NASA Technical Memorandum 89412

# Final Report Spacelab 3 Flight Experiment #3AFT23: Autogenic-Feedback Training as a Preventive Method for Space Adaptation Syndrome

Patricia S. Cowings, Ames Research Center, Moffett Field, California
William B. Toscano
Joe Kamiya, University of California, San Francisco, California
Neal E. Miller, Yale University, New Haven, Connecticut
Joseph C. Sharp, Ames Research Center, Moffett Field, California

October 1988

National Aeronautics and
Space Administration

**Ames Research Center**
Moffett Field, California 94035

CONTENTS

LIST OF FIGURES

Page

## SUMMARY

A final report is presented for Spacelab-3 (SL-3) Shuttle experiment, #3AFT23. Four male astronauts participated as subjects in this experiment. Crewmembers A and B served as treatment subjects (i.e., received preflight training for control of their own motion sickness symptoms) and Crewmembers C and D served as controls (i.e., did not receive training). A preliminary evaluation of Autogenic-Feedback Training (AFT) was made from visual inspections of graphs that were generated from the preflight and inflight physiological data which included:

1. Baseline rotating-chair tests for all crewmembers.

2. Posttraining rotating-chair tests of treatment group subjects.

3. Preflight data from joint integrated simulations (JIS) for all crewmembers.

4. Flight data for all crewmembers during mission days 0 through 4 and mission day 6 for treatment subjects only.

A summary of the conclusions based on these data is outlined in the following sections. The preflight training schedule given to treatment group subjects was, on average, 90 days longer than planned because of delays in the launch date. This change in the schedule and its effect on training performance was discussed in two earlier reports (SL-3 Flight Readiness Review, April 25, 1985 and the SL-3 30-Day Report, June 12, 1985). The investigators concluded that the generally poorer performance of crewmembers in this study was primarily due to the change in the schedule, although motivation may have been a secondary factor. The data of crewmembers A and B were compared to the data of 40 test subjects who were given AFT using a more optimal schedule in the laboratory. The increase in the number of rotations tolerated from the pre- to posttraining rotating-chair tests was computed for all subjects and their scores were ranked from the largest to smallest increase. Crewmember A showed an increase of 398 rotations and his score among the sample of 42 subjects was about average, at the 54th percentile. Crewmember B, however, showed much less improvement in motion sickness tolerance after training, with an increase of only 102 rotations. His score among the larger sample of subjects was at the 18th percentile.

Each crewmember's initial susceptibility to motion sickness, (i.e., number of rotations tolerated before reaching severe malaise), was recorded during their baseline rotating-chair test. The physiological responses of treatment subjects which changed the most during motion-sickness stimulation from their resting baseline levels were selected as training measures for subsequent AFT sessions.

Both Crewmembers A and B were each given 12 preflight AFT sessions without rotation in which they were taught to increase and decrease, on alternate trials, their heart rate (HR), skin conductance (SC), and finger pulse volume (FPV) with the aid of visual and auditory feedback. These subjects were also instructed to use the feedback from the three different responses to change a pattern (i.e., HR and SC up, FPV down or HR and SC down, FPV up) without changing respiration rate or muscle activity. An example of the physiological data from one training session is included in this report.

The physiological data of Crewmember A collected during the pretraining rotating-chair test was compared to the data from his posttraining rotating chair test. A visual inspection of the data for this subject showed a reduction in sympathetic tone (i.e., decreased stress) for all three physiological responses in his posttraining test. Further, while this crewmember maintained lower physiological levels, he was able to tolerate much higher rotational velocities than during his pretraining test. When the pre- and posttraining rotating-chair tests of Crewmember B were compared, there was some reduction in heart rate after training, whereas skin conductance and finger-pulse volume still showed a stress response and motion sickness tolerance increased only slightly.

On the basis of their preflight training and motion-sickness-test data, the investigators predicted (meeting minutes documented in the SL-3 Flight Readiness Review, April 25, 1985) that Crewmember A would have a higher probability of success at preventing or controlling his symptoms in space than Crewmember B.

The inflight symptom reports revealed that crewmember A did not experience any severe-symptom episodes during the mission, whereas crewmember B reported one severe-symptom episode. Both control-group subjects, C and D (who took anti-motion-sickness medication) reported multiple-symptom episodes on mission day 0. When the inflight physiological data of crewmember A were compared to those of the other crewmembers participating in this study, he showed reduced sympathetic tone for all physiological variables measured.

The following recommendations were made by the investigators for future flights. (1) Use a better preflight training schedule for treatment subjects that would begin at 10 months to 1 yr prior to launch with "follow-up" AFT sessions at launch minus 3 months. (2) Reduce inflight requirements for physiological monitoring to the first three mission days only. (3) Modify flight hardware to facilitate crew mobility and comfort.

The preliminary results from this Spacelab-3 experiment are encouraging. The measurements and inflight procedures that were used should eventually enable the investigators to evaluate AFT as a countermeasure for space adaptation syndrome (SAS), and to objectively document human psychophysiological responses to the microgravity environment. However, it is clear that additional data must be obtained inflight (i.e., eight treatment group subjects and eight control group subjects) before these goals can be achieved.

# INTRODUCTION

Space Adaptation Syndrome (SAS) is a motion sickness-like disorder which affects up to 50% of all people exposed to microgravity in space. Autogenic-feedback training (AFT) is a physiological conditioning procedure which can be used to reduce motion sickness symptoms as an alternative to pharmacological management. The Spacelab-3 mission was the first in a series of shuttle flight tests of AFT. Detailed descriptions of both preflight and inflight procedures for Spacelab-3 experiment, #3AFT23, are presented here. Data obtained are given in graphic form.

The research objectives of this experiment were as follows.

1. The first objective was to determine if preflight AFT is an effective treatment for space motion sickness. Those subjects who received AFT should experience fewer symptoms inflight than control group subjects who received no treatment or an alternative treatment.

2. The second objective was to determine if preflight improvements in motion sickness tolerance can be used to predict crewmembers' success in controlling symptoms inflight. Crewmembers who demonstrate greater physiological control and are able to tolerate motion sickness stimulation significantly longer after training should experience fewer symptoms during the mission.

3. The third objective was to identify differences and similarities between the physiological data from preflight motion-sickness tests and data collected during observed symptom episodes in space.

# METHODS

## Subjects

Four men (ages 42 to 60) participated in this experiment as Spacelab-3 crewmembers. There were two control group subjects and two treatment group subjects. Two backup crewmembers, ages 34 to 38, also served as treatment group subjects and participated in all preflight activities. The preflight data of backup crewmembers are included in Appendix A. All subjects were medically certified (class 1 flight physical) to serve as crewmembers aboard Space Shuttle Missions.

## Apparatus

Flight Hardware And Measures- An ambulatory monitoring system was used to record the autonomic responses of crewmembers in space and provide real-time feedback of physiological information. This system (see Appendix B), is made up essentially of four major components: (1) the Biosuit, a customized undergarment

designed for attachment of respiration transducers and cabling; (2) a cable harness, consisting of electrode and transducer wiring which mounts to the biosuit with velcro ties and interfaces with (3)and (4); (3) the Autogenic Feedback System (AFS), a portable instrument mounted on a crewmember's belt which contains analog and digital electronics as well as an 8-track, digital, cassette tape recorder; and (4) a wrist-worn digital display used to control the mode of operation of the AFS and provide physiological information (feedback) to trained crewmembers. The AFS was also used to monitor physiological responses during preflight baseline testing, training sessions, and joint integrated simulations. Physiological measures recorded with the AFS included the following.

1. The electrocardiogram (ECG) was derived from precordial placement of silver-silver chloride disposable electrodes.

2. The respiratory wave form was derived from two piezoelectric transducers mounted over the chest and abdomen. Only relative changes in compartmental volume were measured.

3. The basal skin resistance (BSR) was derived from two silver-silver chloride disposable electrodes mounted on the volar surface of the left wrist.

4. The finger pulse volume (FPV) was measured with a photoplethysmograph transducer mounted on the volar surface of the little finger on the left hand. Changes in the peak-to-peak amplitude of the waveform were monitored to obtain a relative measure of peripheral vasomotor activity.

5. The skin temperature (ST) was measured on the little finger on the left hand using a semiconductor transducer. Both the photoplethysmograph (FPV) and temperature transducers were mounted in a rubber ring which was attached to the finger with tape.

The AFS also included electronics for measuring X-, Y-, and Z-axis accelerations. A 5-g accelerometer was mounted to a lightweight headset, which was part of the crewmember's standard equipment. These measurements, taken only during the flight, were used to evaluate the relationship between motions of the head and symptom onset.

Training Hardware and Measures- The physiological measures described below were also recorded during preflight baseline and AFT sessions.

1. Heart rate (HR) was measured with a biotachometer which detected R-peak to R-peak intervals from the ECG signal.

2. Respiration rate (RR) was measured with a biotachometer which detected zero crossings from the respiratory wave form.

3. Skin conductance level (SCL) was measured with silver-silver chloride electrodes mounted on the index and middle finger of the left hand, using a J & J Enterprises, model #M-68 amplifier.

4. Skin temperature (ST) was measured with two thermistors mounted on the index fingers of the left and right hands using a J & J Enterprises model #M-68 amplifier.

5. Electromyography (EMG) of the left and right forearm extensor muscles was derived from three silver-silver chloride disposable electrodes using a J & J Enterprises, model #M-58 amplifier.

6. Finger pulse volume (FPV) was measured with a photoplethysmograph transducer mounted on the right index finger using an L & M Electronics model #101 amplifier.

Biomedical amplifiers and the AFS were mounted on the rear of a rotating chair and the physiological signals were sent through slip rings to laboratory equipment. These signals were recorded on strip charts and on a 14-track FM analog tape, and were digitized in real time with a LSI-11 computer. A special playback system was to be used to transfer the flight data from digital cassette tape to 9-track magnetic tape. However, the system was never provided to the investigators. Instead, an alternate playback system provided by Johnson Space Center was used to reduce flight and JIS data. This process involved converting digital data to analog tape and then reproduced the data on strip-chart recorders. The accuracy of the data contained in this report was confirmed by inspection of hardcopy waveforms. A DEC PDP 11/34 computer was used for data reduction.

During formal AFT sessions (see Procedure, Section B. Autonomic Conditioning/ Testing), visual feedback of the crewmember's physiological responses was displayed on a wide-screen oscilloscope and on eight digital panel meters. Verbal instructions from the experimenter were delivered to subjects by an intercommunication system. Auditory feedback tones were provided by two speakers mounted above the subject's head.

Preflight motion-sickness tests

1. A Stille-Werner rotating chair was used to provoke the symptoms of motion sickness. Padded head rests were mounted at 45° angles from the vertical position on the left, right, front, and back of the chair which enabled the subjects to execute head movements in these directions.

2. A second motion-sickness test was conducted in the Vertical Acceleration and Roll Device (VARD). The VARD is a light-proof enclosed cab. Vertical motion of the cab was maintained at a constant frequency. Subjects were monitored by closed-circuit video and by an intercommunication system during the test.

## PROCEDURE

### Preflight Crew Participation Requirements

Baseline Motion Sickness Tests- The initial symptoms of motion sickness were induced in the rotating chair. Physiological responses were monitored and the individual's symptoms were documented using a standard diagnostic rating scale (refer to Appendix C for an explanation of the scoring procedure). Subjects were blindfolded during rotating chair tests. Rotation of the chair was initiated at 6 rpm (0.628 rad/sec) with 2-rpm (0.209 rad/sec) increments every 5 min. The maximum velocity was 30 rpm (3.142 rad/sec). During each 5-min interval at a constant rotational velocity, subjects executed 150 head movements at 45° angles in four quadrants. Instructions for making head movements at 2-sec intervals were delivered to subjects by a tape-recorded voice. The direction of head movements was randomized. There was a 30-sec pause between each 5-min period (no head movements but continued rotation) during which time the diagnostic scale was administered. Tests were terminated at 30 rpm or malaise level III (Appendix C).

Motion sickness symptoms were also induced using the VARD. Physiological responses were monitored and the individual's symptoms documented. The VARD tests were conducted by maintaining vertical motions of the cab at 0.33 Hz and 0.35 g, with a maximum displacement of ±2.5 ft. Subjects were instructed to make head movements in four quadrants at 2-sec intervals. Diagnostic symptom reports were taken at 5-min intervals. The VARD tests were terminated after 75 min of motion or malaise level III was reached (Appendix C).

Resting baseline sessions were conducted in a reclining chair within a darkened, quiet chamber while the subject listened to tape-recorded music for a period of 30 min on two consecutive days. His physiological responses were monitored and these data were then compared to motion-sickness test data for establishing an individual "stress profile." Emphasis in subsequent AFT sessions was placed on those autonomic responses which showed large magnitude changes from the subject's resting baseline levels.

Autonomic Conditioning/Testing- Four crewmembers (two prime and two backup) were trained to control their autonomic responses during 12 AFT sessions. Each 30-min training session was divided into 3-min trials during which crewmembers were taught to produce alternating increases and decreases in physiological activity levels. These 12 sessions were distributed over a 7-month period (launch minus 8 months to launch minus 1 month). Launch delays forced a modification of the planned training schedule which was to have been a 3-month period (launch minus 4 months to launch minus 1 month).

Three rotating-chair tests were given to each crewmember to evaluate changes in motion-sickness tolerance following 2, 4, and 6 hr of AFT.

## Inflight Crew Participation Requirements

Appendix B is the Payload Flight Data File Book (PFDFB) from SL-3. The FDFB describes in detail the AFT procedures performed by both treatment and control subjects. These procedures are outlined below.

Continuous Physiological Monitoring- All crewmembers who participated in this experiment were required to wear the ambulatory monitoring system continuously during waking hours (approximately 12 hr), on mission days 0 through 4. This requirement involved the following activities.

1. During the postsleep activity period on each mission day, the crewmember donned the ambulatory monitoring system and initiated data recording. The cassette tape was replaced daily after 7 hr of operation. A spare tape and a diagnostic log book for recording symptoms were kept in a belt-worn pouch containing the AFS.

2. Battery packs were replaced on alternate mission days.

3. Electrodes and/or transducers were replaced on an as-needed basis, using spares from the stowage locker.

4. The biosuit, AFS, cassette tapes, and diagnostic log book were removed and restowed during the pre-sleep activity period.

Time-Lined and Symptom-Contingent Diagnostic Scale Reports- All crewmembers who participated in this experiment were required to keep a written log of their symptoms using the diagnostic rating scale at specific times twice daily (i.e., time-lined). If symptoms occurred at any time during the mission, crewmembers were again required to administer the diagnostic scale (i.e., the scale was symptom-contingent).

Time-Lined and Symptom-Contingent Autogenic Feedback Training (Treatment Subjects Only)- Immediately following the first, daily, time-lined diagnostic scale, treatment group subjects were instructed to practice AFT for a 15-min period with the aid of the wrist-worn feedback displays. No other flight activity occurred during this period. If a symptom episode occurred, the crewmember was again required to apply AFT to counteract his symptoms. This activity was not to exceed 30 min, and the crewmember could continue any scheduled mission activities during this period. The crewmember was required to administer the diagnostic scale immediately following this AFT session.

## Postflight Crew Participation Requirements

All crewmembers who participated in this experiment were required to attend a 2-hr debriefing session within 14 days postflight.

## RESULTS

### Baseline Data Collection

Resting Baseline- Table 1 is a summary of the preflight resting baseline data for each subject. Means and standard deviations were computed for each physiological variable from 60 1-min averages which were collected during two 30-min sessions. Each crewmember's physiological data from JIS and the flight were transformed to z-scores. Graphs of the z-score values (figs. 13-39) show changes in the physiological activity levels that are relative to each crewmember's resting baseline means and standard deviations (SD).

TABLE 1.- RESTING BASELINE DATA MEANS AND STANDARD DEVIATIONS OF EACH PHYSIOLOGICAL RESPONSE

| Crewmember | Finger pulse volume, units/min | Respiration rate, breaths/min | Heart rate, beats/min | Basal skin resistance, log kohm | Finger temperature, °F | |
|---|---|---|---|---|---|---|
| A | 3.3 | 17.1 | 74.3 | 4.605 | 92.6 | Mean |
| | 2.6 | 1.5 | 2.8 | 0.075 | 0.7 | SD[a] |
| B | 14.1 | 10.4 | 78.6 | 5.002 | 93.5 | Mean |
| | 5.8 | 1.6 | 2.1 | 0.007 | 0.6 | SD |
| C | 9.7 | 14.3 | 60.9 | 5.166 | 93.0 | Mean |
| | 4.4 | 1.6 | 1.8 | 0.040 | 0.8 | SD |
| D | 23.9 | 17.1 | 51.3 | 5.532 | 81.6 | Mean |
| | 6.8 | 1.5 | 1.6 | 0.043 | 1.1 | SD |

[a]SD = Standard Deviation

Baseline Motion Sickness Test- The physiological data of each crewmember recorded during his/her initial rotating-chair test are shown in figures 1-4. The four physiological variables selected for these graphs were similar to those measures recorded during the flight with two exceptions. Skin conductance level (SCL), the reciprocal of BSR, was plotted and hand temperature was substituted for FPV because the flight transducers and electronics were not functional when baseline motion-sickness tests were conducted.

The X-axes on these graphs were divided into three segments: baseline, minutes 1 through 10 which preceded the start of rotation; test minutes, the time during actual rotation which varied for each subject; and baseline, 10 min immediately following the end of chair rotation.

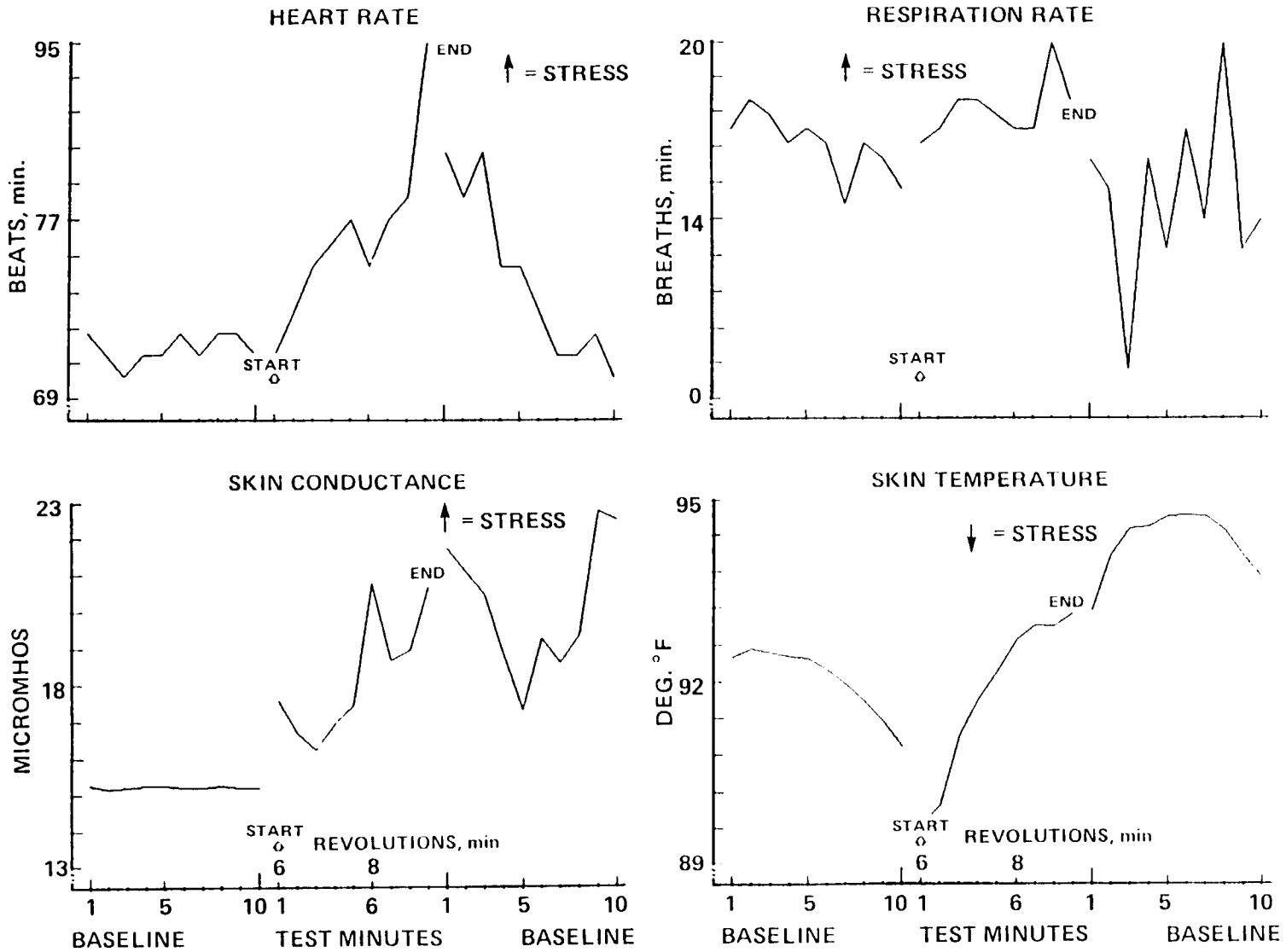



Figure 1.- Baseline rotating-chair test: Crewmember A.

