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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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Presented to the panel on The Clinical Monitoring of Blood Pressure and Adjunct Rhythms, Automatically and by Self-Measurement at the International Hotel, Los Angeles, California, March 18, 1971.
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In: Proceedings of the 1971 Manned Spacecraft Center Endocrine Program Conference. Houston, Texas, National Aeronautics and Space Administration, Lyndon B. Johnson Space Center. 13 pages. [NASA-TM-X058093]
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[NASA-CR-114781]
*See Texas Women's University for Parts 1 and 3.
335. WINGET, C.M., J. VERNIKOS-DANELIS, C.W. DEROSHIA, S.E. CRONIN, C.S. LEACH, and P.C. RAMBAUT. 1973.
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Phase relationships between circadian rhythms and the environment in humans during hypokinesia.
Presented at the International Society for the Study of Biologic Rhythms.
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Characteristics of the nasal vascular system reaction during 120-day hypokinesia.
Space Biology and Medicine 5(3):91-97.
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Functional staff of the human auditory analyzer in an experiment with two-month hypokinesia.
Space Biology and Medicine 1(3):104-110.
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Study of reactions of human otorhinolaryngological organs during hypokinesia.
Space Biology and Medicine 6(4):79-87.
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Space Biology and Medicine 6(4):52-61.
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Space Biology and Medicine 1(2):106-110.
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Physical conditioning for man under conditions of prolonged 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. 196-204. [NASA-TT-F-639]
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Ames Research Center, Moffett Field, California. 22 pages. [NASA-TR-R-406]

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Performance of operators during prolonged bed confinement.
Space Biology and Medicine 4(1):87-92.
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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

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 CSCL06P

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.

3
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 effec-
tive 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.

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. Dlusskaya, R. K. Kiselev, and T. A. Kislovskaya ~~in~~ *Space Biol. and Med.*, Vol. 6, No. 4, 1972 29 Sep. 1972 p 110-116 refs (For availability see N73-22002 13-04)

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

Eng transl.

A72-43921 # Effects of physical training and electric muscle stimulation on the metabolism (Vlianie fizicheskoi trenirovki i elektrostimulatsii na obmen veshchestv). I. S. Balakhovskii, V. T. Bakhteyeva, R. V. Beleda, E. I. Biryukov, L. A. Vinogradova, A. I. Grigor'ev, S. I. Zakharova, I. G. Dlusskaia, R. K. Kiselev, and T. A. Kislovskaiia. *Kosmicheskaiia Biologiya 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.

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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 for 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 occlusion 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. Creatinine 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."

7
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: HCS3 00/MFS0 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 pat-
terns. M.W.R.

A68-44091 #

EFFECT OF 62-DAY HYPODYNAMIA ON THE HUMAN
ORGANISM [VLIYANIE 62-SUTOCHNOY 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 succes-
sively during the experiment are described as physical discomfort
observed between the third and sixth day, adaptation to the environ-
mental conditions between the seventh and twentieth day, develop-
ment 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 de-
creased during the experiment, especially in the three of the sub-
jects who performed physical exercises. Decreased gastric se-
cretion, 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.

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.

11
Eng
transl.

[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.

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

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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.

1968.

ABSTRACT:

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.

CHANGE IN WATER-SALT METABOLISM DURING 62-DAY HYPOKINESIA

Ye. N. Biryukov, L. I. Kakurin, G. I. Kozyrevskaya, Yu. S. Koloskova,
Z. P. Payok, 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. 16

FORM: AUTHOR CARD COMPLETED ✓

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

ABSTRACT:

1963

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 O₂ 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

† 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, 1-25, 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) throughout 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 O₂ 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.

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:

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)

1966

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 3½, 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 145% 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. Kozirevskaya, 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

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

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

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.

23
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-TT0F-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

24
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 between 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.

BRIEGLEB, W. 1968.

Biological problems of weightlessness.

In: W. Briegleb, ed. Contributions to Space Biology and Biophysics.

Deutsche Versuchsanstalt für Luft- und Raumfahrt, Institut für 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,
Environment 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.

9347. 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.

29

[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 $\times$ 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.]

✓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. Calhoun (California, University, Dept. of Nutritional Sciences, Berkeley, Calif.).

New York, N. Y. Academy of Sciences, 1967. 295 p.
\$7.00.

30

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.

NG5 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 ERGOM-
ETER TEST

D. Cardus, W. A. Spencer, C. Vallbona, and F. B. Vogt Wash-
ington, 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, CO₂ 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

NG5-21738*# 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 EXCRE-
TION OF 17-HYDROXYCORTICOSTEROIDS

D. Cardus, C. Valbona, F. B. Vogt, W. A. Spencer, H. S. Lips-
comb 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 de-
terminations 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 modi-
fied. 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-day 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)

445-26168

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.

NS7-18553*7 Texas Inst for Rehabilitation and Research, Houston.
A STUDY OF THE POSSIBLE PREVENTIVE EFFECTS OF
MUSCULAR EXERCISES AND INTERMITTENT VENOUS
OCCLUSION ON THE CARDIOVASCULAR DECONDITION-
ING OBSERVED AFTER 10 DAYS BED RECUMBENCY: EX-
PERIMENTAL 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 065

An experimental program designed to study the efficacy
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.

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:

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 antidiuretic 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.

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 ($\text{max } \dot{V}_{O_2}$), 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 $\text{max } \dot{V}_{O_2}$, whereas changes in work capacity occurred independently of changes in $\text{max } \dot{V}_{O_2}$ and vice versa. The highest $\dot{V}_{O_2}$ attainable during exercise to exhaustion on a bicycle ergometer underestimated $\text{max } \dot{V}_{O_2}$ 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 $\text{max } \dot{V}_{O_2}$ was decreased after bed rest by an increment in $\dot{V}_{O_2}$ during the bicycle test. Unless $\text{max } \dot{V}_{O_2}$ 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 hypokinetic 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 hypokinetic 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.

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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

DOCUMENT NO.: N70-39216

ACCESS. NO. 23, 628

FORM: _____ AUTHOR: _____ 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. *Kosmicheskaiia 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)

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

CHEREPAKHIN, M.A. 1968.

Normalization of physiological functions during bed rest by means of physical exercises.

Space Biology and Medicine 2(1):52-59.

41
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: 11 AUTHOR CARD COMPLETED 1

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 USLOVIYAKH GIPOKINEZII METODOM VOSPOLNENIIA DEFITSITA MYSHECHNOI AKTIVNOSTI].

M. A. Cherepakhin.

Kosmicheskaya Biologiya 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 CARDIO-
VASCULAR ORTHOSTATIC RESPONSE Final Report
Loren D Carlson [1967] 183 p refs
(Grant NGR 05-004-026)

(NASA CR 93247) CFSTI HCS3 00/MFS0 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.

NG9-31943*// 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 CSCL06P

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.

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: 1323, 1929.

Cuthbertson¹ 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.

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Eng
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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 circulatory 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.

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
L. J. J.

TASK NUMBER: 970-51-17-02

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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.

Subjects 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. Subjects 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. Calcium was determined by atomic absorption spectrometry. Phosphorus was analyzed by a Technicon Autoanalyzer, using standards adjusted to the pH of samples. Nitrogen, Sodium, Potassium and Magnesium balance data were obtained as well as psychiatric, biometric and fluid compartment analyses.

Urinary Calcium 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 Calcium loss during the entire bed rest period averaged 4.2% of estimated total body Calcium, comparing well with previous studies indicating a .4%-.6% loss/month. Phosphorus patterns in urine and body balance were similar to Calcium patterns. Serum levels of both minerals revealed little appreciable change during bed rest but significant drops during reambulation. Gamma ray transmission scanning of the os calcis 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 osteopenia, 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. Holley, 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.

54
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 demineralization 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.

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.

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, twisted, and darker in color. The optic disk had faded. The transition to motor activity resulted in gradual recovery of the disturbed functions.

Author

56

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 74-76 (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 antithrostatic 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 perivascular 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

Eng. transl

A72-43916 # State of the optic analyzer during hypokinesia
(Sostoianie zritel'nogo analizatora v usloviakh gipokinezii). N. T.
Drozdova and E. P. Grishin. *Kosmicheskaya Biologiya 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 antithrostatic position.
Ophthalmoscopic, photocalibrometric, and ophthalmodynamometric
observation and measurement results are presented and discussed.

M.V.E.

134901. 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.

EPSTEIN, M. 1970.

The effect of simulated weightlessness on renal diluting capacity in normal man.

In: Preprints of the 1970 Annual Scientific Meeting, Aerospace Medical Association, St. Louis, Missouri, April 27-30, 1970.

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 to 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 (U_{osm}), 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 U_{osm} 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.

