (the control phase and the GASS phase) justifies considerable optimism in the gravitational simulation and longitudinal compression approach as a protective method in reducing excessive cardiovascular and musculoskeletal deconditioning.

Beckman, E. L., Coburn, K. R., Chambers, R. M., DeForest, R. E., Augerson, W. S., and Benson, V. G.: Physiologic Changes Observed in Human Subjects During Zero G Simulation by Immersion in Water up to the Neck Level. Aerospace Med. 32: 1031, 1961.

A series of experiments involving seven subjects immersed in water up to neck level for periods of 5 to 23 hours (five subjects for 12 hours) showed a significant weight loss during the period of immersion, which was explained by the diuresis which occurred. Pulmonary volume measurements showed a decrease in the expiratory reserve volume and in the respiratory minute volume during immersion. There was no significant decrement in the performance of a tracking task, attributable to the water immersion, during exposure to a simulated space vehicle reentry deceleration profile. Exposure to 4.5 positive G for 15 seconds following water immersion revealed a decrement in tolerance in most subjects.

Knowledge relative to the effects of prolonged weightlessness is needed in preparing man for space flight. The buoyant force exerted upon immersed bodies effectively simulates the weightless state with respect to proprioceptive sensory responses and perhaps in other ways. An investigation into the physiological effects of immersing subjects in water up to neck level was undertaken. It was found that water immersion produces an unnatural physiological situation in that, during respiration, the inspired air inflates the lungs to atmospheric pressure while the external pressure against the chest, abdomen, and legs, due to the water, is greater than atmospheric. This situation is equivalent to "negative pressure breathing."

**N68-16643*#** National Aeronautics and Space Administration, Washington, D. C.

**EFFECT OF PROLONGED (62-DAY) HYPOKINESIS ON THE HUMAN ORGANISM [VLIYANIYE 62-SUTOCHNOY GIPOKINEZII NA ORGANIZM CHELOVEKA]**

T. V. Benevolenskaya, M. M. Korotayev, T. N. Krupina, I. A. Maslov, G. P. Mikhaylovskiy et al Dec. 1967 5 p Transl. into ENGLISH from RUSSIAN Presented at the 18th Congr. of the Intern. Astronautical Federation, Belgrade, 25–30 Sep. 1967

(NASA-TT-F-11399) CFSTI: HC $3.00/MF $0.65 CSCL 06S

Effects of a 62-day period of bed confinement on six generally healthy young men between the ages of 23 and 36 are described. All subjects were permitted movements in the horizontal position, and three of the men were engaged in a special program of daily exercise. Disturbances were noted in all of the systems and organs of all the men, although difficulties varied among the systems and the men. The most marked disturbances were noted in men who exhibited some difficulties prior to the initiation of the experiment; for example, two nosebleeds occurred in subjects with a slight dryness of the nasal mucous membrane, angina occurred in a subject with chronic tonsillitis, and psychological changes were more pronounced in men who had previous peculiar behavior patterns. M.W.R.

**A68-44091** #

EFFECT OF 62-DAY HYPODYNAMIA ON THE HUMAN ORGANISM [VLIIANIE 62-SUTOCHNOI GIPOKINEZII NA ORGANIZM CHELOVEKA].

T. V. Benevolenskaia, M. M. Korotaev, T. N. Krupina, I. A. Maslov, G. P. Mikhailovskii, T. A. Petrova, K. V. Smirnov, and I. Ia. Iakovleva (Ministerstvo Zdravookhraneniia SSSR, Moscow, USSR).

International Astronautical Federation, International Astronautical Congress, 18th, Belgrade, Yugoslavia, Sept. 24-30, 1967, Paper. 8 p. In Russian.

Results of a hypodynamia experiment in which the central nervous system, the cardiovascular system (and the eyes, ears, nose, throat, and kidneys), and gastric secretion, morphological composition of the blood, and immunological reactivity were studied in a group of six healthy men 23 to 36 years old, confined to 62 days' bed rest. The disorders which developed in the subjects successively during the experiment are described as physical discomfort observed between the third and sixth day, adaptation to the environmental conditions between the seventh and twentieth day, development of asthenia between the twentieth and thirty-fifth day, and asthenia progress during the rest of the period. The diastolic pressure in the central artery of the retina gradually increased, reaching a peak between the thirty-second and the forty-second days, while - on the other hand - atrioventricular conduction decreased during the experiment, especially in the three of the subjects who performed physical exercises. Decreased gastric secretion, increased diuresis and a sharp reduction in general organic reactivity with the progress of the experiment are also noted. V. Z.

Benson, V. G., Beckman, E. L., Coburn, K. R., and Chambers, R. M.: Effects of Weightlessness as Simulated by Total Body Immersion Upon Human Response to Positive Acceleration. Aerospace Med. 33: 198, 1962.

SUMMARY

Twelve members of Underwater Demolition Team 21 used underwater breathing equipment while completely immersed in water for 18 hours. Their response to positive acceleration was determined by observing the G level at which the limitation of ocular motility under acceleration (LOMA) occurred. This G level is approximately the same as when loss of peripheral vision or greyout occurs when subjects are exposed to positive acceleration. The period of immersion was well tolerated. A small but statistically significant decrease in the G level at which LOMA occurred was found following the period of immersion.

11

Eng transl.

BEREGOVKIN, A.V. and V.V. KALINICHENKO. 1974.
Reactions of the cardiovascular system during 30-day simulation of weightlessness by means of antiorthostatic hypokinesia.
Space Biology and Medicine 8(1):106-112.

[Article by A. V. Beregovkin and V. V. Kalinichenko; Moscow, Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina, Russian, Vol 8, No 1, January-February 1974, submitted 19 November 1971, pp 72-77]

Abstract: Cardiovascular reactions of nine healthy male test subjects were investigated during 30-day bedrest with their heads tilted down 4° from the horizontal. Before and after the bedrest experiment the test subjects performed five-minute vertical standing tests. During bedrest tests the subjects exhibited moderate changes in the functional state of the cardiovascular system. The use of preventive measures -- physical exercises, lower body negative pressure and muscle electrostimulation -- had a favorable effect on cardiovascular conditioning. This was suggested by a faster recovery of the functional state of the cardiovascular system after completion of the experiment. Antiorthostatic hypokinesia is an acceptable weightlessness stimulation method in selecting preventive measures of cardiovascular deconditioning.

ACCESS. NO. 19,515 FORM: AUTHOR: DRILL:

BEREGOVKIN, A.V., P.V. BUIANOV, A.V. GALKIN, N.V. PISARENKO, and E.E. SHELUDIAKOV. 1970.
Results of investigations of the cardiovascular system during the aftereffect of 70-day hypodynamia.
In: A.M. Genin and P.A. Sorokin, eds. Problems of Space Biology. Volume 13: Prolonged Limitation of Mobility and its Influence on the Human Organism. Washington, D.C., Scripta Technica, Inc. pp. 227-233. [NASA-TT-F-639].

DOCUMENT NO.: A70-24692
N70-42879

DESCRIPTORS: Circulatory System R/10, EKG BK/34, Exercise GR/61, Human BL/72, Immobilization GR/62, Metabolism GY/13, Pathology GY/66, USSR GR/3 1969.

ABSTRACT:

Discussion of EKGs and hemodynamic tests made on a group of 15 subjects after 70 day exposures to hypodynamia with or without physical exercises and during an orthostatic test. Electrocardiographic studies following exposures indicated changes in the electrocardiac activity and disorders of metabolic processes in the myocardium. The changes observed in the hemodynamic of the subjects indicate disorders in the regulation of the cardiovascular system, and depression of its adaptability to physical loads and orthostatic perturbations. These disorders were more pronounced in the absence of physical exercises. V.Z.

Data on the aftereffect of prolonged hypokinesia are presented and the effectiveness of the preventive measures taken against its unfavorable effects is evaluated on the basis of the stability and degree of the changes in the circulatory system. During 1 to 3 days before the start of the experiment and in the afterperiod until the changes noted had vanished, the subjects were examined by a therapist who used generally accepted clinical methods; electrocardiograms were recorded and hemodynamics was studied by N.N. Savitskiy's method at rest, after measured physical exertion, and during the passive orthostatic test. Electrocardiographic examination during the afterperiod showed a change in the bioelectrical activity of the heart and disturbance of metabolic processes in the myocardium. The hemodynamic changes indicate disturbance of cardiovascular regulation and poor adaptation of the system to physical exertion and orthostatic disturbances. Author

ACCESS. NO. 14,326

FORM: ✓ AUTHOR CARD COMPLETED ✓

13

N69-16916*# California Univ., Davis. Human Performance Lab.
THE EFFECT OF NINE DAYS OF RECUMBENCY, WITH AND WITHOUT EXERCISE, ON THE REDISTRIBUTION OF BODY FLUIDS AND ELECTROLYTES, RENAL FUNCTION AND METABOLISM
E. N. Bernauer and W. C. Adams Nov. 1968 177 p refs
(Grant NGR-05-004-021)
(NASA-CR-73664) Avail. CFSTI CSCL 06S

DOCUMENT SERIES & NO.: N69-16916 (NASA)

DESCRIPTORS: ACTIVITY GR/58, BIOINSTRUMENTATION BK/30, BEDREST GY/39, CIRCULATORY SYSTEM R/10, CONTROL GR/83, DIET GY/35, DESIGN GR/84, EXERCISE GR/61, EXCRETORY SYSTEM R/56, EQUIPMENT GR/86, HUMAN BL/72, INACTIVATION GY/23, KIDNEY R/57, MEASURE P/3, METABOLISM GY/13 PATHOLOGY GY/66, PHYSIOLOGY GY/8, SPACE FLIGHT GR/30, WATER W/77, WEIGHTLESSNESS Y/35.

