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in reply refer to:

NORTHROP SPACE LABORATORIES **inter-office memorandum**

to: Dr. J. Gaume

from: Dr. Bronson

subject: INVITATION BY NASA OFFICIAL (L. FONG) FOR A PROPOSAL FROM NSL WHICH WOULD PROVIDE FOR A RESEARCH CONTRACT LEADING TO THE PUBLICATION OF A NASA TECHNOLOGY SURVEY MANUAL.

date: 8 June 1964

ref: Our telephone call of even date for a coordination meeting.

copies:

L. Bernbach
W. Armstrong
G. Muinch
Dr. Howard
Dr. Roth
G. Mangurian
Dr. Lombard

Mr. Fong and other NASA officials were impressed with our verbal presentation at the recent NASA/UCLA Symposium and Workshop on the Transformation of Knowledge and its Utilization. The subject of our paper was "Applications of Space Biomedical Research to Problems of Rehabilitation." The request was made for a proposal from NSL for a complete literature investigation on the subject of neuromuscular research and developments conducted by NASA contractors and grantees'. This would include the studies on weightlessness, restraint systems, diet studies, and related research. The purpose of this would be to prepare for NASA, a Technology Survey Manual similar to their publication NASA SP-5006 Technology Survey, "The Measurement of Blood Pressure in the Human Body," a state-of-the-art summary. However, this proposed manual would have a much broader base and distribution towards all medical and human research scientists as well as for sale by the Superintendent of Documents, U.S. Government Printing Office for a price to be established.

This manual would be all-inclusive and represent a thorough investigation of the subject proposed title, "Neuromuscular Pathophysiology and Related Research," conducted by NASA contractors.

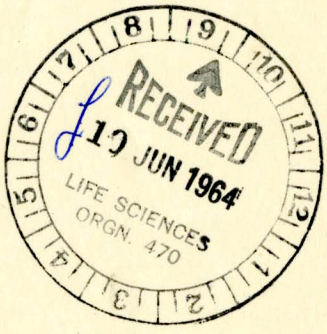
At present, this writer is assigned to the NSL Technology Utilization Contract. However, since this writer is primarily under the cognizance of the NSL Life Science Department, a proposal coordination meeting is requested to determine which NSL department should have cognizance over the proposed proposal effort.*

S Davis Bronson, M.D.

S. Davis Bronson, M.D.
Biodynamics Group
Life Sciences Section

*Proposed meeting date:

10 June 1964 at 10:00 a.m.



APPLICATIONS OF SPACE BIOMEDICAL RESEARCH TO PROBLEMS OF REHABILITATION

by

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Lecture on Applications of Space Biomedical Research to Problems of Rehabilitation presented by S. Davis Bronson, M.D. at the NASA-UCLA Symposium and Workshop on the Transformation of Knowledge and Its Utilization, 2 June 1964, Workshop E - Applied Biomedical Space Research.

This presentation is intended to acquaint this distinguished group with the degree of congruity which exists between the in-process resolution of certain problems connected with manned space flight -- and current problems encountered in the everyday practice of modern medicine.

With this congruity thus established, it will become prudent to point out these areas within which some physiological research and developments currently being accomplished in connection with our national space program, can be directly applied to one of the three major divisions of the practice of medicine. I am referring to: 1) preventative medicine, 2) diagnosis and treatment, and 3) rehabilitation, or physical medicine. It is with this latter division that space medical research and development has brought forth developments that may modify or mitigate the effects of some terrestrial diseases and entities that simulate the purported effects of chronic weightlessness. Some of the advances in space physical medicine have given new hope to individuals who suffer from loss of extremities, use of extremities, muscular atrophy or dystrophy, hemiplegia, paraplegia, quadriplegia, and so forth. Therefore, the remainder of this presentation will specifically relate to the problems of rehabilitation medicine, and how the space medicine program of research developments can and is benefiting humanity.

Rehabilitation programs and physical medicine modalities are designed and planned to (1) separate the patient from the bed and hospital as soon as possible, (2) to restore the patient to normal or near-normal activity in a minimum of time, labor and materials and (3) to facilitate an early adjustment to work, home, community and Country.

