Tuesday, June 10

S4-52
074051

Session TP4
Room 4
2:30 - 5:30 p.m.

The German/Russian MIR '97 Mission: An Overview

LIFE SCIENCE EXPERIMENTS DURING THE GERMAN-RUSSIAN MIR '97 MISSION

G. Ruyters, H.-U. Hoffmann
Deutsche Agentur für Raumfahrtangelegenheiten (DARA, German Space Agency) GmbH, 53227 Bonn, Germany

INTRODUCTION

Manned spaceflight has been an important element of the German space program over the last decades. In February this year, the German cosmonaut Reinhold Ewald stayed for three weeks onboard of the Russian Space Station MIR together with his Russian colleagues Wasilij Zibliew and Alexander Lasudkin. This mission - the so-called German/Russian MIR '97 - was, of course, another cornerstone with regard to the cooperation between Russian and German space organizations. The cooperation in the area of manned missions began 1978 with the flight of the German cosmonaut Sigmund Jähn onboard of Salyut 6, which was followed by the flight of Klaus Dietrich Flade in March 1992 with his stay onboard of MIR. After two further successful ESA missions, EUROMIR '94 and '95 with the two German cosmonauts Ulf Merbold and Thomas Reiter, the decision was taken to perform another German/Russian MIR mission. In Germany, MIR'97 was managed and performed in a joint effort between several partners. DARA, the German Space Agency, was responsible for the overall program and project management, while DLR, the German Aerospace Research Establishment, was responsible for the cosmonaut training, for the mission control at GSOC in Oberpfaffenhofen as well as for the user support.

OBJECTIVES OF THE MISSION

From the very beginning main objectives of the mission were: continuity, cooperation and multidisciplinarity. Continuity with regard to the scientific program meant to provide for access to space before the Intl. Space Station era. Partnership with international partners was to be achieved for strengthening cooperation from an operational as well as from the scientific point of view. And finally, multidisciplinary research comparable to that on the Intl. Space Station was desired as preparation of the upcoming era. In line with these considerations, the Life Sciences Research Announcement was made available not only to German scientists, but also to international participation via ESA, CNES and NASA. In fact, the final program in the area of space Life Sciences contained principal and co-investigators from several ESA member states including France, from the US, and from Russia and Ukraine. Also, the facilities for experimentation were provided not only from Germany, but also from NASA, ESA, and Russia. With regard to multidisciplinarity, experiments from Materials Science, Technology and Operational Tests were performed in addition to those in Life Sciences. Being a manned mission, especially human physiology experiments were in the center of interest. Altogether 27 flight experiments were performed by the cosmonauts in addition to 11 pre-/postflight studies, 11 and 9 of them, respectively, in Life Sciences.

THE LIFE SCIENCES PROGRAM

With regard to the Life Sciences experiments, two main areas were the focal points of the mission, research on the cardiovascular system with the newly developed MEDEX system and research on the area of hormone-regulated processes such as fluid and bone metabolism. In addition, experiments were performed on cognitive processes, on the effects of spine geometry in microgravity, on the effects of microgravity on bone and muscle physiology and performance as well as on the effects of space radiation.

MEDEX is the new system for measuring various parameters of the cardiovascular system, such as ECG, EEG, blood pressure, body temperature, body impedance. The approach taken by DARA and the companies PANKOSMOS and ISM in developing this system was, firstly, to be modular by combining a central data unit with a suite of measuring modules as required for the experiments, and secondly, to use off-the-shelf H/W and adapt it for space application. ORTHOSON, another new small system, is a device for measuring spine geometry by ultrasound technique.

In the contributions following this overview, some of the principal investigators of the experiments will present preliminary results. Also in this regard, the MEDEX experiments and the so-called Metabolic Ward experiments are in the center of interest. In addition, preliminary results of changes in spine geometry and in biomechanical and bioenergetic properties of skeletal muscles and of magnetic resonance imaging will be presented in some detail. In addition, a short summary of the results of other life sciences experiments will be given in this overview.