ABSTRACT: 1968.

A 27 day experiment was designed to study the effects of 9 days of recumbency on the physiological systems related to the redistribution of body fluids, renal function, electrolyte exchange, and metabolism. An effort was made to explore the mechanisms of the pathophysiological changes of these systems which are seen in recumbency, relate them to weightlessness, and to predict the efficacy of procedures employed for future application to space flight. The role of the standardized efficacy bouts of exercise was studied for its effects in attenuating the alterations of the affected physiological systems during bed rest. Ten days of equilibration on a low residue diet of controlled water, electrolyte, and caloric content preceded the 9 days of recumbency. During the bed rest period, four young adult males rode on a bicycle ergometer in the supine position twice daily for 30 minutes, while four other male subjects remained inactive. Position and activity were maintained during the bed rest period. A 7 day ambulatory recovery period, in which pre-bed rest activity patterns were resumed, with ad libitum dietary intake (recorded for each subject), followed bed rest. Measurements taken during the 10 day equilibration period served as baseline comparisons for those taken during bed rest and recovery.

Author

/BONE.

Stanley J. Birge, Jr. and G. Donald Whedon (National Institutes of Health, National Institute of Arthritis and Metabolic Diseases, Bethesda, Md.).

IN: HYPODYNAMICS AND HYPOGRAVICS: THE PHYSIOLOGY OF INACTIVITY AND WEIGHTLESSNESS.
Edited by Michael McCally.
New York, Academic Press, Inc., 1968, p. 213-235. 50 refs.

Brief review of the principal observations presented to date that may assist in understanding the physiological response of the human skeleton to the conditions of hypogravity and hypodynamics to be encountered in future space explorations. It is noted that disuse atrophy of bone has been observed to be clinically associated with varying degrees of immobilization. In addition, experimental animal studies and, particularly, bed-rest studies using normal human volunteer subjects suggest that disuse atrophy may also be an anticipated response of the skeleton to the conditions of hypogravity and hypodynamics of space flights. Although an incomplete simulation of this environment, bed-rest studies have provided a practical and (if properly designed and carefully conducted) a valuable experimental approach to the determination of the skeleton's response to weightlessness.

M. M.

Space Biology and Medicine 1(2): 111-117, 1967.

15

# CHANGE IN WATER-SALT METABOLISM DURING 62-DAY HYPOKINESIA

Ye. N. Biryukov, L. I. Kakurin, G. I. Kozyrevskaya, Yu. S. Koloskova, Z. P. Payek, S. V. Chizhov

pp. 74-79

Kosmicheskaya Biologiya i Meditsina, Vol. 1, No. 2, Moscow, 1967

ABSTRACT. The water-salt metabolism was studied on 6 healthy young men in the 62-day bed-rest experiment. Prior to the experiment they were exposed to accelerations of 13 to 15 g. The diet consumed provided 3000 to 3500 cal/day. The amount of water consumed and urine excreted as well as the diuresis rate were investigated. The electrolytic composition of the blood, urine and feces was determined. The 62-day bed rest resulted in a decrease of water consumption, a change of the diuresis rate and a shift of the electrolytic composition of urine and feces. The changes were of a phasic character. Two periods can be distinguished in the dynamics of water-salt metabolism: the stage of reconstruction covering 3 to 4 weeks and that of a relative stabilization of metabolism at the level adequate to the new conditions. Peculiarities of the shifts revealed in water-salt metabolism indicate the development of dehydration and decalcification.

ACCESS. NO. 1610 BIRKHEAD, N.C. et al. Cardiodynamic and metabolic effects of prolonged bedrest. Final report, Apr. 1962-Apr. 1963. Report no. AMRL-TDR-63-37. Wright-Patterson AFB. Ohio, Biomed. Lab., May 1963. 44 p. 34 Refs.

FORM: _____ AUTHOR CARD COMPLETED ✓

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DOCUMENT SERIES & NO.: N63-19512 (NASA)

DESCRIPTORS: Bedrest GY/39, Circulatory system R/10, Excretory system R/56, Human BL/72, Immobilization GR/62, Metabolism GY/13, Primate BL/69

1963

ABSTRACT:

To evaluate the circulatory and metabolic effects of prolonged inactivity, urinary nitrogen, calcium, and phosphorus excretion were measured in four healthy trained men on a constant diet (2500 cal., 77-gm protein, 74-gm fat, 385-gm CHO, 1724-mg calcium) during 42 days of continuous supine bed rest. Maximum oxygen uptake and hemodynamic response to 70° head-up tilt, and supine bicycle exercise at 3 and 6 times resting $O_2$ uptake levels were determined pre- and post-bed rest. Urinary excretion of calcium and phosphorus increased within the first six days. Calcium excretion reached a peak approximately twice control values after 24 days. No significant change occurred in urinary nitrogen. Tolerance to 70° head-up tilt and physical work capacity decreased following bed rest, but a satisfactory cardiodynamic response to supine exercise was maintained. Physical work capacity returned to near pre-bed-rest values after 18 days of retraining. Author

17

† 14049. BIRKHEAD, N. C., J. J. BLIZZARD, J. W. DALY, G. J. HAUPT, B. ISSEKUTZ, Jr., R. N. MYERS, and K. RODAHL. (Lankenau Hosp., Philadelphia, Penn., USA.) Cardiodynamic and metabolic effects of prolonged bed rest with daily recumbent or sitting exercise and with sitting inactivity. U S AIR FORCE TECH DOC REP [AMRL-TDR-64-61.] 1-28. illus. 1964.--Eight healthy men were studied to evaluate the modifying effects of supine or sitting exercise or quiet sitting on the circulatory and metabolic consequences of prolonged bed rest. They were fed a weighed formula type diet of 2500 calories (78 gm protein, 71 gm fat, 390 gm carbohydrate, and 1.630 gm calcium) thoughout the study. Urinary nitrogen, calcium, and phosphorus excretions were determined from 6-day pooled samples. Four subjects remained at recumbent bed rest for 24 days except for 1 hour daily lying (2 subjects) or sitting (2 subjects) bicycle ergometer exercise, and four subjects remained at recumbent bed rest for 16 hours and sat quietly in a chair for 8 hours daily for 30 days. All subjects underwent physical training for 18 days before and after these periods of inactivity. Just before and after the period of inactivity, the response to 70° head-up body tilt and maximal $O_2$ uptake were determined. One hour daily of lying or sitting exercise prevented the deterioration of physical work capacity previously found during six weeks of bed rest alone. Supine exercise did not prevent the development of tilt intolerance but sitting exercise was effective in one of two subjects. Eight hours daily of quiet sitting added to bed rest resulted in only minor decreases in physical work capacity and maintained tilt tolerance in three of four subjects. Supine or sitting exercise or quiet sitting did not prevent the increased urinary calcium excretion. There was no consistent change in nitrogen balance.

--Authors.

ACCESS. NO. 10,676 FORM: AUTHOR CARD COMPLETED

18

N66-26356# Lankenau Hospital, Philadelphia, Pa.
EFFECT OF EXERCISE, STANDING, NEGATIVE TRUNK AND POSITIVE SKELETAL PRESSURE ON BED REST-INDUCED ORTHOSTASIS AND HYPERCALCIURIA Final Report, Feb. 1964–Jan. 1965
N. C. Birkhead, J. J. Blizzard, B. Issekutz, Jr., and K. Rodahl
Wright-Patterson AFB, Ohio, AMRL, Jan. 1966 36 p refs
(Contract AF 33(615)-1538)
(AMRL-TR-66-6; AD-630921) CFSTI: HC $2.00/MF $0.50

DOCUMENT SERIES & NO.: N66-26356 (NASA)

DESCRIPTORS: Bedrest GY/39, Calcium W/87, Circulatory system R/10, Diet GY/35, Exercise GR/61, Physiology GY/8, Tilting GR/37

ABSTRACT: 1966

Tilt intolerance and hypercalciuria were induced in healthy subjects fed weighed diets by 18–32 days continuous bed rest in a Metabolic Ward. The effect of supplementing bed rest with daily supine bicycle exercise (2 or 4 hours), quiet standing (3 hours), or longitudinal supine skeletal pressure on orthostasis and urinary calcium was determined. Tilt tolerance was evaluated by blood pressure and heart rate response to 10 minutes of 70° head-up body tilt and urinary calcium excretion by analysis of 3- or 6-day urine collections. Supine bicycle exercise was ineffective in significantly reducing tilt intolerance or hypercalciuria. Standing decreased orthostasis in 3 of 5 subjects and decreased urinary calcium in 4 of 5 subjects. Longitudinal skeletal pressure decreased hypercalciuria in 1 of 2 subjects but did not improve tilt tolerance. Intermittent lower body negative pressure during bed rest in one subject impeded development of orthostasis but increased urine calcium. Three hours daily standing is the minimum effective duration for reversing bed rest-induced tilt intolerance and hypercalciuria while supine bicycle exercise is not a practical method for obtaining similar effects. Author (TAB)

13306. BIRKHEAD, NEWTON C., GEORGE J. HAUPT, and RICHARD N. MYERS. (Lankenau Hosp., Philadelphia, Pa., USA.) Effect of prolonged bed rest on cardiodynamics. In: Physiological Society of Philadelphia, October, 1962. Amer. Jour. Med. Sci. 245(1): 118-119. 1963.--Abstract.