Space medicine research programs involve these phases of medicine, to include the prevention of effects of chronic weightlessness, the proper diagnosis and treatment of induced problems of zero and near-zero gravity effects on the body systems, and proper rehabilitation and physical medicine programs. The functional

aspect of the protection of astronauts is to: (1) maintain joint motion and muscle integrity and strength, (2) maintain coordination, motor skills and work tolerance, and (3) to prevent unwholesome physiological and psychological reactions. With the direct relationship of these two problem areas clearly established, it is evident that the same functional devices developed in the space medicine research program can be used in helping physically handicapped individuals to: (1) restore physical function, (2) increase work tolerance, and (3) help the individual to regain special skills. For example, in the treatment of the hemiplegic case caused by a cerebrovascular accident, the immediate therapeutic objective is re-education leading to the active use of the affected extremity. The long term objective consists of education of the sound arm to compensate for the loss of function in the affected arm. Then, (1) to prevent deformities, (2) treat the deformities if they occur, (3) retrain the affected extremity to maximum capacity, (4) to teach the individual to perform activities of daily living using the unaffected extremities. The devices developed to assist the astronaut in the performance of his space duties, with a minimum of expenditure of energy, are directly applicable to assist the hemiplegic in the exercise and performance of his normal functions of movement.

Some of the functional incapacitating entities may be due to genetically transmitted factors, trauma, neurological disorders, hematopoetic factors, metabolic factors, disease, iatrogenic, or unknown etiology. In any case, muscle weakness and imbalance leading to progressive wasting of the body is the sequellae. A vicious cycle of muscle and body deterioration ensues, as depicted in Figure #1.

It has been learned from experience that many of these conditions are reversible, provided that appropriate remedial measures are started before irreversible tissue changes take place.

For example, as indicated in Figure #1, research is progressing in various government and private laboratories on the effects of chronic weightlessness. These are mentioned in the bibliography at the end of this paper. Research is now being conducted at (1) Texas Woman's University on "Fundamental Investigation of Losses of Skeletal Minerals During Prolonged Immobilization, Including a Study of Reducing Mineral Loss;" (2) Frost Engineering, Denver, "Dynamics of Human Restraint;" (3) May Associates, Rochester, Minnesota, "Study of Effects of Sustained Acceleration on Man;" (4) Albert Einstein College, New York, "The Effects of Isolation, Sensory Deprivation, and Sensory Rearrangement on Visual, Auditory, and Somasthetic Sensation, Perception and Spatial Orientation;" (5) Emory University, "Effects of Zero G and Radiation;" (6) Aerospace Medical Research Laboratory, Wright Patterson AFB., "Caloric, Protein and Water Requirements of Man Subjected to Simulated Space Flight Stress."

Motion is a fundamental property of living matter, down to the cellular level and up to the highest form of animal life. In man, motion is based upon transmission of impulses from a receptor, through an afferent neuron and ganglion cell to the muscle. Motor disturbances from any cause whatsoever, can cause weakness and paralysis, which may result in lesions of the voluntary motor pathway, or of the muscles themselves. Impaired motor functioning may result from involvement of muscle, myoneural junction, peripheral nerve, or from the central nervous system. To these causes must be added the involvement due to disuse atrophy, and/or the effects of chronic weightlessness due to zero or near-zero sub-gravity conditions over prolonged periods of time.

This paper is presented in the hope that it may encourage further investigation of terrestrial disease entities that may simulate the effects of chronic weightlessness, and to elucidate the problems in advance of the development of such effects. Procedures, such as instrumentation, medications, therapy, etc.,

are being developed for the diagnosis, prognosis, prevention, and treatment of such disease entities as those simulated by the effects of chronic weightlessness. For as sure as day follows night, man will suffer from the effects of chronic weightlessness if he remains in an area of weightlessness without taking appropriate preventative remedial measures.

In medical literature, one can find well established disease entities that may simulate the deterioration of muscle tone and mobility due to prolonged periods of weightlessness. Such conditions are simulated in part by an assortment of disease entities, which if further collated and correlated, would present an overall picture of the effects on the whole body.

Listed below is a group of terrestrial diseases that may simulate some of the effects of chronic weightlessness and comparable physical conditions on various systems of the human body, especially the muscular systems:

(1) progressive muscular (or nuclear) atrophies.