/A71-23365

Effect of prolonged bed rest on renal diluting capacity in normal man. Murray Epstein (USAF, School of Aerospace Medicine, Brooks AFB, Tex.). *Journal of Applied Physiology*, vol. 30, Mar. 1971, p. 366-369. 19 refs.

The effects of 2 weeks of absolute bed rest on renal diluting capacity were studied in eight normal young male subjects. An acute sustained oral water load of 20 ml/kg was administered during a control period of normal activity, on the 13th day of absolute bed rest and on the 4th or 14th day of postbed-rest recovery. Bed rest did not significantly alter peak urine flow corrected for GFR (V/GFR), ability to generate free water (CH_2O) or to achieve minimal urine osmolality. The results suggest that despite analogies with adrenal insufficiency, including both a decrease in plasma volume and a decrease in adrenocortical reserve, prolonged bed rest does not impair renal diluting capacity. (Author)

FASOLA, A.F.

The renin response to lower body negative pressure stress testing and the effect of exercise during prolonged bedrest.

In: Preprints of the 1970 Annual Scientific Meeting, Aerospace Medical Association, St. Louis, Missouri; April 27-30, 1970.

It would appear from these studies that plasma renin activity is increased as a result of strict bedrest. The observation that renin activity was also increased in the exercising subjects, though not to the same degree, would suggest that the effects of bedrest were attenuated by exercise. If the incidence of syncope is used as the criterion for orthostatic intolerance then exercise as utilized in this study is of no benefit.

It is also apparent that weightlessness, as simulated by strict bedrest, does not remove the stimulus for renin release and that the renin-angiotensin system is reset at a higher than normal level. The mechanism for this increased responsiveness is unknown.

FEDOROV, I.V. 1971.
Hypodynamia and hormonal activity.
Space Biology and Medicine 5(4):85-89.

62
Eng. transl.

[Article by I. V. Fedorov; Moscow, Kosmicheskaya Biologiya i Meditsina (Space Biology and Medicine), Russian, Vol 5, No 4, pp 59-61, 1971, submitted for publication 9 December 1970]

Abstract: Data in the literature on changes in the production of hormones (corticosteroids, adrenalin, adrenocorticotrophic hormone, antidiuretic hormones, and 5-hydroxyindolacetic acid) during hypodynamia are reviewed. Potential results of changes in hormonal activity are discussed.

FISCHER, C.L., C. LEACH, and P.C. JOHNSON. 1971.

Hematologic implications of hypodynamic states.

In: R.H. Murray and M. McCally, eds. Hypogravic and Hypodynamic Environments.
Washington, D.C., National Aeronautics and Space Administration. pp. 27-34.
[NASA-SP-269].

The red cell mass and plasma volume changes noted in the hypodynamic states of bed rest and water immersion are reviewed, and these changes are compared with the hypodynamic and hypogravic state characteristics of earth orbital missions.

Author

A70-19937 *

RENAL FUNCTION, WATER AND ELECTROLYTE EXCHANGE DURING BED REST WITH DAILY EXERCISE.

James H. Fuller, Edmund M. Bernauer, and William C. Adams (California, University, Davis, Calif.).

Aerospace Medicine, vol. 41, Jan. 1970, p. 60-72. 33 refs.

Grant No. NGR 05-004-021.

Investigation of the effect of leg exercise on renal function, electrolyte and water metabolism during bed rest. Eight young adult males underwent nine days of continuous recumbency, during which half exercised 30 min twice daily on a horizontal bicycle ergometer, while the remainder served as controls. Ten days before, and during bed rest, metabolic exchange of water, sodium, potassium, and chloride was calculated; seven days following bed rest, water and electrolyte input was ad libitum and output was measured. Lean body mass (LBM), body fat and total body potassium were measured before and after bed rest. On the first day of recumbency, urinary volumes were increased by 11% and 18%, sodium balance was -71 mEq and -109 mEq, and chloride balance was -61 mEq and -74 mEq in the exercise and control groups, respectively. Thereafter, these parameters were slightly increased, whereas potassium excretion remained elevated throughout bed rest, with a cumulative loss of 80 mEq in the exercise and 174 mEq in the control group. Loss of LBM and total body potassium and gain of body fat was two to three times greater in the controls. It is concluded that the major influence of exercise consists in the attenuation of degenerative changes in certain maintenance systems—i.e., contraction of plasma volume, elevation of renal plasma flow, and glomerular filtration. M.V.E.

FULLER, J. H., E. M. BERNAUER and W. C. ADAMS. *Renal function, water and electrolyte exchange during bed rest with daily exercise*. *Aerospace Med.* 41(1):60-72. 1970.

Eight young adult males underwent nine days of continuous recumbency, during which half exercised 30 min twice daily on a horizontal bicycle ergometer, while the remainder served as controls. Ten days before, and during bed rest, metabolic exchange of water, sodium, potassium and chloride was calculated; seven days following bed rest, water and electrolyte input was ad libitum and output was measured. P-amino hippurate (PAH) and creatinine clearances in resting and exercise states, and blood volume were measured during all three periods, while lean body mass (LBM), body fat and total body potassium were measured before and after bed rest. On the first day of recumbency, urinary volumes were increased by 11% and 18%, sodium balance was -71 mEq and -109 mEq, and chloride balance was -61 mEq and -74 mEq in the exercise and control groups, respectively. Thereafter, these parameters were slightly increased, whereas potassium excretion remained elevated throughout bed rest, with a cumulative loss of 80 mEq in the exercise and 174 mEq in the control group. Renal clearance of PAH increased 250 ml/min, creatinine increased 11 ml/min and plasma volume decreased 7% relative to pre-bed rest values in the control group, whereas these parameters changed only slightly in the exercise group. Loss of LBM and total body potassium and gain of body fat was two to three times greater in the controls. Although body water, sodium, chloride and blood volume seemed to be reset initially at lower levels during recumbency and after several days were less affected, while other parameters appeared to change according to the length of bed rest, and were better stabilized when exercise was employed.

GATTS, J.D., and D.A. BEARD. June 1967.
Human Factors Suitability of the Gravitational Acceleration Simulation
Suit (GASS). Final Report.
Fairchild Hiller Corp., Farmingdale, L.I., N.Y. 52 p.

Studies were performed on five adult male subjects for a period of 3 consecutive weeks to evaluate the human factors suitability and potential use of the Gravitational Acceleration Simulation Suit (GASS) as a protective device for the prevention of the physiological deconditioning associated with prolonged bed rest or weightlessness. The GASS device is designed to simulate the gravitational force acting on an individual in an upright position. This force is perceived by the weight supporting musculoskeletal (antigravity) system independent of gravitational force or the orientation of the longitudinal axis of the body. Therefore, this device has application in a weightless environment. The results of this study indicate that subjects without previous conditioning were able to tolerate the device for 5 hours per day, consecutively for 3 weeks, and then become ambulatory immediately without the deleterious effects of dizziness, weakness, vertigo, and postural degradation normally associated with such an extended recumbent position. The intent of the study was to test the human factors suitability of such a device for use in space flights; however, physiological data was gathered during the course of the study that indicates, though not conclusively, a definite pattern of protection from excessive cardiovascular and musculoskeletal deconditioning. Further research is suggested with larger numbers of test subjects designed to test the physiological acceptability of the GASS device for extended periods.

GENIN, A.M., P.A. SOROKIN, G.I. GURVICH, T.T. DZHAMGAROV, A.G. PANOV, I.I. IVANOV, and I.D. PESTOV. 1969.

Basic results from studies of the influence of 70-day hypodynamia on the human organism.

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. 256-262. [NASA-TT-F-639].

The results obtained during the experiment are examined in juxtaposition to the expected consequences of hypodynamia, which are presented in diagram form. Certain aspects of the influence of prolonged bed rest on the organism are revealed: a decrease in immunological resistance, certain disturbances to the mental functions, the development of trophic changes in the myocardium, and changes in reactivity to medication. The specifically designed physical conditioning procedures were found to be relatively effective in mitigating the detrimental effect of hypodynamia. Author

A70-24696 # Principal results of the investigations of the effect of a 70-day hypodynamia on the human organism (Osnovnye rezul'taty issledovaniia vliianiia 70-sutochnoi gipodinamii na organizm cheloveka). A. M. Genin, P. A. Sorokin, G. I. Gurchik, T. T. Dzhambgarov, A. G. Panov, I. I. Ivanov, and I. D. Pestov). In: Prolonged immobility and its effect on the human organism (Dlitel'noe ogranichenie podvizhnosti i ego vlianie 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. 247-253, 8 refs. In Russian.

Comparison of the experimental results obtained with the hypodynamia consequences expected. In the course of the investigation, some new aspects of the effects of prolonged bed rest on the organism came to light: lowering of the immunological resistance, certain psychic-function disorders, development of trophic changes in the myocardium, changes in responses to pharmaceuticals, etc. The specially developed methods of physical training proved to be the relatively most effective means for reducing the unfavorable consequences of hypodynamia. M.V.E.