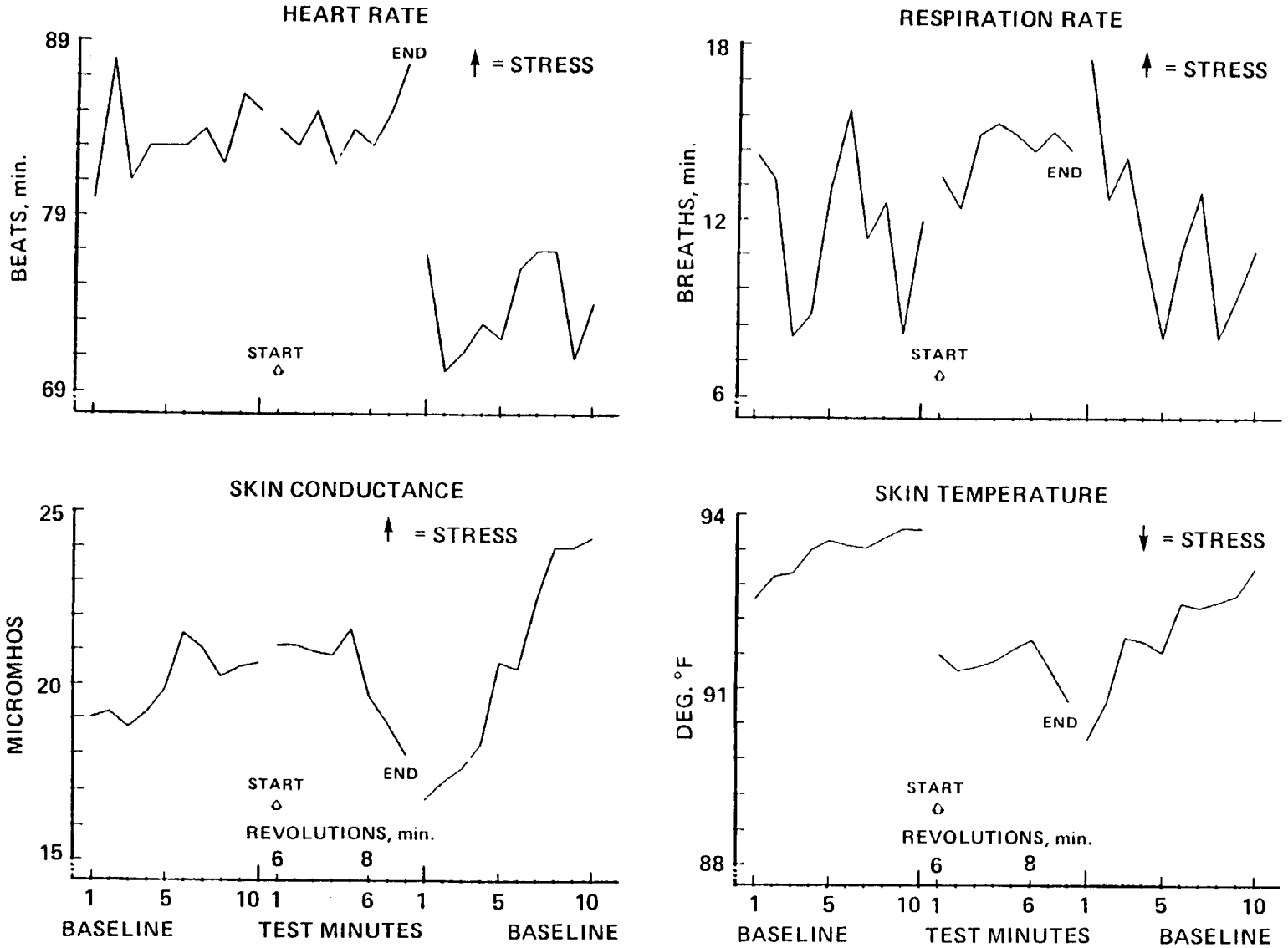



Figure 2.- Baseline rotating-chair test: Crewmember B.

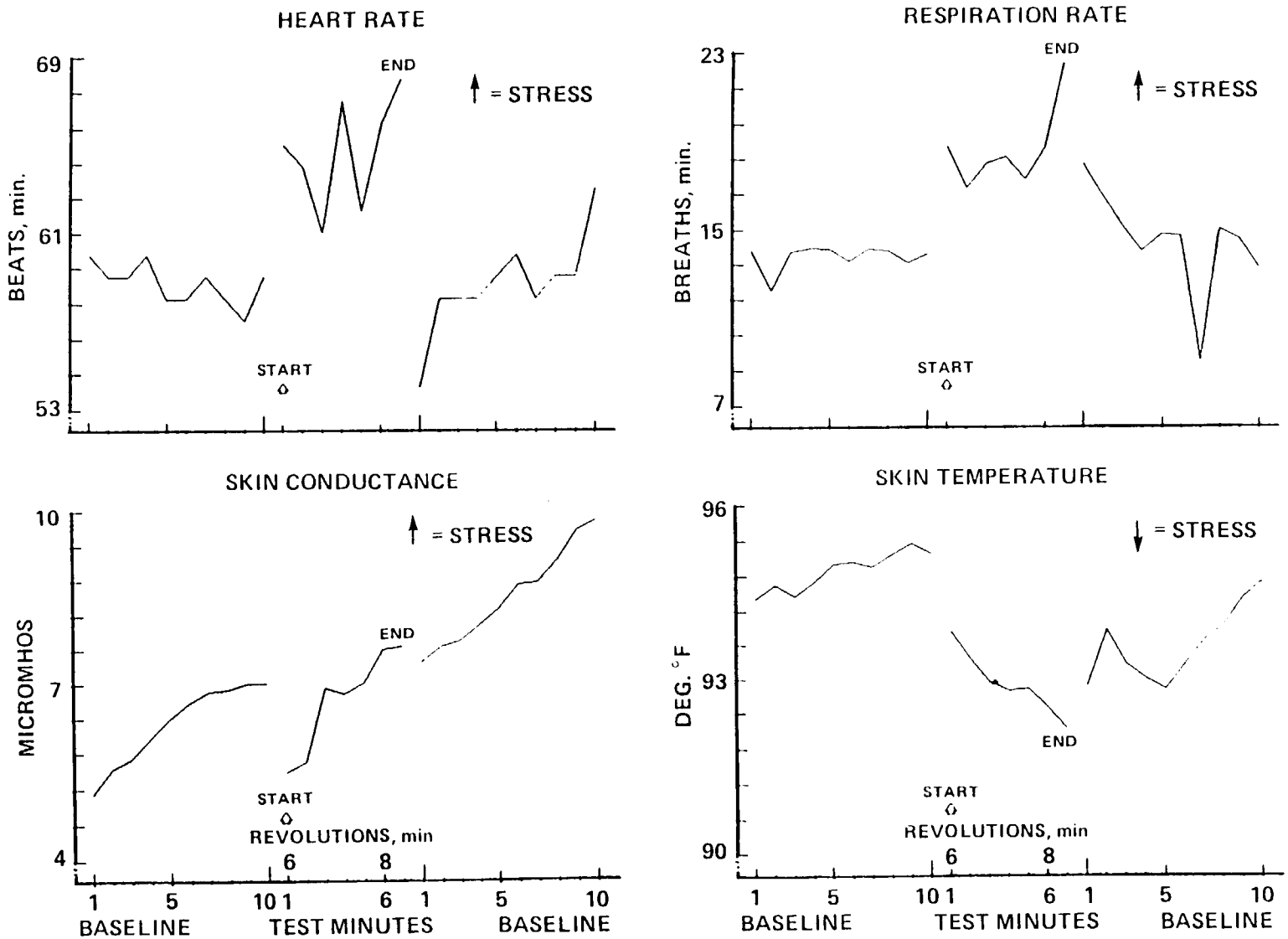



Figure 3.- Baseline rotating-chair test: Crewmember C.

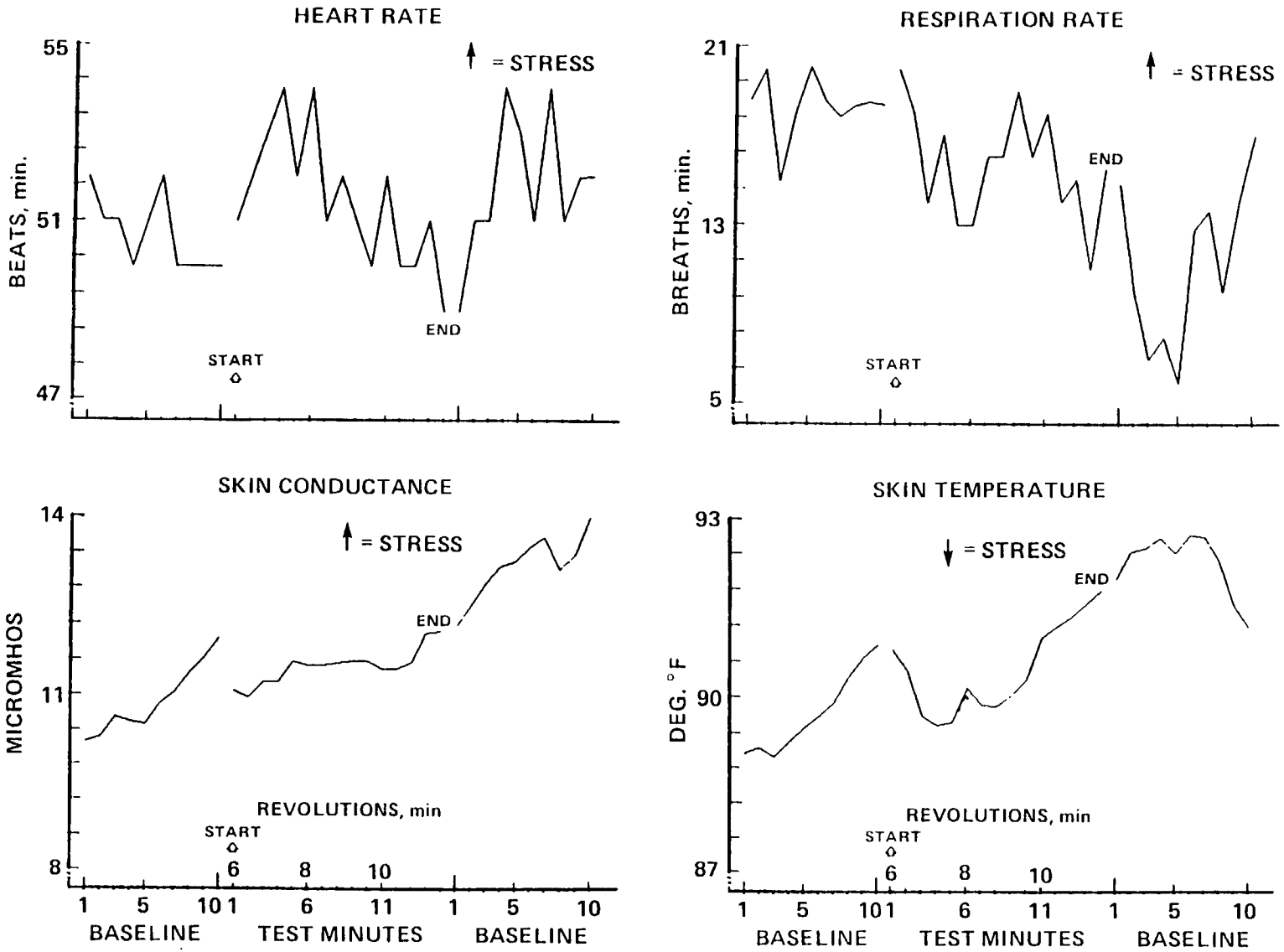



Figure 4.- Baseline rotating-chair test: Crewmember D.

## Autonomic Conditioning/Testing

Sample of Autogenic Feedback Training Session- Following each AFT session, each subject was shown a graph of his physiological data, which was used by the investigators to review the subject's training progress. During laboratory sessions, a multicolor graph of all physiological responses was produced, but for this report, only four physiological variables were plotted. Figure 5 represents data from a crewmember's fifth AFT session. Each session was preceded and followed by a baseline period of 6 min. The training period was for 30 min and was divided into 10 3-min trials. These data were plotted as z-scores based on the means and standard deviations of the 6-min presession baseline for each variable. Subjects were instructed to either increase (arousal) or decrease (relax) their physiological response(s) on alternate trials with the aid of visual and auditory feedback displays. Subjects were also instructed to use the feedback from the three different responses to change a pattern (i.e., HR and SC up, FPV down or HR and SC down, FPV up) without changing respiration rate or muscle activity.

The bidirectional training approach served two purposes. (1) By changing his/her responses in both directions, the subject learns to discriminate or "recognize" physical sensations associated with these changes. (2) With practice, the subject eventually learns to make the correct pattern of physiological responses which enables him to control his motion sickness symptoms. A critical step in this training process involves transfer of learned physiological control from the stationary AFT sessions to the rotating-chair tests that induced motion sickness.

## Increased Motion Sickness Tolerance with Autogenic Feedback Training

Crewmember A- The primary criterion for evaluating the effectiveness of AFT is increased motion-sickness tolerance after 2, 4, and 6 hr of training. Figure 6 shows the number of rotations tolerated by Crewmember A during all preflight rotating-chair tests. Figure 7 shows the physiological response levels produced by this crewmember during his pretraining and posttraining rotating-chair tests. These data were plotted as z-scores based on the means and standard deviations of the 10-min pretest baselines of each variable on both tests. It is clear that this crewmember achieved better control of his own physiology after all training was complete. Following AFT, his heart rate and respiration rate were more stable, although it is unlikely that this change in breathing alone accounted for the stabilizing effect seen in heart rate. Skin conductance level, a measure of sympathetic tone, showed a sharp increase (i.e., stress response) at the start of the pretraining rotating chair test. Following AFT, the overall level of this response is reduced. However, at 5-min intervals when the rotational velocity of the chair was increased, Crewmember A initially responded to this stimulus with an increase in skin conductance, and then brought this response under control. The result was that average sympathetic tone (as measured by this variable) was reduced. Skin temperature of the hand, a relative measure of peripheral resistance, is also an index of sympathetic tone. At the start of the pretraining test, this subject showed a sudden drop in temperature indicating vasoconstriction, (a typical stress response).

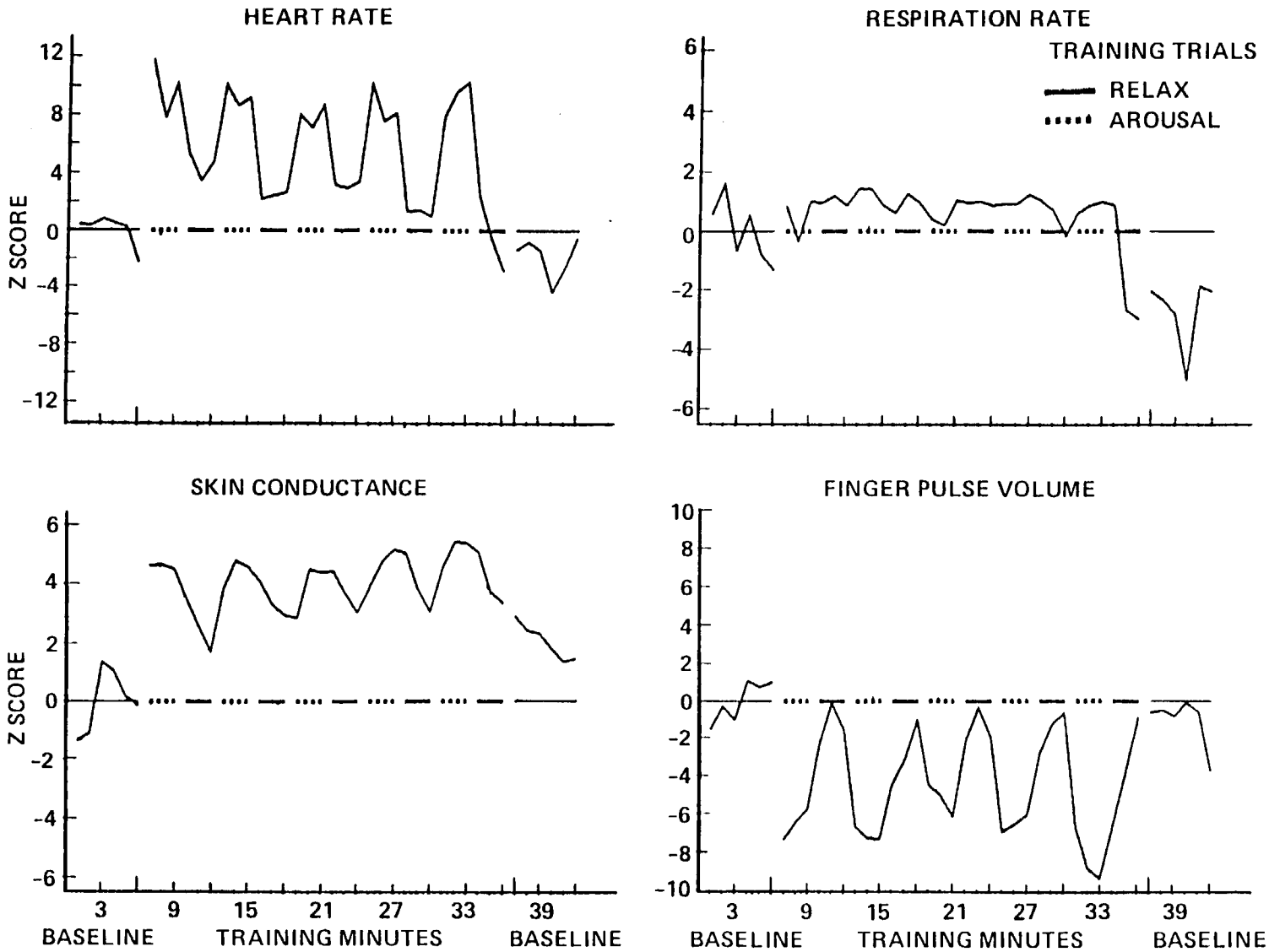



Figure 5.- Sample of an AFT session.