Hypodynamic states such as prolonged bed rest have profound effects on the circulatory system which result in transient orthostatic intolerance and decreased exercise capacity. These effects are attributed to decreased sympathetic activity on the arterial and venous components of the circulation. Hemodynamic data supporting this hypothesis are scarce. To study this problem further, observations were made in 4 healthy young men before and after 6 weeks of complete continuous supine bed rest. The subjects were hospitalized in a metabolic ward on a constant measured diet (daily intake 2,500 calories, 78 gm. protein, 71 gm. fat and 388 gm. carbohydrate) throughout the study. After an 18-day conditioning period before and after the 6 weeks of bed rest, maximum aerobic work capacity and exercise pulse response was determined. Immediately before and after bed rest, cardiac catheterization was performed. The circulatory response to 70° head-up body tilt and supine exercise at oxygen consumptions of 3 to 4 and 5 to 6 times resting values were determined. Central venous and peripheral arterial pressures were recorded by strain gage manometers connected to indwelling catheters and cardiac output was measured by the indicator dilution technique. During the post-bed rest study, one subject developed nodal tachycardia which precluded continuing the catheterization. In the other 3 subjects, tolerance to 70° head-up tilt was markedly reduced after bed rest to 3¼, 1½ and ¾ minutes. Although there was inter-individual variation, average increases in cardiac output after 3 minutes of the two levels of supine exercise were 116 and 208% before and 107 and 148% of resting values after bed rest. Heart rate and systolic and diastolic pressures at rest and during exercise were higher in every instance during the post-bed rest study. In spite of this, calculated vascular resistances were not systematically altered by bed rest. Maximum aerobic work capacity and heart rate response to exercise returned to near pre-bed rest values when measured after 18 days of reconditioning. These data indicate that despite prolonged bed rest which resulted in orthostatic intolerance, a satisfactory cardiodynamic response to supine exercise occurred and arterial vasomotor function could be demonstrated. This study provides further evidence implicating decreased venomotor tone as a predominant factor in the circulatory alterations produced by bed rest.

N67-39021 Joint Publications Research Service, Washington, D. C.

CHANGE IN WATER–SALT METABOLISM DURING 62-DAY HYPOKINESIA

Ye. N. Biryukov, L. I. Kakurin, G. I. Kozyrevskaya, Yu. S. Koloskova, Z. P. Payek et al *In its* Space Biol. and Med., Vol. 1, No. 2 18 Sep. 1967 p 111–117 refs (See N67-39005 23-04)

The water–salt metabolism was studied on 6 healthy young men in a 62-day bed-rest experiment. Prior to the experiment they were exposed to accelerations of 13 to 15 g. The diet consumed provided 3000 to 3500 cal/day. The amount of water consumed and urine excreted as well as the diuresis rate were investigated. The electrolytic composition of the blood, urine, and feces was determined. The 62-day bed rest resulted in a decrease of water consumption, a change of the diuresis rate, and a shift of the electrolytic composition of urine and feces. The changes were of a phasic character. Two periods can be distinguished in the dynamics of water–salt metabolism: the stage of reconstruction covering 3 to 4 weeks and that of a relative stabilization of metabolism at the level adequate to the new conditions. Peculiarities of the shifts revealed in water–salt metabolism indicate the development of dehydration and decalcification. Author

21

BLOCKLEY, W.V. and S.L. FRIEDLANDER. 1968.
Preliminary evaluation test of the Langley cardiovascular conditioning suit concept.
Webb Associates, Malibu, California. 70 pages. [NASA-CR-1206].

DOCUMENT SERIES & NO.: N69-13202 (NASA) + BA (50) 56642

DESCRIPTORS: CIRCULATORY SYSTEM R/10, WATER IMMERSION P/24, BEDREST GY/83, HUMAN BL/72, CONTROL GR/83, CLOTHING BK/13, PRESSURIZED SUIT BK/15, DESIGN GR/84, WEIGHTLESSNESS Y/35, TOLERANCE GR/50, EXERCISE GR/61, TILTING GR/37, STIMULATION GY/74, PRESSURE Y/~~29~~ 28 1968.

ABSTRACT:

Two experiments were conducted, each two weeks in duration, in which the same subject spent the major portion of each day immersed in water and the remainder of the time in bed. The man remained completely horizontal except when submerged. In the control experiment, a simple waterproof garment was worn over ordinary long underwear during water immersion; in the second experiment the man was dressed in a specially constructed pressure suit designed to prevent or retard the deconditioning of weightlessness (cardiovascular conditioning suit or CVCS). The cardiovascular conditioning suit successfully prevented the deterioration in orthostatic tolerance, impairment in tolerance for brief mild exercise, and reduction in maximum work capacity which had been observed in the control experiment. During the initial 5 days, when pressurization time in the suit was less than one hour per day, venous compliance increased roughly 2-fold, but had fallen again to the initial value by the morning of the 11th day. Venous compliance appears to be an excellent predictor of tilt-table response. In the experiment in which the CVCS was used there was essentially no difference in venous compliance between pre- and post-exposure, and the tilt responses were the same except for a slight elevation of diastolic pressures during the post-exposure tilt.
Author

22

BLOMQUIST, G., J.H. MITCHELL, and B. SALTIN. 1971.
Effects of bed rest on the oxygen transport system.
In: R.H. Murray and M. McCally, eds. Hypogravic and Hypodynamic Environments.
Washington, D.C., National Aeronautics and Space Administration. pp. 171-186.
[NASA-SP-269].

Current data on circulatory effects of bed rest are discussed against the background of a recent laboratory study dealing with adaptive changes in oxygen transport and body composition after bed rest and after training. In this investigation, maximal oxygen uptake was used as the index of maximal cardiovascular function. Five 19 to 21 year old college students were selected for the study. The investigation was divided into three phases: (1) a short control period; (2) a 3-week bed rest period; and (3) a 2-month physical training period. Identical sets of studies were performed at the end of each period. Results of the three phases are discussed and presented tabularly and graphically. A.L.

BOGACHENKO, V.P. 1970.
State of psychic activity in subjects during prolonged confinement to bed.
In: A.M. Genin and P.A. Sorokin, eds. Problems of Space Biology. Volume 13: Prolonged Limitation of Mobility and its Influence on the Human Organism. Washington, D.C., Scripta Technica, Inc. pp. 170-174. [NASA-TTOF-639].

Distinct changes in psychic state were studied in subjects who were strictly confined to bed and did not perform physical exercises or receive medication during confinement. The changes were less distinct in the group of individuals who performed specially designed physical exercises. In the two series of experiments in which a composite set of prophylactic measures was applied, practically no changes in the psychic state were detected. The decisive factor in the development of the neuropsychic disturbances was forced immobility.
Author

BOHNN, B. J., K. H. HYATT, L. G. KAMENETSKY, B. E. CALDER and W. M. SMITH. *Prevention of bedrest induced orthostatism by 9-alpha-fluorohydrocortisone.* Aerospace Med. 41(5):495-499, 1970.

Eight healthy volunteers were evaluated during two 10-day bedrest periods and two 10-day ambulant periods. Studies were metabolically controlled. Subjects received 0.4 mgm. of 9-alpha-fluorohydrocortisone daily during one bedrest period and an identical placebo during the other. At the end of drug bedrest mean plasma volume was 348 ml. greater than at the end of placebo bedrest. This greater plasma volume resulted in heart rate responses to tilt and exercise and heart rate recoveries from exercise which were similar to pre-recumbency responses. These results suggest that there is a relationship betwen plasma volume decrease during bedrest and the alterations in cardiovascular response to gravitational stimuli and exercise seen following bed-rest.

Brannon, E. W., Rockwood, C. A., and Potts, P.: Prevention of Debilitating Musculoskeletal Disorders; Physiological Conditioning for Prolonged Weightlessness. Aerospace Med. 34: 900, 1963.

No attempt is made to draw definite conclusions from this study; however, the impression is gained that only a small amount of exercise is necessary to preserve muscle integrity and prevent bone rarefaction in the well-conditioned individual. A cyclic regimen of isometric exercises appears ample to counter the detrimental consequences of lengthy bed rest and relative inactivity. This type of exercise would offer a reasonable and practical conditioning program to insure a sound musculoskeletal system when normal activity could not be accomplished during manned space ventures.

It is hoped that this project will stimulate increased efforts by other investigators toward comparative exercise studies. The accumulation of more data is requisite for the intelligent planning of lengthy sojourns in space.

13,101

26

BRIEGLEB, W. 1968.
Biological problems of weightlessness.
In: W. Briegleb, ed. Contributions to Space Biology and Biophysics.
Deutsche Versuchsanstalt fur Luft-und Raumfahrt, Institut fuer Flugmedizin,
Bad Godesberg, West Germany. pp. 25-48.

DOCUMENT SERIES & NO.: N68-27877 (NASA)

DESCRIPTORS: Acceleration Y/1, Animal BL/33, Bedrest GY/39, Ecology W/10, Enivronment Y/58, Free-fall Y/36, Germany GR/5, Human BL/72, Simulation BK/36 Weightlessness Y/35.

