SPACE NEUROLOGY AND THE USE OF AUSTRONAUT/KOSMONAUT'S EQUIPMENTS IN NEUROREHABILITATION

F. Gerstenbrand, Vienna
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Introduction:

With the possibility to enter the space without influences of gravity, a great dream of manhood to fly free in weightlessness was realized. With the first step on the moon the interplanetary adventure began.

The Second World War was accelerating the development of the rocket techniques, rockets were built to damage hostile human civilization and to destroy human life. A contest for the inheritance of the German rocket technique between the American and the Russian rocketry flared up. The Russian side was the winner of the first phase, enabling them to send the satellite Sputnik 1 into orbit to circumnavigate the globe, only one year later followed by the American Voyager 1. The first animal in space was the Russian dog Laika (3rd November 1957), the Astrochimp Ham, born in Africa, started on 31.January 1962. (Fig. 1a, b). In the following competition the first man in space was Yuri A. Gagarin, starting on April 12th 1961, the first man on the moon was Neil Armstrong (20th July 1969).

Special organizations for space activities, the so-called Space Agencies, became more significant like the NASA (the American Space Agency), the Russian Space Agency and the ESA (the European Space Agency), which are now cooperating internationally. Recently Japan and China build up national space organizations, the Chinese following their own way with own technical developments, the Japanese in closer cooperation with NASA and ESA. Nowadays a common Mars mission is in the planning state, whether the Chinese will cooperate is still open. Technical as well as human preparations for the Mars-Mission are essential.

Special technical accoutrement crucial for a space mission is the construction of special rockets to carry the space capsule into orbit and for the transport of supply to the orbit

station as well as orbit crews and technical replacement. The first successful orbit station was the Russian MIR, constructed for only a short time, but used for more than 5 years until March 2001 (Fig.2).
The international space station (ISS) is utilized by NASA, ESA and the Russian Space Organization (Fig.3). The course of the ISS has to be controlled permanently. One of the control centers, the Moscow Center, can be seen in Fig.4, showing the moment when the ISS was passing Moscow.

Space Medicine, Space Neurology

The main obligation of space medicine is the research on biomedical problems occurring during the stay of a human being in space due to weightlessness, called real micro gravity. Table 1 shows the different problems appearing under the influence of real micro gravity. Besides neurological disturbances, cardiovascular problems must be controlled. Nutrition and hydration have to be adapted to weightlessness and to the restricted place in the orbit station. A special field is the investigation of the radiation effect on biological structures and the technical equipment in space. One of the main problems for human beings in the weightlessness is the disturbance of the proprio-ceptive system, which is an absolute precondition for the existing of man and animals under normal earth gravity, influencing the motor system and all brain functions.

At the beginning of space flights, the pioneer Wernher von Braun expressed his fear of a limitation for a human being in a rocket fly and in weightlessness "not the engineering problems, but rather the limits of human frame will make the final decision as to whether man space flights will eventually become a reality". Neither the dog nor the Astrochimp experiment brought detailed knowledge about the reaction of the human body staying in the weightlessness. Yuri Gagarin, the first man in space, demonstrated that the human body can exist out of the gravity field of the earth. The following experiments proved that Astronauts/Cosmonauts can stay for weeks in space. The cosmonaut Dr. Valery Polyakov, a jet pilot of the Russian Air Force and a trained medical doctor, holds the world record for the longest stay in space. He remained 14 months in the orbit, coming back with more or less small and terminated problems for around 4 days. In a previous space flight Valery stayed in space for 6 months. He now is responsible for the special training of the Russian cosmonauts.

Every movement of a human being, as well as of higher developed animals, needs information about the position of body and extremities before the next movement can start. This information is brought to the brain via the proprioceptive system. Special centers, the sensorimotor areas of the human brain have to be informed in all detail about the condition of the body, the head position as well as the position of trunk and the extremities. For the upcoming movements as well as primitive motoric patterns including reflectory motoric reactions and for the body posture this information is the basis for all human activities.

The consequences of disturbance in the antigravity information in real microgravity lead to a dysfunction of the proprioceptive system followed by a dysregulation of all motor activities in various movements but also in the upright position of the body, as well as higher and highest brain functions and vigility are reduced. The receptors of the antigravity information are located in the foot sole, in every joint of the extremities and the vertebral spine as well as in the muscles and tendons. Figure XY shows a scheme of the proprioceptive system with the pathways beginning in the peripheral receptors leading to the sensorimotor area of the cortex after passing the spinal cord, the brain stem and the thalamus (Fig.XY). A parallel pathway shown in figure .XY gives the connections to the cerebellum.