(2) progressive muscular dystrophy

(3) myasthenia gravis

(4) amyotonia congenita

(5) myotonia congenita

(6) myotonia atrophica

(7) polymyositis

(8) amyotrophic lateral sclerosis

(9) familial myopathies

(10) quadriplegia

(11) hemiplegia (various etiologies)

(12) anterior poliomyelitis

(13) tabes dorsalis and Charcot's disease

(14) adynamic ileus (paralytic)

(15) myotonia acquisita

(16) multiple sclerosis leading to spastic paralysis, disability and cachexia

(17) posterolateral sclerosis (subacute combined system disease)

Some of these conditions are characterized by muscular disfunction in the presence of apparently normal nerve tissue, and some are characterized by a progressive weakness and atrophy of certain groups of muscles. Muscular atrophies can result from neural lesions and chronic weightlessness. Muscular dystrophies result from primary disease of the muscle itself. Disuse atrophy can occur from a neurological basis of loss of muscle tone which can cause disturbances in electrolyte and mineral balance, metabolic defects, loss of protein and nitrogen, and total disruption of homeostatic-metabolic balance.

It has been relatively well established that short periods of weightlessness have little or no effect upon the body. However, prolonged periods of weightlessness may present problems as herein mentioned. As man travels into space for prolonged periods of time, or establishes and maintains a lunar base, his remoteness from medical support becomes an important factor. Research projects are now being performed and proposed to elucidate the medical problems in advance of the development of the effects of chronic weightlessness or prolonged periods of immobility in space suits, vehicles, or support restraint systems.

Studies of simulated prolonged weightlessness effects are currently being performed on animals and humans to evaluate the effects of such an environment. Two such simulated environments are: (1) prolonged bed rest, and (2) water suspension. The effects of weightless environment on the total body as well as

on individual organ systems are being explored. These experiments are attempting to fill in the uncertainties and to extrapolate educated facts.

There are many terrestrial disease entities being diagnosed which develop and present signs and symptoms which simulate the effects of chronic weightlessness. (Figure No. 2). These too are now being studied.

The results obtained from space medicine research will undoubtedly help afflicted individuals to a fuller life through the prevention of muscle atrophy and mitigation of the effects of dystrophy. The devices that will assist the astronaut in maintaining homeostatic function will be therapeutically applicable to those affected with neuromuscular infermaties. For example, the four ranking neuromuscular disorders whose signs and symptoms simulate some of the effects of prolonged weightlessness are: cerebral palsey, Parkinson's disease, multiple sclerosis and other demyelinating diseases, and muscular dystrophy. These are either or both neuropathic and myopathic. Others are: myesthenia gravis, amyotrophic lateral sclerosis, familial myopathies, anterior poliomyelitis, tabes dorsalis, posterolateral sclerosis, subactue combined system disease. All leave the mark of muscular disintegration. Calcium losses during weightlessness are dangerous and undesirable, this is also noted as a factor in the immobilization of invalids or convalescents due to prolonged bed rest.

Statistics show that about one in 900 persons has muscular dystrophy, and two out of three of these are children. The chemistries of these diseases exhibit abnormal distribution of muscle solids, protein content, fat and collagen. They are characterized by changes in serum enzymes, changes in cardiac muscle; mineral and electrolyte changes; negative nitrogen balance; bone demineralization; decreased gastro-intestinal activity; reduction in blood volume; decreased metabolic rate; kidney and urinary changes; and altered superficial and deep reflexes. These same or similar changes are noted and are prognosticated in the effects of prolonged weightlessness on the body. (36).

The developed exercises and devices used in the prevention of some of the effects of prolonged weightlessness (36 and 39) are readily adaptable to the therapy to prevent deformities, treat deformities as they occur, and to compensate for impediments which may present an impasse for everyday living.

Medical statistics also indicate that for every 100 persons, there are eight with some orthopedic impairment. This rate increases with age. The lower extremities and the hip are the most frequent sites of impairment. There are also over 259,000 cases of amputees on record, excluding fingers and toes. These are all potential beneficiaries of the space research developments. Major improvements in function and appearance of prosthetic devices have made them more acceptable to individuals with amputations. Devices being developed or already developed and used for support of persons with musculoskeletal disease and disability are constantly being improved as mechanisms for more efficient conservation and use of body energy. This is in the field of biomechanics (37 and 38) and biotechnology which are direct study areas in space medicine.