67
N70 43004#1
GENIN, A.M. and P.A. SOROKIN, eds. 1970.
Problems of space biology. Volume 13: Prolonged limitation of mobility and
its influence on the human organism.
Washington, D.C., Scripta Technica, Inc. 271 pages.

Original prepared by: Moscow, USSR, 1969
(Contract NASw-2036)

(NASA-TT-F-639) Avail: NTIS CSCL 06S

Papers are presented from a complex clinical-physiology study of healthy subjects who were confined to bed for long periods. The following are described in broad terms: effects of prolonged mobility restriction on functional systems, tolerance to orthostatic tests and load factors, efficacy of physical exercises and other prophylaxis in preventing unfavorable shifts in the organism during prolonged confinement to bed.

GENIN, A.M. and P.A. SOROKIN. 1970.

Prolonged limitation of mobility as a model of the influence of weightlessness on the human organism.

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. 1-7. [NASA-TT-F-639].

Experimental approaches to evaluation of the biological effects of prolonged weightlessness are examined. Laboratory simulation of weightlessness, with prolonged bed rest as an example, is defended. The initial conception that formed the basis for the 70-day hypodynamia study is formulated.

Author

A70-24666 # Prolonged restriction of mobility as a model of the influence of weightlessness on the human organism (Dlitel'noe ogranichenie podvizhnosti kak model' vlianiia nevesomosti na organizm cheloveka). A. M. Genin and P. A. Sorokin. In: Prolonged immobility and its effect on the human organism (Dlitel'noe ogranichenie podvizhnosti i ego vlianie 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. 9-16. 13 refs. In Russian.

Investigation of experimental methods of estimating the biological effects of prolonged weightlessness. Attention is given to the study of reactions arising during laboratory simulation of certain factors which are characteristic for prolonged weightlessness. Emphasis is placed on the relative value of bed confinement, and the basic concepts involved in studies of 70-day hypodynamia are outlined.

T.M.

31,684

69.

Genin, A.M. and L.I. Kakurin. Thirty-day experiment simulating the physiological effects of weightlessness. Kosmicheskaya Biologiya i Meditsina, Vol. 6, No. 4, pp. 26-28, July-August 1972. (Space Biol. & Med. 6(4):42-44)

S&T ALERT

ITEM NO. 985

Scan Topics: 04-04 Aerospace Medicine
04-06 Physiological Factors

An attempt has been made to correlate data on physiological functions within the scope of a light program, the tolerance of test subjects to stresses produced by transition to the vertical position, and the compatibility of various preventive measures. The experiment involved nine test subjects divided equally into three groups confined to strict bedrest for 30 days. To simulate weightlessness, the foot of the bed was raised at a 4° angle. Two general conclusions are drawn. The use of a hypodynamic model with the test subjects in an anti-orthostatic position revealed certain additional elements in the simulation of weightlessness effects reflected in sensations of temporary hyperemia, face pastosity, and an upside-down illusion with the eyes closed. These phenomena are attended by changes in blood redistribution that could be confirmed by observations of the fundus oculi. The second conclusion applies to a positive assessment of the entire set of preventive measures.

(LD)

GEORGIYEVSKIY, V.S. and V.M. MIKHAYLOV. 1968.
Effect of hypokinesia on human circulation.
Space Biology and Medicine 2(3):73-78.

The combined effect of bedrest and accelerations on human circulation was studied using mechano- and polycardiographic techniques. The experiments were conducted on young healthy male test subjects. The experiments demonstrated an increase in heart rate and average blood pressure, a decrease in the ejection period and development of orthostatic hypotension. Variations in some hemodynamic indices indicated a phasic pattern reaching a maximum on the 32d-42d day.

Author

ACCESS. NO. 15,137

FORM: _____ AUTHOR: _____ DRILL: ☒

22880. GEORGIEVSKIY, V. S., and V. M. MIKHAILOV. Vliyanie gipokinezii na krovotok cheloveka. [Effect of hypokinesia on the human circulation.] KOSM BIOL MED 2(3): 48-51, 1968. [Engl. sum.]

DOCUMENT NO.: BA(50)22880

DESCRIPTORS: Acceleration Y/1, Bedrest GY/39, Biological rhythm GY/21, Circulatory system R/10 Human BL/72, Pressure Y/28, Technique P/1, USSR GR/3.

ABSTRACT:

1968.

--A combined effect of bed rest and accelerations on the human circulation was studied, using mechano- and polycardiographic techniques. The experiments were carried out on young healthy male test subjects. The experiments demonstrated an increase of heart rate and average blood pressure, a decrease of the ejection period and development of orthostatic hypotension. Changes of some hemodynamic indices showed a phasic pattern, reaching maximum on the 32-42nd day.--Authors.

GEORGIEVSKII, V.S., L.I. KAKURIN, B.S. KATKOVSKII, and Yu.A. SENKEVICH. 1969. Maximum oxygen consumption and functional state of the circulation in simulated zero gravity.

In: N.V. Lauer and A.Z. Kolchinskaya, eds. The Oxygen Regime of the Organism and its Regulation (Symposium). Jerusalem, Israel Program for Scientific Translations, Ltd. pp. 181-184. [NASA-TT-F-501].

Elucidated were the effects of prolonged, strict bed rest on a subject's consistency of working at maximum intensity. Tests involved increasing physical loads before and after the stay in bed. In bicycle ergometer tests several respiratory and circulatory indexes were recorded in addition to work performed, oxygen consumption, and pulse rate. Experimental data revealed diminishing muscular activity following restriction of motor activity in all subjects. Although the maximum amount of work performed did not reach the normal level, the capacity for increasing energy production during increased duration of muscular work was retained. Performance of the same work following bed rest with restricted motor activity made severe demands on the cardiovascular system which in turn brought the circulation to its initial level.

G.G.

ACCESS. NO. 14,087

FORM: ☒ AUTHOR CARD COMPLETED ☒

MAXIMAL OXYGEN CONSUMPTION AND THE FUNCTIONAL STATE OF THE CIRCULATORY SYSTEM FOLLOWING SIMULATED WEIGHTLESSNESS.

Foreign Technology Div Wright-Patterson AFB Ohio
V. S. Georgievskii, L. I. Kakurin, B. S. Katkovskii,
and Yu. A. Senkevich. 29 Mar 68, 9p Rept no.
FTD-HT-23-124-68

Edited trans. of Simpozium. Posyvashchennyi Izucheniye Kislorodnogo Rezhima Organizma i Ego Regulirovaniya. Kanev, 1965, also pub. as Kislorodnyi Rezhim Organizma i Ego Regulirovanie. Materialy (Oxygen Balance of the Organism and Its Regulation, Materials), Kiev, 1966 400p, by F. Dion.

DOCUMENT SERIES & NO.: AD-679 504-DDC

4 N69-17930

DESCRIPTORS: CARBON DIOXIDE W/72, ACTIVITY GR/58, OXYGEN W/74, CIRCULATORY SYSTEM R/10, SIMULATION BK/36, WEIGHTLESSNESS Y/35, WATER W/77, MUSCULAR SYSTEM R/53, PRESSURE Y/28, HUMAN BL/72, RESPIRATORY SYSTEM R/21, BEDREST GY/39, GRAVITY Y/31, EKG BK/34, BIOINSTRUMENTATION BK/30. 1968.

ABSTRACT:

The effects of simulated weightlessness on oxygen consumption and the functional state of the cardiovascular system were studied in four healthy male subjects aged 22-25 yrs. Weightlessness was simulated by 20 days of rigorous bed rest (the horizontal position of the body during bed rest creating a hydrostatic pressure distribution similar to that produced by the absence of gravity). Motor activity was kept to a minimum; the subjects were aided in feeding and toilet functions by nursing personnel, and passed the time in reading, chatting,

and watching TV. Before and after bed rest the subjects underwent progressive physical-loading tests consisting of work of increasing difficulty on a veloergometer. Endurance limits were considered reached when the subjects were unable to continue and when O₂ consumption and pulse rates reached high levels. The amount of work performed during the test, O₂ consumption and CO₂ excretion, phonocardiograms, carotid sphygmograms, and EKGs were recorded. (Author)

AD-679 504

HC\$3.00 MF\$0.65

GEORGIYEVSKIY, V.S., V.A. GORNAGO, L.Ya. DIVINA, N.D. KALMYKOVA, V.M. MIKHAYLOV, 72
V.I. PLAKHATNYUK, Yu.D. POMETOV, V.V. SMYSHLYAYEVA, N.D. VIKHAREV, and
B.S. KATKOVSKIY. 1974.

Orthostatic stability in an experiment with 30-day hypodynamia.
Space Biology and Medicine 7(6):88-97.