In a special experiment using the functional magnetic resonance imaging (fMRI) the immediate activation of cortical regions after a vibrostimulation of the foot sole could be demonstrated. The activation was observed in the parietal inferior region bilateral (S1), contralateral, in temporal superior region, bilateral in the cerebellum (Culmen, Declive) and bilateral in the parietal superior region (SM1). Those results demonstrate the influence of the gravity due to a stimulation of the foot sole, a part of the body, where most disturbances do not exist in weightlessness. A normal function of the proprioceptive system is the requirement for all motor activities, the voluntary movements as well as for the extrapyramidal system and the primitive motor patterns. In real microgravity astronauts/cosmonauts have great problems especially in exact motor programs, like to serve instruments and in detailed motor activities during the space flight. A dysfunction in different other brain activities and the vigility is the consequence. The so-called Cosmonaut Syndrome can accrue after a short time if no counter-measures are foreseen. Table XY shows symptoms of the Cosmonaut Syndrome with primary muscle atrophy, polyneuropathy symptoms, disturbances in the recognition of the joint position and symptoms of ataxia and a thalamic disturbance, cerebellar ataxia and body scheme disturbances can be observed. Vigility is diminished, vegetative dysregulation can appear including osteoporosis. To avoid these problems during a space flight consequent countermeasures have to be taken.

The simulated microgravity

A great part of research in real microgravity, in weightlessness, can be performed in a simulated microgravity system, using special ground based laboratories. The main philosophy is to produce a similar situation comparable to the real microgravity with diminished influence on the proprioceptive system. The laboratory has to be equipped with EGG, electromyography, apparatuses to control the cardiovascular function and for different laboratory tests. A documentation system for neurological examinations has to be present.

These ground based laboratories are using the Bed Rest method in form of the Head Down Tilt system (HDT) and the Dry Water Immersion model method (DWI).The Head Down Tilt System is organized in a more or less simple way. The volunteers have to stay in a horizontal position, the head tilt compared to the body posture. The healthy volunteer cannot leave this position, for hygienic care the patient has to remain in a horizontal position. The stay in this laboratory situation lasts minimally for 36 hours, in most cases for 3 to 5 days. In literature more than 300 days are reported. (See Fig)

The second method, the Dry Water Immersion needs special equipment consisting of a basin filled with water at body temperature and covered by a special tissue. The volunteers are lying on this tissue like they were floating. In this situation they have no possibility to sit up (See Fig....). The healthy volunteers have to remain in this horizontal position. For hygienic purposes they are lifted out of the basin in horizontal position, the care is done like in the Down Tilt method. The volunteers are examined over 36 hours, mostly for 96 hours. All control equipment has to be available (see Fig....). During the DWI examination besides EEG and electromyography, exact neurological controls must be carried out (See Fig).

The pathological condition compared to simulated microgravity

A similar situation like in simulated micrgravity can be found in the so-called Bed Rest Syndrome, which is developed in patients staying in a horizontal position for a longer time; caused by various diseases like coma state of different forms, traumatic brain injury, cardiovascular dysfunctions, metabolic dysregulations etc., as well as in chronic neurological diseases, and last not least in elderly people without sufficient movement. In table... the symptoms are listed, generally similar to the Cosmonaut Syndrome. Besides cognitive disturbances, motor symptoms in the context of a polyneuropathy combined with a primary muscle atrophy, spinal and cerebellar ataxia, thalamic symptoms and diminishing of vigility can be noted. The Bed Rest Syndrome disturbs the rehabilitation program, mostly in long lasting coma states like the Apallic Syndrome or the Locked-In Syndrome.

Countermeasures in real microgravity during space flights

In table ..... different countermeasures are listed e.g. special apparatuses for exercises of legs and arms, devices for treadmill exercises and for training of the cognitive functions. The crew in the orbit station has to wear electrode trousers and the Penguin Suit. Fig .... shows the countermeasures.

New rehabilitation methods as a spin-off effect

One of the first devices developed for neurorehabilitation is the vibrostimulation pressure apparatus, a stimulation device with a vibration system with special frequencies (50 Hz). Based on recent experiences the shoe is used twice a day for 30 minutes for a program. Indications are the Apallic Syndrome, Locked-In Syndrome and coma states of different origin. The program must start at the intensive care unit. Patients with a severe stroke and after traumatic brain injury should get this special treatment to prevent the Bed Rest Syndrome. The same situation applies to patients in dementia of different origin. Patients with Parkinson or spasticity of different origin can benefit from this new method. The pressure shoe can be used in geriatric departments to diminish the deficit of movement. Besides this stimulation shoe developed and constructed in Austria, a Russian model was constructed, using a pneumatic system for the stimulation effect. The indication for treatment is the same as for the Austrian model. Based on research in microgravity at the IBMP Institute in Moscow, the Korvit System for foot loading imitation was developed. This system imitates the human gait performing a pressure stimulation to the foot sole, alternating left and right, beginning on the ankle region, followed by the top of the foot sole, imitating a human walking program. The main indications of this device are spasticity and Parkinson's disease, with the intention to use it for cerebellar and spinal ataxia in future.

In preparation for longer spaceflights, the axial loading suit Penguin was developed as a space device that could compensate for the deficit of axial loading of the body onboard the spacecraft. The idea to load the musculoskeletal system of the cosmonauts by using a preventive load suit, which creates a constant load on the skeleton, leg muscles and torso, resulted in a dynamic proprioceptive correction method. This suit is applied in health care for the treatment of children with cerebral palsy, thereby shortening the time needed to develop walking skills.

