N87-17771

# HUMAN ADAPTATION AND READAPTATION FOR MARS MISSION

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## ABSTRACT

Human adaptation and readaptation in space appears to involve complex physiological and psychological interactions and adjustments. There has been no comprehensive clinical characterization of the symptoms of these interactions, much less a comprehensive examination and testing of appropriate measures to counteract their near and long term adverse consequences. The variety of credible potential countermeasures is great; however, a systematic clinical research program for Shuttle and Space Station must be implemented as an early part of a Mars Mission strategy.

## INTRODUCTION

The current situation we face relative to human adaptation and readaptation to various environments is more one of ignorance than of knowledge. On the one hand we know that physiological adaptive responses take place when human beings are exposed to weightlessness. All current evidence indicates these responses are reversible upon re-exposure to a gravitational field. We know that the obvious neurololgical symptoms of the first stage of that adaptation process varies in severity from individual to individual; the process seems to be complete within three to four days in all but very few cases.

We know that more subtle symptoms of full cardiovascular adaptation, and probably of most biochemical adaptations, stabilize after several weeks of exposure to weightlessness. The important known exceptions to this are mineral balance and long term vestibular response, both of which have shown continous adverse change during flights of durations approaching those necessary for missions to Mars.

On the other hand, we do not know the basic causative mechanisms of these adaptation symptoms except that vestibular agitation (head motion) aggravates the severity of symptoms in the few days of the first stage, but does not prevent initial neurological adaptation. We do not know which, if any, of the many potential countermeasures against space adaptation symptoms will work. We do not know how, or if, the <u>re</u>adaptation process can be accelerated so that crews exposed to very long periods of weightlessness can rapidly regain function in a gravitational environment.

The development of the capacity to conduct a mission to Mars must include: first, the complete clinical characterization of the physiological and psychological basis for space adaptation and readaptation; second, the clinical or flight testing of countermeasures and readaptation strategies.

Near-term Physiological Adaptation

The presently available anecdotal information on space adaptation symptoms have been summarized by Schmitt (in press) and Oman, et. al. (1984). The operational data in hand relative to these symptoms is grossly incomplete; they do suggest however, that the basic cause of the symptoms is probably a neurological conflict resulting from a wide variety of incompatible signals being received by the balance, vision and orientation processing centers of the brain and from superimposed physiological adaptive responses.

Most of the overload appears to come from visual disorientation cues combined with head motion; however, the full effects of multi-sensory conflict, autonomic dysfunction, hemodynamic alterations, and the absence of the Schumann electromagnetic resonance field have yet to be evaluated. Prolonged exposure to this overload apparently results in a loss of initiative and a general malaise (parasympathetic neural response) in some individuals. In some cases, unexpected aggravation of the overload causes the rapid onset of a single episode of unexpected vomiting which temporarily provides relief from intense symptoms. In other cases, vomiting can be prolonged and potentially detrimental to health and performance.

The known symptoms of space adaptation syndrome (SAS) resemble those of increased intracranial pressure, high altitude sickness and, possibly, other clinical problems observed on Earth aggravated by sensory conflict within the autonomic nervous system rather than symptoms associated with terrestrial motion sickness.

SAS symptoms vary in nature and intensity from person to person and from mission to mission; however, four general levels of severity can be defined as follows: (1) Fullness of the head with other associated symptoms (all crewmen); (2) Slight stomach awareness and/or slight frontal headache (about 75% of crewmen); (3) Strong stomach discomfort and/or severe headache combined with a general loss of initiative or malaise (about 40% of crewmen); (4) Intermittent, single episode vomiting (combined with level 3 above) that, temporarily at least, reduces the level of other symptoms (about 40% of crewmen); and (5) Frequent vomiting with prolonged adaptive period (about 5% of crewmen).

The process of adaptation resulting in these symptoms is, apparently, the brain learning to ignore the inputs from various sources which conflict with visual inputs. This adaptation process generally takes one to four days. The adaptation may be accelerated by pushing oneself up to detectable symptoms and then backing off from them by stopping head and body motion and strong visual orientation changes.

Significant SAS symptoms can be delayed, but probably only delayed, by highly challenging first day activities in which the crew is emotionally involved (sympathetic neural response). This does not include, however, just a full timeline that allows no time for adaptation by those crewmen who need it.