The continuing study of the effects of chronic weightlessness and neuromuscular disease entities will insure better therapeutic devices and remedial measures, and subsequently, a better understanding of the causes which may lead to the prevention or improved techniques in the treatment of such diseases. For example, the leg part of the space suit used to prevent the pooling of blood and fluid in the lower extremities, can act as a venus blood and lymphatic fluid return pump to prevent pooling of body fluids and facilitate their return to the heart. This will ameliorate stagnation, decubeti, and backward heart failure. Such a device may also substitute for Buerger leg exercises in TAO and other occulsive arterial and venus extremity diseases.

The field of physical medicine will benefit by the development of devices which will rehabilitate individuals at a faster and more efficient rate with a resulting lower cost to the public welfare roles. Studies and research programs

are now being pursued in the field of exercise (e.g., isometric exercises) pharmacodynamics, prosthetics, orthotics, occupational therapy, manipulative and slave devices, etc., that are intended to mitigate the effects of chronic weightlessness on an astronaut. These same techniques and devices will eventually be applicable to terrestrial entities, to prevent or mitigate irreversible muscle or bone damage, etc., as well as hasten the return of the individual to normal function.

These advances can be expected to contribute to the economic well being of our nation as well as to the purely humanitarian aspect; since they should reduce the number of disabled persons being cared for under government, state, and local programs and make it possible for them to attain self-supporting status.

This has been a very abbreviated discourse on a relatively small portion of our national space medicine effort. We believe that throughout the ensuing years, the medical profession as a whole, will substantially advance through these efforts. This does not mean that these advances will be accomplished only by those directly connected with our national space programs. You colleagues have, and will in the future make contributions to our knowledge which will materially aid in the eventual accomplishment of our basic space objectives. There should be no line drawn between terrestrial and extraterrestrial medicine- rather, the free exchange of our collective knowledge should be our keynote in the never-ending struggle against sickness and disease.

ACKNOWLEDGEMENTS

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BIBLIOGRAPHY

1. Preliminary Investigation of the Problem of Maintenance of Muscle and Bone Mass and Function under Conditions of Immobilization and Zero Gravity, Hein, M.M. The Martin Company, Denver, Colorado, April 1960.
2. Results of the First United States Manned Orbital Space Flight of February 20, 1962 (Flight MA-6). Manned Spacecraft Center, NASA, U.S. Government Printing Office, Washington 25, D.C., April 1962, Chapter 8, 83-92.
3. "Some Results of Physiological Responses to Space Flight Conditions," Gazenko, O.G., and Yazdovsky, V.J. International Astronomical Federation XIIth Congress, Washington, D.C., October 1961.
4. "Physiological Considerations Relevant to the Problem of Prolonged Weightlessness," Lawton, R.W. Astronautical Sciences Review, Jan-March 1962, 11-38.
5. Physiology of Muscular Activity, Karpovich, P.V., W. B. Saunders Co., Philadelphia and London, Fourth Edition, 1956.
6. Energy and Power in the Legs of Above-Knee Amputees During Normal Level Walking, Bresler, B., et al. Institute of Engineering Research, University of California, Berkeley, California, 1957.
7. Biomedical Design of an Improved Leg Prosthesis, Radcliffe, C.W. Institute of Engineering Research, University of California, Berkeley, California, 1957.
8. Handbook of Orthopaedic Surgery, Shands, A.R. The C.V. Mosby Co., St. Louis, Missouri, 1957.
9. ~~The Work Potential of Man Under Lunar Gravity, Gaume, J.G. and Kuehnegger, W., Martin Company; Denver, Colorado, (Report in preparation).~~
10. Deitrick, J.E., Wheedon, D.G., and Schorr, E.: Effects of Immobilization Upon Various Metabolic and Physiologic Functions in Normal Men, American Journal of Medicine, 4:3, 1948

11. Dock, William: The Undesirable Effects of Bedrest, Surg. Clin. N. Amer., 25-437, 1945.

12. Gazenko, O.G., and Yazdovsky, V.J.: Some Results of Physiological Responses to Space Flight Conditions, Presented at International Astronautical Federation XIIth Congress, Washington, D.C. October 2-7, 1961.

13. Gerathewohl, S.J., Strughold, H., Stallings, H.D.,: Sensomotor Performance During Weightlessness, Journal Av. Med., 28:7, 1957.