The search for methods of restorative treatment for patients with ischemic stroke and traumatic brain injury ended with the development of a modified version of Penguin, the therapeutic suit called Regent.

The 42nd International Danube Neurology Symposium *(by Professor Vida Demarin)*
Date: 21-23 October, 2010
Place: The Regent Esplanade Hotel, Zagreb, Croatia

Wednesday, October 20, 2010

19:00 Opening Ceremony and welcome reception

Thursday, October 21, 2010

Main Theme: Stroke
(Convenors: Vida Demarin, Zagreb, Ana Czlonkowska, Warszaw)

09:00 - 09:30	Ana Czlonkowska:	TIA as an Emergency
09:30 - 10:00	Natan Bomstein:	Management of Hypertension and Hyperglycemia in Acute Ischemic Stroke
10:00 - 10:30	Nadežda Sternić:	Diabetes and Stroke
10:30 - 11:00	Break	
11:00 - 11:30	Kurt Niederkorn:	Neurosonology in Acute Stroke
11:30 - 12:00	Vida Demarin:	Recent Concept of Stroke Prevention
12:30 - 13:00	Dafin Muresanu:	The Impact of Co-morbidities and Neuroprotective Treatments in Stroke Recovery

13:00 Lunch symposium: Approach to aging brain
(Convenors: Danilo Hodoba, Zagreb, Zvezdan Pirtošek, Ljubljana)

15:00 - 17:00	Workshop:	Diagnosis of Brain Death
16:00 - 17:00	Franz Gerstenbrand:	The off-line Brain - is there such a thing?

15:00 - 17:00	Teaching course:	Fabry Disease and Enzyme Replacement Therapy in Neurology

(Convenors: Vida Demarin, Zagreb, Vanja Bašić Kes, Zagreb)

15:00 - 17.00 Society for the Study of Neuroprotection and Neuroplasticity (SSIMIM) Panel
(Convenor: Dafin Muresanu, Cluj)

17:00 - 18:00	Franz Gerstenbrand:	Modern neurology and the Hippocratic principles
17:00 - 19:00	Posters	

Friday, October 22, 2010

Main Theme: Movement Disorders - Non-Motor Symptoms in Parkinson's Disease
(Convenors: Maja Relja, Zagreb, Zvezdan Pirtošek, Ljubljana)

09:00 - 09:30	Werner Poewe:	Continuous dopaminergic stimulation in Parkinson's disease
09:30 - 10:00	Maja Relja:	Non-motor symptoms in Parkinson's disease
10:00 - 10:30	Vladimir Kostić:	Depression in Parkinson's disease
10:30 - 11:00	Break	
11:00 - 11:30	Zvezdan Pirtošek:	Cognition in Parkinson's disease
11:30 - 12:00	David Vodušek:	Urogenital symptoms in differential diagnosis of Parkinsonism

Joint Meeting of Danube Society for Neurological Sciences and Continuing Education with Central and Eastern European Stroke Society (CEESS) and Croatian Stroke Society: Stroke Management

09:00 - 09:30	Ana Czlonkowska:	Thrombolysis in the Region
09:30 - 10:00	Ljiljana Bumbaširević:	Stroke Unit - Secondary Prevention Center
10:00 - 10:30	Vida Demarin:	Carotid Disease
10:30 - 11:00	Bojana Žvan:	Management of subarachnoidal hemorrhage
11:00 - 11:30	Osman Sinanović:	Post-stroke aphasia

09:00 - 17:00 Cochrane European Association Young Neurologists and Trainees (EAYNT) Workshop

15:00 - 17:00 Experimental Pain and Therapy
(Convenors: Claudia Sommer, Wuerzburg, Zdravko Lacković, Zagreb)

Claudia Sommer:	Therapy of neuropathic pain
Lidia Bach-Rojecky:	Experimental model of pain
Zdravko Lacković:	Central effects of botulinum toxin-type A
Alfredo Berardelli:	The impact of botulinum toxin treatment on cortical excitability
Maja Relja:	Botulinum toxin in migraine treatment

17:00 - 19:00 Teaching Course: Dystonia: Diagnosis and Treatment

17:00 - 18:00	Franz Gerstenbrand:	Space Neurology and the use of astronaut/cosmonauts equipments in neurorehabilitation
17:00 - 19:00	Posters	

Saturday, October 23, 2010

Main Theme: Headache and Pain
(Convenors: Laszlo Vecsei, Szeged, Zdravko Lacković, Zagreb)

09:00 - 09:30	Laszlo Vecsei:	The Role of Kynurenate Derivate in Nociception
09:30 - 10:00	Zdravko Lacković:	Experimental Model of Migraine
10:30 - 11:00	Vanja Bašić Kes:	Migraine and Stroke Connection
11:00 - 11:30	Ivo Lušić:	Central Post-stroke Pain
12:00	Closing ceremony	

All participants are most welcome to participate in all social and scientific activities
Deadline for abstract submission: June 1, 2010.
Congress venue: REGENT ESPLANADE HOTEL
Mihanovićeva 1
10000 Zagreb, Croatia
www.regenthotels.com
CONGRESS OFFICIAL TOURIST AGENCY AND TECHNICAL ORGANIZATION
TOP TOURS D.O.O
MESNIČKA 3, 10 000 ZAGREB, Email: top-tours@zg.t-com.hr

All abstracts will be available on CD and via CROSBI, editor Vida Demarin.