The strong effects of spatial disorientation and of head motion in inducing symptoms are clear. Methods should be explored to reduce crew visual dependency on "learned" orientations acquired during training and piloting experience in a one-gravity environment. Development of individual "egocentric" orientation references may be helpful. Considerations also should be given to using variable orientations with respect to gravity for Shuttle and Spacelab simulators and to increased visual and VFR instrument aerobatic maneuvers that give variable orientation of Earth horizon references.

There are many human physiological changes induced by a weightless environment any or all of which may play a role in inducing SAS symptoms. Among these are the following: (1) Multi-sensory conflicts, including head movements, proprioception and vision; (2) Autonomic dysfunction, including desynchronosis; (3) Hemodynamic alterations including cerebral spinal fluid shift, autonomic baroreceptor change, and hydrodynamic pressure; (4) Cardiovascular adaptation; (5) Head, neck, and spinal column position and length changes; (6) Reduction in kinesthetic sensitivity; (7) Increased cardiovascular efficiency in transport and metabolism; (8) General electrolyte, fluid, endocrine and other chemical balances; (9) Hydrogen in the water supply (intestinal gas buildup); (10) Diet and olfactory sensitivity; (11) Shift of internal organs; (12) Sleep deprivation; and (13) Absence of Schumann electromagnetic resonance field.

The bottom line is that we must understand the clinical characteristics and baseline of this early phase of the adaptation process if we are to successfully counter its long-term, more serious effects. The Space Shuttle should be more aggressively utilized to this end.

TRANSITIONAL PHYSIOLOGICAL ADAPTATION

The Skylab missions enabled us to get a general feeling for the transitional adaptation processes that take place in all individuals over a few weeks to a few months. Although it is clear that given a proper exercise regime the cardiovascular system stabilizes, it is not clear what happens to various biochemical and cellular balances. This transitional adaptation process also must be far better understood before the correct mix of countermeasures can be formulated. The early availablilty of the Space Station is crucial to such understanding.

LONG-TERM PHYSIOLOGICAL ADAPTATION

There are two known physiological adaptive responses to prolonged weightlessness that may be highly detrimental to the success of Mars surface activities. These are (1) the apparent loss of mineral mass from at least the more dense skeletal elements and from the otolith and (2) the apparent gradual decline in sensory perception related to upright activities in a subsequently imposed acceleration environment.

If not countered, either of these adaptive responses might seriously impair the efficiency, if not the feasibility, of human activity on Mars, at least for the first several weeks after arrival. On the other hand, the range of potential countermeasures is large and most can be verified during the early years of Space Station operations.

The most obvious countermeasure is to provide some form of artificial "gravitational" acceleration. However, the most commonly proposed means of doing so, namely spacecraft rotation, not only makes for very complex and costly design trade-offs, but it might create as many adaptation problems as it would solve. A more prudent approach would be to provide a means for regular exposure to appropriate levels of linear acceleration. The duration and magnitude of such acceleration could be determined by experiments at the Space Station, probably with no more than one to three months of experimentation. The resulting protocols also probably could be tailored to individual crew members after each had completed a three month tour at the Station,

The specific anti-mineral loss protocol also may be enhanced and/or simplified by diet and exercise adjustments or by use of mineral fixing drugs and electromagnetic stimulation, varieties of which are currently in clinical use here on Earth. Early tests of these approaches, looking at electrolyte and biochemical balances, could be performed during Space Shuttle flights, while testing the complete protocols would require use of the Space Station.

## LONG-TERM PSYCHOLOGICAL ADAPATION

The toughest area to research and to do something about relative to long-term spaceflight is that of psychological adapation and compatibility. It is probably safe to say that history tells us that most human beings can get along in close quarters for long periods of time if they are motivated and productively active. History also tells us that there are exceptions.

The incorporation of major science, training and recreational activities into each mission to Mars should solve most potential psychological problems. Individual hide-aways, hobbies and counseling should help as well. However, a precursor visit to the Space Station by each flight crew as a unit may well be a desirable means of sorting out any individual or group problems.

## CONCLUSION

Many physiological and psychological unknowns remain relative to long duration missions to Mars and to subsequent activities on the Martian surface. However, the potential of the Shuttle and Space Station for systematic clinical studies and clinical tests of countermeasures and the range of potential options are adequate to prepare for such missions. Unfortunately, NASA has not yet begun the process of developing a full clinical understanding of human adaptation to space and readaptation for Mars missions, nor has NASA begun the organized clinical testing of potential engineering and biomedical countermeasures.