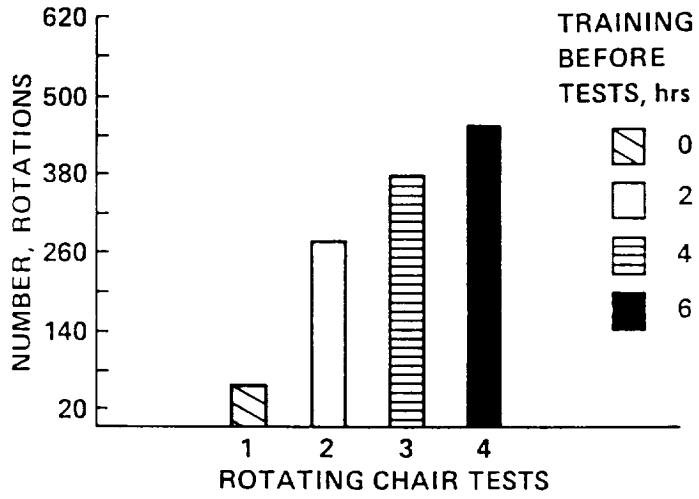



Figure 6.- Motion sickness tolerance before, during and after training: Crewmember A.

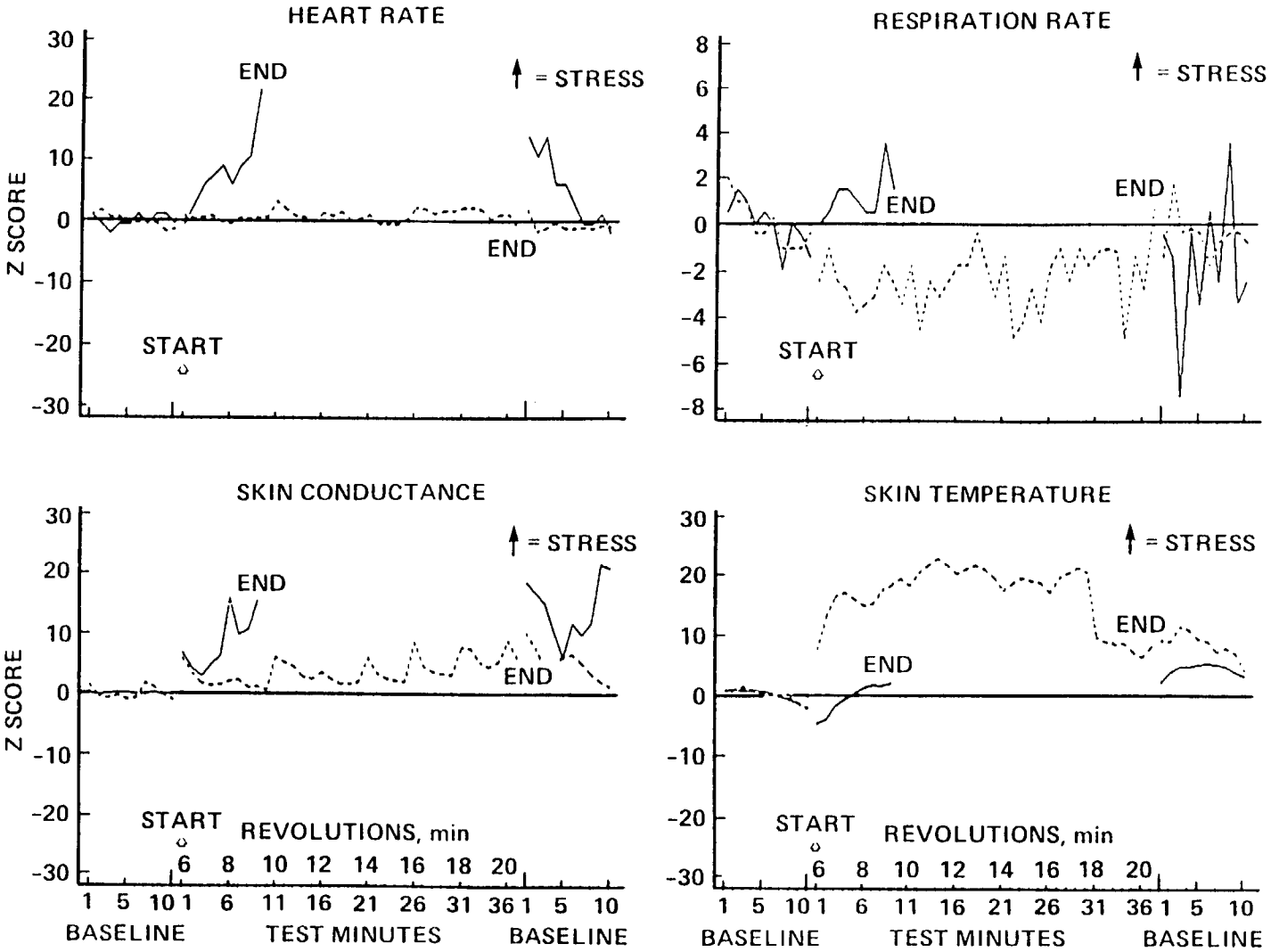



Figure 7.- Physiological data during rotating-chair tests: Crewmember A.

Following AFT, there was an increase in skin temperature at the start of rotation which remained stable until just before the termination of the test. Skin-temperature data also suggest that this subject learned to reduce his sympathetic tone.

The bargraph (fig. 8) of malaise levels reported by this crewmember was consistent with his physiological data. Following AFT, Crewmember A reported fewer symptoms at faster rotational velocities than before training.

Crewmember B- Figure 9 shows the changes in motion sickness tolerance achieved by Crewmember B across preflight motion-sickness tests. This crewmember showed a much smaller improvement than Crewmember A. Figure 10 shows that although some control of heart rate was demonstrated in his posttraining test, no control of respiration or skin conductance level was observed. Skin temperature increased toward the middle of the test, but this was associated with an increase in sympathetic tone for all other physiological responses. This increase in stress levels was associated with an increase in malaise reported (see fig. 11).

## Prediction of Inflight Susceptibility to Space Adaptation Syndrome

Increases in motion sickness tolerance following preflight AFT was the basis for predicting a crewmember's success in preventing or controlling his symptoms in space. In two previous reports (SL-3 Flight Readiness Review, April 25, 1985 and the SL-3 30-Day Report, June 12, 1985), the investigators reported that training effectiveness for the control of motion sickness symptoms was largely influenced by the type of schedule administered. Because of delays in the launch date for SL-3, the training schedule for crewmembers A and B was on average 90 days longer than planned. The investigators concluded that the generally poorer performance of subjects in this report was primarily due to changes in the schedule, although motivation may have been a secondary factor.

The data of crewmembers A and B were compared to the data of 40 test subjects who were given AFT using a more effective schedule in the laboratory. The increase in the number of rotations tolerated from the pretraining to posttraining rotating-chair tests was computed for all subjects and their scores were ranked from largest to smallest increase. Figure 12 shows a frequency distribution of the ranked scores of 42 subjects (including crewmembers A and B) which were divided into 10 rotation intervals. Crewmember A showed an increase of 398 rotations and his score among the total sample of subjects was about average, at the 54th percentile. However, Crewmember B, who showed much less improvement in motion sickness tolerance after training, with an increase of only 102 rotations ranked at the 18th percentile in this larger sample of subjects.

On the basis of preflight improvements in motion sickness tolerance of Crewmembers A and B, it was predicted that Crewmember A would have a higher probability of success in controlling his symptoms in space than Crewmember B. This prediction was reported at the SL-3 Flight Readiness Review.

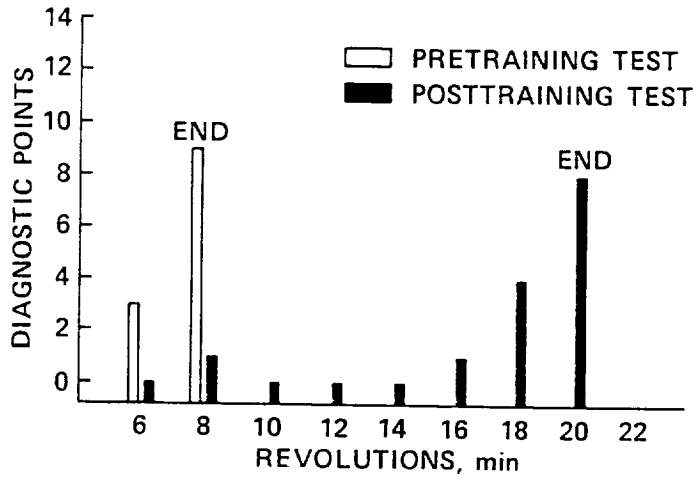



Figure 8.- Malaise level before and after training: Crewmember A.

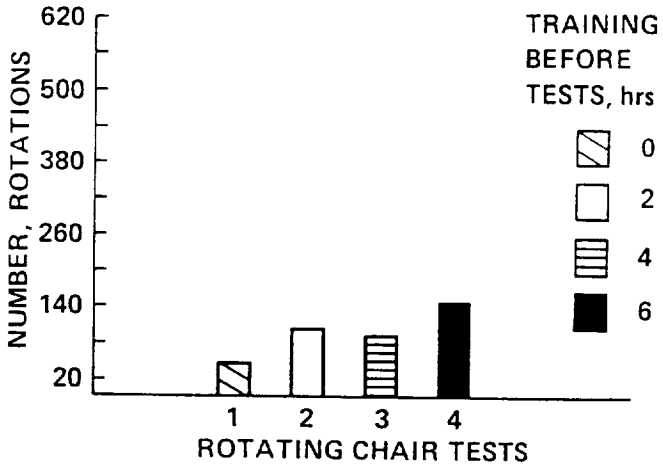



Figure 9.- Motion sickness tolerance before, during and after training: Crewmember B.

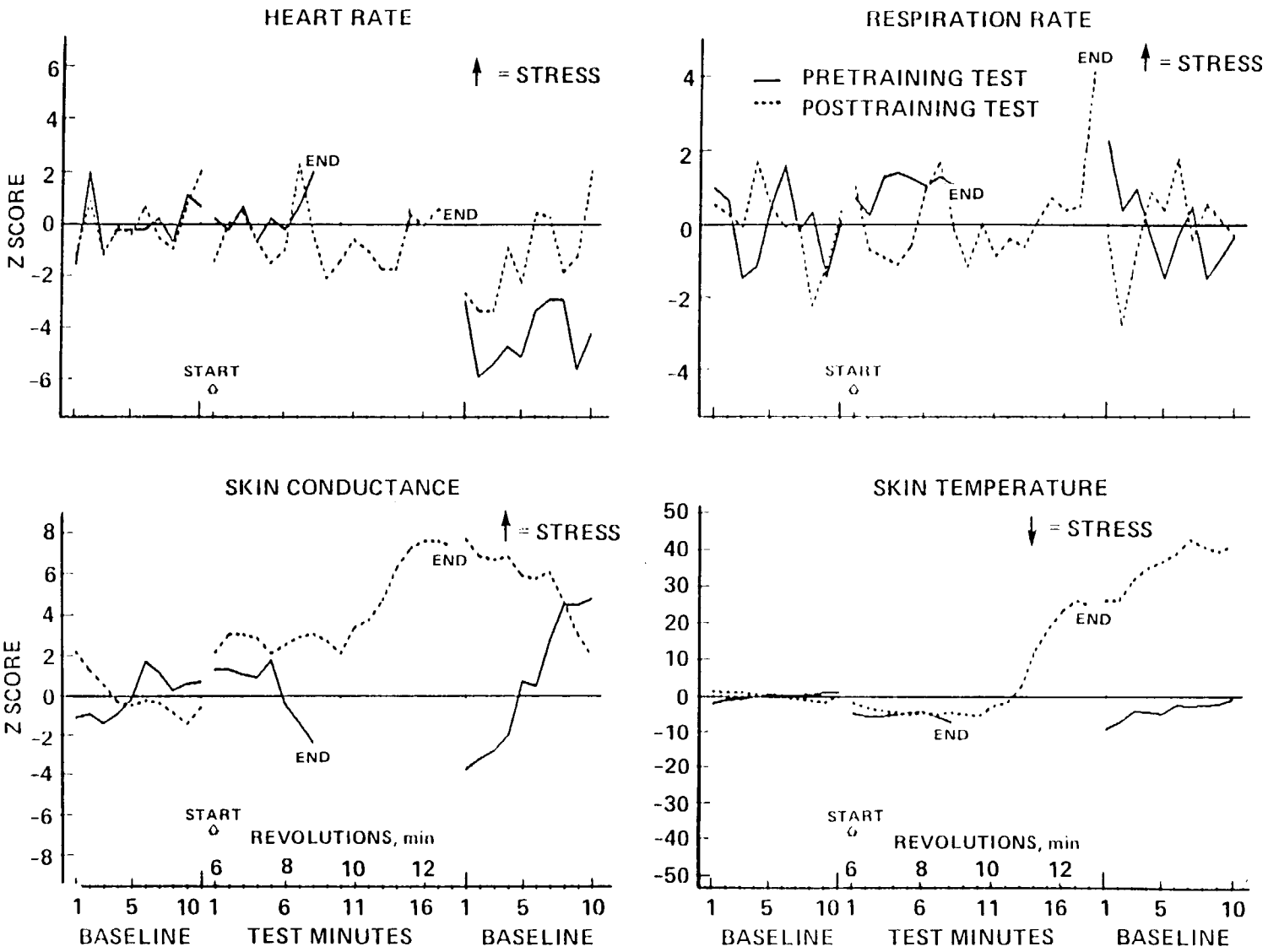



Figure 10.- Physiological data during rotating-chair tests: Crewmember B.

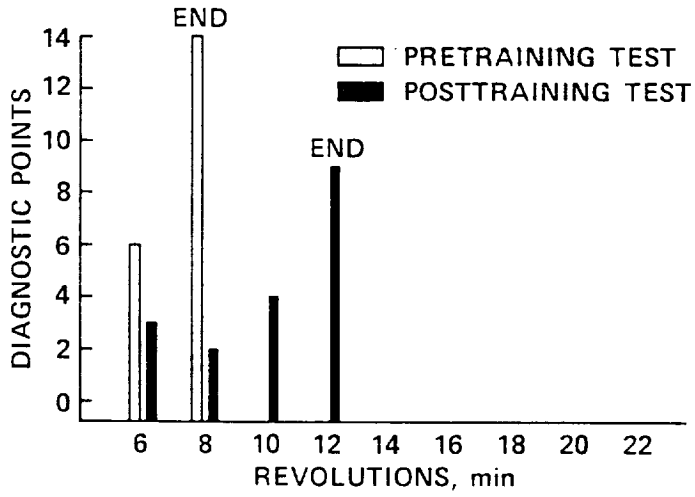



Figure 11.- Malaise level before and after AFT: Crewmember B.

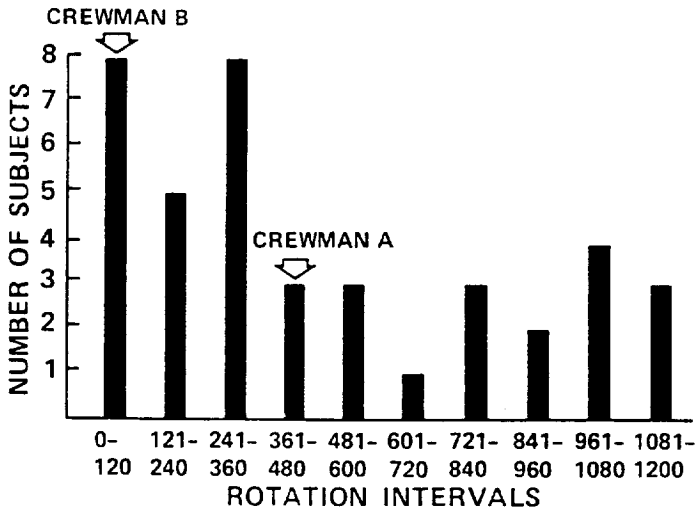



Figure 12.- Increased motion sickness tolerance of 42 subjects given AFT.

## Joint Integrated Simulations

Figures 13-16 show the physiological data of Crewmembers A,B,C, and D, collected during one Joint Integrated Simulation (JIS). Ten-minute averages were generated from the raw data which were then transformed to z-scores using each crewmember's preflight (resting baseline) means and standard deviations. The X-axis on the graphs represents mission elapsed time (MET) over a 15-hr period.

The science requirement for JISs involved physiological monitoring for at least one shift (approximately 8 to 12 hr) for each crewmember. Only Crewmembers A and D met this requirement; in fact, Crewmember D provided additional data. Crewmember C, however, provided only 6 hr of data and Crewmember B provided only 2 hr of data.

These data will be used to compare changes in physiological levels produced during a 12-hr workday on Earth to those changes observed during a similar period in space. Preliminary comparisons can be made by visual inspection of the JIS and flight-data graphs.

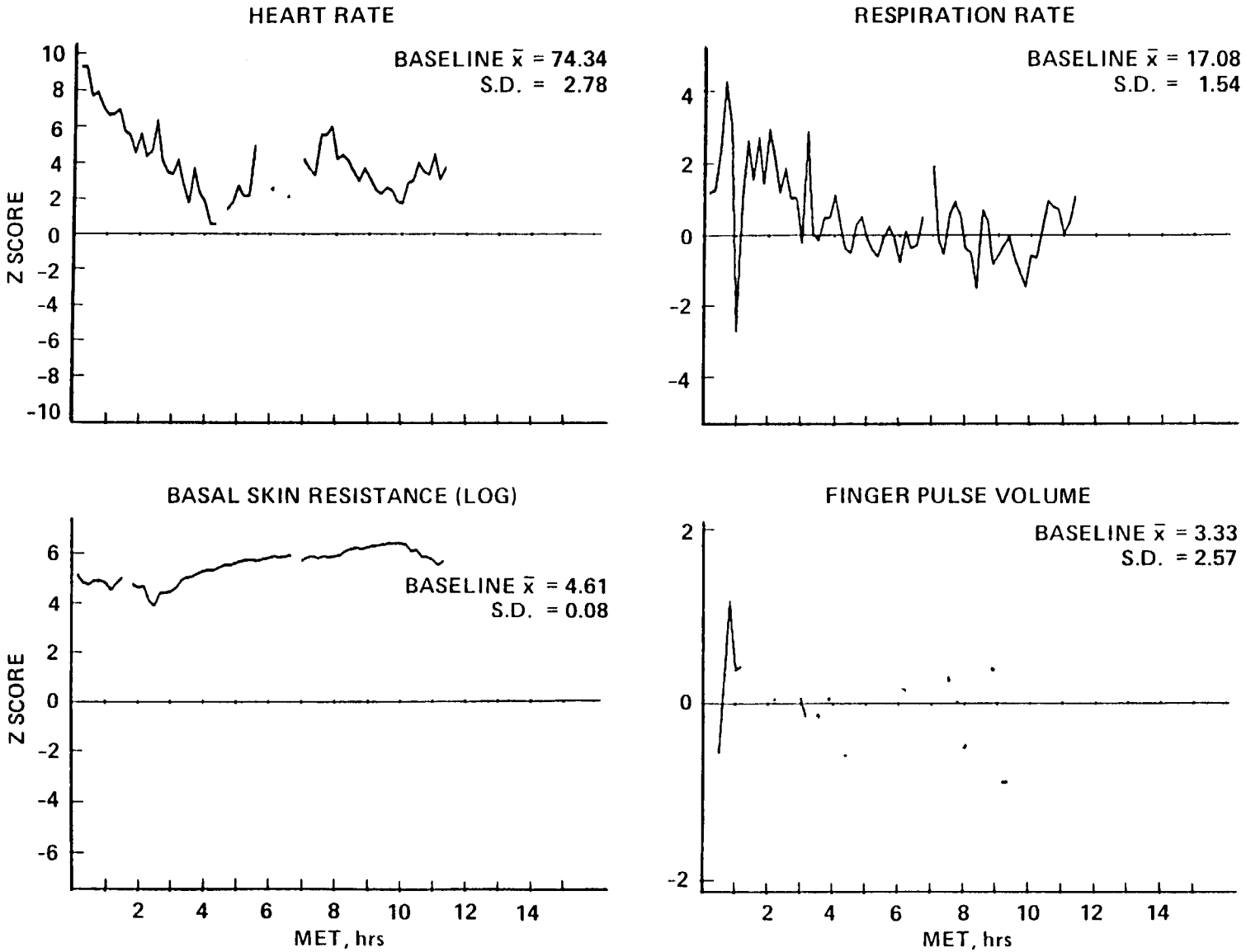



Figure 13.- Physiological data during JIS: Crewmember A (10-min means).

