Wednesday, June 11

S15-52
074088

Session WA1
Room 1
8:30 - 11:30 a.m.

Long-Duration Space Flight

MEDICAL AND PHYSIOLOGICAL STUDIES DURING 438-DAYS SPACE FLIGHTS

A.I.Grigoriev[1], V.V.Polyakov[1]
[1]State scientific centre - Institute of Biomedical Problems, Moscow, Russia

INTRODUCTION

As distinct from the previous long-term space flights, the program of activity cosmonaut-physician provided significant expansion of volume of medical and physiological researches directly during flight.

METHODS

The Mir station is supplied with modern medical and physiological equipment, that allowed to used adequate methods for studies of the main physiological systems of the human body.

RESULTS

Physiological and clinicophysiological researches, carried out cosmonaut-physician, as on most to self, and on other members of crews of three expeditions, making flights under this program by duration up to a half-year, have for the first time found out in flight: decrease of force parameters, developing mainly in leg muscular extensors; more expressed mineral losses in proximal parts of femur and lumbar vertebra at cosmonaut-physician and essential increase at him of risk of occurrence urolithiasis; progressing reduction of concentration in natriuretic peptide in blood; decrease of a level of hydration and volume of blood at the constant contents of erythrocytes. The ultrasonic researches have revealed presence of attributes hypovolemia in flight. In cervicocephalic region and pulmonary circulation signs of hypervolemia and increase of resistance in vessels and significant decrease of vessel tonus and blood flow in the low half of the body are found out. Under influence of stay in weightlessness reduction of ability in femoral vessels to interfere at influence of lower body negative pressure is revealed. It is also discovered decrease of ability cerebral vessels to control cerebral blood flow by reduction of vascular resistance, that testifies to change of hemodynamic regulation in these conditions. Decreased a level of hydration for the account of extracellular fluid, progressing in accordance with increase of flight time, is revealed in cosmonauts, including cosmonaut-physician, during long-term space flights This is rather essential result, directly confirming the stated earlier assumptions. The found out shifts metabolism in a number of cases went outside the limits the clinical norms, but were convertible and rather quickly restored after end of flights. Conducted in postflight period clinicophysiological examination of a condition of health cosmonaut-physician allow to qualify his condition as appropriate usually observable after long space flights.

CONCLUSION

It is shown, that the person rather effectively works in conditions weightlessness duration till 438-days.

HUMAN PERFORMANCE DURING A 14 MONTHS SPACE MISSION

D. Manzey[1], B. Lorenz[1], & V. Polyakov[2]
[1]DLR-Institute of Aviation and Space Medicine, Dept. of Aviation and Space Psychology, Hamburg, Germany
[2]Institute of Biomedical Problems, Moscow, Russia

INTRODUCTION

Results from first performance monitoring experiments during spaceflights conducted during the last 5 years suggest that basic cognitive processes remain fairly stable during spaceflights, whereas visuo-motor processes as well as higher attentional functions are prone to disturbance effects related to the impact of environmental stressors in space. However, all of the research so far has been conducted during short-term spaceflights lasting 6 to 20 days. The 438 days space mission of the Russian cosmonaut Valeri Polyakov provided a unique opportunity to conduct a first performance monitoring study during an extraordinary long-term space mission. The following questions were addressed in this study: How long does it take to recover fully from initial performance disturbances during long-term spaceflights ? Is it possible to maintain stability of mental efficiency after complete adaptation to space during a long-term spaceflight ? Do similiar performance decrements as during adaptation to space emerge also during re-adaptation to Earth after a long-term spaceflight ? Do prolonged stays in space induce any long-term performance deficits after return to Earth ?

METHOD

One Russian cosmonaut participated in the study on his second long-term space mission. Performance monitoring was conducted by a self-administrable computerized performance monitoring device which included six tasks in order to assess the following performance functions: (1) logical reasoning and decision making functions (Grammatical Reasoning Task), (2) Memory retrieval functions (two levels of a Memory Search Task differing in memory load), (3) perceptual-motor functions (Unstable Tracking Task), (4) human time-sharing functions (two dual-tasks each consisting of Unstable Tracking with concurrent Memory Search). All tasks were taken from the battery of Standardized Tests for Research with Environmental Stressors (STRES) which has been published by AGARD. In addition to performance assessment, several subjective ratings concerning mood and workload were collected. The experiment included a total of 41 experimental sessions (4 pre-flight assessments, 29 in-flight assessments distributed over the entire 14 months in space, 6 post-flight assessments during the first two weeks after landing, 2 follow-up assessments six months after landing).