ABSTRACT: 1968

Physiological weightlessness effects on human and animal organisms are studied by evaluating environmental ecology factors and free fall aspects, as well as results from simulation studies that included prolonged bed rests, acceleration, and submergence. It is shown that the human body is able to adjust to a weightlessness environment; however, the vasomuscular reflex lost part of its ability to adjust readily to normal hydrostatic pressure immediately after gravity is reinstituted. Orthostatic circulatory resistance in humans to zero gravity seemed less affected by real weightlessness situations than in simulated bed rest or submergence studies.
G.G.

9847. BROWSE, N. L. (Westminster Hosp., London, England.) Effect of bed rest on resting calf blood flow of healthy adult males. Brit. Med. Jour. 62 (5294): 1721-1723. 1962.--Calf blood flow was measured daily in 29 healthy male patients of whom 12 were ambulant and 17 confined to bed. Values were remarkably constant in any one subject, and after walking fell to the resting level after an hour of lying down.
--J. N. Mills.

BROWSE, N.L. The Physiology and Pathology of Bed Rest. Springfield, Ill., Charles C. Thomas. 1965.

BUZNIK, I.M. and S.A. KAMFORINA. 1973.
Elimination of creatinine in the urine during prolonged hypokinesia.
Space Biology and Medicine 7(4):92-99.

[Article by I. M. Buznik and S. A. Kamforina; Moscow, Kosmicheskaya Biologiya i Meditsina, Russian, Vol 7, No 4, July-August 1973, pp 60-64, submitted 7 April 1972]

[Abstract: Elimination of creatinine in the urine was examined in six test subjects exposed to a 94-day bedrest experiment. Three of them performed physical exercises with energy expenditures of 250 Cal/day. Beginning with the second week of hypokinesia the elimination of creatinine with the urine increased. Beginning with the 50th day of the experiment the test subjects who had performed no exercises exhibited a greater increase in elimination. These changes were traced using the CN index (urine creatinine nitrogen : total urine nitrogen × 100). This index is more precise than the creatinine coefficient and the absolute values, reflects changes in creatinine metabolism and can be recommended for their evaluation. An increase in the CN index gives evidence that catabolic processes predominate in the muscle tissue. Physical exercises do not eliminate but alleviate these changes, exerting a normalizing effect on the metabolism. There is a distinct correlation between creatinine excretion, total urine nitrogen and diuresis.]

30

A68-29808
HUMAN ECOLOGY IN SPACE FLIGHT. VOLUME 2 - PROCEEDINGS OF THE SECOND INTERNATIONAL INTERDISCIPLINARY CONFERENCE, PRINCETON, N. J., OCTOBER 11-14, 1964.
Conference sponsored by the Office of Naval Research of the U. S. Navy and NASA.
Edited by D. H. Calloway (California, University, Dept. of Nutritional Sciences, Berkeley, Calif.).
New York, N. Y. Academy of Sciences, 1967. 295 p.
$7.00.

DOCUMENT SERIES & NO.: A68-29808 (IAA)

DESCRIPTORS: Bedrest GY/39, Control GR/83, Ecology W/10, Human BK/72, Muscular system R/53, Nervous system R/48, Proceedings GR/26, Simulation BK/36, Skeletal system R/27 Space environment GR/17, Space flight GR/30, Temperature Y/25

ABSTRACT:

1967

CONTENTS:

PREFACE. W. O. Fenn (Rochester, University, Rochester, N. Y.), p. 9.
INTRODUCTORY REMARKS. Frank Fremont-Smith (New York Academy of Sciences, New York, N. Y.), p. 11, 12.
RESPONSE TO THE SPACE ENVIRONMENT AND ITS SIMULATION BY BEDREST. Siegfried J. Gerathewohl (NASA, In-Flight Science Branch, Washington, D. C.) and Pauline B. Mack (Texas Woman's University, Denton, Tex.), p. 13-81. [See A68-29809 14-04]
PSYCHOLOGICAL AND NEUROMUSCULAR PROBLEMS ARISING FROM PROLONGED INACTIVITY. Robert B. Livingston (National Institutes of Health, Bethesda, Md.), p. 82-108. [See A68-29810 14-04]
BONE-BODY FLUID CONTINUUM AS INFLUENCED BY PROLONGED INACTIVITY. Marshall R. Urist (California, University, Los Angeles, Calif.), p. 109-223. [See A68-29811 14-04]
ENERGY RESERVES, WATER AND TEMPERATURE CONTROL IN MINIMAL ENVIRONMENT. David Schwarz (Schwarz Bio-Research, Inc., Orangeburg, N. Y.) and Sheldon Margen (California, University, Berkeley, Calif.), p. 224-262. [See A68-29812 14-04]
SUMMARY. W. O. Fenn (Rochester, University, Rochester, N. Y.), p. 263-279.
REFERENCES, p. 280-290.
INDEX, p. 291-298.

N65-20472*# Texas Inst. for Rehabilitation and Research, Houston.

THE EFFECT OF BEDREST ON VARIOUS PARAMETERS OF PHYSIOLOGICAL FUNCTION. PART VII: CARDIAC AND VENTILATORY RESPONSE TO THE BICYCLE ERGOMETER TEST

D. Cardus, W. A. Spencer, C. Vallbona, and F. B. Vogt Washington, NASA, Apr. 1965 22 p refs

(Contract NAS9-1461)

(NASA-CR-177) CFSTI: HC $1.00/MF $0.50

A study on effects of 14 days bed rest on tolerance to physical work was carried out on 6 healthy subjects. Tolerance was tested with the bicycle ergometer. Oxygen consumption, $CO_2$ production, pulmonary ventilation, breaths per minute, and frequency of the heart at different work loads, and recovery time of heart rate after cessation of exercise were measured. Results indicate that changes observed after 14 days bed rest in respiratory gas exchange, ventilation, and mechanical efficiency were not significant; heart rate at rest and during exercise was significantly higher after 14-days bed rest. Isometric exercises carried out in a second 14-day bed rest period did not completely prevent the observed changes in heart rate.

Author

N65-21738*# Texas Inst. for Rehabilitation and Research, Houston.

THE EFFECT OF BEDREST ON VARIOUS PARAMETERS OF PHYSIOLOGICAL FUNCTION. PART XIV: EFFECT OF BEDREST ON PLASMA LEVELS AND URINARY EXCRETION OF 17-HYDROXYCORTICOSTEROIDS

D. Cardus, C. Vailbona, F. B. Vogt, W. A. Spencer, H. S. Lipscomb et al Washington, NASA, Apr. 1965 17 p refs (Contract NAS9-1461)

(NASA-CR-184) CFSTI: HC $1.00/MF $0.50

Plasma levels of 17-hydroxycorticosteroids at 0800, 1200, 1600, 2000 and 2400 hours were determined on six healthy subjects who were submitted to bedrest for 3 days. The determinations were made with a modification of the Peterson method and the Porter-Silber technique. During bedrest the peak level at 0800 seemed a little lower than normal, but the circadian rhythm of 17-hydroxycorticosteroids was not modified. During bedrest and isometric exercises, the rhythm and the levels of 17-hydroxycorticosteroids were normal. Relatively short periods of physical inactivity seem to have no effect on the circadian rhythm of 17-hydroxycorticosteroids. Author

**A67-10949 ***

EFFECTS OF 10 DAYS RECUMBENCY ON THE RESPONSE TO THE BICYCLE ERGOMETER TEST.

David Cardus (Texas Institute for Rehabilitation and Research, and Baylor University, College of Medicine, Texas Medical Center, Houston, Tex.).

Aerospace Medicine, vol. 37, Oct. 1966, p. 993-999. 10 refs.
Contract No. NAS 9-1461.

Eleven healthy men were subjected to three periods of 10-days bed recumbency with intervening 3-week periods of normal activities. In one of the bed recumbency periods, they were subjected to bed rest alone. In another period, half of the subjects followed a program of muscular exercises with limited movement and the other half a program of intermittent venous occlusion in the lower extremities. In the third bed recumbency period, the treatments were switched. Bicycle ergometer tests were conducted before and after bed recumbency periods. Heart rate, pulmonary ventilation and metabolic gas exchange measurements were done at different work load levels. After bed recumbency the heart rate at rest and during exercise was higher than before bed recumbency. The oxygen intake at the heart rate of 160 was diminished after bed recumbency. No changes were observed in pulmonary ventilation, frequency of breathing and mechanical efficiency. The effect of muscular exercises and intermittent venous occlusion as preventive treatments for the altered heart rate response observed after bed recumbency seemed to be different for the two groups of subjects. Possible interpretations of this observation are discussed. (Author)

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A65-26168

INFLUENCE OF BEDREST ON PLASMA LEVELS OF 17-HYDROXY-CORTICOSTEROIDS.

David Cardus, Carlos Vallbona, Fred B. Vogt, William A. Spencer, Harry S. Lipscomb, and Kristen B. Eik-Nes (Baylor University, College of Medicine, Dept. of Rehabilitation, Dept. of Physiology, and Dept. of Pediatrics; Texas Institute for Rehabilitation and Research, Houston, Tex.; Utah, University, College of Medicine, Dept. of Biological Chemistry, Salt Lake City, Utah).

Aerospace Medicine, vol. 36, June 1965, p. 524-528. 12 refs.
Contracts No. NAS 9-1461; No. NAS 9-1294.