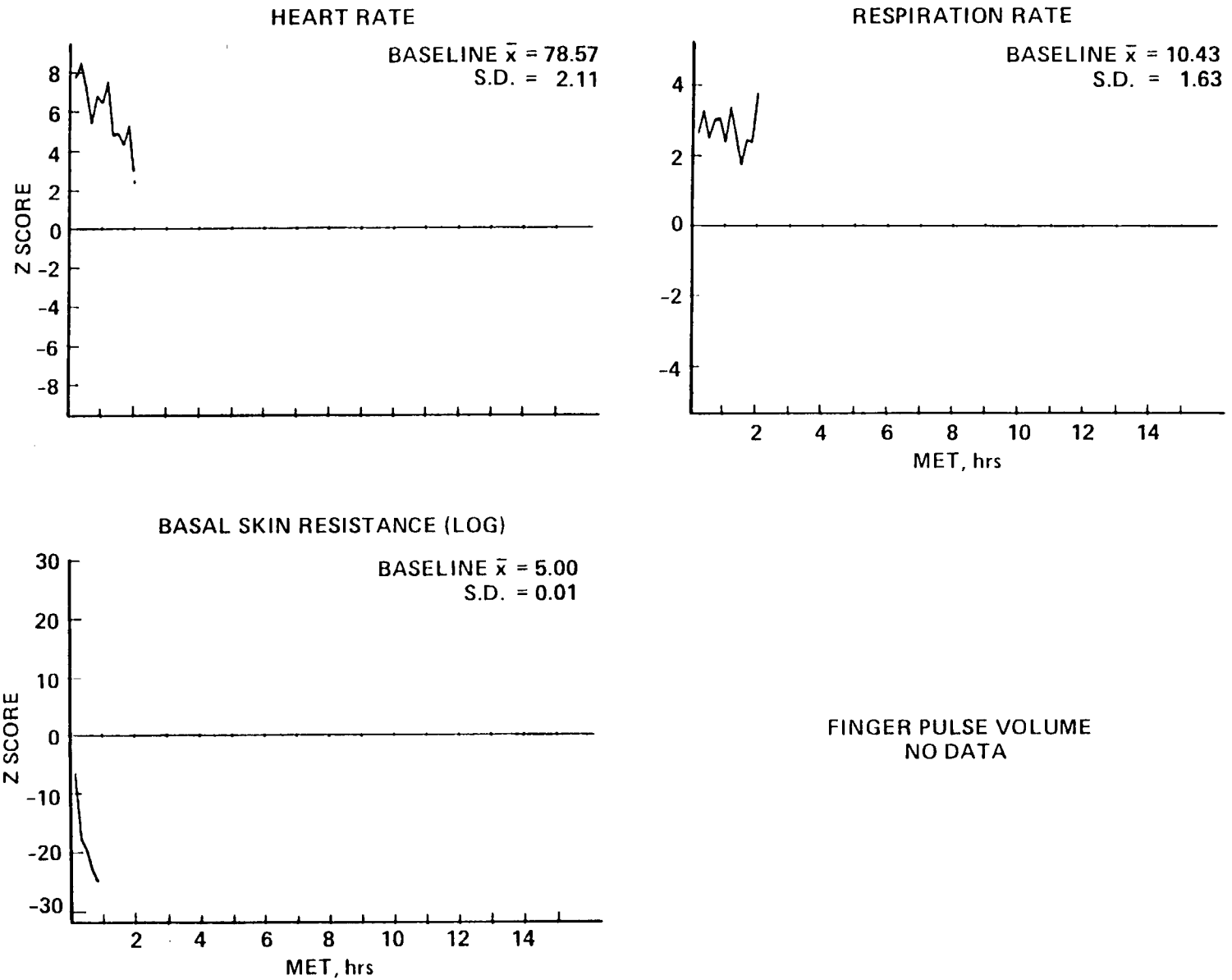



Figure 14.- Physiological data during JIS: Crewmember B (10-min means).

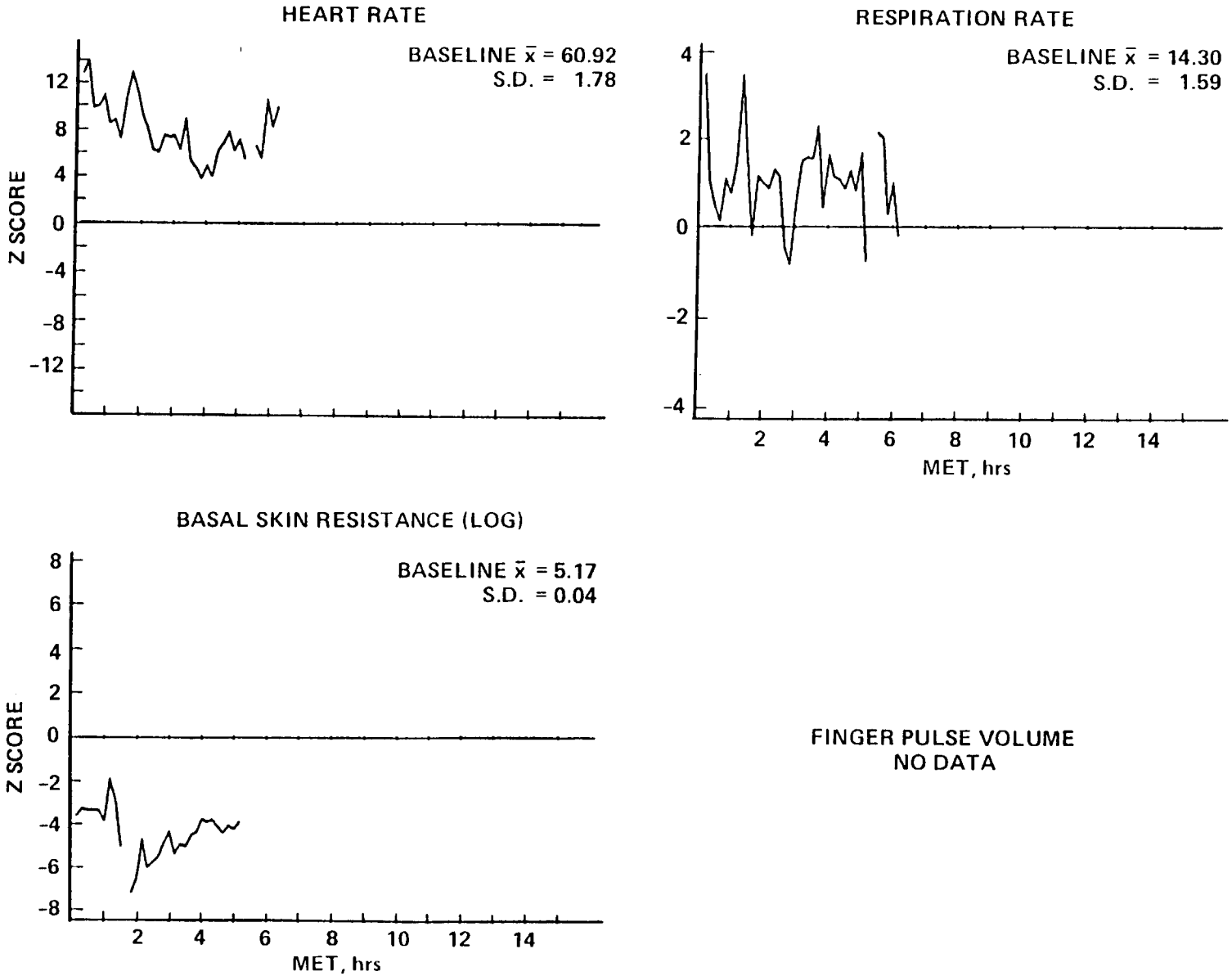



Figure 15.- Physiological data during JIS: Crewmember C (10-min means).

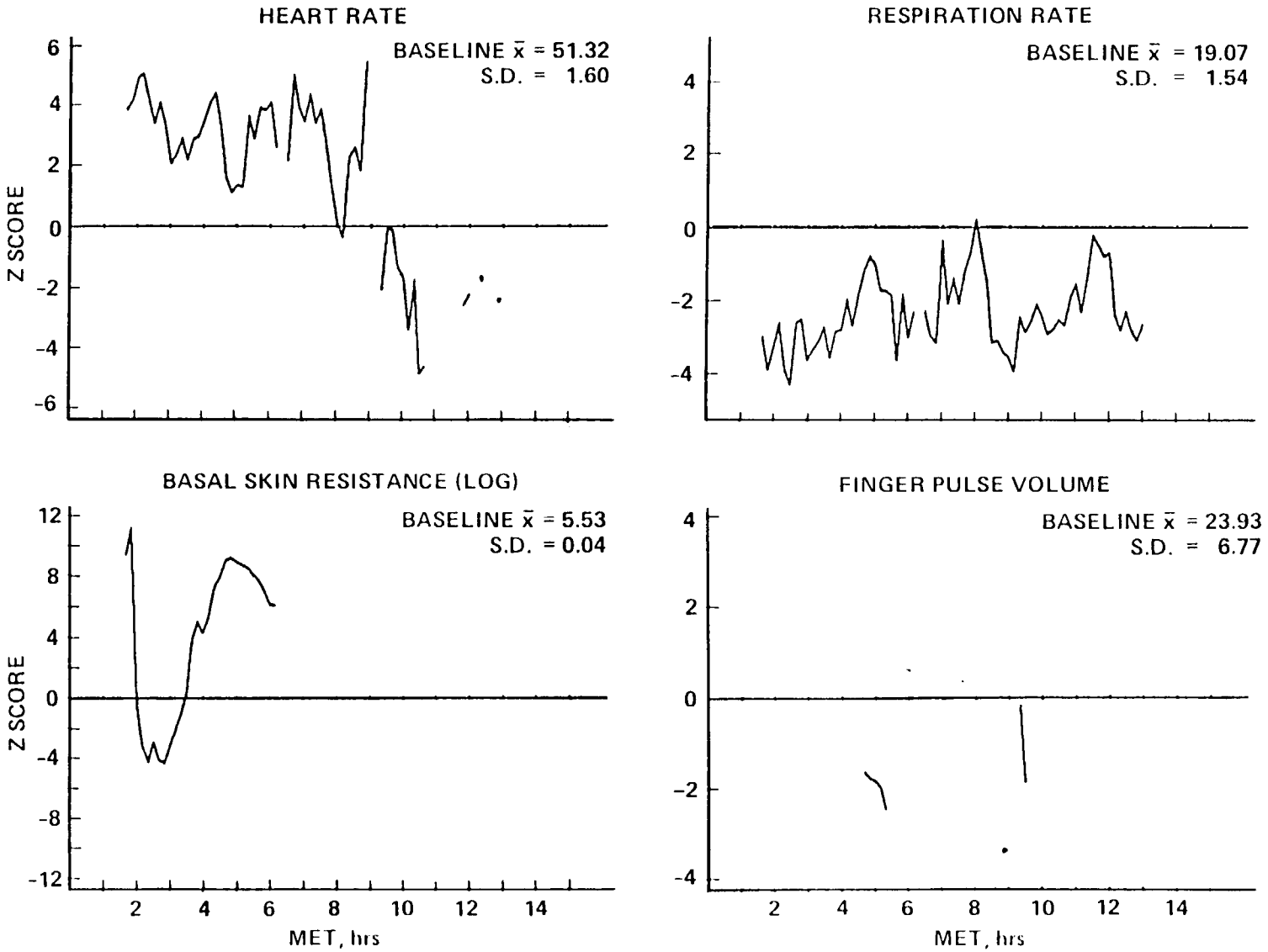



Figure 16.- Physiological data during JIS: Crewmember D (10-min means).

## Inflight Physiological Data

Table 2 is a summary of the results of SL-3, showing each crewmember's preflight susceptibility to motion sickness (number of rotations tolerated); the increased tolerance of Crewmembers A and B following AFT; and the number of severe symptom episodes experienced by all crewmembers in space.

TABLE 2.- SUMMARY OF SPACELAB-3 RESULTS

| Preflight motion sickness tolerance (number of rotations) | Crewmembers | | | |
|---|---|---|---|---|
| | Treatment | | Controls | |
| | A | B | C | D |
| Before training | 62 | 54 | 46 | 120 |
| After training | 460 | 156 | -- | --- |
| Inflight severe symptom episodes | 0 | 1 | 4[a] | 2[a] |

[a]Took anti-motion sickness medication.

The physiological flight data was reduced to 90 10-min averages and then transformed to z-scores using each crewmember's preflight resting baseline means and standard deviations. These data were further reduced to a daily mean for each physiological variable for each crewmember. Figure 17 compares the daily z-score averages of physiological data for all crewmembers. The data represented in this figure can be summarized as follows.

Heart Rate- The average HRs of Treatment Subjects A and B were below their preflight resting levels, except for mission day 0 for Crewmember B. During the preflight motion-sickness tests, heart rate was the only variable which Crewmember B could reliably control. Crewmember C (control group) showed a higher HR on mission day 0; the rate declined on mission days 1 and 2 and increased slightly on the last two mission days. However, Crewmember D (control group) showed elevated HR across all mission days.

Respiration Rate- The average respiration rate of Crewmember A was below his preflight resting level for all mission days, except for a slight increase above his mean on mission day 1. Crewmember B's average respiration rate was always higher than his preflight level. Crewmember C's respiration rate on mission day 0 was elevated, but was below his preflight mean level on all subsequent mission days. Crewmember D's average respiration rate was considerably lower than preflight levels on all mission days.

Log Skin Resistance- Only Crewmember A showed skin resistance levels above his preflight mean across all mission days. Crewmember B showed a large decrease in his average skin resistance following mission day 0. Both Crewmembers C and D (control group) showed skin resistance levels below their preflight resting means on all mission days, with a gradual improvement (toward baseline levels) on the last two mission days.

Finger Pulse Volume- Only Crewmember A showed average FPV levels higher than his preflight mean for all mission days. All other crewmembers showed finger-pulse-volume levels lower than than preflight averages. Note that the missing bars for Crewmember D on mission day 1; Crewmember C on mission days 2-4; and Crewmember B on mission day 4 indicate loss of data for this variable.

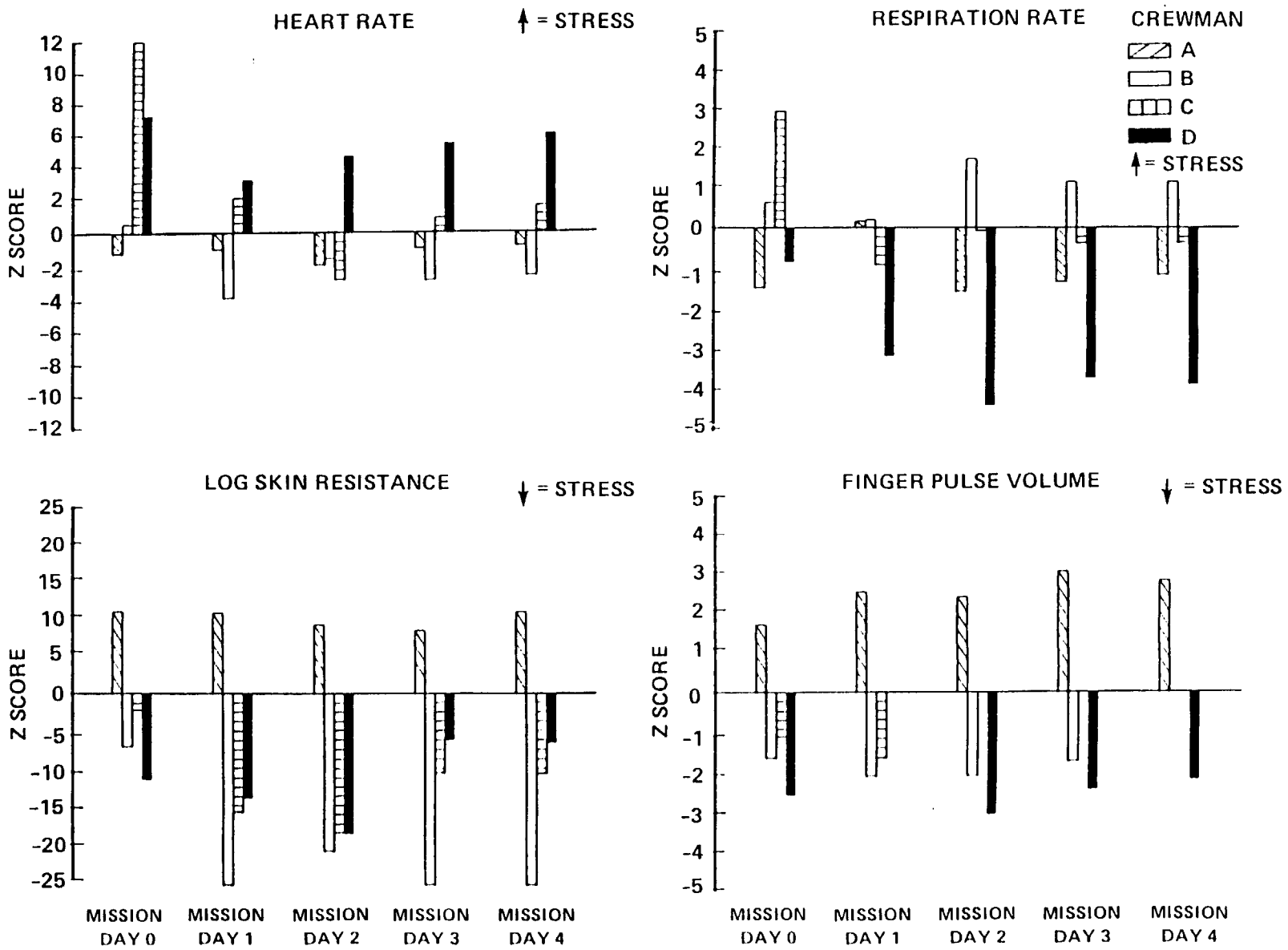



Figure 17.- Daily z-score averages of physiological data.

## Mission Days 0-4

Figures 18-39 are graphs of the z-scores of physiological data of all crewmembers collected on mission days 0-4. A maximum of 90 10-min averages (15 hr) for each mission day is plotted. Preflight baseline means and standard deviations are shown on each graph. Crewmembers A and B also participated in data collection during reentry on mission day 6. Mission elapsed time is represented on the X-axes. The data collection periods (start and stop MET) for each crewmember were based on information written in his flight diagnostic log book. These graphs provide more detailed information about changes in the physiological levels during each mission day.

Mission Day 0- Physiological data were collected for all crewmembers.

Crewmember A: The physiological data associated with launch and approximately 4 hr following orbit insertion were lost for this test subject because of a malfunctioning cable. This crewmember reported moderate malaise during the first 3 hr following orbit insertion, which he was able to control by using the skills he learned during preflight training. The data shown here (fig. 18) were recorded during the Silver Shift (night shift) (MET 10 through 24). Low heart rate, high skin resistance and finger pulse volume indicated low stress. There were no SAS episodes reported in this time period. No data were collected during the second half of his shift because the crewmember reported (in a communication to the Payload Operation Control Center (POCC)) that he could not locate stowage containers which supported this experiment. No anti-motion-sickness medication was taken on any mission days.