ORTHOSTATIC INTOLERANCE FOLLOWING MICROGRAVITY: A ROLE FOR AUTONOMIC DYSFUNCTION

F. J. Baisch, L. Beck, J. Drescher,[1] C. G. Blomqvist,[2] D. L. Eckberg,[3] and D. Robertson[4]
[1]Institute of Aerospace Medicine, DLR, Cologne-Porz, Germany, [2]University of Texas Southwestern Medical Center, Dallas, Texas 75235-9034, [3]McGuire Research Institute, Inc., Department of Cardiovascular Physiology, 1201 Broad Rock Blvd., Richmond, VA 23249, [4]Center for Space Physiology and Medicine, Department of Medicine, Pharmacology and Neurology, Vanderbilt University, Nashville, TN 37232-2195

The most common mechanism underlying orthostatic intolerance may be defined as the inability to maintain adequate tissue perfusion (particularly of the central nervous system) in the upright body position. Orthostatic intolerance is present in up to 500,000 Americans, mostly in individuals under 50 years of age and also a common finding after space flight.

The exact pathophysiological mechanisms are known only in a minority of patients by primary myocardial dysfunction is rarely a factor. Clinical orthostatic intolerance of cardiovascular origin has multiple potential components, including decreased cardiac filling and stroke volume, inadequate postural heart rate and/or systemic vasoconstrictor responses, and impaired cerebrovascular autoregulation. Hypovolemia with decreased cardiac filling is a prominent finding after space flight and a likely major factor contributing to the orthostatic intolerance that is present in a majority of crew members even after space flight and a likely major factor contributing to the orthostatic intolerance that is present in a majority of crew members even after space flight of relatively short duration. However, the hypovolemia is universal whereas the presence or absence of individual post-flight orthostatic intolerance appears to be linked to inadequate compensatory regulatory responses, including systemic vasoconstriction and baroreflex-mediated tachycardia.

We propose to test the general hypothesis that adaptation to microgravity produces cardiovascular regulatory dysfunction and to identify specific mechanisms by (i) evaluating the afferent signal flow to the brain in different receptive areas, (ii) by modeling central data processing, and (iii) by investigating efferent information flow via the sympathetic nervous system to the muscle vasculature, the main contributor to peripheral resistance.

Afferent signal flow to the brain will be tested by using multiple and relatively simple procedures (controlled breathing, Valsalva, static exercise, cold pressor, and LBNP, etc.) to produce quantifiable, reproducible, and reasonably specific cardiovascular responses, all mediated by the autonomic nervous system but activating different afferent pathways and (presumably) different sites for central integration.

Controlled breathing maneuvers will assess the CO2 dependence of brain perfusion, heart rate variability, and blood pressure. With different Valsalva strain levels, baroreflex responses will be recorded. The cold pressor test will be used as a model nociceptive stimulus. With lower body negative pressure (LBNP) the cardiovascular system will be challenged by an orthostatic stress which can be applied on ground and in weightlessness.

To model central data processing, weight changes in an artificial neural network are tested. These weight changes representing plasticity will be analyzed whether or not neural plasticity is a contributor to altered cardiovascular neurohumoral regulation. In a preliminary approach, the baroreflex is simulated and hemodynamic post-flight data of blood pressure and heart rate will be compared with preflight responses. The artificial neural network will be trained to mimic pre-flight responses on one hand and on the other hand, the same network will be trained to reproduce post-flight presyncopal tracings. The weight changes in the artificial neural network will be analyzed if changes in afferent traffic have caused these alterations.

To evaluate sympathetic outflow, microneurography (for assessing electrical activity in sympathetic nerves) and norepinephrine spillover (for estimating neurotransmitter turnover and clearance) will be introduced step by step during the next Russian Mir missions. Pre- and post-flight investigations will be added initially and finally, in-flight tests will be performed in combination with LBNP on the NASA Neurolab Mission.