[Article by V. S. Georgiyevskiy, V. A. Gornago, L. Ya. Divina, N. D. Kalmykova, V. M. Mikhaylov, V. I. Plakhatnyuk, Yu. D. Pometov, V. V. Smyshlyayeva, N. D. Vikharev and B. S. Katkovskiy; Moscow, Kosmicheskaya Biologiya i Meditsina, Russian, Vol 7, No 6, November-December 1973, pp 61-68, submitted 1 October 1971]

Abstract: Nine test subjects were kept for 30 days in bed with their heads tilted 4° downwards. At the end of the experiment they exhibited a decrease in orthostatic stability. The use of different countermeasures, including physical exercises and lower body negative pressure (LBNP), considerably improved their orthostatic stability. Electric stimulation of the muscles also produced a preventive effect, although to a lesser extent. It should be expected that a combination of physical exercises, LBNP and electric stimulation of the muscles during prolonged space flight may exert a positive effect on orthostatic stability.

A68-29809 *

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.).

IN: HUMAN ECOLOGY IN SPACE FLIGHT. VOLUME 2 - PROCEEDINGS OF THE SECOND INTERNATIONAL INTERDISCIPLINARY CONFERENCE, PRINCETON, N.J., OCTOBER 11-14, 1964.

[A68-29808 14-04]

Conference sponsored by the Office of Naval Research of the U.S. Navy and NASA.

Edited by D. H. Calloway.

New York, N.Y. Academy of Sciences, 1967, p. 13-81.

Group discussion of the human response to the space environment and the simulation of this environment by bedrest, including a comparison of U.S. and USSR methods of treating the problem of manned space exploration. Advantages to be realized by combining physics and biology are outlined. Observed responses to space flight are considered with reference to problems of weightlessness, muscular work and posture, and response to long-term bedrest.

F. R. L.

74

A72-43389 # Calcium metabolism under stress and in re-
pose. R. S. Goldsmith (Mayo Foundation, Rochester, Minn.). In:
Life sciences and space research X; Proceedings of the Fourteenth
Plenary Meeting, Seattle, Wash., June 21-July 2, 1971. (A72-
43381 23-04) Berlin, East Germany, Akademie-Verlag, 1972, p.
87-101. 36 refs.

Derangement of calcium metabolism constitutes a major threat
to the health of participants in exploration of space. Experiments are
described which indicate that during prolonged bed rest osteopenia
and complications of the demineralizing process (resorption of bone)
develop and endanger the survival of the organism. Such complica-
tions include hypercalcemia, hypercalciuria and nephrolithiasis, and
muscle wasting. Available techniques for study of the effects of
weightlessness and prophylactic agents are outlined. F.R.L.

ACCESS. NO. 2996

A64-24971

CARDIOVASCULAR DECONDITIONING - ROLE OF BLOOD VOLUME AND SYMPATHETIC NEUROHORMONES.

D. E. Graveline (USAF, Systems Command, Aerospace Medical Div., Brooks AFB, Tex.).

IN: LIFE SCIENCES AND SPACE RESEARCH II: INTERNATIONAL SPACE SCIENCE SYMPOSIUM, 4TH, WARSAW, POLAND, JUNE 3-12, 1963.

Sponsored by the Committee on Space Research (COSPAR).

Edited by M. Florkin and A. Dollfus.

Amsterdam, North-Holland Publishing Co.; New York, Interscience Publishers, 1964, p. 287-298. 29 refs.

FORM: 1 AUTHOR CARD COMPLETED

75

DOCUMENT SERIES & NO.: A64-24971 (IAA)

DESCRIPTORS: Bedrest CY/39, Chemical W/29, Circulatory system R/10, Endocrine system R/65, Gravity Y/31, Human BL/72, Immobilization GR/62, Nervous system R/48, Water immersion P/24

ABSTRACT:

1964

Demonstration, by means of studies of prolonged bed rest and water immersion, that serious deconditioning of certain gravity-oriented biologic systems occurs with extended exposures to environments in which the necessity for gravity compensation has been reduced. It is stated that the precise physiologic mechanisms responsible for the loss of orthostatic tolerance following such studies are unknown, but may be related to diminished blood volume, decreased muscle or tissue pressure in the extremities, or to functional alterations in the sympathetic nervous system. It is noted that, in view of the fact that noradrenaline is the principal agent for maintaining vascular tone, attention has been focused on the sympathetic nervous system as being the system most likely responsible for the loss of orthostatic tolerance following such experiments. The contributory effects of diminished circulating blood volume resulting from such environments are also discussed.

Graveline, D. E. and Barnard, G. W.: Physiologic Effects of a Hypodynamic Environment: Short-term Studies. *Aerospace Med.* 32: 726, 1961.

SUMMARY

By a technique involving complete immersion in water, a hypodynamic situation was produced in which normal weight sensations were altered and movement was relatively effortless. Four subjects were evaluated after six, twelve and twenty-four hours of this environment. Tilt table, centrifuge and heat chamber studies demonstrated significant cardiovascular deterioration even after the six-hour runs, becoming progressively more severe with the twelve and twenty-four hour experiments. Pertinent psychomotor evaluations, anthropometric measures and urine and blood studies also were done. The results of this study indicate that the cardiovascular adaptation to a hypodynamic environment of this type occurs early and the deterioration from even a six-hour exposure is readily apparent.

TASK NUMBER: 970-21-17-05

0548

77

CITATION: GREENLEAF, J.E., H.L. YOUNG, E.M. BERNAUER, R.H. ARMBRUSTER, L.A. SAGAN, R.W. STALEY, L. JUHOS, W. VAN BEAUMONT and H. SANDLER. Effects of isometric and isotonic exercise on body water compartments during 14 days bed rest. In: *Preprints of the 1973 Annual Scientific Meeting, Aerospace Medical Association*, Las Vegas, Nevada, May 7-10, 1973. p. 23-24. AVAILABLE: Aerospace Medical Association.

PERFORMING INSTITUTION: ARC IN HOUSE

KIND OF DOCUMENT: Research Report

SUBJECTS: Seven healthy adult males

RES. OBJECT.

Study the effect of reduction in hydrostatic pressure on fluid and electrolyte shifts and losses and the effect of isometric and isotonic exercise training on fluid and electrolyte changes.

METHOD

Plasma volume (PV) and extracellular fluid volume (ECF) were measured periodically on 7 healthy men (19-22 yr) who underwent 2 14 day ambulatory control period, 3 14-day bed rest periods separated by 2 21-day recovery periods; and a final 4 days of recovery. During the control and recovery periods the subjects exercised 1 hr daily at 50% of their max O₂ uptake in the upright position on a bicycle ergometer. During bed rest the subjects performed in the supine position (a) no exercise (NOE); (b) 2 30-min periods daily of isometric exercise (IME) at 21% of their max leg extension force with 1 min work and 1 min rest; and (c) 2 30-min periods of isotonic leg exercise (ITE) on the ergometer at 60% of their max oxygen uptake. The subjects ate a controlled diet of normal foods. All emunctory functions were performed in the horizontal position. Plasma vol and plasma and urinary electrolytes were measured.

RESULTS

Systolic and diastolic blood pressures, respiration and oral temperature were essentially constant during the control, bed rest and recovery periods and the 2 exercise regimes had no effect on these variables. Body weight decreased about 2.5 kg in the control period and remained constant during bed rest with no exercise and isometric exercise, but declined by 1.8 kg during bed rest with isotonic exercise due, in part, to the increased energy expenditure of about 800 kcal/day (800 kcal/day = wt loss of 1.3 kg/2 wk). Basal pulse rate decreased in the 3 control periods and under all 3 exercise conditions exhibited a 7-day cycle with a maximal amplitude of 6 to 8 beats per minute. The 2 types of exercise appeared to have no influence on the frequency or amplitude of the cycle. Compared with control values, the average ECF values dropped 2.6% and 2.7% on day 4 with IME and ITE, but decreased 4.4% (860 ml) with NOE; the ECF returned to control levels by day 13. Average PV on day 4 decreased by -11.3% (387 ml) with NOE, -11.3% (396 ml) with IME, but only -6.3% (208 ml) with ITE; the control value for ITE was lower than for the other two conditions. By day 13, the PV remained depressed with IME and ITE and continued to decline with NOE. A diuresis was evident on the first day of bed rest, followed by a decline to control levels for 2 days and then stabilization at about 1.8 L/24 hr with IME and NOE and about 1.5 L/24 hr with ITE.

CONCLUSIONS

In general, the fluid and electrolyte changes during 14 days bed rest were not significantly affected by moderately heavy isometric and isotonic exercise. The major stimulus for these changes appears to be the reduction in hydrostatic pressure within the cardiovascular system with the accompanying decreased stress on the muscles and bones. Since ECF was restored to control levels by the end of bed rest in the presence of hypovolemia, it appears the controlling mechanism is influenced by the total ECF vol rather than PV.