Crewmember B: Data recording was initiated at approximately 90 min prior to launch. Crewmember B (fig. 19) shows a high heart rate following ingress into the orbiter, which began to decrease before the launch. The second peak in heart rate, which is marked on the X-axis, is associated with launch. The interruption in the graph shown at MET 2:00 to 2:30 corresponds to the time during middeck reconfiguration. Although this crewmember reported moderate malaise on mission day 0, there were no emetic episodes. Heart rate was below preflight resting levels except for MET 9 when he reported increased physical exertion that may have accounted for this observation. Skin resistance levels decreased gradually throughout this shift and finger pulse volume was below resting levels. No anti-motion-sickness medication was taken on any mission days.

Crewmember C: Recording was initiated at approximately 90 min prior to launch and the data reflect similar responses to those seen in Crewmember B (fig. 20) following ingress and launch. This crewmember reported multiple emetic episodes on mission day 0, the first of which occurred soon after orbit insertion when data recording was in progress. This crewmember chose not to initate recording for the remainder of his shift; therefore objective physiological data on the number and severity of subsequently reported emetic episodes was not obtained. Anti-motion-sickness medication was taken "more than once" by this crewmember. The actual dosages and times of medication were not reported during the postflight debriefing.

Crewmember D: Again, data recordings were initiated at launch minus 90 min and the characteristic ingress and launch levels were observed (fig. 21). When data recording was recommenced at MET 2, his heart rate level was high, skin resistance was low and FPV was low. The intermittent loss of data for finger pulse volume was due to movement artifact. Although more than one emetic episode was reported by this subject on mission day 0, these episodes occurred during MET 1:00 to 1:40 when physiological-recording hardware was disconnected. The physiological levels that were observed indicate high stress. However, anti-motion-sickness medication was taken (actual dosages and times of medication were not reported during the postflight debriefing) and may have had an effect on his physiological levels.

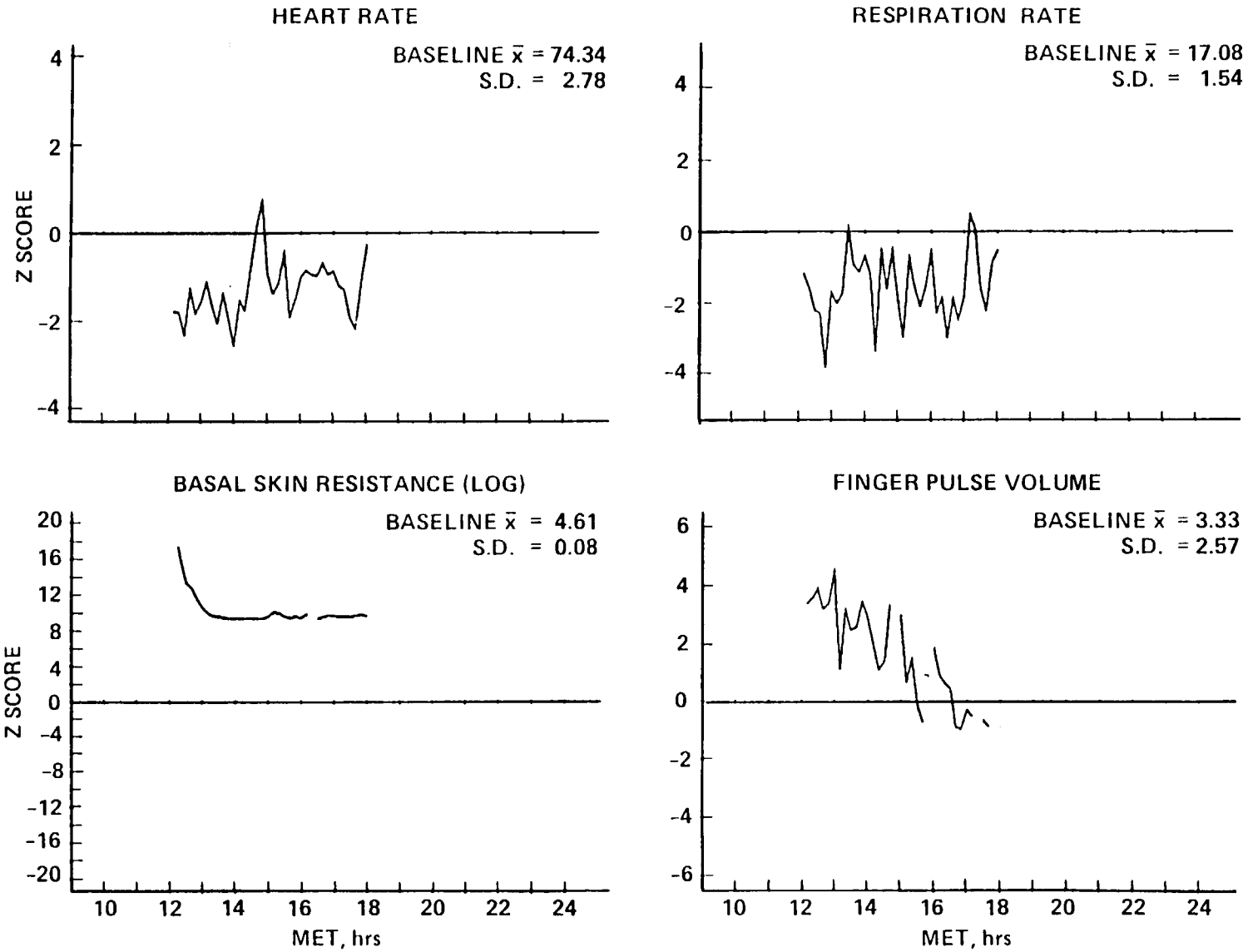



Figure 18.- Mission day 0: Crewmember A (10-min means).

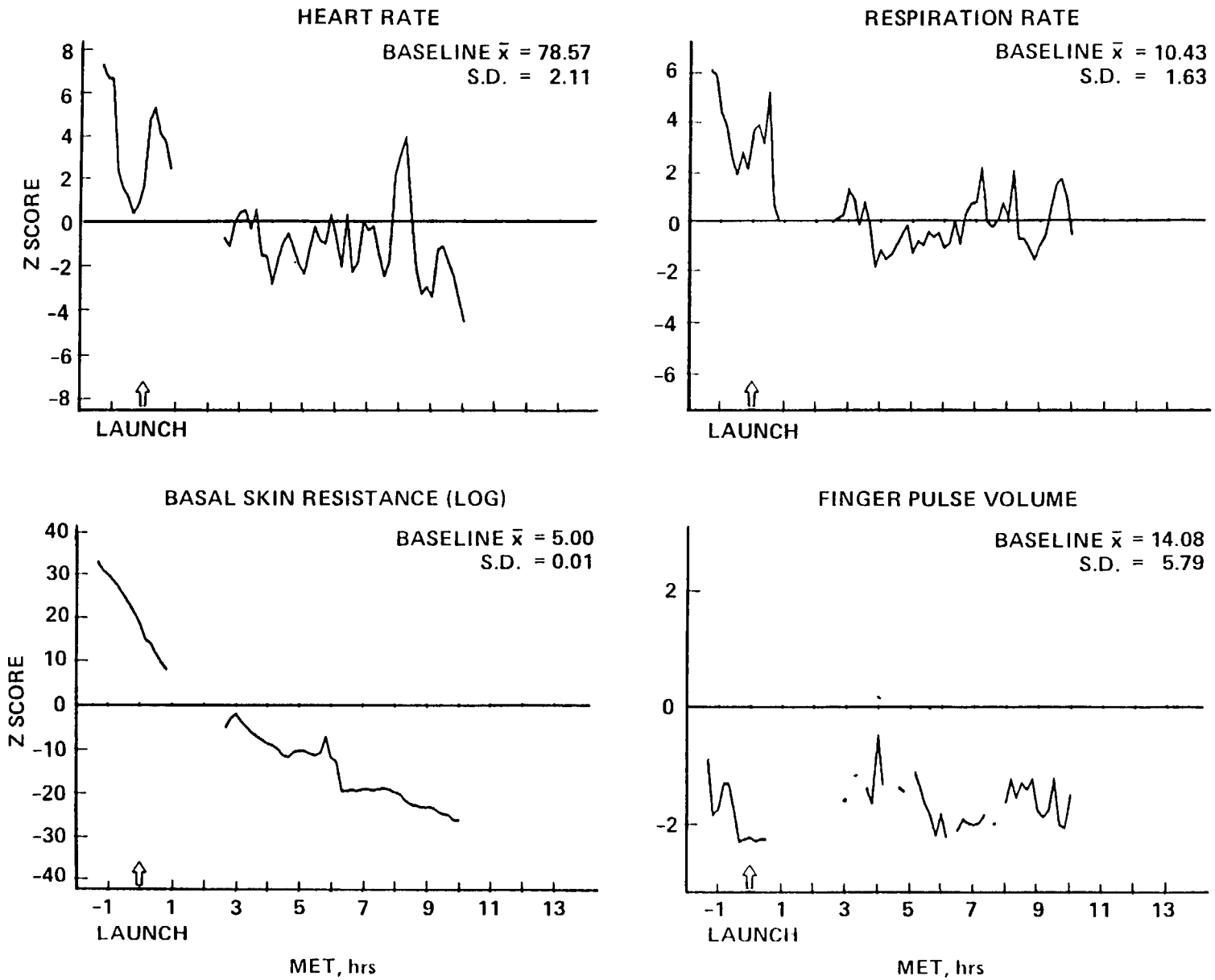



Figure 19.- Mission day 0: Crewmember B (10-min means).

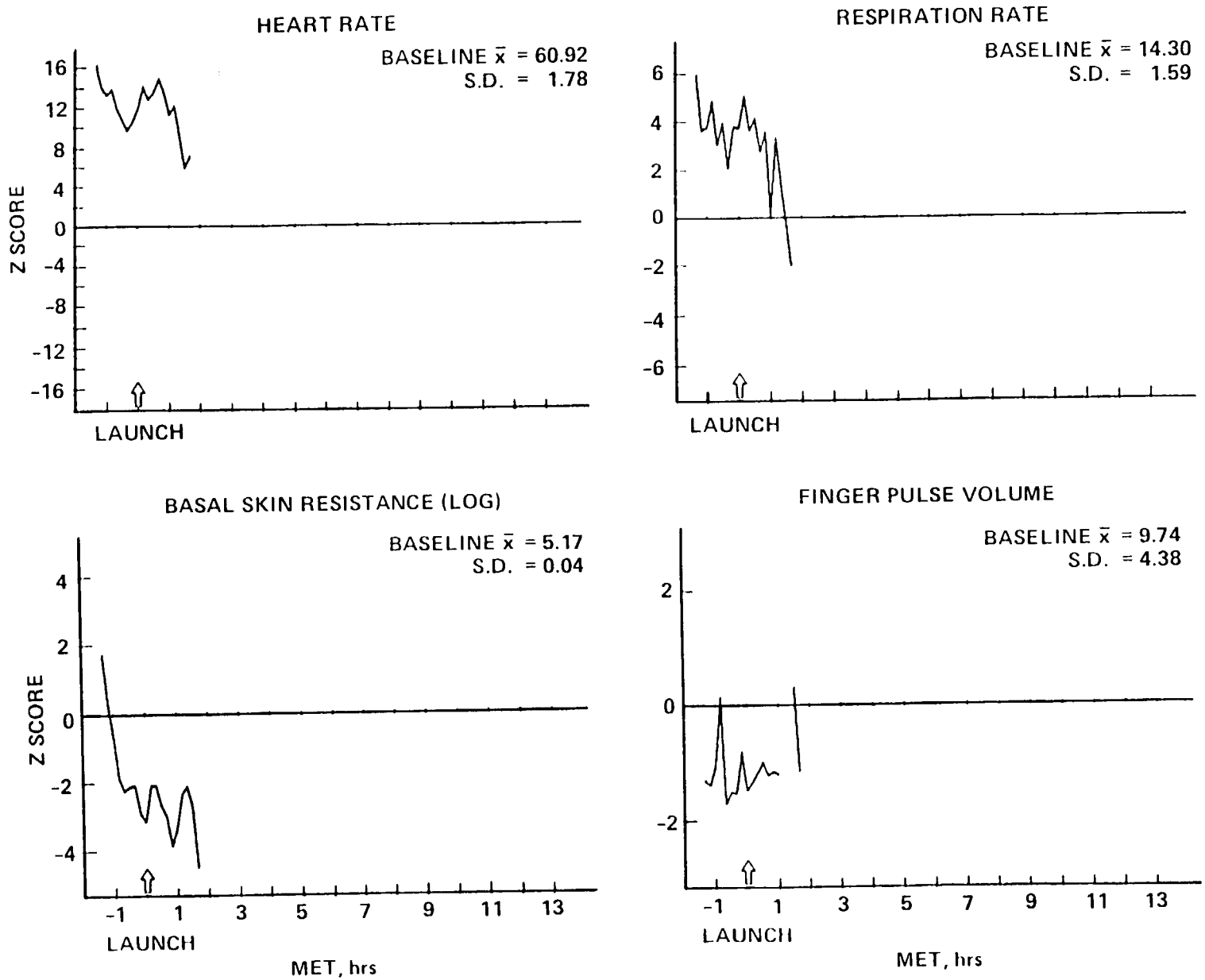



Figure 20.- Mission day 0: Crewmember C (10-min means).

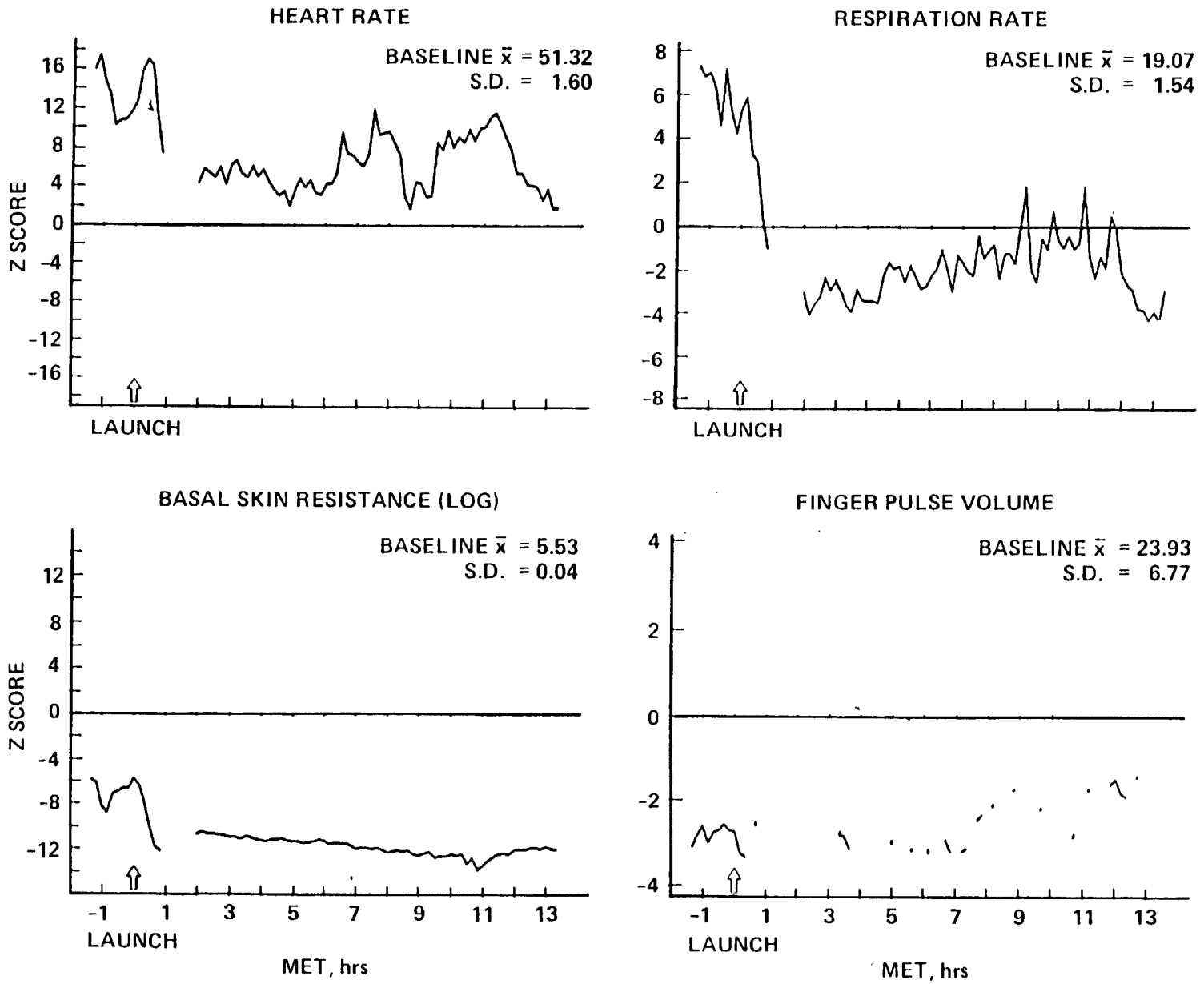



Figure 21.- Mission day 0: Crewmember D (10-min means).

Mission Day 1-

Crewmember A: The heart rate of this subject shows two peaks during this 15-hr period (fig. 22). The first peak in heart rate at MET 16 occurred when the crewmember left the module to return to the middeck for a meal. There was a sharp increase in heart rate at MET 19:30, but all other physiological data indicate that the subject was experiencing low stress. Skin resistance and FPV levels were very high. No malaise was reported for the remainder of the mission.

Crewmember B: This crewmember reported one emetic episode prior to initiating data recording (fig. 23). Although his HR was below baseline throughout this shift, the low skin resistance and FPV data indicate increased sympathetic tone (i.e., higher stress levels). The crewmember reported some distress because of a malfunctioning experiment payload and this may be related to observed physiological levels. Only slight malaise was reported during this shift. No SAS malaise was reported during the remainder of the mission.

Crewmember C: Heart rate was generally lower than on mission day 0 (fig. 24). An increase in heart rate occurred at MET 5:30 when he was scheduled to leave the module for a meal. Respiration rate was initially low but gradually increased to his preflight resting level. Skin resistance was low with a gradual decrease during the shift. Finger-pulse-volume level was low with intermittent peaks around midshift. No malaise was reported and no anti-motion-sickness medication was taken during this shift nor for the remainder of the mission.

Crewmember D: The high HR and low skin resistance suggest high sympathetic tone throughout this shift (fig. 25). Finger-pulse-volume data were lost during this shift, although the postflight evaluation of hardware showed no malfunction. No malaise was reported and no anti-motion-sickness medication was taken during this shift nor for the remainder of the mission.