The Autonomic function tests on DARA Mir 97 are the beginning of a chain of cardiovascular experiments on the Russian Mir Space Station and the NASA Space Shuttle.

With this integrated approach we should be able to detect whether or not post-flight orthostatic intolerance results from alterations in the afferent signal flow, and/or in central dynamic circulatory control, and/or in the efferent branches of the autonomic nervous system.

HEART RATE VARIABILITY AND SKIN BLOOD FLOW IN MAN DURING ORTHOSTATIC STRESS IN WEIGHTLESSNESS

J. Drescher; A. Diedrich
DLR-Institute of Aerospace Medicine Cologne; Working Group for Non-Invasive Diagnostics AGNID
RWTH Aachen / Chair of Flight Medicine ; Linder Höhe 51170 Cologne, Germany

INTRODUCTION

The question of cardiovascular deconditioning of cosmonauts during long term missions and development of adequate countermeasures are central tasks in space medicine. The cardiovascular adjustment to the weightlessness conditions, to real and artificial orthostatic stress simulated by Lower Body Negative Pressure application with the Russian Tschibis-LBNP device inflight are the primary topics of this research. We conducted a pilot study of stepwise Tschibis-LBNP application for the simulation of active standing. in -6° HDT body position The ground based research data have to be compared with the inflight cardio-vascular reaction pattern during LBNP testing on the MIR 97 and MIR 97 Extension space missions.

METHODS

The DARA MEDEX diagnostic system with the BASIS-module for ECG, blood pressure and breathing pattern monitoring and the two channel MCD module for microcirculation diagnostics with Near Infrared in the forehead skin and the big toe are used. The Portapres and Transcranial Doppler measurements provide cardiovascular reference parameters. The investigations of the heart rate variability (HRV) as central mediated parameter and the skin microcirculation (MCD) in the upper and lower body regions are provided during Tilt table and LBNP functional testing. The tests were provided on young healthy men, cosmonauts and astronauts during the MIR 97 space mission.. The sympatho-vagal balance SVB and sympathetic vasoconstriction activity (SQN) are calculated during the experimental phases.

RESULTS

In preflight studies we already estimated the sympatho-vagal influences and regulatory pattern during real and simulated orthostatic stressor influences. The continuously ECG R-R interval analysis showed an increase of the spectral power of the HRV in the mid frequency range and a decrease of the HF power during orthostatic stressor load. Typical spectral power distributions SVB characterizing the amount of orthostatic stressor load during active standing were found during -35 / -45 mmHg. The noninvasive measurements of the local skin microcirculation dynamics (maximal volume velocity) discovered the blood volume shifts, blood velocity and flowmotion reaction pattern during ortho- and antiorthostatic stressor load.. The simulation of orthostatic stress comparable to the active standing body position needs a -35 / -45 mmHg LBNP pressure application in supine or -6° HDT body position. This has to be proofed for real spaceflight conditions.

CONCLUSION

The HRV dynamics and the skin microcirculatory reaction pattern in the upper and lower body regions contribute the clarification of space related disturbances of autonomous nervous functions, e.g. orthostatic syndrome. The temporal coordination and functional relationships between the macro- and microcirculatory systems enable the physician to estimate the risk of syncope. In case of dysregulation (maladapation, autonomous disorders) the central modulation of the complex interactions of heart and blood vessels functions disappears and yields to orthostatic intolerance.