RESULTS

A comparison of *pre-flight* and *inflight* assessments showed: (1) Impairments of cognitive performance were found only during the week immediately *before* launch. After entering the space environment performance in the cognitive tasks recovered rapidly to pre-flight baseline level. (2) During the first week in space, significant disturbances of tracking performance were found; a complete recovery of tracking performance to pre-flight baseline level was achieved only after approximately three weeks. After this time period tracking performance remained fairly stable throughout the following 13 months. (3) Only few significant impairments of time-sharing performance were observed most of which occurred during the first two weeks in space. (4) Corresponding to the impairments of visuo-motor performance and dual-tak performance, the subjetive data indicated feelings of increased workload, increased fatigue and reduced emotional balance during the first three weeks in space. Results from *post-flight* assessments revealed significant disturbances of visuo-motor performance during the first week, and disturbances of cognitive and time-sharing functions during the first two weeks after landing. Again, these performance disturbances were accompanied by feelings of raised workload, increased fatigue, and reduced emotional balance. *Follow-up* assessments six months after the mission did not reveal long-lasting performance deficits after the stay in space.

CONCLUSIONS

The results of the present study provide first insights into the efficiency of human performance during extraordinary prolonged space flights. Two conclusions may be drawn: First, the first three weeks in space and the first two weeks after a long-term space mission appear to represent critical adaptational phases which are associated with both, considerable decrements of visuo-motor (tracking) performance and occasional dual-task performance decrements, as well as elevated workload ratings and clear drops in subjective mood. Secondly, the impressive stability of mood and performance during the second to fourteenth month in space indicates that after adaptation to the extreme environmental conditions during space flights, mental efficiency and emotional state can be maintained on a level as high or even higher as on Earth for a long period of exposure.

HOMEOSTASIS IN LONG -TERM MICROGRAVITY CONDITIONS

A.D.Egorov[1], A.I.Grigoriev[1], A.S.Kaplansky[1]
[1]State scientific centre - Institute of Biomedical Problems, Moscow, Russia

INTRODUCTION

Carryed out in conditions of long-term microgravity researches were directed not only on study of phenomenology of this factor influence, but also on receiving of data, allowing to analyze a state of homeostasis in these conditions from the point of view of normal and pathologic physiology.

METHODS

The systematization and generalization of the data concerning responses of the main body systems of man and animals obtained in long-term space flight by using some physiological, biochemical, and morphological and others methods are made.On this basis mechanisms of changes and establishment of new level of homeostasis in microgravity conditions have been analyzed.

RESULTS

It is shown, that in conditions of long-term microgravity a level of functioning in the basic body systems and number of parameters of metabolism and internal medium are changed. As a consequence of these changes with the passage of time the new level of energy exchange and plastic (protein) metabolism is established. Catabolic processes are intensifyed and neuroendocrine regulatory mechanisms are altered. At the same time structural changes in some tissues and organs, especially in skeletal and muscule systems, are developed.The main changes in internal medium during long-term stay in microgravity conditions are manifested by hypohydration of organism (a reduction of volume of extracellular fluid), negative balance of some ions, functional erythrocytopenia. and others The most significant changes of endocrine system are characterized by decrease of plasma and urine levels of ADG and activation of renin-angiotensin-aldosteron system on a background of absence of significant changes of stress- dependent hormones.Morphological changes of atrophic nature was found out primarily in bone and muscle systems of cosmonauts and animals. First of all it concerns to postural muscles and weigh-bearing bones. There is also the redistribution of mineral components in bones as reduction of mineral density of the lumbar vertebrae and their dorsal elements and increase of mineralization in a skull and arms. An increase of the sizes of a number of internal organs is revealed as well. The shifts formed during adaptation in human body and animals are adequate to new conditions of existence. However, it is not clear yet as far as they are durable. The physiological measure of protection against adverse influence of microgravity on the expiration of acute period of adaptation appear sufficient for an establishment of relative balance in system organism - environment and maintenance of an adequate level of capacity for work in these conditions.

