INTRODUCTION
SPACE NEUROLOGY

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The results of studies investigating the adaptation process and the pathophysiological disturbances experienced by human beings in space are not only used for optimizing biological systems in training programmes for cosmonauts and astronauts, they also provide new insight into the function of the human brain and the human body and can find practical application in routine medicine. Numerous open questions of space medicine need further examination, such as the disturbance of motor control in space including eye movements, the dysfunction of the vestibular apparatus and of the proprioceptive input, cognitive dysfunction in microgravity and the disturbance of body fluid circulation and of the cardiovascular system.

Many problems of space adaptation can be studied in simulated microgravity using the dry water immersion model and the bed rest model in special laboratories. Only a small, but very important part of the experiments must be carried out in manned space flights.

Of the many disturbances caused by the decrease of g-loads, the effects on the function of the nervous system, the skeletal muscles and the motor regulatory system are of major importance. Studies carried out in real and simulated weightlessness have shown a weigthlessness dependent neurophysiological alteration, which mainly represents neurophysiological adaptation. Such changes are primarily physiological adaptation processes; only as a later consequence they can be classified as pathological changes.

The lack, or better the change of information registered by the gravity receptors in microgravity is responsible for the neurological disturbances of a healthy man in space. Via the rapidly conducting pathways of the dorsal column, the brain receives information about the position of the head, the trunk and the upper and lower extremities within the gravitational field of the earth. Furthermore, this system informs the brain about the movements of head, body and extremities. Changes in the sensory motor system occur in real as well as in simulated microgravity. Motor performance, coordination of movements, accuracy of fine movements are disturbed in real microgravity. The control executed by the vestibular system over movements of eyes, head, trunk and extremities is also affected. The vestibular apparatus adapts within a relatively short period to real microgravity, while dysfunction of the proprioceptive system is deteriorating with prolonged microgravity. Consequently false perception of the joint positions, changes of vibratory sensibility, disturbances of coordinated movements of eyes, head and extremities, cerebellar ataxia and spinal ataxia occur. Secondary dysfunctions include disturbed body scheme control, reduced vigility and disturbed cortical functions, such as associative reactions, critical faculty, memory, spatial orientation etc. In parallel with the dysfunction of the proprioceptive system, vegetative disorders occur influencing the cardiac and circulatory system as well as body fluid transport and sleep wake regulation.

The changes during the initial phase of a flight in space represent the space adaptation syndrome, with vestibular disturbances as main symptoms (vertigo, nausea, vegetative dysregulation, the motion sickness symptomatology), movement disorders (hypermetry, dysmetry), optomotor dysregulation and some proprioceptive disturbances, such as slight false perception of the position of head, trunk and joints, hyporeflexia, disturbances of coordinated movements and pseudoapraxia. After prolonged space flight, the adaptation syndrome gives way to the cosmonaut syndrome, also called pseudotabic syndrome, with more pronounced symptoms of proprioceptive disturbances, such as intensive false perception of head, trunk and joint positions, spinal ataxia, cerebellar ataxia, primary muscle atrophy, polyneuropathy, disturbed body scheme control, reduced vigility and disturbances of higher cortical functions. In addition, vegetative disorders, such as cardiac and circulatory irritation, osteoporosis, etc. occur.

Several attempts have been made to simulate microgravity in ground based laboratories. Various papers on the advantages and disadvantages of such methods as water immersion, prolonged bed rest, suspension in special devices with many degrees of freedom, walking in a treadmill, parabolic flight, etc. have been published. For human experiments the water immersion model and the bed rest model seem to be the most practicable ones.

Basis pre-flight data have predominantly been gathered by investigations in simulated microgravity. This procedure was also applied in experiments conducted for the Austromir programme in 1991. It is also a useful tool for manned space flight selection and the training programmes and medical care for astronauts and cosmonauts.

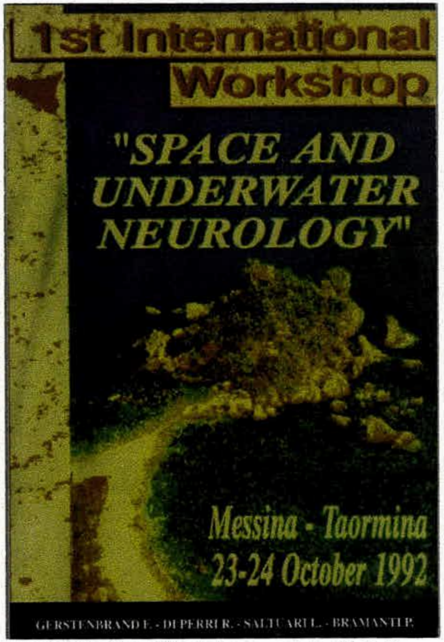
Studies using the dry water immersion model or the bed rest model in healthy volunteers also showed interesting changes of the sensory motor system with disturbances of the proprioceptive system manifested by changes in vibratory sensibility, control of joint positions etc. and effects on tendon reflexes and muscle tonus. Special experiments demonstrated skeletal muscle enzymes to be changed.

Experimental findings in simulated microgravity and the cosmonaut syndrome are similar to the bed rest syndrome occuring in patients after prolonged bed rest (coma stages, chronic cardiac diseases, fractures of vertebral spine or pelvis, etc.) and elderly people. The pathophysiological basis of the bed rest syndrome is also a disturbance of the proprioceptive feedback of the extremities, the trunk and the cervical spine in addition to disturbances of the autonomic nervous system. In its severest form, the bed rest syndrome in coma patients may be accompanied by other complaints leading to severe polyneuropathy and encephalopathy and may develop into a severe defect stage.

Our knowledge about the development of a bed rest syndrome in coma patients caused us to introduce vertigotherapy and vibratory treatment of the foot soles in patients with apallic syndrome, locked-in syndrome and other similar pathological conditions. Findings obtained in simulated microgravity experiments can be used in the early diagnosis of movement disorders such as Parkinson's disease and cerebellar dysfunctions and for monitoring therapeutical efficiency in these diseases.

Research in space neurology is a completely new field in modern neuroscience. It furnishes new information about sensory motor functions, especially about the proprioceptive system. The results of experiments in simulated microgravity can be used for designing new diagnostic and therapeutic programmes for certain neurological conditions.

SUMMARY



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