EFFECTS OF MICROGRAVITY AND LOWER BODY NEGATIVE PRESSURE ON CIRCULATORY DRIVES FROM EXERCISING CALF MUSCLES

D. Essfeld[1], K. Baum[2], U. Hoffmann[1], D. Leyk[1]
[1]Physiologisches Institut, [2]Institut für Rehabilitation und Behindertetensport, Deutsche Sporthochschule Köln, Carl-Diem-Weg 6, 50933 Cologne, Germany

INTRODUCTION

Skeletal muscles are reflexogenic areas of the cardiovascular system. It could be shown both on ground and during the MIR'92 mission that local fluid losses enhance cardiovascular drives from exercising lower limb muscles. These changes are probably mediated by slow-conducting afferents terminating as so-called free nerve endings in the interstitium of the muscle. According to our hypothesis the activity of these afferents during exercise in microgravity should be reduced by any measure that increases the interstitial fluid volume of the muscles. During the missions MIR'97 and MIR'97E we will study the immediate after-effects of lower body negative pressure.

METHODS

Heart rate and blood pressure responses to light, isometric foot plantarflexion will be measured in two cosmonauts during the missions MIR'97 and MIR'97E. The exercise protocol will be performed during a period of local circulatory arrest so that the role of muscle chemoreceptors can be distinguished from the influence of central command and muscle mechanoreceptors. Measurements before and immediately after lower body negative pressure (LBNP) will allow to study the short-term after-effects of LBNP. Ground controls are performed both during sitting and in a -90° tilted sitting posture assumed 30 min before the onset of local circulatory arrest.

RESULTS

The preflight measurements showed the expected increase in heart rate and blood pressure responses when lower limb volumes are decreased. The inflight exercise responses before and after LBNP during MIR'97 will be presented at the meeting.

THE MIR STATION IN ITS SECOND DECADE - CREW SCIENCE OPERATION DURING MIR '97

Reinhold Ewald, Y.A. Gagarin Cosmonaut Training Center, Star City, Russian Federation
and DLR Astronaut Office, D - 51170 Cologne

ABSTRACT

A first-hand report of the German-Russian MIR'97 spaceflight is given. The subjects covered are the cosmonauts' training and the actual working conditions on board the Russian MIR space station.

In analogy to the profile of the MIR '92 flight the German science research cosmonaut has performed a 20 day research program under μg-conditions during the crew exchange in February 1997. In preparing this mission German Aerospace Research Establishment DLR assigned on request of DARA two members of the German Astronaut Team to take up training in the Y.A. Gagarin Cosmonaut Training Center (TsPK).

The training comprised the phases

0 Language course
I Basic Cosmonautics
II Soyuz and MIR systems
III Crew Training

Additionally, in parallel to phases II and III the research cosmonauts trained for the experiment program. The duration of the training in TsPK is defined in accordance with duration and aim of the space flight and takes into account the experience of the foreign cosmonauts. In the full-task Soyuz simulator the flight profile is performed several times following the board documentation, as well in the nominal case as with selected off-nominals. The full-scale MIR station simulators (Base module, Kwant, Kwant II and Kristal) allow to run complete typical days with e.g. repair and maintenance tasks assigned to the MIR crew and a science program to the research cosmonaut.

In distinction from the situation in 1992 on board of MIR several cooperative programs are now run in parallel. On one hand an US-American astronaut is continuously present on board. On the other hand the Russian cosmonauts perform extension programs of other cooperative bilateral missions. So, the MIR-23 crew performs NASA and CNES experiments together with the DARA program. Subsequently this puts stress on the preparation period especially with regard to travel and BDC times. The German cosmonaut has worked together with the Soyuz TM 25 crew ("up"), but also with the "down" crew Soyuz TM 24 and the NASA-4 astronaut. Download items are returning in three vehicles, two Soyuz crafts and the Space Shuttle.

MIR '97 and other missions of this type already reflect crew training and working conditions of astronauts preparing for and performing a mission to the International Space Station. In this respect the exploitation of the experience gained on MIR in its second decade of function gives valuable information. Preparation and operation of future space station mission have to be adapted in order not to overload crew performance.