CONCLUSION

In microgravity conditions functional load on various systems is redistributed that renders influence on regulation of homeostasis.of organism. First of all increased load on a number of regulatory systems, directed on cupping of sensory conflicts, and also on an establishment of a new level of functioning of the basic systems and maintenance of homeostasis. A functional load on bone and muscle systems and on some parts of cardiovascular system is reduced, that provokes the development of deconditioning in these systems. In result there is loss of a number properties, acquired by the person during individual development and life in conditions of earthly force of weight. It conducts to reduction of functional opportunities of human body after long-term stay in microgravity and to development of readaptive gravitational syndrom.

STRATEGY OF PRESERVATION OF HEALTH OF COSMONAUTS IN PROLONGED AND SUPERPROLONGED SPACE FLIGHTS.

A.I.Grigoriev[1], V.V.Polyakov[1], A.D.Egorov[1]
[1]State scientific centre - Institute of Biomedical Problems, Moscow, Russia

INTRODUCTION

In prolonged and superprolonged space flights the problem is the maintenance of health and capacity for work at a level, appropriate to fulfillment of the program of flight and promoting high efficiency of activity of crew in case of occurrence non- standard situations. In this connection the paramount importance gets creation adequate loads on all systems of human body in conditions of microgravity and maintenance of an earthly spectrum of distribution of body fluids and afferent impulse flows. It is natural, that the uniform method of the decision of all these problems does not at the moment exist. It follows that there is the problem of determination of strategic lines of researches, directed on the decision of listed problems.

METHODS

Currently using means and some results of medical monitoring and countermeasures in long-term space flights as well as of postflight rehabilitation are studied by method of the theoretico-physiological analysis.On this basis the main directions on further investigations and points of the application of countermeasures are determined and substantiated.

RESULTS

The leading role in creation of adequate load on human body in conditions of microgravity belongs to artificial force of weight. However, the practical realization of this method is connected to large technical difficulties and financial charges. At the moment in this direction extensive researches in our country, and abroad are carried out. Simultaneously, researches develop principles and new methods of non-gravitational countermeasures with reference to space flights increased durations. Thus the major importance has determination of points of the application of countermeasures for the most effective their influence with the minimum expense of time and development of methods of an objective estimation of a level of physical condition of each member of crew with the purpose of a choice on this basis of an adequate mode (regime) of trainings. From here follows necessity of conducting of monitoring not only condition of health of crew, but also degree of physical condition of each crewmember, including rational use of means of countermeasures. The medical monitoring in long-term manned space flights includes: the current control, estimation and diagnostics of adverse condition; prediction of changes in crewmembers' health in different phases of flight and after landing; assessment of the possibility to continue flight; planning and controlling of medical examination and countermeasures during the flight. The rehabilitation is founded on the following principles: local and general therapeutic influence on human body; active participation of patients in realization of procedures; selection of certain recovery methods and means and sequence of their application depending on cosmonauts' general state and fitness and phase of readaptation; regularity and required duration carrying-out of procedures; gradual increase of loads; complex , continuity and proper sequence of rehabilitation measures during all phases of readaptation; regular medical monitoring during the whole period of readaptation; complete restoration (renewal) the functional state of organism.

CONCLUSION

The preservation of health of cosmonauts in prolonged and superprolonged flights in a broad sense these word is connected to realization of monitoring, creation of conditions for normal ability to live, maintenance with the help of various methods of physical and mental health and capacity for work of crews at all stages of preparation, in flight and in early postflight period.

REHABILITATION OF COSMONAUTS' HEALTH FOLLOWING LONG-TERM SPACE MISSIONS

V. V. Bogomolov*, I. B. Kozlovskaya*, V. I. Pochuev**
*Institute for Biomedical Problems, **Gagarin's Crew Training Center,
Moscow, Russia

Return of cosmonauts from extended space missions (SM) to the Earth's' gravity gives rise to alteration of the functional state of various body systems as compared with pre- and inflight indices. Shifts are observed in circulation, neurological status, neuromuscular apparatus, processes of bone mineralization, hematological, immunologic, and metabolic parameters. These deviations are associated with changes in the regulatory systems of the body and generally treated as adaptive or functional. On the other hand, some investigators approach the severity of these shifts as a factor which may limit further prolongation of piloted SM.