Determination of plasma levels of 17-hydroxycorticosteroids at 0800, 1200, 1600, 2000, and 2400 hr on six healthy subjects who were submitted to two three-day periods of bed rest. During the first period the subjects were in bed rest only. During the second a program of isometric exercises was added. The determinations of 17-hydroxycorticosteroids in plasma were made with a modification of the Peterson method and the Porter-Silber technique. During bed rest the peak level at 0800 seemed a little lower than the peak values observed while the subjects were ambulatory, but the difference was not statistically significant. Rest did not modify the circadian rhythm of 17-hydroxycorticosteroids in plasma. During the period that isometric exercises were added to bed rest the rhythm and the levels of 17-hydroxycorticosteroids were normal. One to two days' bed rest has no effect on the circadian rhythm of 17-hydroxycorticosteroids.

(Author) F.R.L.

35

N67-18953*# Texas Inst. for Rehabilitation and Research, Houston.
A STUDY OF THE POSSIBLE PREVENTIVE EFFECTS OF MUSCULAR EXERCISES AND INTERMITTENT VENOUS OCCLUSION ON THE CARDIOVASCULAR DECONDITIONING OBSERVED AFTER 10 DAYS BED RECUMBENCY: EXPERIMENTAL DESIGN

David Cardus, Willis C. Beasley, and Fred B. Vogt Washington, NASA, Feb. 1967 173 p refs
(Contract NAS9-1461)
(NASA-CR-692) CFSTI: HC $3.00/MF $0.65 CSCL 06S

An experimental program designed to study the efficacity of exercise and/or intermittent leg cuff inflation in preventing cardiovascular deconditioning is described. Consideration is given to the experimental subjects participating in the study, the planning and conditions of the experiments, the methods and techniques of physiological and psychological testing, and the general procedure of data handling.

A.G.O.

ACCESS. NO. 12,109 FORM: AUTHOR CARD COMPLETED

Sheff

36

CARIS, T.N. 1967.
Hypodynamics: Cardiovascular aspects.
In: Lectures in Aerospace Medicine, 6th Series, School of Aerospace Medicine, Brooks Air Force Base, Texas. pp. 233-239.

DOCUMENT SERIES & NO.: N68-20557 (NASA)

DESCRIPTORS: Bedrest GY/39, Chemical W/29, Circulatory system R/10, Endocrine system R/65, Human BL/72, Immobilization GR/62, Physiology GY/8, Space flight GR/30, Water Immersion P/24,

ABSTRACT: 1967

Changes in the cardiovascular regulatory mechanism during orbital flight, prolonged bed rest, or total body water immersion are used to explain the orthostatic postural intolerance that some pilots exhibit after assuming an erect posture. If man is maintained in a recumbent position, the hydrostatic column of blood due to gravity shortens considerably by a shift from the lower extremities to the rest of the body, primarily into the vascular beds within the chest. Thus, increasing amounts of sodium and water are excreted until the shifted fluid is eliminated and the increased circulating blood volume results in increased filling of the heart chambers and inhibition of the normal antodiuretic hormone by the pituitary gland. Exposure of the lower half of the body to negative pressures for two or three days after prolonged bed rest results in plasma volume repletion and complete tolerance to orthostasis. G.G.

37

A67-16283

INDEPENDENCE OF CHANGES IN FUNCTIONAL AND PERFORMANCE CAPACITIES ATTENDING PROLONGED BED REST.

G. A. Chase, C. Grave (Boeing Co., Aerospace Group, Space Div.; Washington, University, Dept. of Medicine, Seattle, Wash.), and L. B. Rowell (Washington, University, Dept. of Medicine, Seattle, Wash.).

Aerospace Medicine, vol. 37, Dec. 1966, p. 1232-1238. 37 refs.

Eighteen young men were studied before and after 15 and 30 days bed rest to examine the effects of absolute bed rest and recumbent exercise during bed rest on the pulse rate response to submaximal work, cardiovascular functional capacity (max $\dot{V}_{O_2}$), physical work capacity, and orthostatic tolerance. Changes in the submaximal pulse rate as a result of the conditions of this study did not predict the trend in either work capacity or max $\dot{V}_{O_2}$, whereas changes in work capacity occurred independently of changes in max $\dot{V}_{O_2}$ and vice versa. The highest $\dot{V}_{O_2}$ attainable during exercise to exhaustion on a bicycle ergometer underestimated max $\dot{V}_{O_2}$ 4 to 23%. When recumbent exercise was carried out during bed rest, the difference in the highest $\dot{V}_{O_2}$ attainable on a bicycle ergometer and the max $\dot{V}_{O_2}$ was decreased after bed rest by an increment in $\dot{V}_{O_2}$ during the bicycle test. Unless max $\dot{V}_{O_2}$ was increased during bed rest, subjects had decreased adaptability to posture afterward. (Author)

CHAZOV, Ye.I. and V.G. ANANCHENKO. 1964.
The status of anticoagulating mechanisms under conditions of prolonged hypokineses. In: V.V. Parin, ed. Aviation and Space Medicine. Washington, D.C., National Aeronautics and Space Administration. pp. 414-415.

To judge the effect of hypokinesis on anticoagulation capacities of the organism, researchers studied the content of free heparin in the blood, the fibrinolytic activity of the blood, the plasma heparin tolerance, and thromboelasticity. In the first series, studies were carried out before and after a 3-day period under hypokinesic conditions. Three of the four subjects did not show any regularity in changes of state of the thrombus-forming properties of the blood. More regular changes were obtained in the second series of investigations with prolonged hypokinesic states, when four subjects were in a state of prolonged rest for a period of 20 days. It was found that prolonged hypokinesis in healthy persons leads to an increase in the anticoagulating and lytic properties of the blood, which lessens the possibilities for thrombus formation. In the third series, four subjects also remained on a prolonged bedrest regime, but systematically carried out a complex of definite physical exercises. No increase was noticed in the fibrinolytic activity of the blood and in the content of free heparin.

R.L.K.

ACCESS. NO. 22,204 FORM: AUTHOR: NP DRILL:

39

N70-39216# Joint Publications Research Service, Washington, D.C.
EFFECT OF A REDUCED DIET AND HYPOKINESIA ON HUMAN TOLERANCE TO STATIC LOADS
M. A. Cherepakhin *In its* Space Biol. and Med., Vol. 4, No. 3, 1970 4 Sep. 1970 p 103–110 refs (See N70-39201 22-04)
Avail: NTIS

JPRS 51315

DOCUMENT NO.: N70-39216

ACCESS. NO. 23,628 FORM: AUTHOR: NP DRILL:

A70-40198 # Effect of reduced diet and hypokinesia on the human tolerance to static loads (Vliianie ponizhennogo ratsiona pitaniia i ogranicheniia dvigatel'noi aktivnosti na vynoslivost' cheloveka k staticheskim napriazheniiam). M. A. Cherepakhin. *Kosmicheskaia Biologiia i Meditsina*, vol. 4, May-June 1970, p. 67-72. 21 refs. In Russian.

DOCUMENT NO.: A70-40198

DESCRIPTORS: Acceleration Y-1, Bedrest GY-39, Clothing BK-13, Diet GY-35, Human BL-72, Immobilization GR-62, Nutrition GY-34, Tolerance GR-50, USSR GR-3.

1970.

ABSTRACT:

Three series of 15 day experiments were conducted using 18 test subjects at the age of 24-37. In all experiments lyophilized products were used that supplied a calorie value of 1800 Kcal/day. In the first experimental series the test subjects performed normal motor activities; in the second series they were kept in bed; and in the third series they remained in bed being exposed to chest-to-back accelerations of 8g for 120 sec before and after the experiment. The above nutrition pattern did not affect human tolerance to static loads, if motor activity remained normal. This nutrition adversely affected the tolerance in the case of bed rest. The human tolerance to accelerations can be assayed and predicted, using provocative static tests that can be performed in small chambers, bed, fixed position, and pressure suit. (Author)

40

N68-33918# Joint Publications Research Service, Washington.

CHEREPAKHIN, M.A. 1968.
Effect of prolonged bedrest on muscle tone and proprioceptive reflexes in man.
Space Biology and Medicine 2(3):64-72.

A 62-day experiment was carried out to study the effect of prolonged bedrest and physical exercises on the muscle tone and proprioceptive reflexes in man. One group of test subjects performed physical exercises in a prone position. The exercises were performed for 2 1/2 hours daily with an intensity 600-1,200 kgm/min. The prolonged bedrest experiment reduced the muscle tone in the test subjects, particularly in those who performed no physical exercises. The decrease in muscle tone produced no effect on the proprioceptive reflexes, their latent periods being dependent on the length of the reflex path. Author

41

CHEREPAKHIN, M.A. 1968.
Normalization of physiological functions during bed rest by means of physical exercises.
Space Biology and Medicine 2(1):52-59.

Eng transl.

ABSTRACT. The paper describes measures taken to normalize the physiological functions of humans during a 62-day period of bed rest. Two series of experiments were conducted. During the first series, the test subjects adhered strictly to bed rest, while during the second series they performed 2-1/2 hours of physical exercise per day in the recumbent position, with an intensity of 600-1200 kgm/min. The experiments indicated a favorable effect of the physical exercises on acceleration tolerance, orthostatic tolerance, bone density and immunobiological resistance of the organism.

ACCESS. NO. 11,966

FORM: NL AUTHOR CARD COMPLETED ✓

A68-27188 #
NORMALIZATION OF PHYSIOLOGICAL FUNCTIONS UNDER CONDITIONS OF HYPOKINESIA BY A METHOD OF COMPENSATING THE MUSCULAR ACTIVITY DEFICIT [K VOPROSU O NORMALIZATSII FIZIOLOGICHESKIKH FUNKTSII V USLOVIIAKH GIPOKINEZII METODOM VOSPOLNENIIA DEFITSITA MYSHECHNOI AKTIVNOSTI].
M. A. Cherepakhin.
Kosmicheskaia Biologiia i Meditsina, vol. 2, Jan.-Feb. 1968, p. 37-42. 13 refs. In Russian.