METABOLIC WARD (WATER, SODIUM, CALCIUM AND BONE METABOLISM) AND ENDOCRINOLOGICAL EXPERIMENTS DURING THE MIR'97 MISSION

C.Drummer#, M.Heer, P.Norsk, P.Bie, P.Stehle, A.Zittermann, I.McCarthy, C.Vermeer, C.Alexandre, L.Shakelford, C.Gunga, M.Bidlingmaier, C.Strasburger, P.Rettberg, G.Horneck, V.Oganov, D.Vorobiev

#Spokesperson from DLR-Institute of Aerospace Medicine, Cologne, Germany

During the German-Russian MIR'97 Space-Mission, various medical disciplines, such as endocrinology, nutritional sciences, nephrology, physiology, clinical pharmacology, rheumatology, orthopedics, and radiology have been combined to perform joint metabolic experiments. The respective results will be evaluated not only on the basis of the individual's experiences, but shall lead to a potentiated understanding of microgravity induced alterations. During the complete 21-day space mission alimentary variables, such as energy-, sodium-, calcium-, and vitamin D intake, have not only been passively monitored but have been maintained at a constantly controlled level. Baseline values of blood and urine hormones which mediate water- and sodium-metabolism have been measured several times during the mission, as well as those hormones and biomarkers which participate in calcium- and bone metabolism. Metabolic balances have been determined on a daily base. Additionally, stimuli such as oral sodium load, water load, or calcium load have been applied, so that a more sensitive evaluation of microgravity induced alterations in body fluid regulation and calcium- and bone metabolism is obtained. An oral strontium load test has also been applied for evaluating intestinal calcium absorption. Biofilms have been fixed to the astronauts body and to various places on board the MIR space station for the dosimetric measurement of UV-radiation, which is an essential component of endogenous vitamin D synthesis and thus of the vitamin D dependent calcium-metabolism. Before and after the spaceflight, various radiological measurements (Bone Densitometer, Bone Stiffness Measurement Device, Dual Energy X-ray Absorptiometry) have been applied to characterize bone architecture, substance, and quality. These measurements, in combination with respective biochemical analyses of samples that have been obtained during the flight, give a more comprehensive picture of the changes to the bone structure of the astronauts during the 21-day period in microgravity. In addition to body fluid and bone related questions, another endocrinological experiments also focuses on the microgravity-induced reduction in red cell mass and hemoglobin concentration. It was assumed that a reduced erythropoietin production by the kidneys might have been responsible for the reduced red cell mass, since this hormone is firmly established to be the predominant regulator of erythropoiesis. Therefore, erythropoietin production as well as bone marrow activity (by means of serum transferrin receptor concentrations) has been measured before, during and after flight. Finally, the influence of microgravity on the responsiveness of the cortisol-associated stress-hormone system to specific stress-stimuli has been examined. Throughout the mission, salivary cortisol concentrations in response to a psychomental performance task as well as to a bicycle ergometric physical test (submaximal workload) have been measured. Respective blood hormone measurements during baseline data collections on ground will help to understand the altered stress hormone response in microgravity. First preliminary mission results will be presented.

LONG-TERM MONITORING OF THE SPINE-GEOMETRY DURING THE MIR'97 MISSION. INTRODUCTION OF A NEW METHOD.

K. Baum[1], D. Essfeld[2]
[1]Institut für Rehabilitation und Behindertensport, [2]Physiologisches Institut, Deutsche Sporthochschule Köln, Carl-Diem-Weg 6, D-50933 Köln

INTRODUCTION

During space flights the occurrence of back pains has often been reported by astronauts. This phenomenon comes as a surprise since on Earth unloading of the spine is frequently applied in rehabilitative programs of patients with back pain. The pain sensations under ug-conditions may be evoced by overall changes in the vertebral geometry leading to stretching of spinal and/or paraspinal tissues. Unfortunately, only poor information exists concerning the curvatures of the spinal column during microgravity. This also holds for daily activities on Earth. The lack of knowledge is probably due to the fact, that - so far - there was no adaequate equipment available for long-term monitoring of the spine in freely moving subjects.