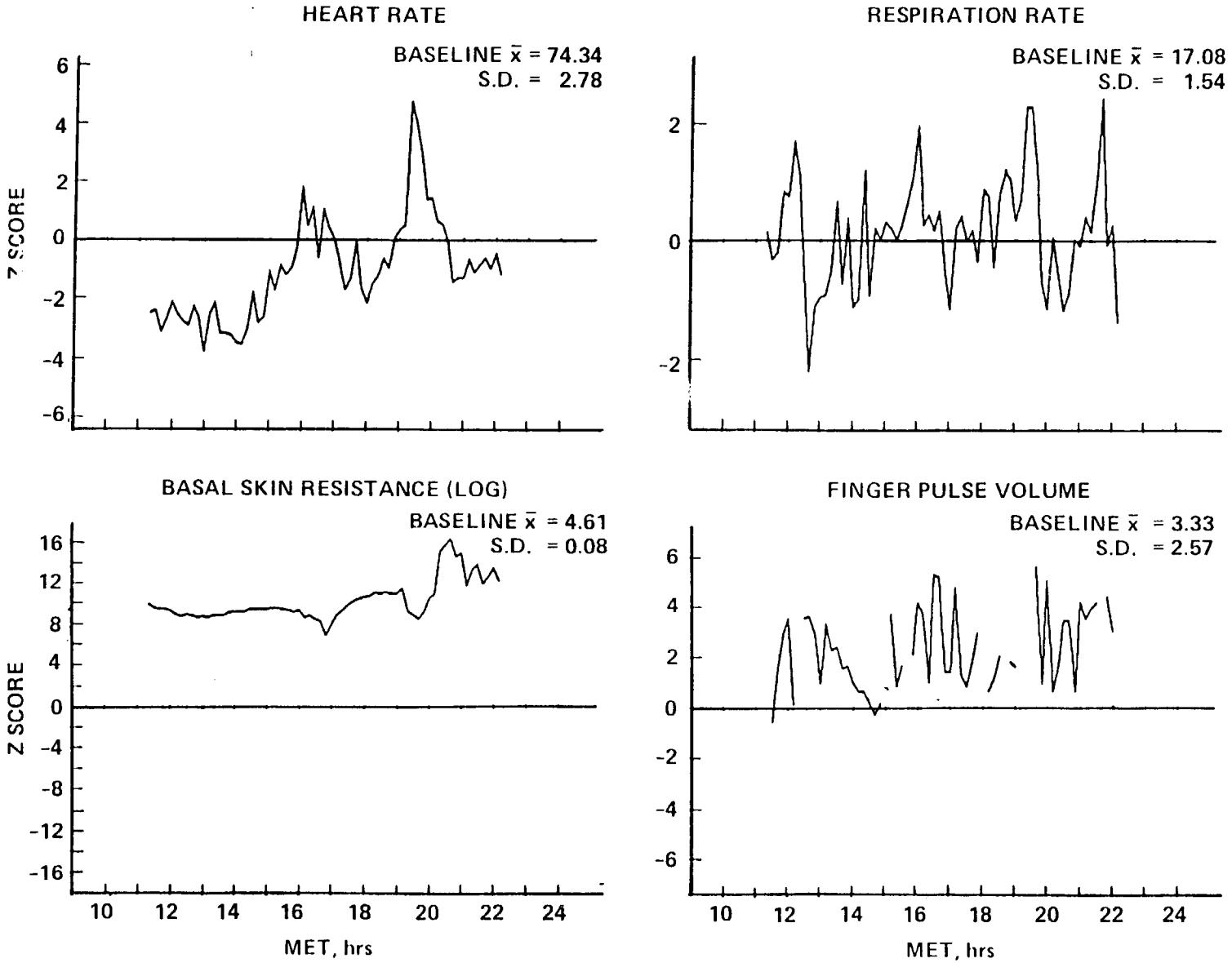



Figure 22.- Mission day 1: Crewmember A (10-min means).

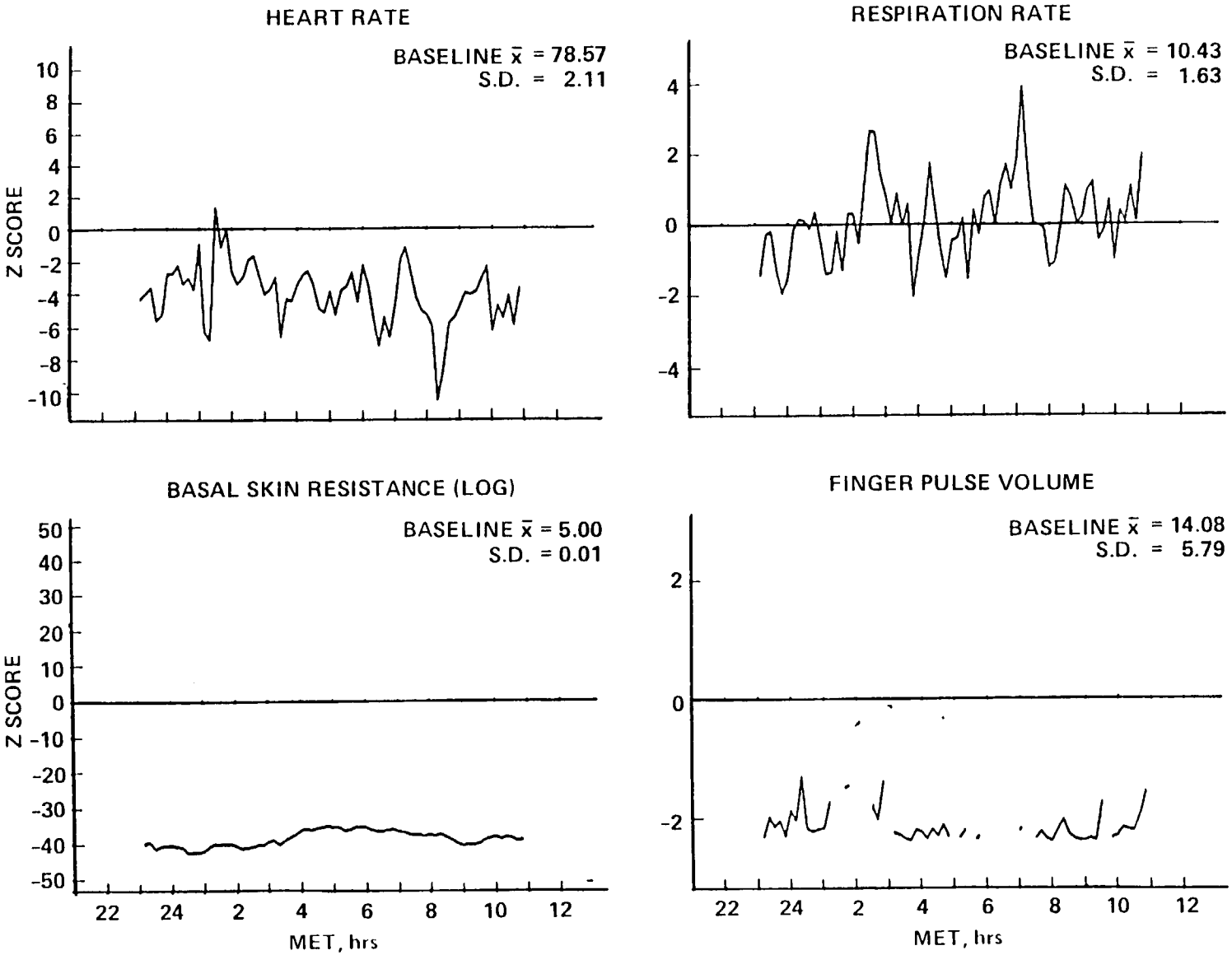



Figure 23.- Mission day 1: Crewmember B (10-min means).

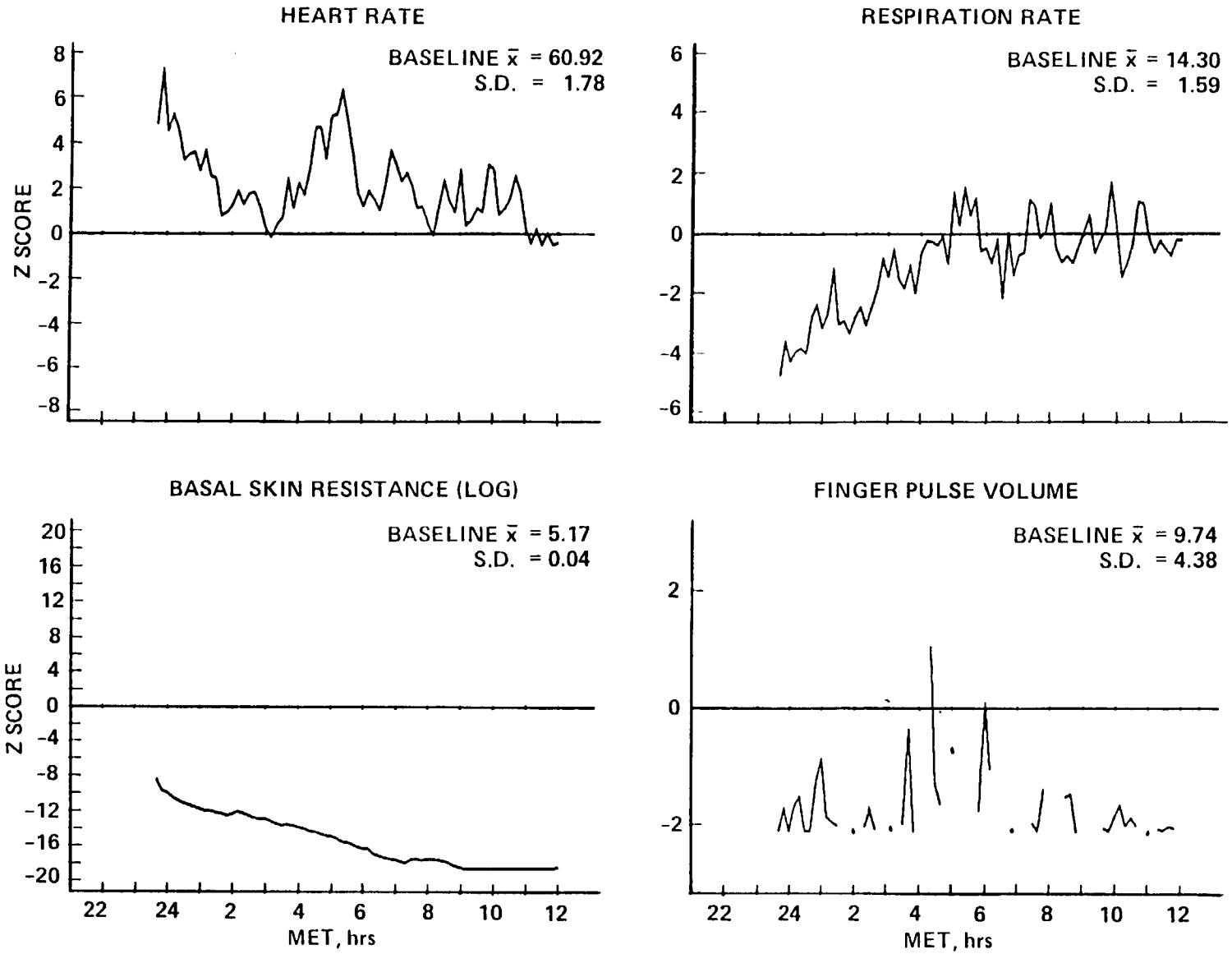



Figure 24.- Mission day 1: Crewmember C (10-min means).

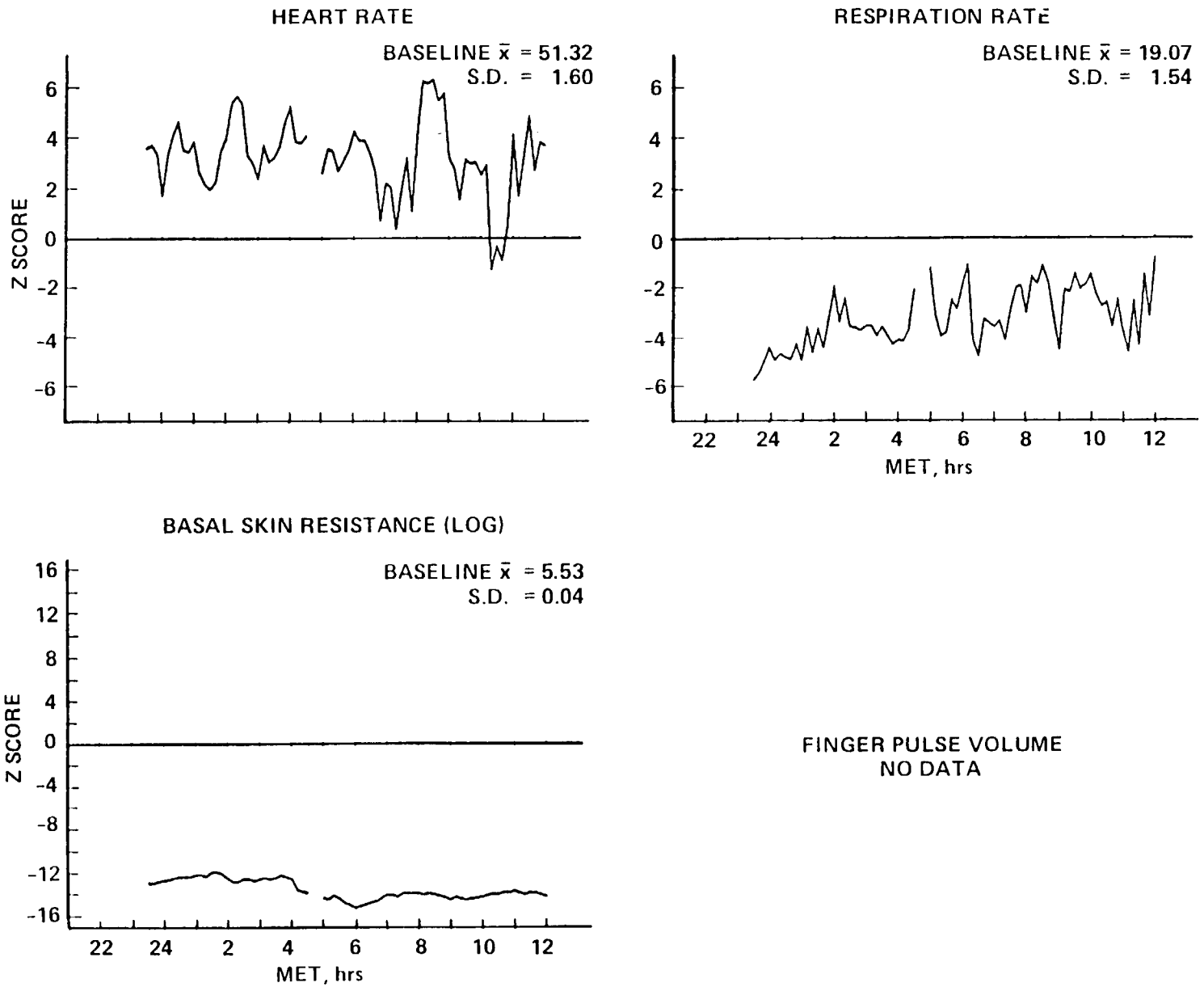



Figure 25.- Mission day 1: Crewmember D (10-min means).

Mission Day 2-

Crewmember A: The low HR, high skin resistance and high FPV suggest that this crewmember was not experiencing stress (fig. 26).

Crewmember B: Although the HR was low, skin resistance and finger pulse volume levels were below normal resting levels and therefore indicate high sympathetic tone (fig. 27). The intermittent loss of data for skin resistance and finger pulse volume was due to movement artifact. This crewmember did not perform the inflight requirement of changing cassette tapes on any mission day following mission day 1, which was not reported to the POCC during the mission. Consequently, only half of the required data was obtained for this crewmember after mission day 1.

Crewmember C: The AFS recorder failed to function for this crewmember at the beginning of his shift (fig. 28). Data recording using the spare AFS did not occur until late in the day. During the last 3 hr of his shift, HR was low, respiration was near his preflight levels, but skin resistance was well below his baseline. Finger-pulse-volume data were lost. Postflight examination of the finger transducer indicated a malfunction. The spare transducer was not used; consequently no data for this response were recorded for the rest of the mission.

Crewmember D: The HR levels were high during this shift while respiration rate was below his preflight baseline level (fig. 29). The SR and FPV data (although intermittent) were well below baseline levels.

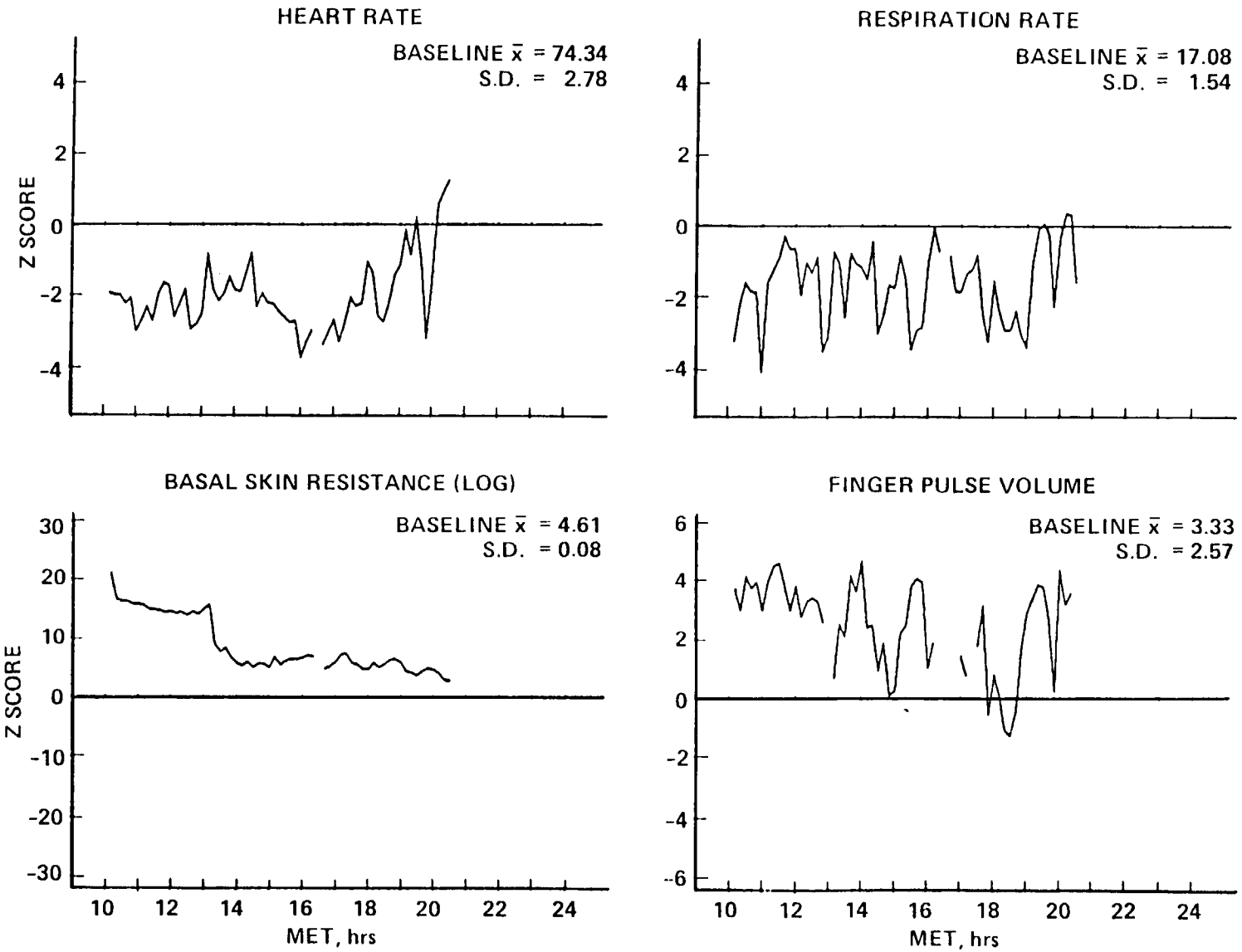



Figure 26.- Mission day 2: Crewmember A (10-min means).