19.75 C

CITATION: GREENLEAF, J.E., W. VAN BEAUMONT, E.M. BERNAUER, R.F. HAINES, H. SANDLER, R.W. STALEY, H.L. YOUNG and J.W. YUSKEN. Effects of rehydration on +G_z tolerance after 14-days' bed rest. *Aerospace Medicine* 44(7):715-722. 1973.

PERFORMING INSTITUTION: ARC IN HOUSE

KIND OF DOCUMENT: Research Report

SUBJECTS: Eight healthy young men

RES. OBJECT.

Determine magnitude of reduction in centrifugation (+G_z) tolerance following bed rest deconditioning; evaluate degree of lowered plasma volume (hypovolemia) involved; assess if rehydration prior to acceleration would improve +G_z tolerance.

METHOD

During a period of 10 weeks, the subjects underwent a 3-week ambulatory control period (C), 2 weeks of bed rest (BR-1), 2 weeks of ambulatory recovery (R), 2 weeks of bed rest (BR-2) with rehydration prior to centrifugation, and a final week of recovery. Centrifugation (+G_z) tolerance was measured immediately before and at the end of each bed rest period. Subjects ate a balanced diet and exercised 1/2 hr each day on a bicycle ergometer at 50% of their maximal oxygen uptake. All subjects were exposed to +G_z acceleration profiles of 2.1, 3.2, and 3.8G, presented in random order, on the ARC 8.8m human centrifuge. Acceleration tolerance was determined by loss of central vision (blackout) or of peripheral vision (greyout). Subjects were rehydrated with 1.0 to 1.9 liters of a cooled drink containing 143 mEq/l Na, 31 mEq/l K, with total osmotic concentration of 620 mOsm/l given over a 3-hr period to replace the calculated loss of extracellular fluid (ECF) volume before centrifugation in BR-2. Plasma volume was determined with the Evans Blue dye dilution method and measurement was made spectrophotometrically.

RESULTS

There were significant reductions in average +G_z tolerances following both bed rest periods at all 3 G-levels. Compared with control values, the average tolerances following BR-1 decreased 36% at 2.1G, 30% at 3.2G, and 44% at 3.8G. Compared with recovery values, the average tolerances following BR-2 decreased 23% at 2.1G, 29% at 3.2G, and 34% at 3.8G. Rehydration increased tolerance only at 2.1G but not to the level of control values. There was large interindividual variability in tolerance. During BR-1 the average plasma volume decreased from 3,118 to 2,787 and the decrease was slightly greater during BR-2. Rehydration increased plasma volume by 6.5% (183 ml) which is approximately half the 11.9% loss during BR-2.

CONCLUSIONS

(a) 2 weeks of bed rest with moderate daily isotonic exercise results in a significant decrease in +G_z tolerance; (b) there is no additional loss in tolerance after 2 weeks of bed rest compared with 1 week of bed rest without exercise, i.e., 1/2 hr of moderate isotonic exercise does not alter the reduction in tolerance after bed rest; and (c) at 2.1G, replacement of 59% of the calculated extracellular fluid loss restores 64% of the tolerance lost from bed rest deconditioning.

GREENLEAF, J. E., W. VAN BEAUMONT, E. M. BERNAUER, R. F. HAINES, H. SANDLER, R. W. STALEY, H. L. YOUNG, and J. W. YUSKEN. Effects of rehydration on +G_z tolerance after 14 days' bed rest. *Aerospace Med.* 44(7):715-722. 1973.

To determine if rehydration increases +G_z tolerance following bed rest deconditioning, eight male volunteers (21-23 yrs) were subjected to acceleration levels of 2.1 G (740 sec), 3.2 G (327 sec) and 3.8 G (312 sec) presented in random order; the rate of acceleration was 1.8 G/min. Acceleration tolerance was determined by either loss of peripheral vision (greyout) or by loss of central vision (blackout) to a white light with a luminance of 1.2×10^{-2} candles/cm (35.3 foot-lamberts). The experimental design consisted of a 3-week ambulatory control period (C), 2 weeks of bed rest (BR1), followed by a 2-week ambulatory recovery period (R), then 2 weeks of bed rest with rehydration prior to centrifugation (BR2) and a final week of recovery. +G_z tolerance was measured immediately before and at the end of each bed rest period. The subjects ate a calorically controlled, nutritionally balanced diet and exercised 1/2 hr each day on a bicycle ergometer at 50% of their maximal oxygen uptake approx. 450 kcal/day) during the entire study. The subjects were rehydrated with 1.0 to 1.9 liters of a drink, containing 143mEq/l Na, 31 mEq/l K and a total osmolarity of 620 mOsm/l, given over a 3-hour period before centrifugation in BR2.

There were significant ($p < 0.05$) reductions in average +G_z tolerances following both bed rest periods at all three G-levels. Compared with control values, following BR1, average ramp plus plateau tolerances decreased 36% at 2.1 G, 30% at 3.2 G and 44% at 3.8 G. Compared with recovery values, following BR2, average tolerances decreased 23% at 2.1 G, 29% at 3.2 G and 34% at 3.8 G. Rehydration increased tolerance ($p < 0.001$) only at 2.1 G, but tolerance was not completely restored to control values. Compared with control values, average tolerances at all three G-levels were lower after the recovery period, suggesting that 2 weeks of recovery is not long enough to permit tolerance to return to pre-bed rest levels. After bed rest the time full visual capability can be maintained at plateau during these acceleration profiles can be estimated from the equation: Tolerance (sec) = $345 + (1605/G\text{-level})$. In relaxed, deconditioned men without protective garments, tolerance at 2.0 G is 7.6 min and the level of instant blackout is about 4.7 G. It is concluded that 2 weeks of bed rest results in a significant decrease in centrifugation to tolerance which occurred despite the use of moderate daily isotonic exercise. Compared to nonhydration control values, rehydration significantly improves +G_z tolerance only at 2.1 G but did not return tolerance to ambulatory control levels.

A72-28295 * # +Gz tolerance after 14 days bed rest and the effects of rehydration. J. E. Greenleaf, W. van Beaumont, E. M. Bernauer, R. F. Haines, H. Sandler, H. L. Young, and J. W. Yosken (NASA, Ames Research Center, Biotechnology Div., Moffett Field, Calif.). In: Aerospace Medical Association, Annual Scientific Meeting, 43rd, Bal Harbour, Fla., May 8-11, 1972, Preprints. (A72-28251 12 04) Washington, D.C., Aerospace Medical Association, 1972, p. 112, 113; 10 refs.

Measurement of the reduction in centrifugation tolerance after two weeks of bedrest with moderate daily exercise, with an attempt to determine if rehydration improves +Gz tolerance. There were significant reductions in +Gz tolerance during bedrest periods at three acceleration levels. Rehydration resulted in a significant increase in tolerance at 2.1G but it did not restore tolerance to control levels. Rehydration did not affect tolerance at 3.2G and 3.8G. F.R.L.

In: Preprints of the 1972 Annual Scientific Meeting, Aerospace Medical Association, Bal Harbour, Florida, May 8-11, 1972. p. 112-113.

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GRINIO, L.P., T.N. KRUPINA, and N.N. BOBKOVA. 1971.
Cytogenetic investigations in relation to manned space flight.
Space Biology and Medicine 5(3):77-83.

[Article by L. P. Grinio, T. N. Krupina and N. N. Bobkova; Moscow, Kosmicheskaya Biologiya i Meditsina, Russian, Vol 5, No 3, 1971, pp 51-55, submitted 20 October 1969]

Abstract: No increase in chromosomal aberrations was found in the blood of test subjects during a 120-day bedrest experiment. No significant changes in the chromosomal apparatus were detected in cytogenetic examinations of the cosmonaut G. T. Beregovoy. These findings indicate that manned space flights made along the trajectories and in radiation environments involved up to this time are genetically safe.

30, 378. GRINIO, L.P., T.N. KRUPINA, and N.N. BOBKOVA. Cytogenetic studies related to a space flight of man (Tsitogeneticheskie issledovaniia v sviazi s kosmicheskim poletom cheloveka). Kosmicheskaya Biologiya i Meditsina, vol. 5, May-June 1971, p. 51-55. 25 refs. In Russian.

A71-39227

A chromosome analysis was carried out in peripheral blood leukocytes from 4 healthy men after 120 day hypokinesia, and cytogenetic tests on Soviet astronaut Beregovoi prior to and after his space flight. An increase in chromosome aberrations in the subjects or significant changes in the chromosome apparatus of the astronaut could not be established by the study. It is concluded that the Soiuz 3 flight of Beregovoi was safe in terms of cytogenetic radiation damage.