ZAGREB 2010

42nd DANUBE SYMPOSIUM FOR NEUROLOGICAL SCIENCE AND CONTINUING EDUCATION
WITH A FULL-DAY COCHRANE-EAYNT WORKSHOP IN EVIDENCE-BASED NEUROLOGY

20. - 23.10.2010

5th CONGRESS OF THE CROATIAN SOCIETY FOR NEUROVASCULAR DISORDERS OF THE CROATIAN MEDICAL ASSOCIATION AND THE CROATIAN STROKE SOCIETY

10th CONGRESS OF EUROPEAN SOCIETY FOR CLINICAL NEUROPHARMACOLOGY

JOINT MEETING OF CENTRAL EASTERN EUROPEAN STROKE SOCIETY

Gerstenbrand, Franz ; Golaszewski, Stefan; Pichler, Gerald;
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Naslov	Title
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Autori	Autors
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Vrsta, podvrsta i kategorija rada	Type, subspecies and category of work
Sažeci sa skupova, sažetak, znanstveni	Summary of meetings, abstracts, scientific
Izvornik	Original
Abstracts: The 42nd International Danube Neurology Symposium October 21 - 23, 2010, Zagreb CD / Vida Demarin - Zagreb, 2010, CD-CD	
Skup	Event
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Mjesto i datum	Location and date
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Vrsta sudjelovanja	Kind of participation
Plenarno	Plenary
Vrsta recenzije	Type of review
Nije recenziran	No review
Ključne riječi	Keywords
svemirska medicina; svemirska neurologija; simulirana i stvarna mikrogravitacija; protumjere; metode rehabilitacije; spin-off	space medicine; space neurology; simulated and real microgravity; countermeasures; rehabilitation methods; spin- offs
Sažetak	Abstract

Karl Landsteiner Institut für Neurorehabilitation und Raumfahrtneurologie

Austrian Society for Aerospace Medicine Life Sciences in Space

Space Neurology and the use of astronaut/cosmonaut's equipments in neurorehabilitation

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42nd Danube Symposium for Neurological Sciences and Continuing Education
October 21-23, 2010
Zagreb, Croatia,

Requirements for Space Missions

- Development of technical equipment
- Radiation effect on technical equipment and biological structures
- Communication system
- Influence on crystallization phenomena
- Biomedical problems in manned space mission
  - biophysiological exposure
  - radiation exposure

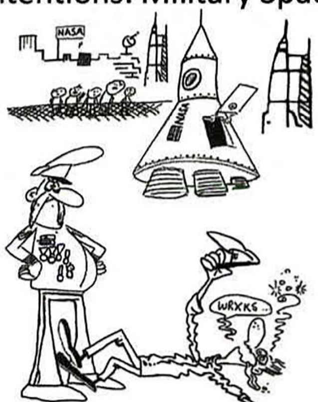
Organization and cooperation

- Organization of Space Agencies
- Development of International Space Organization
- Cooperation of national and regional space agencies (NASA, ESA, Japanese Space Agency, Chinese Space Agency, Russian Space Agency)
- Research in ground based laboratories
- Research programs during space flights
- Preparation and construction of orbit station
- Preparation of moon flight missions, moon based laboratories
- Preparation of a Mars mission

Research in Manned Space Missions

- Is based on
  - the biological predisposition for a stay of human beings out of the normal earth gravity
  - physiological adaptation to the microgravity
  - preparation time for a space flight
  - research in pathophysiological reactions during the start phase
  - research in pathophysiological problems during a space flight
  - research after return to earth gravity

First Intentions: Military Space Flight



coming back to earth

Research in Space
Space Medicine in real microgravity

- Influence of real microgravity on human beings, animals, plants and biological material
- Radiation effects in space – biological and technological material
- Influence of psychosocial factors
- Technological development of equipment for human beings during space flight
- Communication system between control center and orbit crew

Construction of a Control System for the Orbit Station

„Our job is not only to make sure astronauts can function adequately in space, but also that they can function on their return to earth." (Frank Sulzmann)

Source: G. Gerstenbrand

Space Medicine
Influence of Microgravity

- Research in biomedical problems
  - space neurology
  - cardiovascular alterations
  - immunology, infection and hematology
  - human performance factors, sleep and chronobiology
  - nutrition and digestion
- Development of new medical devices for countermeasures during space missions

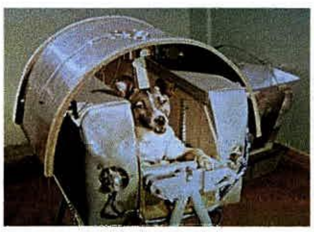
Statement to Manned Space Flight

Wernher von Braun, 1951:

"I believe that the time has arrived for medical investigation of the problem of manned rocket flight, for it will not be the engineering problems but rather the limits of human frame. That will make the final decision as to whether manned spaceflight will eventually become a reality."