DOCUMENT SERIES & NO.: A68-27188 (IAA)
Transl. JPRS: 45,483

DESCRIPTORS: Bedrest GY/39, Exercise GR/61, Human BL/72, Immobilization GR/62, Physiology GY/8, USSR GR/3

ABSTRACT: FOR SEE 1968

Description of experiments in which a group of 6 healthy male subjects confined to 62-day bed rest, performed daily 2.5-hr physical exercises by stretching rubber braids in various prone positions in an attempt to make up for the absence of normal muscular activity. The positive effect of these exercises on the resistance to orthostatic and dynamic loads, on the muscular system of the brachial girdle, on the acceleration endurance, and on the immunological properties of the organism is noted. V.Z.

FOR 11965 SEE 25133

A67-29102

CARDIOVASCULAR STUDIES DURING AND FOLLOWING SIMULATION AND WEIGHTLESSNESS.

Loren D. Carlson (Kentucky, University, Dept. of Physiology and Biophysics, Lexington, Ky.).

IN: LIFE SCIENCES AND SPACE RESEARCH V; INTERNATIONAL SPACE SCIENCE SYMPOSIUM, 7TH, VIENNA, AUSTRIA, MAY 10-18, 1966, PAPERS. [A67-29096 15-04]

Symposium sponsored by the Committee on Space Research, the International Union of Biochemistry, the International Union of Biological Sciences, and the International Union of Physiological Sciences.

Edited by A. H. Brown and F. G. Favorite.

Amsterdam, North-Holland Publishing Co., 1967. p. 51-54. 6 refs.

Evaluation of the extent to which the simulation of weightlessness by bed rest and water immersion appears valid. The simulation of weightlessness is compared with the actual state, and it is found that major differences occur in the recovery time of the tilt response and in the extent to which venous filling occurs during a tilt. The application of lower body negative pressure during bed rest is the only measure which seems to have positive results in preventing post-simulation orthostatic intolerance.

B.B.

N68-17734*# California Univ., Davis.
PERIPHERAL VOLUME MEASUREMENTS AS INDICES OF PERIPHERAL CIRCULATORY FACTORS IN THE CARDIOVASCULAR ORTHOSTATIC RESPONSE Final Report
Loren D. Carlson [1967] 183 p refs
(Grant NGR-05-004-026)
(NASA-CR-93247) CFSTI: HC $3.00/MF $0.65 CSCL 06P

Three techniques of measuring changes in limb volume were evaluated: (1) limb circumference changes by a resistance transducer, (2) limb volume change by capacitance measurement, and (3) limb volume change by impedance measurement. None of the techniques seem qualified for in-flight use. Each must be used with great care in controlled laboratory experiments. Data obtained from their use with tilt table or negative pressure devices were tentative due to the possibilities of artifact. A bedrest study was conducted to evaluate the cardiovascular function following bedrest. Metabolic balance, basal and work metabolisms, fluid spaces, body composition, strength, renal function, and blood and urine composition were measured. Heart rate and blood pressure served as reference and comparative values for other tests. Both heart rates and blood pressures were higher in the evening than in the morning and neither differed in response to tilt at the two times. Negative pressure tests showed changes in heart rate and blood pressure that were similar to the tilt tests, but to a lesser degree. Leg volume increases were greater following bedrest. R.N.A.

44

N69-31943*# California Univ., Berkeley.

PERIPHERAL VOLUME MEASUREMENTS AS INDICES OF PERIPHERAL CIRCULATORY FACTORS IN THE CARDIOVASCULAR ORTHOSTATIC RESPONSE

Loren D. Carlson, Richard F. Walters, Stephen J. Bartok, Steven H. Weinberg, Dennis C. Lindberg et al [1968] 192 p refs

(Grant NGR-05-004-026)

(NASA-CR-101812) Avail: CFSTI CSCL 06P

Non-invasive techniques for measuring changes in limb volume and the application of these techniques in assessing the deconditioning caused by bedrest were evaluated. This involved blood flow measurements by venous occlusion plethysmography and the following three techniques: (1) limb circumference changes measured by a resistance transducer; (2) limb volume changes by capacitance measurements; and (3) limb volume changes by impedance measurement. The bedrest study was conducted with ten subjects in conjunction with a medical examination which covered metabolic balance, basal metabolism, work metabolism, fluid spaces, body composition, strength tests, renal function, and composition of blood and urine. Results in the present study reflect the cardiovascular function of the subjects following bedrest. Heart rate and blood pressure served as a reference and comparative values for other tests. The tests involved various cycles of bedrest, activities, negative pressure runs, and periods of rest on tilt tables.

K.W.

/ 45

ACCESS CHASE, G., C. GRAVE, J. GOODE, and G. GRAHAM. 1966. ED✓
Development of a device for physical conditioning during weightlessness.
In: Proceedings of the Interdisciplinary Symposium on Apollo Application Programs. 12-13 January 1966. National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Alabama. pp. 241-248. [NASA-TM-X-53558].

DOCUMENT SERIES & NO.: N67-24279 (NASA)

DESCRIPTORS: Astronaut BK/2, Bedrest GY/39, Equipment GR/86, Exercise GR/61, Proceedings GR/26, Simulation BK/36, Weightlessness Y/35

ABSTRACT: 1966

Reported are laboratory and engineering design studies of an exercise device for maintaining the functional integrity and physical well being of astronauts during exposure to a weightless environment. The device, which resembles a double trampoline, was designed for testing in an experimental simulation (bed rest) of the zero-g environment. It provides conditioning for the muscular, skeletal, and cardiovascular system by imparting cyclic, pulsatile accelerations along the long axis of the body. A runner-mounted carrier supports the subject in a face-up, horizontal position and is free to move back and forth between two vertical, opposed trampolines. The subject oscillates by bouncing between the trampolines over a distance necessary to develop the desired acceleration-time profile. Preliminary implications of laboratory studies, and details of machine construction are included. Also included is a concept for a lightweight model for eventual application in a space station. It is suggested that the trampoline device be tested and analyzed along with other methods for preventing deconditioning of the astronaut. S.C.W.

COOPER, K.H., and J.W. ORD. 1968.
Physical effects of seated and supine exercise with and without subatmospheric pressure applied to the lower body.
Aerospace Medicine 39(5):481-484.

Eight subjects were evaluated on a bicycle ergometer once a week for four weeks in both the upright and the supine position, with and without the addition of -30 mm. Hg lower body negative pressure. Upright ergometry without negative pressure was associated with the highest maximum oxygen consumption, whereas upright exercise with negative pressure and supine exercise with and without negative pressure were remarkably comparable. The cardiovascular response during submaximal upright exercise with negative pressure resembled that seen after physical deconditioning. This difference was not as apparent at maximum performance. These results indicate that in an earth environment the integration of LBNP with upright exercise provides an overload phenomenon that may be used to accelerate a cardiovascular conditioning response. In space, the mechanics of exercise might be facilitated, a good cardiovascular conditioning device could be provided, and a means of orthostatic stress testing would be available.

Cuthbertson, D. P.: The Influence of Prolonged Muscular Rest on Metabolism. Biochem. 23: 1328, 1929.

Cuthbertson[1] conducted one of the first studies of the effects of prolonged bedrest in healthy human subjects in 1929. He kept eight subjects (six men and two women) on bedrest for periods ranging from 9 to 12 days. His observations, mainly metabolic, included a loss of sulphur, nitrogen, phosphorus and calcium (to a lesser degree) during bedrest. He did not comment on the increased urinary output of the subjects during bedrest, but he reported the values of 24-hour urine in three of his experiments. These values indicate a significant increase in urinary output, especially at the beginning of bedrest. The metabolic changes were more profound at the initial stages of bedrest and they seemed to level off as bedrest continues. This was especially evident in calcium losses. He attributed the losses of metabolic products to the decreased activity of the musculoskeletal system and stated clearly the need for studies of longer duration to obtain clear cut trends of the changes observed.

48

Eng transl

DEGTYAREV, V.A., A.D. VOSKRESENSKIY, N.D. KALMYKOVA, and Z.A. KIRILLOVA. 1974.
Functional test with decompression of the lower body in thirty-day antiorthostatic hypokinesia.
Space Biology and Medicine 8(1):88-92.

[Article by V. A. Degtyarev, A. D. Voskresenskiy, N. D. Kalmykova, and Z. A. Kirillova; Moscow, Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina, Russian, Vol 8, No 1, January-February 1974, submitted 19 November 1971, pp 61-65]

Abstract: During a 30-day hypokinetic experiment nine test subjects underwent functional tests with LBNP applied at -35 and -45 mm Hg for ten minutes. Subjectively they tolerated the tests well. Cardiovascular responses were similar to orthostatic responses but less pronounced. During hypokinesia the response to the tests increased. A statistical analysis of the relationship between the heart rate and integral evaluations revealed a correlation between responses to LBNP of -45 mm Hg and the orthostatic load ($r = 0.71$). This indicates the possibility of predicting orthostatic reactions on the basis of LBNP tests.

Deitrick, J. E., Whedon, G. D., and Shorr, E.: The Effects of Immobilization on Various Metabolic and Physiologic Functions of Normal Men. Amer. J. Med. 4: 3, 1948.