40345. GRINIO, L. P., T. N. KRUPINA and N. N. BOBKOVA. Tsitogeneticheskie issledovaniia v svyazi s kosmicheskim poletom cheloveka. [Cytogenetic studies related to manned space flights.] KOSM BIOL MED 5(3): 51-55. illus. 1971. [Engl. summ.]--No increase of chromosome aberrations was found in the blood of test subjects during a 120 day bed rest experiment. No significant changes in the chromosome apparatus were detected through cytogenetic examinations of the cosmonaut G. T. Beregovoy. Manned space flights performed along the trajectories and in the radiation environments used to date are safe from the genetic point of view.--M. L. W.

ACCESS. NO. 24,163

FORM: _____ AUTHOR: L.B. DRILL: P-1

GURFINKEL, V.S., et al. 1970.

Changes in certain human motor functions after prolonged 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. 148-159. [NASA-TT-F-639].

81

DOCUMENT NO.: N70-42869

DESCRIPTORS: Activity GR-58, Human BL-72, Immobilization GR-62, Pathology GY-66, Therapy GY-38,
Technique P-1, USSR GR-3.

1970.

ABSTRACT:

The influence of prolonged hypodynamia on the retention of such motor functions as maintaining vertical position, walking, and rising from the supine position, and the innervation relationships (crossover effects in the spinal cord, vestibulospinal effects) on which these functions are based were investigated and the various ways of preventing hypokinetic disturbances were evaluated. The motor functions studied were selected because they are primarily automatic and independent of voluntary intervention under ordinary conditions. The physical conditioning methods used in the experiments were effective in preventing gross motor disturbances.

R.B.

N67-39112 Joint Publications Research Service, Washington, D. C.

BRAIN HEMODYNAMICS DURING PROLONGED HYPOKINESIA

G. I. Gurvich and G. D. Yefimenko *In its Space Biol. and Med.*, Vol. 1, No. 3 22 Sep. 1967 p 97-102 (See N67-39097 23-04)

The rheoencephalographic technique was applied to a study of cerebral hemodynamics of four test subjects exposed to prolonged (up to 75 days) hypokinesia. Examinations were made prior to, during, and following the bed rest experiment. Observations also were made with the aid of orthostatic tests performed at the end of bed rest. The studies revealed a phasic pattern of changes of cerebral hemodynamics and their correlation with changes of higher nervous activity. In addition the experiments revealed that the rheoencephalographic technique can be used for early diagnosis of intolerance to prolonged hypokinesia and precollaptoic states during orthostatic tests.

Author

A67-36266 #

BRAIN HEMODYNAMICS DURING PROLONGED HYPOKINESIA
[GEMODINAMIKA GOLOVNOGO MOZGA V PROTSESSE DLITEL'-
NOI GIPOKINEZII].

G. I. Gurvich and G. D. Efimenko.

Kosmicheskaya Biologiya i Meditsina, vol. 1, May-June 1967,
p. 62-66. 7 refs. In Russian.

Application of a rheoencephalographic technique to the study of the brain hemodynamics of four human subjects exposed to hypokinesia for periods of up to 75 days. Medical examinations were made before, during, and after the bed-rest period, and included orthostatic tests at the end of the period. The observations revealed a phasic pattern of changes in brain hemodynamics and their correlation with functional changes of the central nervous system. The results indicate that the rheoencephalographic technique is well suited for early diagnosis of intolerance to prolonged hypokinesia and precollaptoic states during orthostatic tests.

V. P.

✓N68-13195# Joint Publications Research Service, Washington, D. C.

CHANGE OF THE PSYCHOPHYSIOLOGICAL STATE OF THE BODY BY AUTOGENOUS AND EXOGENOUS SUGGESTION

G. I. Gurvich, V. L. Marishchuk, M. I. Tishchenko, G. D. Yefimenko, and B. S. Khvoynov. *In its Space Biol. and Med.*, Vol. 1, No. 4 19 Dec. 1967 p 114-118 refs (See N68-1318104-04)

The objective of this study was an investigation of changes of the activity of organs and systems of the human body subjected to prolonged bed rest by autogenous or exogenous suggestion. Six test subjects underwent a 70-day bed rest. Three test subjects served as controls. The other three subjects were trained for the first two weeks on how to stress or relax different muscle groups with subsequent sleep suggestion. According to ECG and EEG recordings and myotonometric and actographic data sleep began in the seventh-fifteenth minute after the second-third week of the experiment. Beginning with the fifth week the test subjects engaged in autosuggestion, attaining similar results. Exogenous suggestion also was performed, employing a radio and a tape recorder. The procedure described provided sound refreshing sleep of the test subjects at the scheduled time.

Author

A67-41855 =

CHANGING OF THE PSYCHOPHYSIOLOGICAL STATE OF THE ORGANISM BY AUTOGENEOUS AND EXOGENEOUS SUGGESTION [IZMENENIE PSIKHOFIZIOLOGICHESKOGO SOSTOYANIYA ORGANIZMA PUTEM AUTOGENNOGO I EKZOGENNOGO VNUSHENIYA]. G. I. Gurvich, V. L. Marishchuk, M. I. Tishchenko, G. D. Efimenko, and B. S. Khvoynov.

Kosmicheskaya Biologiya i Meditsina, vol. 1, July-Aug. 1967, p. 73-76. 10 refs. In Russian.

Application of autogenous and exogenous suggestion to the study of the activity of the organs and systems of the human organism after exposure to prolonged (70 days) bed rest. It was found that after three days of training, the test subjects were capable of finding a sound refreshing sleep even against a stress-factor background and to fall asleep at a prescribed time.

V. P.

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A72-23297 * # Effect of bedrest and positive radial acceleration upon peripheral visual response time. R. F. Haines (NASA, Ames Research Center, Moffett Field, Calif.). In: Aerospace Medical Association, Annual Scientific Meeting, 43rd, Bal Harbour, Fla., May 8-11, 1972, Preprints. (A72-23251 12-04) Washington, D.C., Aerospace Medical Association, 1972, p. 116, 117. 7 refs.

Attempt to determine if peripheral visual response time (RT) could be used as a reliable advanced predictor of 4G sub z-related blackout or grayout. The relatively high luminance of the peripheral stimuli used in the experiments may account for the finding that peripheral RT was not sensitive to impending blackout or grayout. The relatively consistent mean RTs within subjects across test days in bed is probably due to the relatively constant response characteristics of the retina and to the high repeatability of the stimuli. F.R.L.

In: Preprints of the 1972 Annual Scientific Meeting, Aerospace Medical Association, Bal Harbour, Florida, May 8-11, 1972. p. 116-117.

A73 24866 * Effect of passive 70 deg head-up tilt on peripheral visual response time. R. E. Haines (NASA, Ames Research Center, Moffett Field, Calif.). *Journal of Applied Physiology*, vol. 34, Mar. 1973, p. 329-333, 32 refs.

Peripheral visual response time was measured continuously in seven young men during a 30 min, 70 deg head-up tilt before and after 14 days of bed rest. Small test lights were flashed on at unexpected times and locations along the subject's horizontal retinal meridian to determine what effect tilt would have on peripheral visual sensitivity and to better understand the physiological mechanisms that underlie peripheral visual sensitivity. Blood pressure was also measured every other minute throughout this period. The results indicated that response time lengthens significantly to stimuli imaged beyond about 70-deg arc from the line of sight for both the pre- and postbed-rest periods during tilt.

(Author)

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N73-15117# National Aeronautics and Space Administration,
Ames Research Center, Moffett Field, Calif.
EFFECT OF PROLONGED BEDREST AND PLUS G_z
ACCELERATION ON PERIPHERAL VISUAL RESPONSE
TIME

Richard F. Haines Washington Jan. 1973 66 p refs
(NASA-TN-D-7161; A-4566) Avail: NTIS HC \$3.00 CSCL
06S

Peripheral visual response time changes during +G sub z acceleration following fourteen days of bedrest are considered as well as what effect prolonged bedrest has upon this response. Eighteen test lights, placed 10 deg apart along the horizontal meridian of the subject's field of view, were presented in a random sequence. The subject was instructed to press a button as soon as a light appeared. Response time testing occurred periodically during bedrest and continuously during centrifugation testing. The results indicate that: (1) mean response time is significantly longer to stimuli imaged in the far periphery than to stimuli imaged closer to the line of sight; (2) mean response time at each stimulus position tends to be longer at plateau g than during the preacceleration baseline period; (3) mean response time tends to lengthen as the g level is increased; (4) peripheral visual response time during +G sub x acceleration at 2, 3.2, and 3.8 g was not a reliable advanced indicator that blackout was going to occur; and (5) the subject's field of view collapsed rapidly just before blackout. Bedrest data showed that the distribution of response times to stimuli imaged across the subject's horizontal retinal meridian remained remarkably constant from day to day during both the bedrest and recovery periods.