We expect that microgravity reduces range and frequency of spinal movements both during sleep and daily activities. After return to 1g-conditions, atrophy of trunk muscles may cause an altered geometry of the vertebral coloumn in the upright position.

METHODS

Measurements will be made by means of 6 pairs of ultrasound transmitters and receivers fixed on the back in parallel to the spine. The approach is based on the fact that each change in the spinal curvature will also change the distance between the ultrasound transmitters and receivers. During the experiments, a small device generates the ultrasound signals and stores the data. The spatial resolution is less than 1 mm.

As a first approach to quantify the overall changes in the spinal curvature we will monitor continuously (sampling rate: 1 Hz) 48h profiles pre-, post, and inflight. In addition to the normal daily activities, the maximal flexion and extension of the trunc will be measured in standard positions.

RESULTS

All subjects reported that the equipment neither disturbs the daily activities nor sleeping. Preliminary results from preflight sessions show high variations in the vertebral geometry during daily activities. During sleep the variability is markedly reduced. A detailed analysis of pre-, post, and inflight data will be available by the time of the meeting.

EFFECTS OF 20 DAYS OF MICROGRAVITY (GERMAN/RUSSIAN MIR 97 MISSION) ON THE MECHANICAL AND ELECTROMYOGRAPHIC CHARACTERISTICS OF EXPLOSIVE EFFORTS OF THE LOWER LIMBS AND OF CYCLOERGOMETRIC EXERCISES OF MILD TO SPRINT-LIKE INTENSITY

G. Antonutto[1], P. Zamparo[1], F. Bodem[2], J. Kass[2], J. Heine[2], P.E. di Prampero[1]
[1] Dept. of Biomedical Sciences, University of Udine, Italy, [2] Dept. of Orthopaedic Surgery, Johannes Gutemberg University, Mainz, Germany.

INTRODUCTION

The power developed during very short (< 10 s) all out efforts of the lower limbs was determined on four subjects before and after the two missions Euromir 94 and 95. The duration of the exposure to microgravity (μg) lasted from 31 to 180 days.

The experiments were performed on a specially designed ergometer, the multipurpose ergometer dynamometer (MED), a detailed description of which is to be found elsewhere (1, 2). Briefly, the MED is constituted by a metal frame (3.0 x 0.9 m) hinged at one end to an equal frame. An isokinetic cycloergometer, powered by a 4 kW electric motor, and two force platforms are fixed to the upper frame. The subject sits on a seat free to move on rails fixed to the upper frame. The MED can be used as any isokinetic cycloergometer, in which case the seat is blocked in a predetermined position and the force platforms are lifted upwards, not to interfere with the motion of the pedals. Alternatively, the force platforms are lowered and the subject, pushing maximally on them, accelerates himself and the seat backwards. In this case, the seat is free to move on the rails which are inclined upwards (usually 20°). In this mode, the maximal mechanical power developed by the subject is obtained from the product of the force on the platforms times the velocity of the seat, determined by means of a wire tachometer. Thus, the MED allowed us to measure the maximal power developed during very short maximal explosive efforts, the duration of which (0.25 - 0.30 s) is essentially equal to that of a maximal standing high jump off both feet. The power developed during this type of efforts is defined Maximal Explosive Power (MEP). The subjects were also asked to perform a maximal cycling effort of 5 seconds on the isokinetic cycloergometer at a pedal frequency, imposed by the motor, of 1 Hz. This type of maximal power is defined Maximal Cycling Power (MCP).