SUMMARY

A study of the effects of immobilization upon various metabolic and physiologic functions of four normal, healthy, young men was carried out on a metabolism ward during control (five to seven weeks), immobilization (six to seven weeks) and recovery (four to six weeks) periods. Throughout the study, dietary intake was kept constant. During the immobilization period the subjects were placed in bi-valved plaster casts extending from the umbilicus to the toes.

1. Nitrogen excretion began to increase on the fifth to sixth day of immobilization and reached its peak during the first half of the second week. Total nitrogen losses ranged from 29.8 to 83.6 Gm., and averaged 53.6 Gm.

2. Both urinary and fecal calcium excretion increased during immobilization, maximum excretion being reached by the fourth to fifth week. Total calcium losses ranged from 9 to 23.9 Gm. The calcium content of the urine was doubled during immobilization. The absence of appreciable increase in urine volume, the slight rise in urinary pH and the failure of urinary citric acid to rise parallel with the increase in calcium would all favor the precipitation of calcium phosphate in the urinary tract. A slight elevation in serum calcium levels occurred at the end of the immobilization period.

3. During immobilization there was an increase in the excretion of phosphorus, total sulfur, sodium and potassium. Total sulfur was excreted in the urine in close correlation from week to week with urinary nitrogen in the ratio in which these elements exist in muscle protoplasm: The changes in phosphorus excretion showed moderately good correlation with the changes in nitrogen and calcium excretion.

4. During recovery there was retention of nitrogen, calcium, phosphorus, sulfur and potassium. The recovery or return to control levels of metabolic functions was slow, retention of nitrogen and phosphorus continuing for six weeks. Re-stabilization of calcium metabolism appeared to require more than six weeks.

5. Although creatine and creatinine excretion remained fairly constant, there was a definite lowering of creatine tolerance during immobilization. This impairment in creatine metabolism was accompanied by a significant decrease in muscle mass and muscle strength in the immobilized limbs.

6. In only one subject was there a significant lowering of 17-ketosteroid excretion during immobilization; this subject also experienced the largest nitrogen losses.

7. The decline in basal metabolic rate during immobilization averaged 6.9 per cent among the four subjects.

8. Immobilization brought about a deterioration in the mechanisms essential for adequate circulation in the erect position as indicated by an increased tendency to faint in tilt table tests. Experiments indicated that the legs were the principal site of changes responsible for this deterioration and suggested that increased venous engorgement, increased extravascular fluid, capillary fragility and impaired venous or muscle tone play a rôle.

9. Other circulaotry changes brought about by immobilization were a decline in total blood volume averaging 5.4 per cent, marked decreases in exercise tolerance as measured by Master and Schneider tests and an increase in the resting pulse rate of 3.8 beats per minute during immobilization, followed by an additional increase of 4.7 beats per minute during the first three weeks of recovery.

10. The recovery or return to control levels of most physiologic functions required three to four weeks; exercise tolerance and leg girth required four to six weeks and the reclining pulse rate more than six weeks.

11. Changes in body weight during immobilization were small, probably as a result of the simultaneous loss of muscle protoplasm and storage of fat or carbohydrate.

12. There were no significant changes due to immobilization in blood coagulation studies, blood circulation time, heart size, electrocardiograms, resting arterial blood pressure, hematocrits, blood counts, vital capacity, maximum ventilation capacity or breath-holding.

DI GIOVANNI, C., JR., and BIRKHEAD, N. C. Effect of minimal dehydration on orthostatic tolerance following short-term bed rest. Aerosp. Med. 35:225-228. Mar. 1964. 10 Refs.

DOCUMENT SERIES & NO.: A64-80271 (IAA) 50

DESCRIPTORS: Bed rest GY/39, Immobilization GR/62, Temperature Y/25

ABSTRACT: 1964

A healthy subject was exposed to 48-hour bed rest periods under conditions of comfortable temperature and fluid ad libitum, comfortable temperature and restricted fluid, heat, and fluid ad libitum, and a 26-hour period of heat combined with restriction of fluid. Minimal dehydration was achieved. Seventy-degree tilt was tolerated for 10 minutes following all bed-rest periods, except the 26-hour period of combined heat and dehydration at the end of which presyncope developed by the eighth minute of tilt. This study suggests the need for well-controlled, multiple stress studies to maximize potential application to manned space flight.

1097

FORM: _____ AUTHOR CARD COMPLETED ✓

DI GIOVANNI, C., AND CHAMBERS, R.M. Psychophysiological aspects of reduced gravity fields. Report no. 6. Johnsville, Pa., Naval Air Develop. Center, Aviation Med. Accel, Lab., Dec. 30, 1963. 25 p. Refs.

DOCUMENT SERIES & NO.:

N64-15753 (NASA)

51

DESCRIPTORS:

Bedrest GY/39, Physiology GY/8, Psychology GY/68,
Water immersion P/24, Weightlessness Y/35

ABSTRACT:

1963

Considerable data have been collected concerning acceleration physiology from centrifuge, rocket sled, and drop tower studies but weightlessness has remained a poorly understood environment primarily because there is no way to duplicate it on earth. This report considers the various methods used to study or approximate the subgravity state, and the results and extrapolations that have been drawn from them. The cardiovascular and musculoskeletal aspects of recent bed-rest and water-immersion studies are examined, and results are compared with the data from actual space flights. Real weightlessness apparently has been an innocuous environment thus far, and the only factor of concern has been a tendency toward postural hypotension detected immediately following recovery after missions of 9 and 34 hours. As longer missions are achieved, other problems, such as muscle atrophy and excessive calcium mobilization, may appear. Author

TASK NUMBER: 970-51-17-02

CITATION: DONALDSON, C.L., S.B. HULLEY, J.M. VOGEL, R.S. HATTNER, J.H. BAYERS and D.E. MCMILLAN. Effect of prolonged bed rest on bone mineral. *Metabolism* 19(12):1071-1084. December 1970.

PERFORMING INSTITUTION: USPHS Hospital, San Francisco, California

KIND OF DOCUMENT: Research Report

SUBJECTS: 3 healthy adult males

| RES. OBJECT. | METHOD | RESULTS | CONCLUSIONS |
|---|---|---|---|
| To examine rates of bone mineral loss that might be seen during prolonged bed rest and establish whether bone dissolution occurs to a greater extent in weightbearing bones. | Ss were restricted to complete bed rest for 30-36 weeks. Balance data obtained during bed rest were compared to those of 3-week ambulatory periods pre- and post bed rest. Ss ate special diets on raised elbows, were not allowed to sit up or dangle their legs, and performed defecation and micturition while supine. Serum collections were made weekly. Stool and urine were collected daily and 48 hour sweat collections were made. Ca was determined by atomic absorption spectrometry. Phosphorus was analyzed by a Technicon Autoanalyzer, using standards adjusted to the pH of samples. N, Na, K and Mg balance data were obtained as well as psychiatric, biometric and fluid compartment analyses. | Urinary Ca excretion was elevated throughout bed rest, averaging 61 mg/day above the base line value of 193 mg/day. Maximum excretion topped the base line value by as much as 136 mg/day. Measured Ca loss during the entire bed rest period averaged 4.2% of estimated total body Ca, comparing well with previous studies indicating a .4%-.6% loss/month. P patterns in urine and body balance were similar to Ca patterns. Serum levels of both minerals revealed little appreciable change during bed rest but significant drops during reambulation. Gamma ray transmission scanning of the oscalcis revealed decreased mass in the central portion of the bone ranging from 25%-45%. Reambulation reversed mineral loss speedily. | Bone dissolution during bed rest may occur to a greater extent in weightbearing bones than in the remainder of the skeleton and the process appears to be reversible. The best explanation for disuse ostopenia, or rest-induced bone mineral loss, remains the absence of pressure forces on the skeleton and the possible alteration of piezoelectric forces within the bone. |

N70-25205*# Public Health Service Hospital, San Francisco, Calif. Metabolic Unit.

THE EFFECT OF PROLONGED SIMULATED NON-GRAVITATIONAL ENVIRONMENT ON MINERAL BALANCE IN THE ADULT MALE, VOLUME 1 Final Report

Charles L. Donaldson, Stephen B. Hulley, Donald E. McMillan, Robert S. Hattner, and Jon H. Bayers [1970] 91 p refs

(NASA Order T-58941)

(NASA-CR-108314) Avail: CFSTI CSCL 06S

Three healthy adult males were restricted to complete bed rest for periods of 30 to 36 weeks; freedom of movement in the horizontal plane was permitted. Tests conducted are described and results are reported. Findings include: (1) Urinary calcium excretion was elevated throughout bed rest, averaging 67 mg/day above the baseline value of 193 mg/day. Mean peak excretion occurred during the 7th week and was 136 mg/day above the baseline value. (2) Mean calcium balance during bed rest ranged from 200 to 256 mg/day for the three subjects. This represents an estimated loss of 0.5 to 5.5 percent of the skeleton. (3) Recovery of calcaneus mineral to values above the initial (3 month) level was observed 5 - 10 months following reambulation; disuse osteopenia therefore may be reversible. (4) Serum parathyroid hormone concentration increased during bed rest and achieved levels compatible with hyperparathyroidism in all three subjects. (5) Clinical evaluation revealed no major morbidity during bed rest. During reambulation the soles of the feet were tender for 3 - 4 weeks and easy fatigability was subjectively noted for 4 - 6 months. Author

N70-25206*# Public Health Service Hospital, San Francisco, Calif. Metabolic Unit

THE EFFECT OF PROLONGED SIMULATED NON-GRAVITATIONAL ENVIRONMENT ON MINERAL BALANCE IN THE ADULT MALE, VOLUME 2 Final Report

[1970] 58 p

(NASA Order T-58941)

(NASA-CR-108315) Avail: CFSTI CSCL 06S

Additional data in tabular and graphical form are presented in support of the study on the effect of prolonged simulated non-gravitational environment on mineral balance in the adult male.