Author

HAINES, R. F. *Effect of prolonged bedrest and $+G_z$ acceleration upon peripheral visual response time.* *Aerospace Med.* 44 (4): 425-432, 1973.

Cardiovascular deconditioning, dehydration, and other physiological changes which occur as a result of prolonged exposure to the zero-g space environment raise some questions about the applicability of much previous research which has shown that spacecraft reentry accelerations pose no appreciable physiological or performance problems for the astronauts. The present paper deals with whether or not peripheral visual response time changes during $+G_z$ acceleration after 14 days of bedrest. Eighteen test lights, placed 10° apart along the horizontal meridian of the subject's field of view, were presented in a random sequence. The subject was instructed to press a button as soon as a light appeared. This testing occurred periodically during bedrest and continuously during centrifugation testing. The results indicated that: (1) mean response time was significantly longer ($p < 0.01$) to stimuli imaged in the far periphery than to stimuli imaged closer to the line of sight during $+G_z$ acceleration, (2) mean response time at each stimulus position tends to be longer at plateau g than during the pre-acceleration baseline period for that run by an amount which ranged from about 20 to 120 msec, (3) mean response time tends to lengthen as g level is increased, and (4) under these testing conditions peripheral visual response time during $+G_z$ acceleration within approximately 40 seconds of blackout does not provide a reliable indicator that blackout is going to occur. The bedrest response time data showed that the distribution of RTs across the horizontal retinal meridian remained remarkably constant within subjects from day to day during the bedrest and recovery periods. These findings are discussed in relation to previous studies and to the design and placement of aerospace vehicle cockpit instruments.

HAINES, R.F. 1973.

Effect of Prolonged Bedrest With Exercise on Body Balance.

In: Preprints of the 1973 Annual Scientific Meeting, Aerospace Medical Association, Las Vegas, Nevada. p. 17-18.

The following questions were raised here:

(1) What effect does 14 days of bedrest have on body balance immediately after bedrest? (2) Is it possible for body balance after bedrest to be maintained at prebedrest levels by daily isometric (IM) or isotonic (IT) leg exercise? (3) What is the learning rate before and relearning rate after bedrest on various balance tests? (4) Are some balance tests more sensitive than others in detecting the effects of prolonged bedrest?

Neither type of leg exercise was effective in preventing the debilitating effects of 14 days of bedrest on body balance. These results suggest that a factor other than bedrest-related muscular weakness or disuse atrophy of the leg muscles accounted for these decrements. This bedrest may have produced sensory, kines-

thetic, and/or proprioceptive neural information to postural control centers that was different from the information produced under normal, upright, ambulatory conditions. Some Ss remarked that, although they knew they were starting to fall, they could not get their limbs or torsos to move fast enough to compensate appropriately to forestall the excessive sway. After bedrest, balance skill was relearned rapidly so that performance on most tests had returned to prebedrest levels by the third recovery day. Nevertheless, the learning rate for the eyes-closed tests was about the same before bedrest as after. The one-leg rail balance/eyes-open test was the most sensitive test of the debilitating effects of bedrest using a criterion of prebedrest balance score stability versus postbedrest change.

A70-33991 * Human circadian circulatory rhythms during weightlessness in extraterrestrial flight or bedrest with and without exercise. Franz Halberg (Minnesota, University, Minneapolis, Minn.), Carlos Vallbona (Baylor University; Texas Institute for Rehabilitation and Research, Houston, Tex.), Lawrence F. Dietlein, John A. Rummel, Charles A. Berry (NASA, Manned Spacecraft Center, Houston, Tex.), Grover C. Pitts, and Sarah A. Nunneley (Ohio State University, Columbus, Ohio). *Space Life Sciences*, vol. 2, May 1970, p. 18-32. 32 refs. PHS Grants No. 5-K6-GM-13,981; No. FR-00254; Grant No. NGR-24-005-006; Contracts No. NAS 9-6162; No. NAS 2-1554; No. NAS 2-2738.

Detection of human circadian rhythms in heart rate and in the durations of electromechanical systole and of the entire cardiac cycle by an inferential statistical analysis, the cosinor method. These findings apply to men on earth in bed for several days, whether or not they intermittently perform isometric exercise. Rhythms also are demonstrated in men at a few hundred nautical miles from earth experiencing weightlessness for several days during extraterrestrial space flight; whether or not these circadian rhythms are 24-hour synchronized cannot be discussed with the data on hand. Such demonstrations of rhythm persistence in astronauts and cosmonauts underline the need for further work on mammals to define and to control those rhythmic factors affecting not only the longer-term scheduling of human activities in extraterrestrial space but also rhythmic behavior in health and disease on earth. Given such background information, the long-term behavior of rhythms in organisms transferred to terrestrial, lunar, and eventually solar orbits remains a major challenge for research in extraterrestrial space. M.V.E.

TASK NUMBER: 970-51-17-02

0473

CITATION: HANTMAN, D.A., J.M. VOGEL, C.L. DONALDSON, R. FRIEDMAN, R.S. GOLDSMITH and S.B. HULLEY. Attempts to prevent disuse osteoporosis by treatment with calcitonin, longitudinal compression and supplementary calcium and phosphate. Submitted for publication to *Journal of Clinical Endocrinology*. May 1973.

PERFORMING INSTITUTION: USPHS Hospital, San Francisco, California

KIND OF DOCUMENT: Research Report

SUBJECTS: 6 healthy males

RES. OBJECT.

To study the efficacy of various treatments in the prevention of disuse osteoporosis during prolonged bed rest.

METHOD

Subjects were studied during 19 weeks of continuous bed rest and three treatment regimens were tested for their effectiveness in preventing bone mineral loss: 1) 100 MRC units of synthetic salmon calcitonin was administered daily; 2) intermittent compression in the longitudinal axis was applied by springs attached to a special suit (a force equal to 80% of body weight was applied 45 times per minute for 4 hours daily); and 3) calcium and phosphate supplements were administered, increasing daily intake of calcium from 1.0 to 1.8 or 2.3 gm, and that of phosphorus from 1.7 to 3.0 gm.

RESULTS

1) Synthetic salmon calcitonin (100 MRC units daily) did not prevent the negative calcium and phosphorus balances which are observed during untreated bed rest. The increase in urinary calcium and hydroxyproline excretion was unusually large in one of the two subjects. 2) The negative mineral balances were not substantially affected by this regimen. 3) Calcium balances were significantly less negative than those of control subjects in four of five cases; phosphorus balances showed similar patterns. Combined administration of these three regimens to two subjects also produced a beneficial response. These results which are based on mineral balance data were only partially confirmed by gamma ray transmission scanning of the central calcaneus, and some discrepancies were noted.

CONCLUSIONS

It was concluded that the two month course of calcium and phosphate supplements retarded the development of disuse osteoporosis, but that the intermittent compression and calcitonin were ineffective.

HAMRIN, E. 1971.

Anatomical and functional changes in joints and muscles during long term bed rest.

Nordisk Medicin 85:293-8. 11 Mar. 1971

Anatomical and functional changes in joints and muscles during long-term bed rest

ELISABETH HAMRIN

This paper presents a survey of the literature on *Anatomical and functional changes in joints and muscles during long-term bed rest*. The study was carried out at the Institute of Anatomy and Histology at the University of Uppsala, Sweden. No clinical research has been made at the present stage, but some practical conclusions have been drawn on the basis of experience from the Uppsala sick-care district.

Research on the adverse effects of bed rest has been very sparse. Between 1929 and 1963, only 15 investigations were published, but this figure does not include any reports from Russia, and only 9 of them concerned proper bed rest (29). Space medical research in the 1960s, however, has shown great interest in the effects of bed rest on the organism. Several of these investigations are included in the survey.

A71-39480 • The summation-dial, a vectorial representation of time series data. N. W. Hetherington, C. M. Winget, L. S. Rosenblatt (NASA, Ames Research Center, Physiology Branch, Moffett Field, Calif.), and P. B. Mack (Texas Woman's University, Denton, Tex.). (*International Institute for Interdisciplinary Cycle Research, International Interdisciplinary Cycle Research Symposium, 2nd, Noordwijk, Netherlands, June 14-19, 1970.*) *Journal of Interdisciplinary Cycle Research*, vol. 2, Aug. 1971, p. 365-377.

Development of mathematical methods which would be applicable to data both stationary and nonstationary in time. The basic method suggested has been utilized for many years in the study of geomagnetism, and is here extended to the study of the interrelationships between two rhythms. These methods are described, and examples derived from a study involving 8 male human subjects who had undergone 56 days of bed rest, following a 6 day ambulatory or control period, are cited.

F.R.L.

HOFFLER, G.W., M.D., R.A. WOLTHUIS, PH.D., and R.L. JOHNSON, M.D.

Effect of seven days of bed rest on cardiovascular responses
to lower body negative pressure.