History of Space Medicine 1

- Takeover of experiences in aviation medicine
- Research in training centrifuge
- Research in rocket sledge
- First Department for Space Medicine in Randolphsville, TX, USA
- Institute for Biomedical Problems (IBMP), Moscow, Russia
- Animal experiments in the orbit (IBMP Moscow – Laika, first dog in space)



Laika, Nov 3rd,1957

„Ham the Astrochimp", Jan 31st, 1962

History of Space Medicine 2

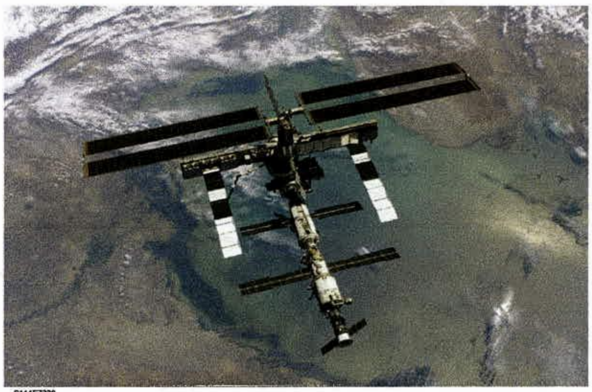
- April 12th, 1961 - Juri A. Gagarin
  first manned space flight, space capsule Wostok 1
- May 5th, 1961- A. Shepard
  first American in space,
- March 18th, 1965 - Alexei Leonov
  first space walk
- July 16th, 1969 - first moon landing
- July 20th, 1969 - Neil Armstrong,
  first moon walk
- Feb 20nd, 1986 - start of space station MIR (base module)
- Nov 20nd, 1989 - start of construction of ISS - first module SARJA
- Manned Mission to Mars, in preparation

Neil Armstrong, 1969

Buzz Aldrin, 1969

MIR in space,
destroyed March 23rd 2001

Launch of Soyuz TMA-5



S114E7220

International Space Station (ISS) organized by Americans, Russians, Europeans

Surface of Mars

Northpole of Mars, ice on polar cap, NASA

Twinpeaks, photographed by Pathfinder Lander, 1997, NASA

Space life in MIR

Austrian cosmonaut Franz Viehböck with Russian crew in MIR

Space life in MIR

Cosmonauts in MIR during free time

"Lunch-time"

Counter Measures in Real Micrograviy

- Treadmill exercises
  - Daily fixed program
- Special exercises legs and arms
- Adaptation of fine motor skills
  - Target training
- Adaptation training of cognitive functions
- Electrode trousers
- Penguin suit

Real Microgravity

Cosmonauts in MIR during training

Real Microgravity

Cosmonauts counter measure:
Electrode trousers: stimulation of muscle receptors

Penguin-Suit, worn for hours per day. Every movement has to be carried out against resistance of suit.

Research in Microgravity

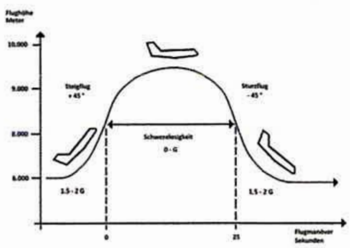
- Real microgravity
- Parable flight
- Simulated microgravity
  - Ground based laboratory

Research Experiment in Space Real Microgravity

Motor exercises, recording with EMG

Source: http://images.jsc.nasa.gov/images/pao/STS44

Passagere Microgravity - Parable Flight



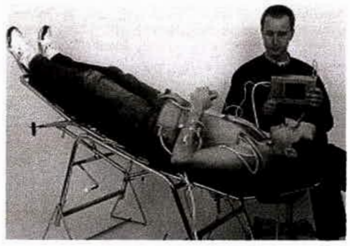
Microgravity only for few seconds diminishes research program

Simulated microgravity
Ground based laboratory

Special equipment necessary

- Methods
  - Bedrest system
    - Head down tilt-system – HDT
  - Body weight discharge
  - Dry water immersion model – DWI-method

Simulated microgravity



Head down tilt position (HDT), bedrest method

Unilateral body weight discharge

Simulated microgravity
Dry water immersion model – DWI-method

Healthy volunteer, experiment 72 hours, consequent neurological control.