In view of the experience of medical support for long-term SALYUT and MIR space missions lasting from several months up to 438 days and analysis of the readaptive shifts, we can state it as a fact that their depth and severity are not as much dependent on SM length as flight conditions, and, what is of paramount importance, on the intense and intelligent use of the Russian system of countermeasures against the unfavorable changes in cosmonaut's body developed for extended SM.

System of the postflight medical recovery developed and applied within the Russian program of piloted cosmonautics includes a set of therapeutic/rehabilitative measures to be used in a stepwise fashion and based on the functional methods of rehabilitation. On the initial phase (first 3 weeks) the goal of rehabilitation boils down to blocking the symptoms of asthenization, vestibular and orthostatic instability, locomotor and coordination disorders, normalization of functioning of the main body systems. Phase two (21-35-day rest in sanatoria and health resorts) results in the most complete recovery of the functional systems, the velocity/strength properties of muscles and coordination, fitness and endurance, and, possibly, more effective recovery of the reserve abilities and psychological status of cosmonauts. After many months on SM, the active rehabilitative programs takes two months. Over this period,. functioning of the main body systems regains its preflight level although a number of hematological, biochemical indices and changes in bone tissue in some cosmonauts returns to the norm at later time points.

The report focuses on the time frame needed for the postflight readaptive shifts to be eliminated and functioning of cosmonaut's body following long-term SM (including repeated ones) recovered with allowance for individual patterns of readaptation and character of countermeasures administered in SM. Plans, methods, and criteria of adequacy of the rehabilitative measures are presented.

PERFECT COSMONAUT: SOME FEATURES OF BIO-PORTRAIT

N.G. Lacota, I.M. Larina, V.V. Polyakov
Institute for Biomedical Problems, Khoroshevskoye shosse 76-a
Moscow, 123007 Russia. Phone: (7-095) 195-2363, Fax: (7-095) 195-2253

The human data were obtained using the techniques simulate of space mission effects: exposures in snow-pit (48 hours - 6 man), suit immersion (3 hours...3 days - 46 man, including 18 cosmonauts and candidats), swimming in ice-water (6...20 hour - 20 man), bed rest (14...120 days - 36 man and 8 women), isolation by "HUBES" (135 days - 3 candidats) and "ECO-PSY" (90 days - 3 man). All exposures were complicated by the operative (including visual-motor programs), vestibular, orthostatic and physical provocative test. The part of volunteers was observed in the various and repeated experiments. The special autothermotopometric study was carried out onboard Orbital Complex "Mir" by 2 scientist cosmonauts (12 and 174 flight days), who had participated in suit immersion exposures.

The analyses of results have shown the following features of a perfect cosmonaut: a) low thermal sensibility; b) low hydro-ionic sensibility; c) the norepinephrine-type (NE-type) of sympathoadrenal system (SAS) functioning; d) high sensitivity serotonin-responsive structures which corresponds to low basal serotonin-concentration in blood; e) constitutional type of person should be like a sprinter which corresponds to high anaerobical qouta in total energy expenditure; f) minimal deviation of biomechanical parameters of respiration; g) vestibuloresistance by I. Bryanov-test.

Physiological role of thermal and hydro-ionic sensibility, unfinding out in usual life-work state is increased under experimental models significantly. If the space is unload, the direct correlation of the heat sensibility and the hydro-ionic sensibility is infringed and vestibuloresistance is correlated weakly to them. For example, the extremely wide range of individual thermal and water-salt sensibility was revealed in suit immersion. The motion sickness of 0-I class (A) was determined by: short period of thermogomeastatics resulted in a decrease of oral temperature to 0.2-0.4 deg. C; maintenance of blood osmolarity and pressure. The motion sickness syndrom of III-IV class (B) was determined by: a nonsteady heat state with decreased oral T by one deg. C, body mass loss, negative water balance, associated with hyperventilation, disorder adrenosympathetic circadian rhythm and hyperactivity of water-salt regulating hormones. Among 46 subjects the ratio of "A" and "B" reaction was 1:4 during suit immersion. The baseline stability to physical loads (PWC-170 test) and endurance to work with constant power (0.76 PWC-170 is "Individual tolerance" test) kept approximately for 4-5 from 30 subjects after 1-3 days of suit immersion (average decrease is equal to 1/4 and 1/2 of background). Only these 4-5 participants had the features determining the bioportrait of perfect cosmonaut. Their psychophysiological capability was confirmed by the successful work in space misssions from the first up to the last day (including super long-term flight).