In: Preprints of the 1971 Annual Scientific Meeting, Aerospace Medical
Association, Houston, Texas, April 26-27, 1971. P. 174-175.

A68-31829 #

CIRCULATORY EFFECTS OF WATER IMMERSION UPON HUMAN SUBJECTS.

William B. Hood, Jr., Raymond H. Murray, Charles W. Urachel, John A. Bowers, and Jack K. Goldinan (USAF, Systems Command, Aerospace Medical Div., Aerospace Medical Research Laboratories; Indiana University, Cardiopulmonary Laboratory, Wright-Patterson AFB, Ohio).

Aerospace Medicine, vol. 39, June 1968, p. 579-584. 35 refs.
Contract No. AF 33(616)-8378.

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DOCUMENT SERIES & NO.: A68-31829 (IAA)

DESCRIPTORS: Bedrest GY/39, Bradycardia GY/45, Circulatory system R/10, Human BL/72, Water immersion P/24

ABSTRACT:

Changes in hemodynamics were studied in five human volunteer subjects during two separate eight-hour periods of bed rest and total water immersion. During immersion subjects showed a decline in pulse rate, arterial blood pressure, and peripheral vascular resistance, and exhibited elevation of stroke volume compared to the control state. Central venous mean blood pressure fell with immersion, presumably in response to the relative negativity of the airway pressure supplied to the subjects. These findings suggest that water immersion results in these circulatory changes: (1) relative bradycardia, with a secondary increase in stroke volume, and (2) peripheral vasodilatation, with secondary decline in arterial pressure. These findings are not explained either by loss of plasma volume or by relative negative pressure breathing, and presumably are a consequence of exposure to the "buoyant state."

(Author)

CITATION: HULLEY, S.B., D.R. LOCKWOOD, C.L. DONALDSON and J.M. VOGEL. Attempts to prevent bone mineral loss during prolonged bed rest. Presented at the 23rd International Astronautical Congress, Vienna, Austria, October 8-15, 1972. 10 p.

PERFORMING INSTITUTION: USPHS Hospital, San Francisco, California

KIND OF DOCUMENT: Research Report

SUBJECTS: 34 adult males

ES. OBJECT.

To determine the nature and extent of the alterations in the bone metabolism caused by bed rest, which parallels those of prolonged weightlessness.

METHOD

Over a period of 4 yrs, 34 young men were rested in bed continually for periods of 17-36 wks. Movements in the horizontal plane were not restricted. Whole food metabolic diet contained 1.0 gm calcium and 1.6 gm phosphorus per day. Skeletal changes were assessed by metabolic balance techniques and by ¹²⁵Iodine gamma ray transmission scanning of the calcaneus. The researchers also undertook physical and chemical countermeasures such as longitudinal compression and oral administration of minerals respectively.

RESULTS

Calcium is gained before it is lost. Hypercalciuria reaches a peak of 100 mg/day at about the 6th week of bedrest; similar fecal gains were also shown. However, continued bed rest yields only losses at an overall rate of 1/2% of total body calcium per month.

CONCLUSIONS

Scans show that minerals are lost from the calcaneus at a tenfold greater rate, suggesting that demineralization occurs differentially from weight-bearing bones. Fortunately, the calcaneus is completely replenished during reambulation. But treatment regimens did not prevent phosphorus and calcium loss to any meaningful degree. While treatment worked on hypercalciuria, it failed to prevent increased hydroxyproline excretion during bed rest.

TASK NUMBER: 970-51-17-02

CITATION: HULLEY, S.B., J.M. VOGEL, C.L. DONALDSON, J.H. BAYERS, R.J. FRIEDMAN and S.M. ROSEN. The effect of supplemental oral phosphate on the bone mineral changes during prolonged bed rest. *The Journal of Clinical Investigation* 50(12):2506-2518. 1971.

PERFORMING INSTITUTION: USPHS Hospital, San Francisco, California

KIND OF DOCUMENT: Research Report

SUBJECTS: 5 healthy males

RES. OBJECT.

To determine whether administration of oral potassium phosphate prevents the development of disuse osteoporosis.

METHOD

Subjects underwent 24-30 wk continuous bed rest. Pre- and post bed rest data. Diet consisted of 7 daily menus and 1 hexavitamin tablet daily. Supplemental phosphate was orally administered as Hyper-Phos-K tablets. Serum, stool, urine and sweat were collected. Specimens were digested in nitric acid for Ca and Mg determinations and in sulfuric acid for P and N determinations. Changes in skeletal mineral content were assayed indirectly by Ca balance techniques and directly by gamma ray transmission and scanning of the calcaneus and radius.

RESULTS

During the first 12 wk bed rest the rate of total body Ca in untreated Ss was 0.5-0.7%/month. Rate of loss of central calcaneus material was 10 times higher but mineral content of the radius was unchanged. Changes in P balance resembled Ca pattern and increased N and hydroxyproline also occurred during bed rest. Upon reambulation the Ss' Ca balance became positive after 1 month and recovery of the calcaneus mineral was complete within 10-20 weeks. Potassium phosphate treatments entirely prevented the hypercalciuria of bed rest but fecal Ca tended to increase. In the first 12 wks Ca balance was less negative than during bed rest. Mg patterns of excretion were similar to Ca. Fecal and urinary phosphorus excretions were doubled and phosphorus balance became positive. Mineral loss from the central calcaneus was similar to that of untreated Ss.

CONCLUSIONS

This form of phosphate supplementation reduces urinary Ca excretion but does not prevent bone loss during bed rest.

HYATT, K.H., P.C. JOHNSON, G.W. HOFFLER, P.C. RAMBAUT, J.A. RUMMEL, S.B. HULLEY, J.M. VOGEL, C. HUNTOON, and W.R. SPEARS. 1973. The Effect of Potassium Depletion in Normal Males: An Apollo 15 Simulation.

In: Preprints of the 1973 Annual Scientific Meeting, Aerospace Medical Association, Las Vegas, Nevada. p. 100-101.

CONCLUSIONS

Although the bedrest subjects showed no clinical evidence of hypokalemia, the results of this limited study do not totally exclude the possibility of hypokalemic manifestations in the Apollo 15 astronauts. All of the environmental and atmospheric factors of Apollo 15 could not be reduplicated in the present study. In this regard, Knochel has shown that six subjects who underwent intensive physical conditioning in a hot climate showed a mean potassium deficit of 422 meq after 11 days in spite of a daily potassium intake of 100 meq (7).

The present study, while not providing definitive answers regarding the experiences of Apollo 15, points up the need for more detailed studies of the effect of manned space flight on potassium metabolism. Additional ground-based studies relating ^{42}K measurements to potassium balance under a variety of conditions should be performed. Similar detailed studies should be performed on the astronauts of Skylab to allow correlation with these ground-based studies. Until our knowledge of the effects of space flight conditions on such significant bodily functions as electrolyte metabolism is accurate and sufficient, more extensive space exploration could contain risks for which we are ill-prepared to avoid or manage.

HYATT, K.H., P.C. JOHNSON, G.W. HOFFLER, P.C. RAMBAUT, J.A. RUMMEL,
S.B. HULLEY, J.M. VOGEL, C. HUNTOON, and W.R. SPEARS. 1973.
The Effect of Potassium Depletion in Normal Males: An Apollo 15 Simu-
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The present study, while not providing definitive answers regarding the experiences of Apollo 15, points up the need for more detailed studies of the effect of manned space flight on potassium metabolism. Additional ground-based studies relating ^{42}K measurements to potassium balance under a variety of conditions should be performed. Similar detailed studies should be performed on the astronauts of Skylab to allow correlation with these ground-based studies. Until our knowledge of the effects of space flight conditions on such significant bodily functions as electrolyte metabolism is accurate and sufficient, more extensive space exploration could contain risks for which we are ill-prepared to avoid or manage.

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EXTRAVASCULAR DEHYDRATION AS AN ETIOLOGIC FACTOR IN POST-RECUMBENCY ORTHOSTATISM.

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The hemodynamic and metabolic effects of two weeks of absolute bedrest have been evaluated in twenty normal volunteers. Post-recumbency tilting resulted in a more profound decrease in stroke volume and cardiac output than had been present before bedrest. This was coupled with a failure to augment stroke volume and cardiac output to prerecumbency levels during 50-watt exercise after bedrest. A large diuresis and saluresis occurred during bedrest. In spite of this, plasma volume was at prerecumbency levels at the end of two weeks of bedrest. It is suggested that the fluid loss must have been derived from extravascular compartments with resultant lowering of tissue pressure. It is likely that a large transudation of plasma water into lower extremity tissue spaces occurred during post-recumbency tilting. The resultant decrease in plasma volume during tilt would then account for the decrement in stroke volume and cardiac output during tilting and exercise. A possible mechanism for induction of vasodepressor syncope is hypothesized. (Author)