The MEP was reduced to about 70 % of pre-flight values after one month (one subject) and to about 50% after six month (three subjects). MEP was also determined on one additional subject after, but not before, 438 days of space flight. Even if a direct comparison could not be made in this subject, MEP was reduced to about 50 % of the values expected, before flight, for normal subjects of his age and body mass. Thus, after about six months in space, MEP seems to attain a steady value which does not decline further. The reduction of MEP after one month in μg was larger than that observed after a similar period (42 days) of bed rest (Ferretti et al., 1996, personal communication). Furthermore, in all cases it was much larger than the concomitant decrease of muscle mass, which was on the order of 6-20 % (Zange et al., 1996, personal communication).

The decline of MCP after μg was significantly less than that of MEP: MCP was reduced to about 84 % of pre-flight values after one month (one subject) and to about 67 % after six month (three subjects). However, also in the case of MCP, the decline of power was larger than that of muscle mass.

It is concluded that a substantial fraction of the observed decreases of MEP and of MCP must be due to a deterioration of the motor co-ordination brought about by the absence of the constant pull of gravity. Furthermore, since in both type of all-out efforts: i) the energy source were the same, essentially phospho-creatine splitting, ii) no recovery of elastic energy could occur (2) and iii) the muscle groups involved were essentially the same, the two exercise modes can be directly compared. Hence, the observed larger decline of MEP, as compared to MCP, suggests that the deterioration of motor co-ordination is greater for those types of efforts in which the recruitment and derecruitment of the motor units of agonist and antagonist muscles must be fast and well balanced.

The aim of this study was to evaluate separately the effects of muscle atrophy and of motor co-ordination deterioration on the decrease of maximal all out power of the lower limbs due to μg. We therefore determined simultaneously the mechanical power and the electromyographic activity of agonist and antagonist muscle groups during MEP and MPC performances as well as during moderate cycloergometric exercises.

METHODS

The same equipment and experimental procedures described above will be used to measure the same variables (MEP and MCP) on two astronauts before and after 20 days of μg, in the course of the German/Russian MIR 97 mission. In addition, during the same type of explosive exercise in which MEP and MPC will be assessed, we plan to record also the electromyographic (EMG) activity by means of surface electrodes. The EMG activity will also be recorded during aerobic cycloergometric exercise, up to about 150 W. In addition, MPC will be determined during 5 s all out cycling efforts, not only at a pedal frequency of 1 Hz, as was the case in the experiments described above, but also at lower and higher frequencies (from 0.6 to 2.5 Hz). Finally, we will also determine gas exchange, heart rate, arterial blood pressure and cardiac output, by means of a non invasive method (3), during several steps of three minutes duration of aerobic cycloergometric exercise of increasing intensity. This will allow us to obtain a close estimate of the astronauts' maximal oxygen consumption. The experiments will be performed three times before flight and 1, 6, 15 and 30 days after re-entry.

EXPECTED RESULTS AND CONCLUSION

Initially, the analysis of the data will be directed towards the assessment of the maximal power and of the electromyographic activity of the (agonist and antagonist) muscle groups of the lower limbs that are involved in MEP and MPC performance. In addition, the relationship between MPC and pedal frequency will also be determined. This combined assessment of maximal explosive power and of electromyographic activity of the same muscle groups ought allow us: 1) to evaluate the effects of μg on the activation pattern of the muscle groups involved in external power production and hence 2) to estimate separately the fractions of the decrease of MEP and of MPC after μg which are due to motor co-ordination deterioration or to muscle atrophy.

REFERENCES

1. Antonutto G., Capelli C., Girardis M., Zamparo P., di Prampero P.E.: Effects of microgravity on muscular explosive power of the lower limbs in humans. Acta Astronautica 36: 473-478, 1995.
2. Zamparo P., Antonutto G., Capelli C., Girardis M., Sepulcri L., di Prampero P.E.: Effects of elastic recoil on maximal explosive power of the lower limbs. Eur. J. Appl. Physiol., 1996 (in press).
3. Antonutto G., Girardis M., Tuniz D., di Prampero P.E.: Noninvasive assessment of cardiac output from arterial pressure profiles during exercise. Eur. J. Appl. Physiol. 72: 18-24, 1995