First Biennial Space Biomedical Investigators' Workshop, League City, TX, Jan 11-13, pp. 117-119, 1999

MONITORING AND CORRECTING AUTONOMIC FUNCTION ABOARD MIR: NASA TECHNOLOGY USED IN SPACE AND ON EARTH TO FACILITATE ADAPTATION.

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INTRODUCTION

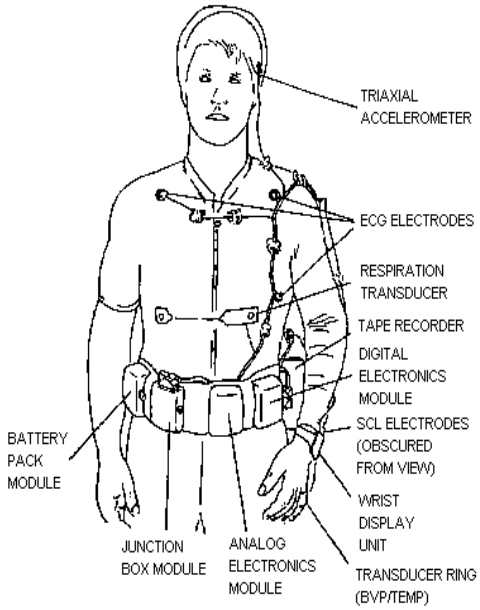
The broad objective of the research was to study individual characteristics of human adaptation to long duration spaceflight and possibilities of their correction using autonomic conditioning. The changes in autonomic state during adaptation to microgravity can have profound effects on the operational efficiency of crewmembers and may result in debilitating biomedical symptoms. Ground-based and inflight experiment results showed that certain responses of autonomic nervous system were correlated with, or consistently preceded, reports of performance decrements or the symptoms. Autogenic-Feedback-Training Exercise (AFTE) is a physiological conditioning method that has been used to train people to voluntary control several of their own physiological responses. The specific objectives were: 1) To study human autonomic nervous system (ANS) responses to sustained exposure to microgravity; 2) To study human behavior/performance changes related to physiology; 3) To evaluate the effectiveness of preflight autonomic conditioning (AFTE) for facilitating adaptation to space and readaptation to Earth; and 4) To archive these data for the NASA Life Sciences Data Archive and thereby make this information available to the international scientific community.

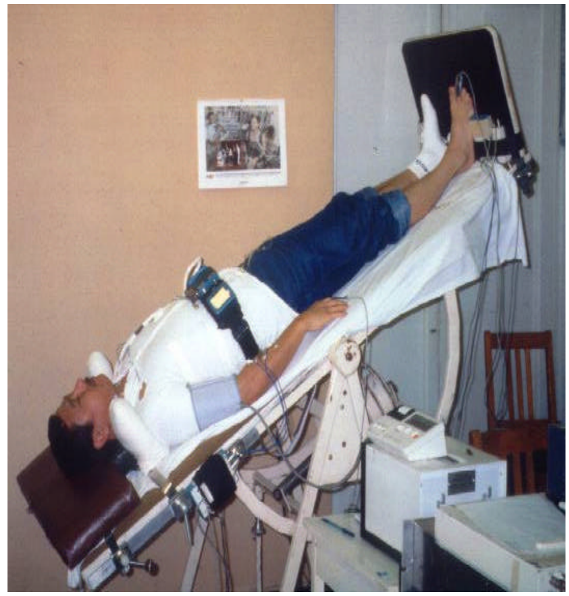
METHODS

Overview. Four cosmonauts (men, ages 43-47) participated in this study. Preflight training was performed at Star City, Russia prior to the MIR missions 23 and 25. Preflight baseline data were collected (tilt-table) and training in autonomic control administered within 4 months prior to launch. Inflight, eight data collection days were distributed throughout the 6-month missions. Inflight crew activities included: 8-hour ambulatory monitoring, and performing computer-based performance task batteries, mood assessment and symptom diagnostic scales three times per day on test days. Flight data were returned to the investigators post-flight.

Apparatus. The Autogenic Feedback System-2 (AFS-2) is a self-contained ambulatory monitoring system designed to monitor human physiological responses. The system includes a garment, transducers, signal-conditioning amplifiers, a microcontroller, a wrist-worn feedback display and a cassette tape recorder. This system was developed and tested on astronauts during a space shuttle mission in 1992. Data collected with the AFS-2 was used to evaluate physiological responses to microgravity during the mission. This technology is also currently in use by the U.S. Army for evaluating environmental effects of motion within command and control vehicles on soldier performance and by physicians at the University of Tennessee for diagnoses of nausea and syncope incidents in patient populations (see Figure 1).