14. Graveline, D.E., Balke, B.: The Physiologic Effects of Hypodynamics Induced by Water Immersion, School of Aviation Medicine, USAF, Report No. 60-88, September 1960.

15. Haber, H., and Gerathewohl, S.J.,: On the Physics and Psychophysics of Weightlessness, Journal Av. Med., Vol. 22:180, 1951.

16. Hartman, B., McKensie, R.E.,Graveline, D.E.: An exploratory Study of Changes in Proficiency in a Hypodynamic Environment, School of Aviation Medicine, USAF, Report No. 60-72, July 1960.

17. Hein, M.M.: Preliminary Investigation of the Problem of Maintenance of Muscle and Bone Mass and Function Under Conditions of Immobilization and Zero Gravity, Internal Report, The Martin Company, Denver, Colorado, April 1960.

18. Lansberg, M.P.: Some Consequences of Weightlessness and Artificial Weight, Presented at Symposium on Space Medicine, British Interplanetary Society, London, England, October 16-17, 1958.

19. Levine, S.A.: Some Harmful Effects of Recumbency in Treatment of Heart Disease, J.A.M.A., 126:80, 1944.

20. Shock, G.J.D.: A Study of Animal Reflexes During Exposure to Subgravity and Weightlessness, J. Aerospace Med., 32:336, 1961

21. Symposium: Abuse of Bed Rest, J.A.M.A., 125, 1075, 1944.

22. Ward, J.E., Hawkins, W.R., Stallings, H.D.: Physiologic Response to Subgravity, School of Aviation Medicine, USAF, Report No. 59-2, January 1959.

23. Wiggers, Carl J.: Physiology in Health and Disease, Fifth Edition, pp 969-973, Philadelphia, Lea and Febiger, 1949.

24. Gaume, J.G., Physio-Pathologic Implications of Chronic Weightlessness, Proceedings of the First USAF Latin American Medical Conference, Published by Office of the Surgeon General, USAF; Washington 25, D.C. March 1962.

25. Health Statistics Series B-35, July 1962 and Series B-36, October 1962, National Health Survey, Public Health Service. U.S.D.H, E & W.

26. Shape-Up, Navy-Marine Corps Exercise Pamphlet, Isometric Exercise Programs of the U.S. Navy and Marine Corps.

27. Natress, L.W., Jr., and Litt, B.D.; Orthotic Services U.S.A. 1962, The American Orthotics and Prosthetics Association, Washington, D.C., 1963.

28. Mercury Project Summary - NASA SP-45 including results of the Fourth Manned Orbital Flight.

29. Results of the Project Mercury Ballistic and Orbital Chimpanzee Flights, NASA SP-39.

30. Guyton, Arthur C., Textbook of Medical Physiology, 2nd ed. W. B. Saunders Company, Philadelphia, 1961.

31. Chusid, J. and McDonald, J.J., Correlative Neuroanatomy and Functional Neurology, Lange Medical Publications, Los Altos, Calif., 1960, 10th edition.

32. Brainerd, H., Margen, S., Chatton, M.J., Current Diagnosis and Treatment, Lange Medical Publications, Los Altos, Calif. 1964.

33. Sodeman, W.A., Pathogenic Physiology, 3rd edition, W.B. Saunders Company, Philadelphia, 1961.

34. Bourne, G.H., Medical and Biological Problems of Space Flight, Chapter 6, Weightlessness: Its Physical, Biological and Medical Aspects, by Generales, C.D.J., Jr., Academic Press, Inc., N.Y. 1963

35. McCally, M., Capt. USAF, MC, The Pathophysiology of Disuse and the Problem of Prolonged Weightlessness: A Review, TD Report No. AMRL-TDR-63-3, June 1963.

36 Gaume, J.G. and Kuehnegger,W., Effects of Chronic Lunar Gravity on Human Physiology, Technology of Lunar Exploration, Academic Press, July 1962

37 Kuehnegger, W., The Work Potential of Man in the Lunar Environment, Northrop Space Laboratories Report NSL 64-97, March 1964

38 Kuehnegger, W., Biomechanical Elements in the Analysis of the Lunar Working Potential of Man, San Diego Symposium of Biomedical Engineering, June 1964

39 Kuehnegger, W., The Gravity Suit - A Method to Substitute the Gravitational Force, Northrop Space Laboratories Report (in preparation)