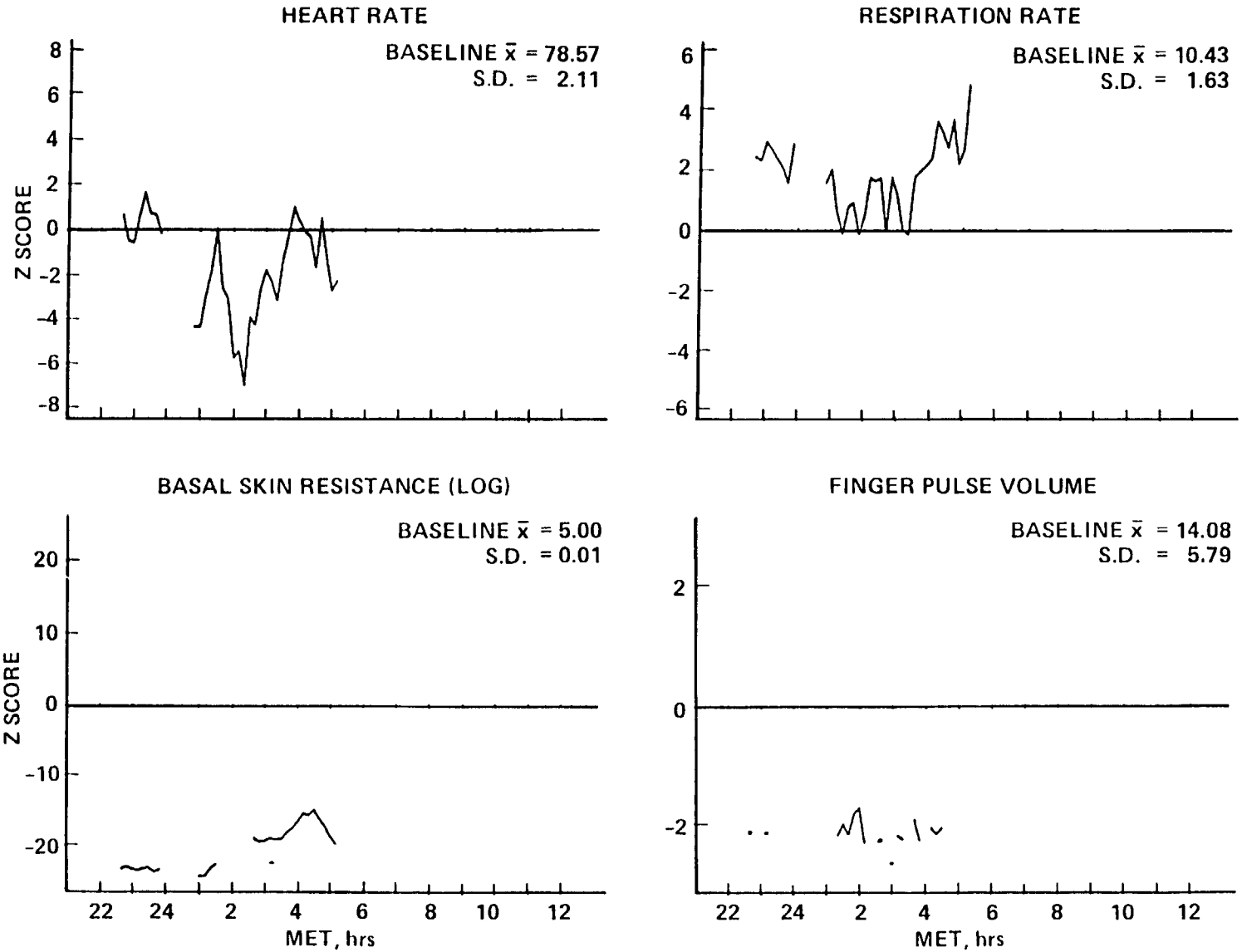



Figure 27.- Mission day 2: Crewmember B (10-min means).

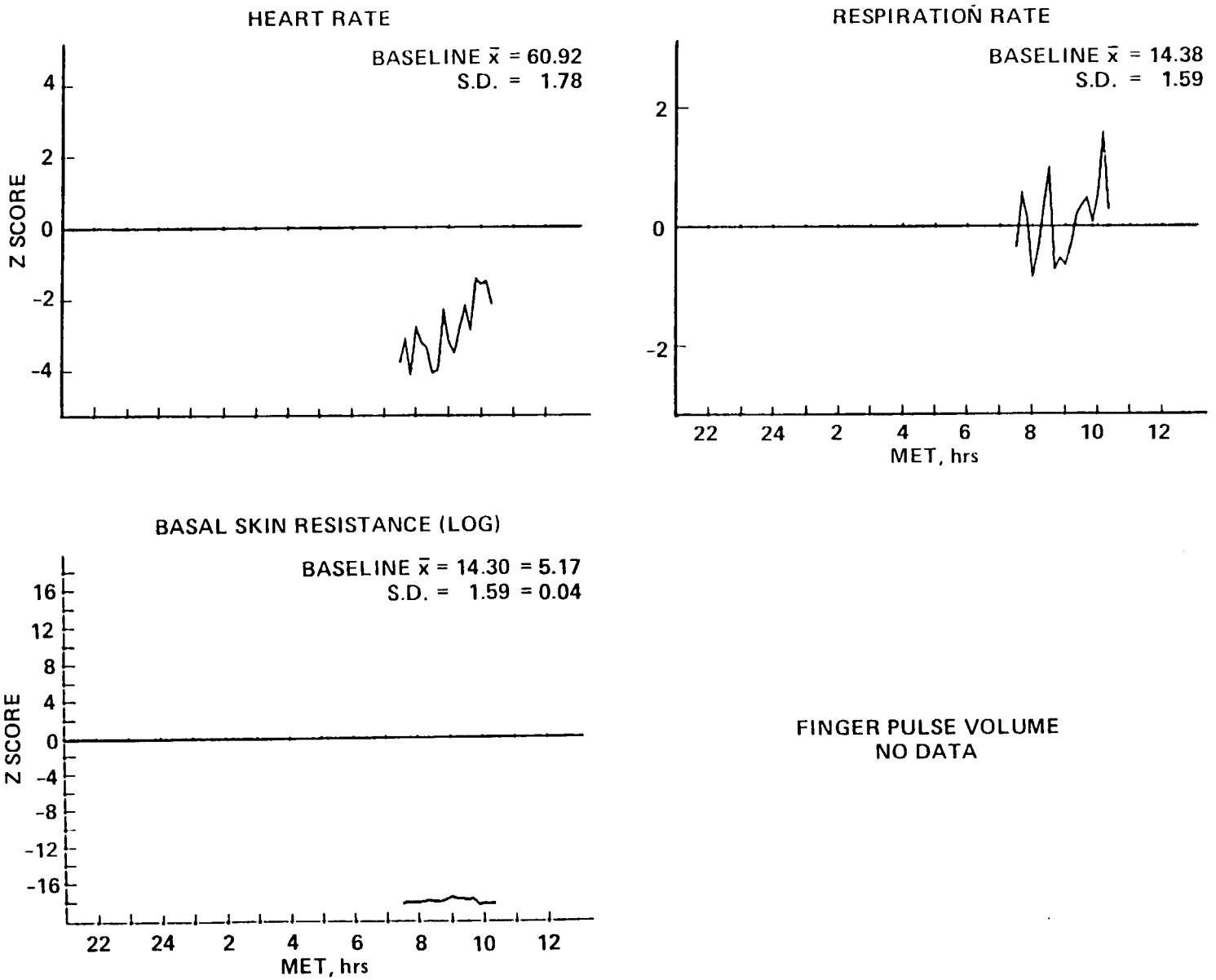



Figure 28.- Mission day 2: Crewmember C (10-min means).

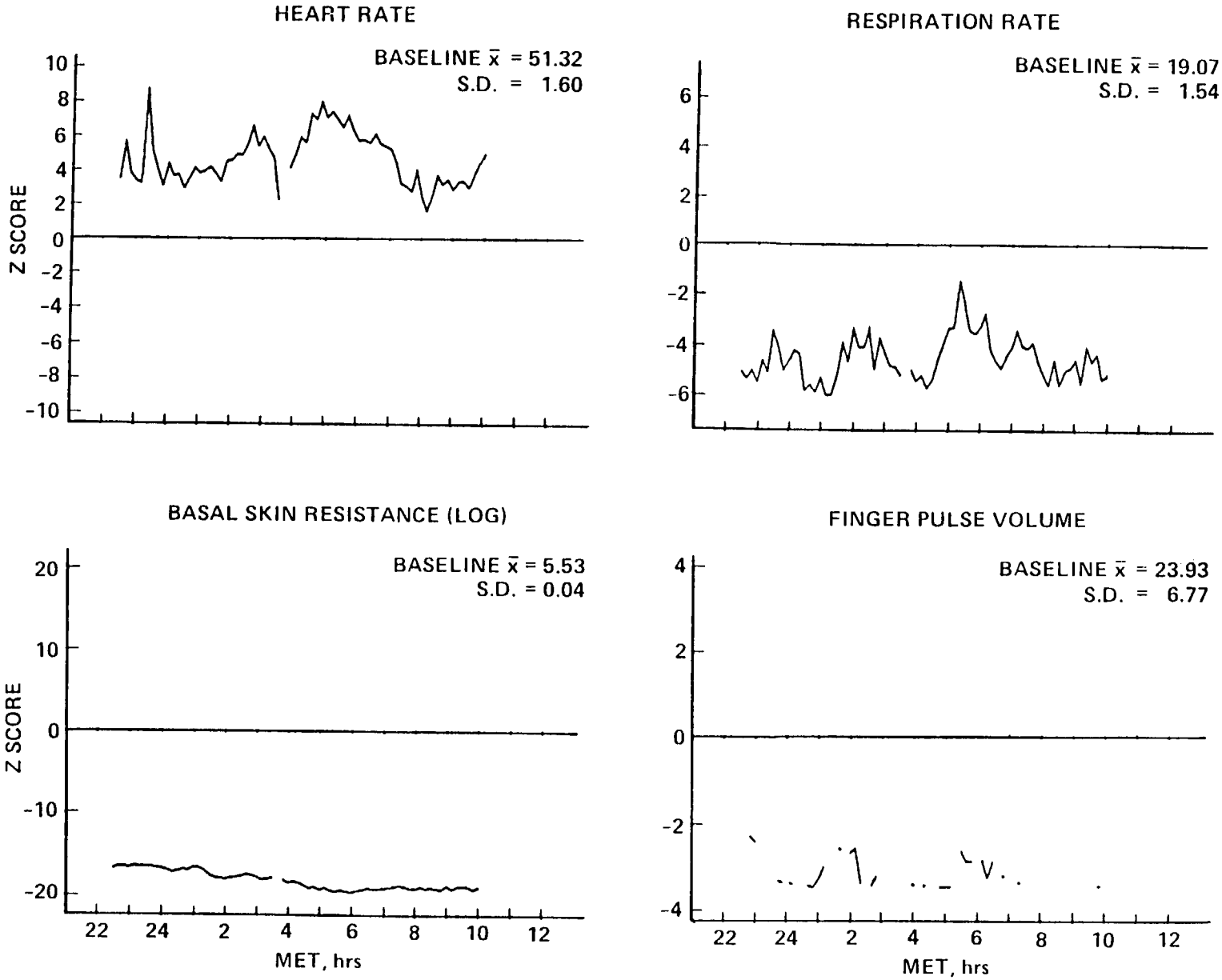



Figure 29.- Mission day 2: Crewmember D (10-min means).

Mission Day 3-

Crewmember A: HR was generally below the baseline level with a peak occurring at the beginning and close to midshift (fig. 30). Both skin resistance and FPV remained high, while respiration was low.

Crewmember B: HR gradually declined and then increased to baseline levels at the end of data recording (midshift) (fig. 31). Respiration rate was high and both skin resistance and finger pulse volume were lower than preflight resting levels.

Crewmember C: HR was initially high, followed by a decrease at midshift and an increase at the end of the day (fig. 32). Respiration rate was at or below preflight resting levels. Skin resistance was initially high and gradually decreased over a 3-hr period and remained at this low level throughout the shift.

Crewmember D: HR levels remained high and respiration rate was low (fig. 33). Skin resistance showed more fluctuations and was generally higher than on previous mission days. Finger pulse volume was still below baseline levels.

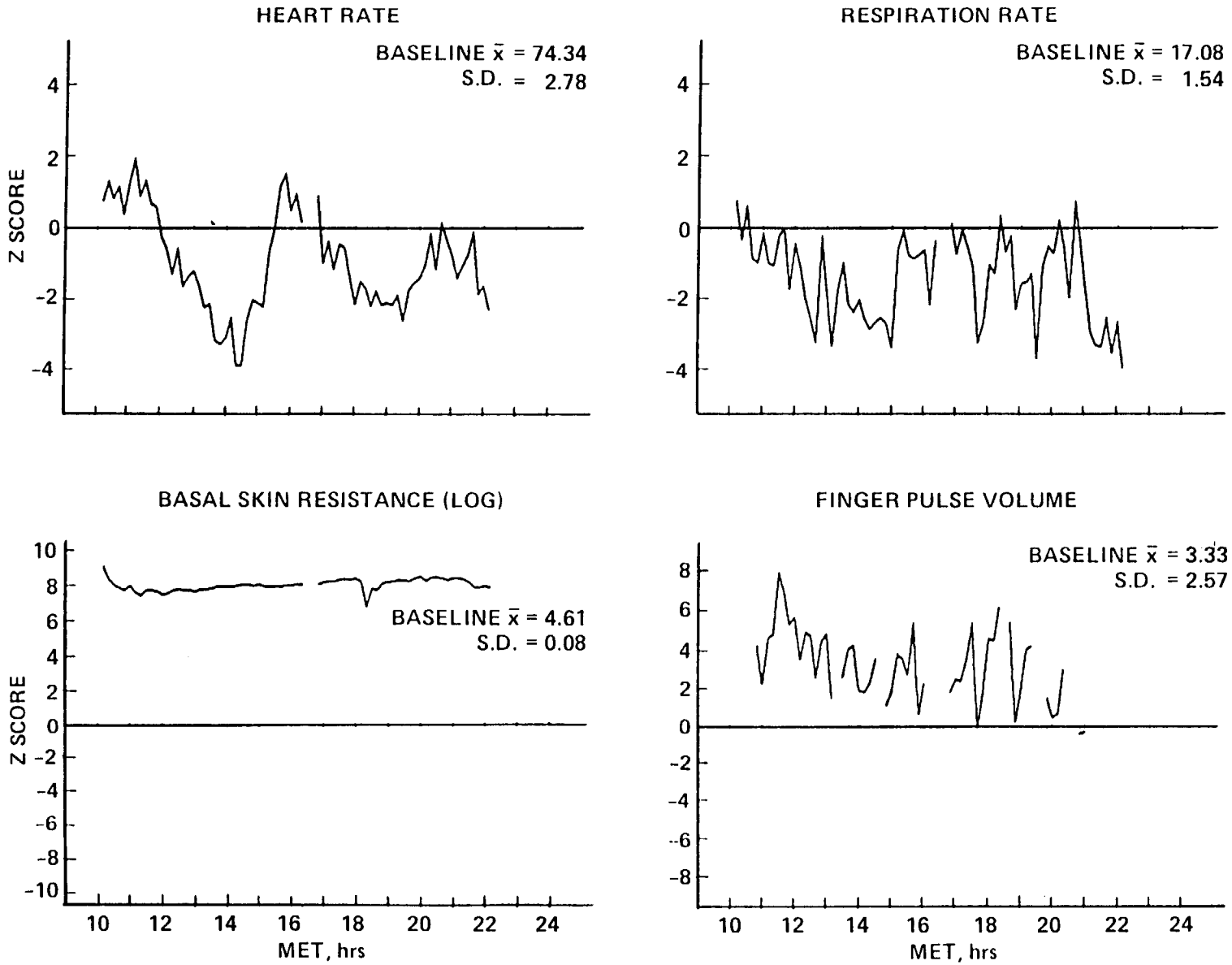



Figure 30.- Mission day 3: Crewmember A (10-min means).

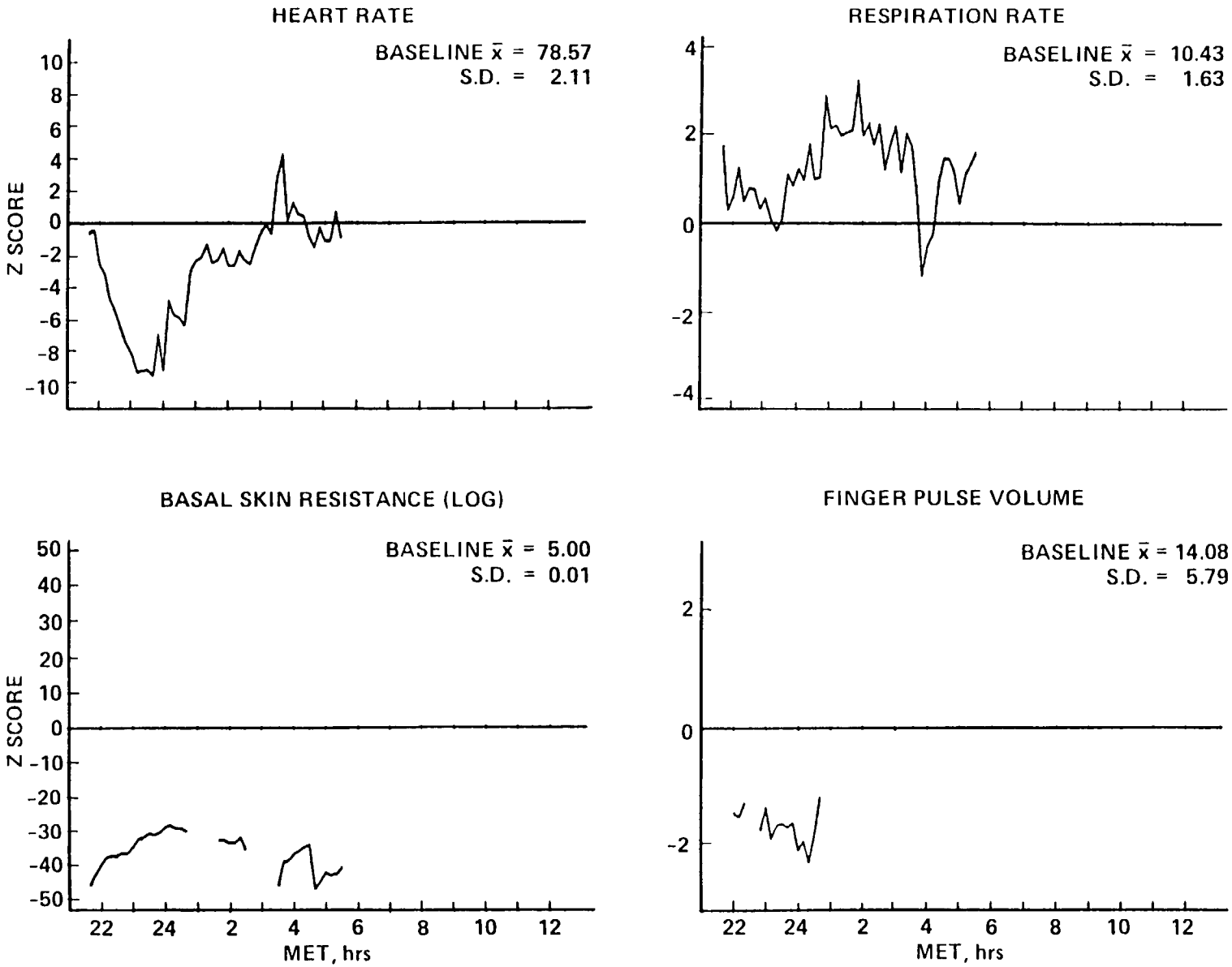



Figure 31.- Mission day 3: Crewmember B (10-min means).