DONALDSON, C.L., D.E. MCMILLAN, S.B. HULLEY, R.S. HATTNER, and J.H. BAYERS. 1971.
The effects of long-term bed rest on mineral metabolism.
In: R.H. Murray and M. McCally, eds. Hypogravic and Hypodynamic Environments. Washington, D.C., National Aeronautics and Space Administration. pp. 249-260. [NASA-SP-269].

This study was initiated to determine the effect of long term bed rest on mineral balance and bone density in normal individuals. Three healthy male volunteers were studied during 4 weeks of ambulation, 30 to 36 weeks at rest in bed, and another 4 weeks of ambulation after bed rest. They were maintained on a diet of 2100 calories with 903 mg calcium and 1386 mg phosphorus-throughout ambulation and bed rest. Calcium and magnesium in serum, urine, sweat, stool, and diet were determined by atomic absorption spectrophotometry. Standard autoanalyzer methods were used for measuring phosphorus. A second phase of the study, comparing the effectiveness of exercise with that of phosphate in modifying the changes of bed rest, showed that isometric and isotonic exercise has not proved effective in preventing the negative mineral balance induced by bed rest. Results indicated that nine months of horizontal bed rest caused distinct os calcis dimineralization in three healthy young men, accompanied by a negative calcium balance that persisted until reambulation. Measures designed to prevent these changes of calcium balance and bone are under investigation. A.L.

DOROKHOVA, Ye.I. 1970. 55

Coagulability of blood during prolonged hypodynamia according to thrombo-elastographic data.

In: A.M. Genin and P.A. Sorokin, eds. Problems of Space Biology. Volume 13: Prolonged Limitation of Mobility and its Influence on the Human Organism. Washington, D.C., Scripta Technica, Inc. pp. 108-112. [NASA-TT-F-639].

Prolonged hypodynamia was accompanied by the appearance of a general hemophilic reaction of the blood. The partial blood coagulation reactions varied in the opposite direction. Physical exercises reduced the hemophilic shifts. Combining physical exercises on a treadmill or bicycle ergometer with occlusion conditioning slightly reduced the antihemophilic effect of the physical exercises.

Author

ACCESS. NO. 19,500 FORM:_____ AUTHOR: DRILL:

A70-24678 # Coagulability of blood according to thrombo-elastographic data obtained during prolonged hypodynamia (Svertyvaemost' krovi po dannym tromboelastografii pri dlitel'noi gipodinamii). E. I. Dorokhova. In: Prolonged immobility and its effect on the human organism (Dlitel'noe ogranichenie podvizhnosti i ego vliianie na organizm cheloveka). (A70-24665 10-04) Edited by A. M. Genin and P. A. Sorokin. Moscow, Izdatel'stvo Nauka (Problemy Kosmicheskoi Biologii. Volume 13), 1969, p. 109-115. In Russian.

DOCUMENT NO.: A70-24678

DESCRIPTORS: Circulatory System R/10, Equipment GR/86, Exercise GR/61, Human BL/72, Immobilization GR/62, Measure P/3, Physiology GY/8, USSR GR/3. 1969.

ABSTRACT:

Study of blood coagulation in humans subjected to conditions of prolonged hypodynamia. Prolonged hypodynamia was found to be accompanied by the occurrence of an overall hemophilic reaction of the blood. The partial reactions of blood coagulation changed in opposite directions. Physical exercises were found to decrease hemophilic shifts. A combination of physical exercises on a treadmill and a veloergometer with occlusion training somewhat reduced the antihemophilic effect of physical exercises. A.B.K.

DROZDOVA, N.T., et al. 1970. 56

State of the visual analyzer during hypodynamia.

In: A.M. Genin and P.A. Sorokin, eds. Problems of Space Biology. Volume 13: Prolonged Limitation of Mobility and its Influence on the Human Organism. Washington, D.C., Scripta Technica, Inc. pp. 192-195. [NASA-TT-F-639].

A decrease in certain visual functions and a change in the fundus picture of the eye were observed from effects of prolonged hypodynamia on the visual analyzer. Visual acuity decreased by 21% and intraocular pressure by 3 mm Hg; there was a 15 deg loss in peripheral vision, the point of clear vision had moved out 4.5 cm, the size of the blind spot had increased by 38%, and there was a 120% increase in the time to recover visual acuity after flashing light in the eyes. Reactive vascular effects were noted on the fundus of the eye: the veins were dilated, tensed, and darker in color. The optic disk had faded. The transition to motor activity resulted in gradual recovery of the disturbed functions. Author

57

Eng. transl

N73-22014 Joint Publications Research Service, Arlington, Va.
STATE OF THE VISUAL ANALYZER UNDER HYPOKINETIC CONDITIONS
N. T. Drozdova and Ye. P. Grishin Space Biol. and Med., Vol. 6, No. 4, 1972 29 Sep. 1972 p 74-78 (For availability see N73-22002 13-04)

During a 30-day bed rest experiment close and distant visual acuity was measured and ophthalmoscopic, photocalibrometric and ophthalmodynamometric examinations were performed with subjects who were in an antiorthostatic position. Beginning with the fourth to fifth day of hypokinesia their visual acuity, especially at close range, decreased substantially. Hemodynamic shifts were more distinct in those test subjects who were subjected to no preventive measures. In two cases perivasal and peripapillary edema of the retina was found. The mentioned changes exerted no significant effect on visual performance of the subjects. The above mentioned shifts disappeared when they started to work actively.
Author

A72-43916 # State of the optic analyzer during hypokinesia (Sostoianie zritel'nogo analizatora v usloviiakh gipokinezii). N. T. Drozdova and E. P. Grishin. *Kosmicheskaia Biologiia i Meditsina*, vol. 6, July-Aug. 1972, p. 46-49. In Russian.

Study of the short- and long-range visual acuity in test subjects, confined to bed rest for 30 days in an antiorthostatic position. Ophthalmoscopic, photočalibrometric, and ophthalmodynamometric observation and measurement results are presented and discussed.
M.V.E.

58

† 34901. EDE, M. C. MOORE (Dep. Physiol., Harv. Med. Sch., 25 Shattuck St., Boston, Mass., 02115, USA.), M. H. FAULKNER and BARBARA E. TREDRE. An intrinsic rhythm of urinary calcium excretion and the specific effect of bedrest on the excretory pattern. CLIN SCI (OXF) 42(4): 443-455. Illus. 1972.--The diurnal rhythms of urinary Ca excretion were studied in healthy subjects under 4 different regimens in which diet, activity and posture were varied. The excretory rhythms observed were compared with those of K, obtained under the same conditions. When the subjects were active throughout the day and night and were either fasting or eating standard 3-hourly meals, an intrinsic Ca rhythm was isolated with maximum amounts excreted between 06.00 and 09.00 hr. Continuous supine bedrest had a specific effect on Ca excretion. The total 24 hr excretion was markedly increased compared with that found on constant activity but on the same diet, and 78% of the increase occurred between 09.00 and 18.00 hr.

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## INTRODUCTION

Impairment of water diuresis is frequently observed in patients with adrenal insufficiency and in other conditions characterized by a contraction of extracellular volume. The recent suggestion that adrenocortical reserve is significantly impaired following prolonged bedrest and the documentation of a contracted blood volume following weightlessness raise the strong possibility that prolonged bedrest may result in impairment of the renal diluting mechanism. Previous attempts to survey this parameter failed to disclose significant abnormalities when casual urine specimens were tested. However, such normal "basal" values are frequently misleading, masking underlying deficits, thereby leaving this question unanswered. The current study was designed to evaluate renal diluting capacity by serially stressing the diluting mechanism in a standard manner, before, during, and following recovery from bedrest.

## METHODS AND RESULTS

Eight normal volunteer subjects aged 18 to 22 were studied. All subjects were trained to void spontaneously every 30 minutes while remaining recumbent. Maximal urinary diluting capacity was studied during the control period, following 13 days of absolute bedrest and again 4-14 days following recovery from bedrest. The study was performed under conditions controlled for dietary sodium content, state of hydration, time of day and posture, in addition to the control of environmental parameters including room temperature and humidity. Maximal urinary diluting capacity was assessed by administering a standard acute oral water load of 20 ml./Kg t each subject and sustaining the diuresis by oral water repletion every 30 minutes equal to the volume of urine of the previous clearance period. The test was continued until a plateau of maximal urine flow rate was achieved with individual clearance period values differing by only 0.5-2.0 ml./min. Parameters studied included peak urine flow rates (V), minimal urine osmolality (Uosm), solute-free water clearance during the period of peak urine flow ($C_{H_2O}$), and endogenous creatinine clearance ($C_{cr}$).

The results, to be discussed, revealed a significant decrease in (V) following bedrest ($p<0.025$), without change in Uosm or $C_{H_2O}$ ($p>0.05$). Our results indicate that prolonged bedrest and presumably weightlessness do not impair the kidney's ability to dilute urine.