Simulated microgravity
Dry water immersion model – DWI-method

DWI institution, Innsbruck, Neurospace Institute, 2 healthy volunteers, 48 hours experiment

DWI experiment, healthy volunteer lifted out for showering

Simulated microgravity
Dry water immersion model – DWI-method

Preparation phase, EMG control

Preparation phase

Experimental phase

Experiment for exact hitting a changing target

Simulated microgravity
Dry water immersion model – DWI-method

Optomotoric examination

Examination of the positional reflexes

Neurological examination, healthy volunteer

Ground based laboratory IBMP, Moscow

Space Neurology - 1

- Research content: influence of microgravity
  - Real microgravity
    - Influence on the proprioceptive system
    - Influence on the vestibular system (otolit system)
  - Simulated microgravity, ground based laboratory
    - Influence on the proprioceptive system

Space Neurology - 2

- Use of the research results in acute neurology
  - Neurodiagnosis
  - Neurorehabilitation
- Development of new methods and of new devices
  - Acute neurology
  - Neuro-rehabilitation

Neurological Disturbances in Real Microgravity

- Adaptation phase to real microgravity
  - disturbances during start phase
    - Space Adaptation Syndrome
- Neurological disturbances during space mission
  - Cosmonaut syndrome

Space Adaptation Syndrome (SAS)

- Vestibular disturbances (vertigo, nausea, vegetative symptoms)
- Motor disturbances (hypermetry, dysmetry, etc.)
- Optomotoric disturbances
- Proprioceptive disturbances
  - Body scheme disturbances
  - Pseudoapraxia

Space Adaptation Syndrome

Astronauts acclimating during parabolic flight.

Complaints:
- Disorientation
- Visual illusion
- Motion sickness (Nausea)

Source: http://science.nasa.gov/science-news/science-at-nasa/2001/ast07aug_1/

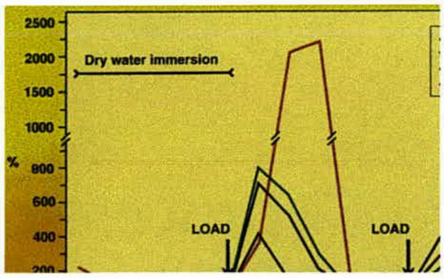
Cosmonaut Syndrome
(Astronaut Syndrome)

- Primary muscle atrophy (changing of muscle enzymes)
- Polyneuropathy
- Proprioceptive disturbances (joint position recognition, vibration perception, hypo/areflexia, spinal ataxia)
- Thalamic disturbances, changing in body scheme
- Programmed motor disturbances (eye-head-coordination, etc.)
- Cerebellar ataxia
- Body scheme disturbances
- Decrease in vigilance
- Vegetative dysregulation
- Osteoporosis

Bedrest Syndrome

- Primary muscle atrophy with muscular changes and structural lesions
- Changing in muscle enzymes
- Polyneuropathy
- Proprioceptive disturbances (spinal ataxia, deep sensation disturbances)
- Thalamic symptoms
- Decrease in vigilance
- Cognitive disturbances
- Body scheme disturbances
- Osteoporosis

Pattern of Skeletal Muscle Proteins after DWI for 5 days followed by isometric muscle load



- Myoglobin: Myo
- Myosin heavy chain fragments: MHC
- Creatine kinase enzyme activity: CK
- Creatine kinase MB isoenzyme enzyme mass: CK-MB

Source: Artner Dworzak et al, 1993

Pattern of skeletal muscle proteins which were measured in the plasma of a healthy male volunteer. The concentrations are shown as percent increase from baseline value. Total immobilization (DWI) lasted for 5 days followed by a standardized isometric muscle load. After a regeneration period of 14 days the same procedure of muscle load was performed but with a 2-fold increased isometric load.

Bedrest Syndrome - Etiology

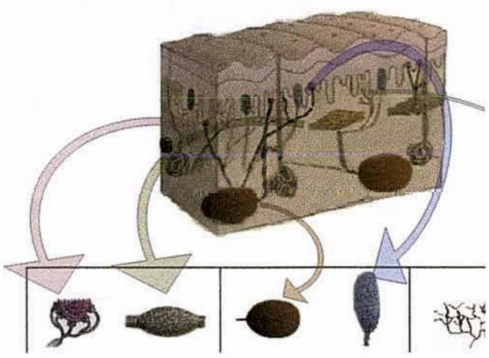
- Experimentally induced – ground based laboratory
- Pathogenic origin
  - Long-lasting coma states, apallic syndrome, etc.
  - Cardiovascular disturbances, long stay in bed
  - Post-traumatic statuses, severe bone fractures, Parkinson Syndrome – reduced mobility
  - Dementia – reduced mobility
  - Spasticity
- Psychiatric patients, reduced motion, drug induced
- Elderly people, reduced movements

Pathophysiological sequences in Cosmonaut and Bedrest Syndrome

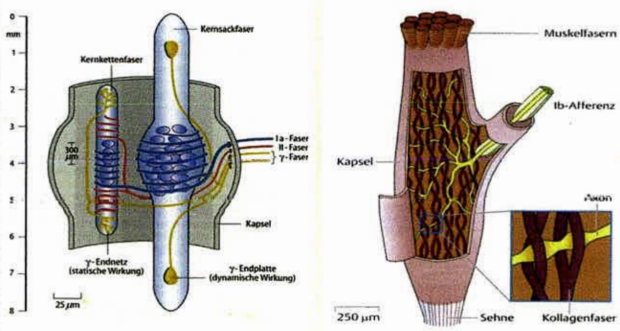
(real and simulated microgravity)