Figure 1. **AFS-2: Drawing, and as worn by a cosmonaut during preflight tests**





The physiological parameters currently monitored with this system include: (1) electro-cardiography ; (2) respiration rate; (3) finger pulse volume; (4) skin temperature; (5) skin conductance level; and (6) triaxial accelerometer to measure head and upper-body movements.

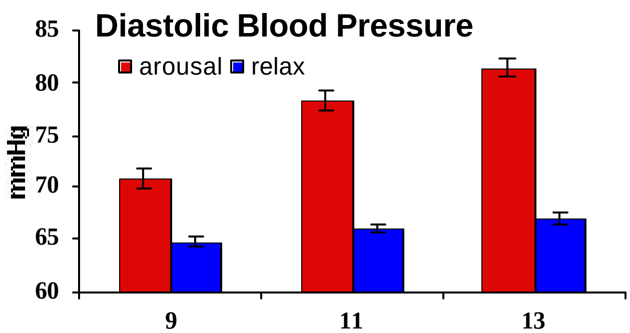
Autogenic Clinical Laboratory System (ACLS). During preflight training and post flight tests, physiological signals are collected and displayed using a Pentium computer with custom display and acquisition software referred to as the Autogenic Clinical Laboratory System (ACLS). The system provides real-time acquisition and display of 16 input variables, 20 digitally-displayed output variables and printed averages, plus coupled audible tones, voice commands and respiratory pacing signals. The system contains an analog to digital converter (A/D) and a video controller, which allows four monitors, two for the operator's console and two for subject displays.

Autogenic-Feedback Training Exercise (AFTE). Each subject received 6 hours of AFTE, which is administered in twelve 30-min sessions. Following a 6-min pretest baseline, each 30 min. session was divided into ten 3-min. trials during which subjects were instructed to alternatingly increase and decrease their response levels (e.g., heart rate accelerations and decelerations, peripheral vasodilatation and constriction, etc.). There was a 6-min resting baseline following each session (total 42 min). The purpose of the training sessions was to provide subjects with the ability to recognize bodily sensations associated with both increases and decreases in their physiological response levels and with practice to improve their skill in controlling these responses. Subjects eventually learn to maintain their physiological response levels at or near their own resting baseline levels and improve their tolerance to environmental stressors (e.g., tilt-table, conditions of microgravity, etc.).

Performance Task Batteries, Symptom and Mood/Alertness Scales were administered using a PC system. Crewmembers received training in the use of these assessment tools on the same days as preflight AFTE. The performance battery included tests of reaction time, manual dexterity and spatial transformation. A computer program was used by subjects to rate their own symptoms using a standardized symptom diagnostic scoring procedure. Mood was assessed using a visual analog scale in which crewmembers self-reported their levels of “ease of concentration”, motivation, and emotional state.

RESULTS

Crewmembers (prime and alternate) for the first mission participated in only 3.5 to 4 hours of training. Only one crewmember showed significant control of autonomic responses. This crewmember was given an additional 4 hours of training prior to the second mission (one year interval) and his performance continued to improve (see figure 2). Based on preflight learning rate and retention, it was predicted that AFTE effects would be most beneficial for this subject.



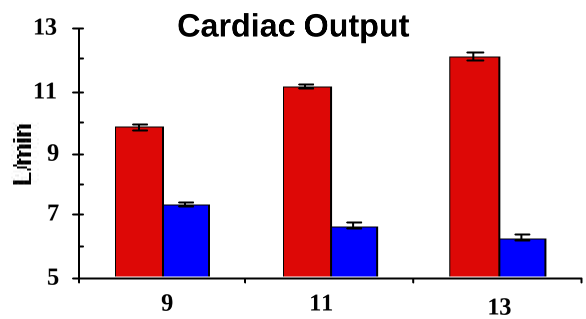


Figure 2: Average diastolic blood pressure and cardiac output levels during AFTE sessions 9, 11, and 13 (year two) for one cosmonaut during preflight training.

A total of 110 hours of data were obtained from flight. The crewmember whose preflight data are shown in figure 2, showed similar control of physiological responses during flight. This crewmember reported no space motion sickness and showed significant resistance to post-flight orthostatic intolerance.

CONCLUSIONS:

Flight data are currently being analyzed and will be discussed in the final report. These data will be made available for access from the NASA Life Sciences Archive. The objectives of this study were successfully met. The use of three converging indicators: physiological responses, self-rated symptom reports, and task performance was an effective means of evaluating the incidence of space motion sickness and the impact of sustained exposure to microgravity on overall crew operational capacity. AFTE may be a valuable supplement to crew training/exercise protocols.