- Experimental state and patients
- Microgravity influencing the gravity receptors with disturbances of the proprioceptive system
  - Disturbances of motor system, body movement
  - Disturbances of the upright position
  - Disturbances of the sensory system, reafference
  - Disturbances of the thalamic function
  - Disturbances of frontal lobe functions, cognitive abilities (psycho-motoric coordination, associativity, critisism, emotional control)
  - Disturbances of vigilance

Scheme of Mechano-Receptors

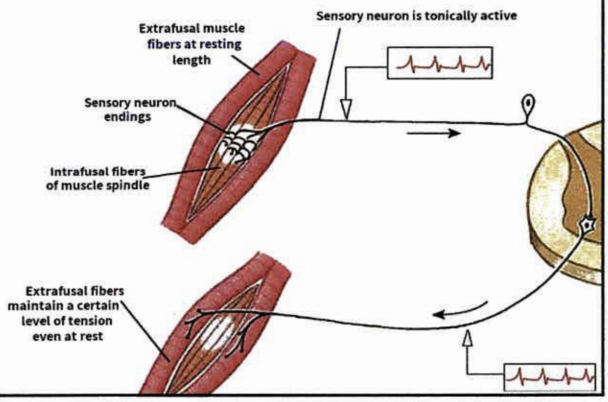


Scheme of muscle spindles

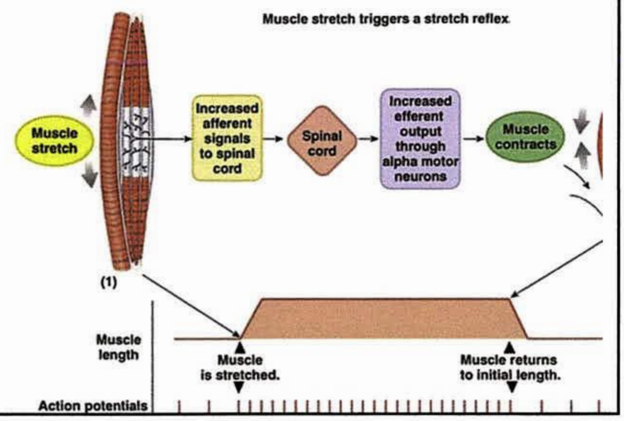


Schmidt, Lang, Heckmann, Physiologie des Menschen, Springer, 2010

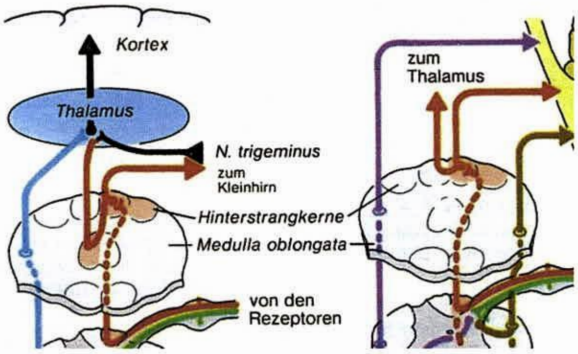
Function of muscle spindles



Function of muscle spindles



The Proprioceptive System
Responsible for the perception of gravity



Experimental Verification
Influence of foot sole vibrostimulation

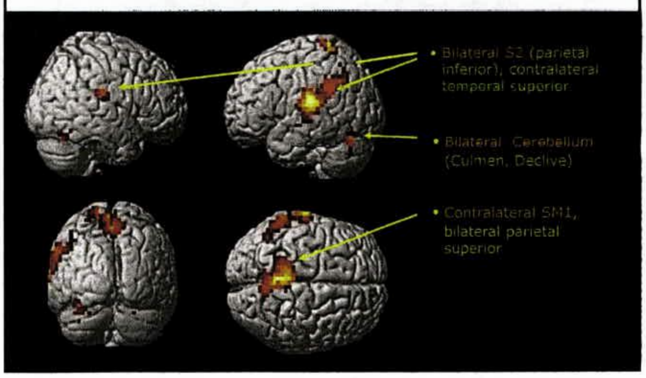
- Functional MRI (fMRI) in healthy volunteers
  - BOLD-effect (Blood oxygenation level dependent), main focus in centers of the postural system (motoric, proprioceptive, epicritic, cerebellar centers)
  - BOLD effect in other foci like frontal lobe, temporal lobe, thalamus, cingulate gyrus, inferior part of parietal lobe

Vibrotactile Stimulation of the Foot Sole, Moving Magnet Actuator System

Vibration frequency 50 Hz

Stimulation of muscle spindles and Paccini-corpuscles

Result of vibrostimulation of the foot sole
Different methods in neurorehabilitation



Use of Research Results in Neurology and Neuro-Rehabilitation

- Bedrest examinations, acute results
  - manifestation of minimal brain lesions during examination phase
- Use of research results in real and simulated microgravity
  - Different methods in neurorehabilitation
  - Geriatrics
  - Psychiatric disorders
  - Methods in wellness

Counter Measures in Real Microgravity

- Treadmill exercises
  - Daily fixed program
- Special exercises legs and arms
- Adaptation of fine motor skills
  - Target training
- Adaptation training of cognitive functions
- Electrode trousers
- Penguin suit

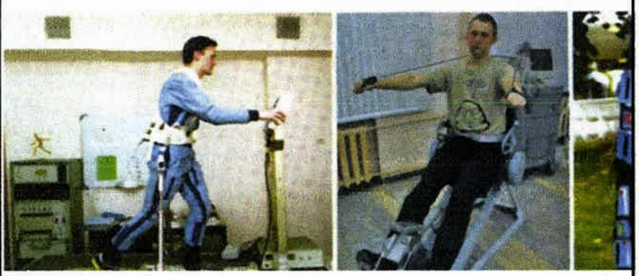
Use of counter measures in Neurorehabilitation

- Motoric disturbances (Parkinson Syndrome, spasticity, cerebellar disturbances, disturbances of the peripheral nerve system)
- Apallic syndrome, Locked-in syndrome
- Severe conditions after stroke, motoric disturbances, cognitive failures
- Severe conditions after traumatic brain injury
- Prevention of bedrest syndrome
- Dementia

Different Devices as a Spin-off effect of Space Neurology

- Prevention tools for space missions (treadmill, weight trainer, trousers with electrostimulator)
- Pressure shoe – Austrian model
- Pressure shoe – Russian model
- Korvit System – Foot loading imitator
- Regent – treatment suit
- Penguin System
- Adeli System

New Neurorehabilitation Methods



Used in:
minimal neurological disturbances (spasticity, cerebellar disturbances, Parkinson Disease, polyneuropathy, early dementia state)
Geriatrics, wellness training

Source: Manned Mission to Mars, Russian Academy of Cosmonautics, 2006

Pressure shoe – Austrian model

Used in:

long-lasting coma states (intensive care units)

Locked-in syndrome

Apallic syndrome

Severe stroke defects

Severe states after traumatic brain injury

Planned:

Geriatric institutions

Korvit - Foot loading imitator imitating gait movement

Used in:
Gait disturbances; Parkinson's Disease; Spasticity, different origin; Spinal cord lesions; Polyneuropathy;

Planned: Dementia, Geriatric institutions

Regent – Treatment Suit

Used in

Spasticity

Parkinson's Disease

Spinal cord lesions

Polyneuropathy

Stroke, severe defects

Planned In:

Dementia, Geriatric

Penguin suit

Used in:

Cerebral palsy

Spastic spinal paralysis

Planned:

Parkinson's Disease

Dementia

ADELI-SYSTEM

Used in:

Cerebral palsy

Spastic spinal paralysis

Stroke

Some diseases of vertebral spine

Planned:

M. Parkinson

Dementia

Source: ADELI Folder

Partial microgravity Neurorehabilitation underwater method

- Scuba Diving - 4-5m depth
- Scuba Diving - 20-30m depth
- Scuba Diving in underwater tower
- Snorkel-Diving-System

Scuba Diving – A New Neurorehabilitation method – 1

Partial microgravity, influence to proprioceptive system

- Diminishing stimulation of the proprioceptive system
- Diminishing of the vestibular system
- Relaxation of vertebral spine system
- Pathophysiological explanation open
  - Reduced stimulation of the proprioceptive system

Scuba Diving – A New Neurorehabilitation method - 2
Partial microgravity, influence to proprioceptive system

- Indications:
  - minimal spinal cord lesions (traumatic, MS, etc.)
  - vertebral spine disturbances
    - cervical myelopathy
    - lumbalgia with radicular/pseudo-radicular symptoms

Scuba Diving – A New Neurorehabilitation method - 3
Partial microgravity influence to proprioceptive system

- Additional method in neurorehabilitation
  - Mild Parkinson syndrome
  - Mild spasticity (after stroke, TBI, etc.)
  - Mild form of cerebellar ataxia

Scuba Diving in depth 4 - 5 m

Precondition:

Always in pairs with specially trained physio-therapist

Development of new medical devices for neurodiagnosis in neurological diseases

- Using bedrest method in early state of Parkinson Disease, spasticity, cerebellar disturbances, frontal lobe syndrome, etc.
- Examination during a stay in a bedrest monitoring program, lasting for 72 hours
- Monitoring of a neurological state, clinically and with additional methods (EEG, EMG, MRI pre- and post examination program, other specific methods)
- Multiplication of minimal symptoms, subclinically to a veritable clinical level (rigidity, spastic signs, frontal lobe signs, etc.)

Space Neurology in Future - 1

- Scientific programs focused on simulated microgravity methods (ground based laboratory)
  - More detailed results in knowledge of the proprioceptive system and its influence to the highest and higher brain functions
  - New methods in neurorehabilitation
  - New methods in neurodiagnoses

Space Neurology in Future - 2

- Scientific program in real microgravity based on orbit flights (ISS)
- Co-operation of NASA, ESA, Russian Space Program including Chinese Space Program as well as Japanese Space Program
- Combined programs with neuropharmaceutical methods
- Scientific program in partial microgravity in underwater conditions