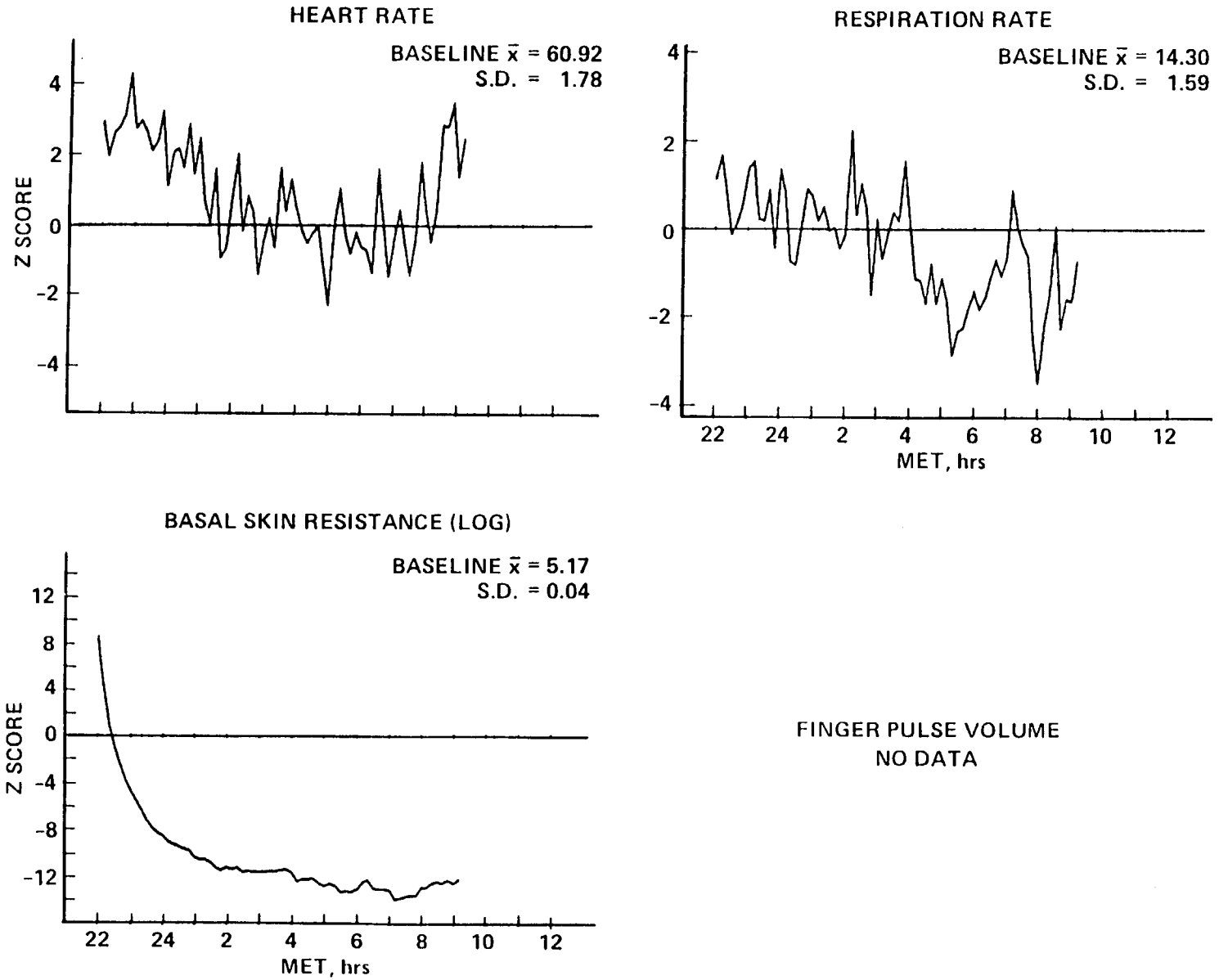



Figure 32.- Mission day 3: Crewmember C (10-min means).

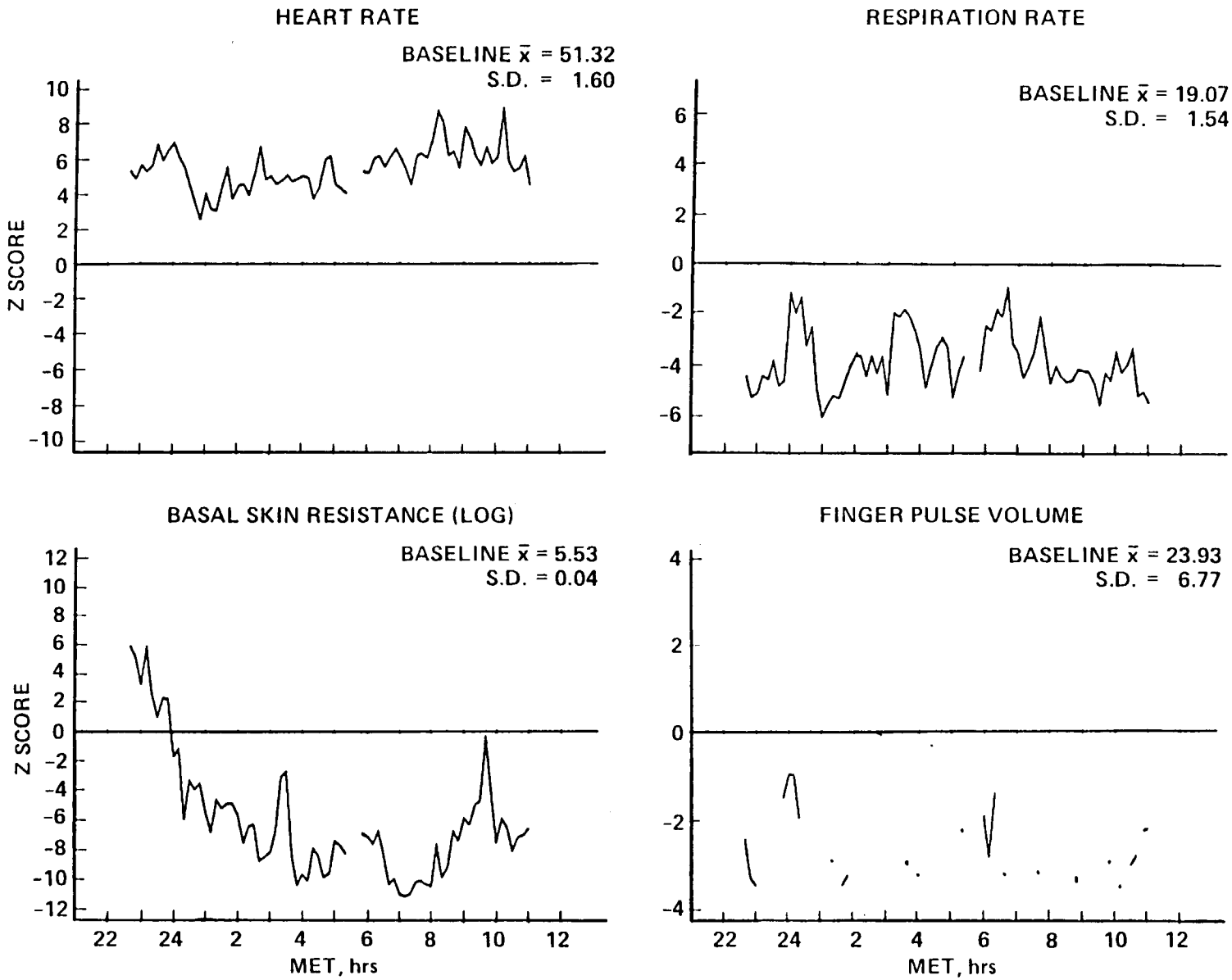



Figure 33.- Mission day 3: Crewmember D (10-min means).

Mission Day 4-

Crewmember A: HR and RR were near or below preflight resting levels (fig. 34). Skin resistance and finger-pulse-volume levels remained high.

Crewmember B: HR showed large fluctuations although the level remained below baseline (fig. 35). Respiration was higher while skin resistance showed a gradual decrease during the shift. Finger-pulse-volume data were lost during this shift; a postflight examination of the transducer showed a malfunction. This crewmember reported experiencing some gastrointestinal discomfort which was unrelated to SAS.

Crewmember C: HR was initially high with a gradual decrease at midshift and then an increase during the remainder of the day (fig. 36). Respiration rate showed large fluctuations at or near the resting level. Skin resistance remained low.

Crewmember D: HR was above his baseline level during the shift, while respiration rate was low (fig. 37). Skin resistance was initally low with a gradual increase to baseline at the end of the shift. Finger pulse data were minimal and below baseline levels. The break in data occurred when this crewmember removed AFT hardware to perform another payload-related task.

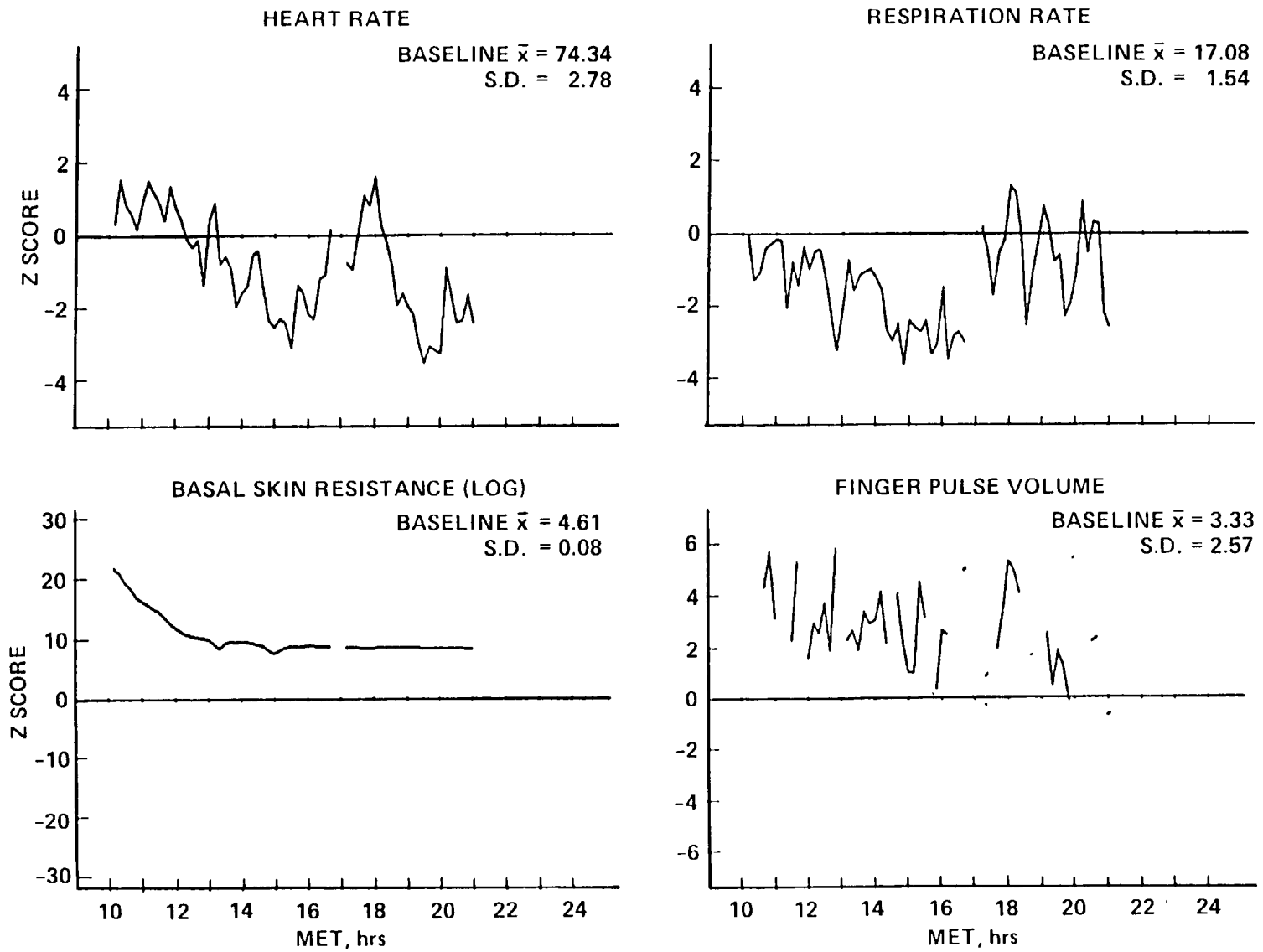



Figure 34.- Mission day 4: Crewmember A (10-min means).

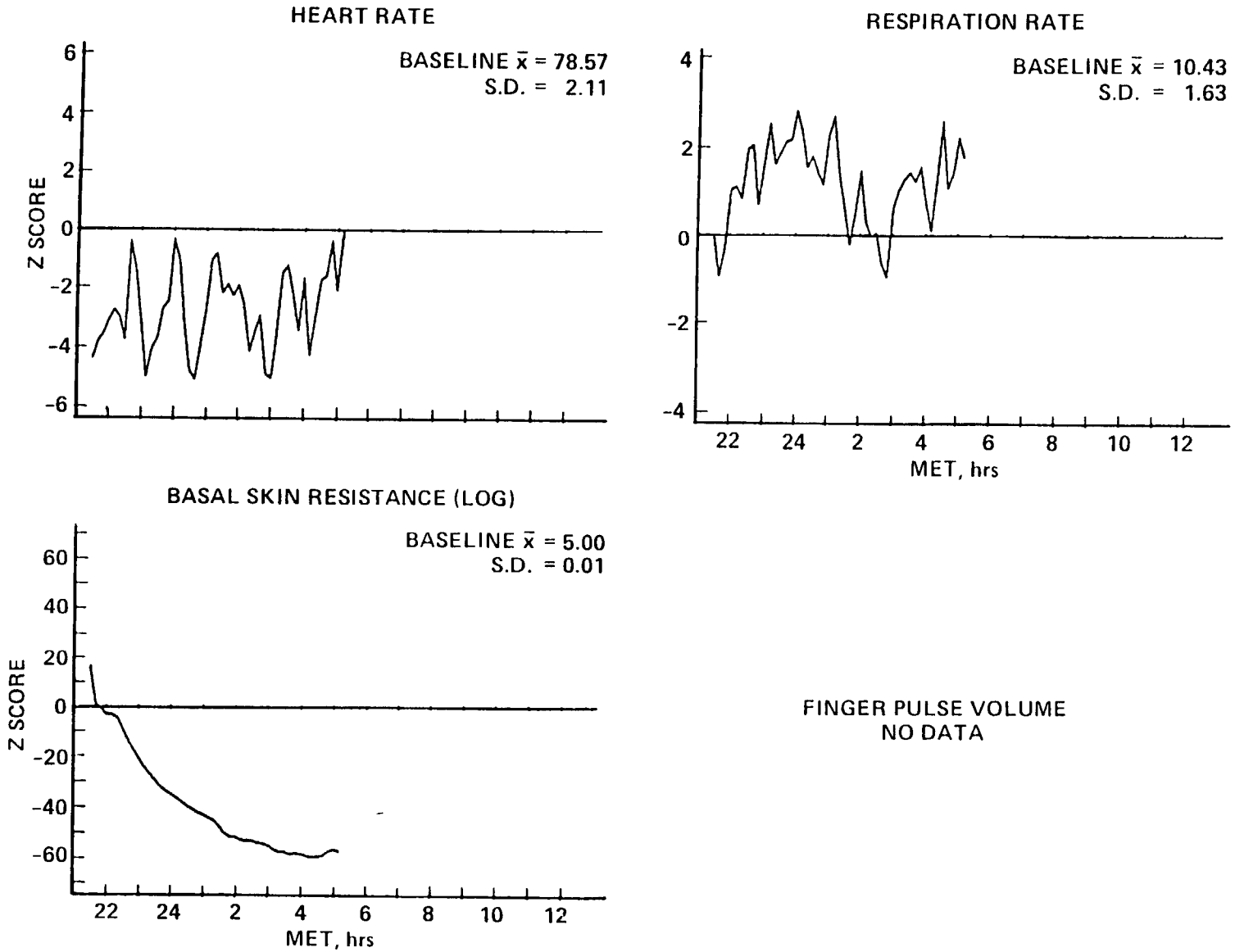



Figure 35.- Mission day 4: Crewmember B (10-min means).

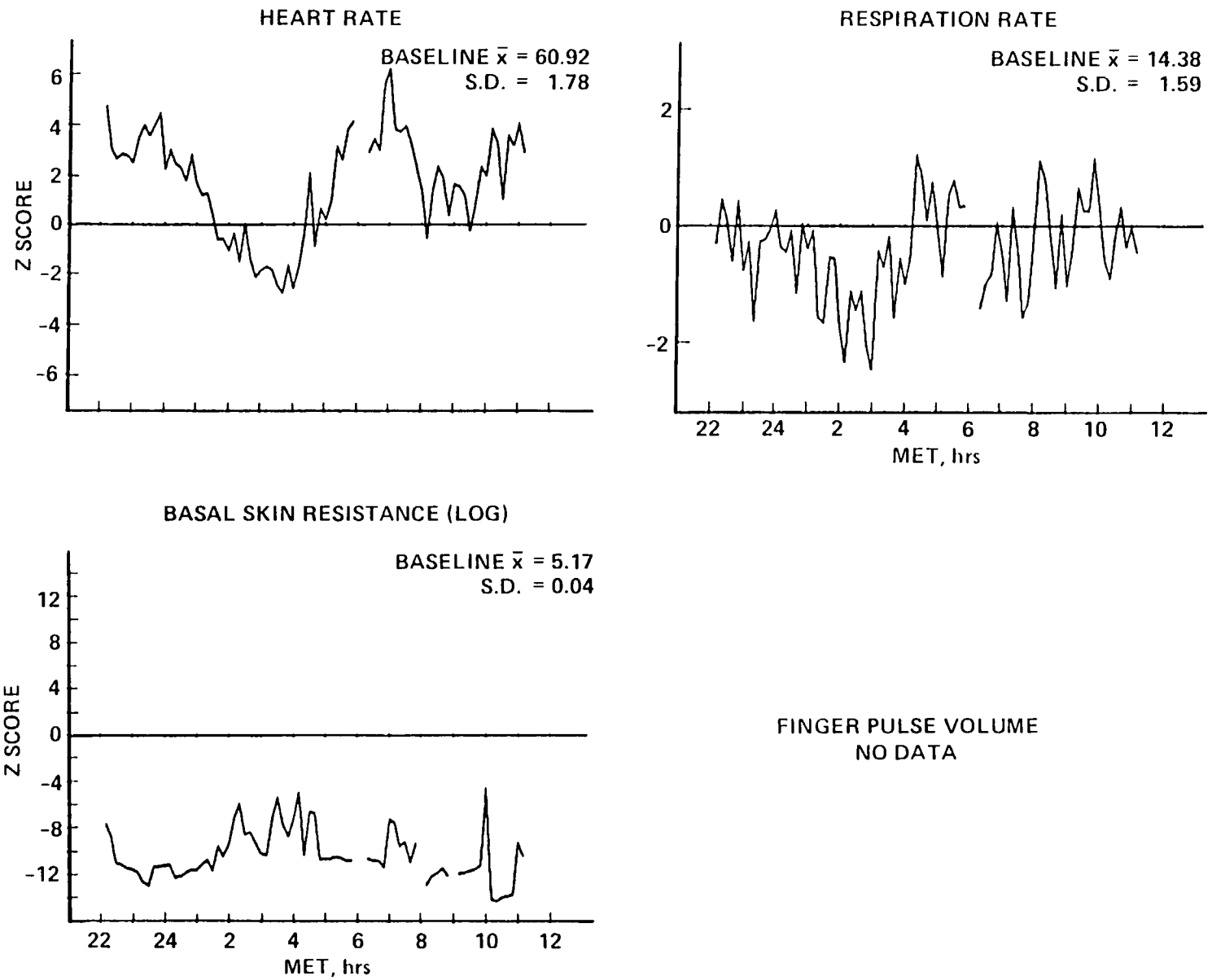



Figure 36.- Mission day 4: Crewmember C (10-min means).

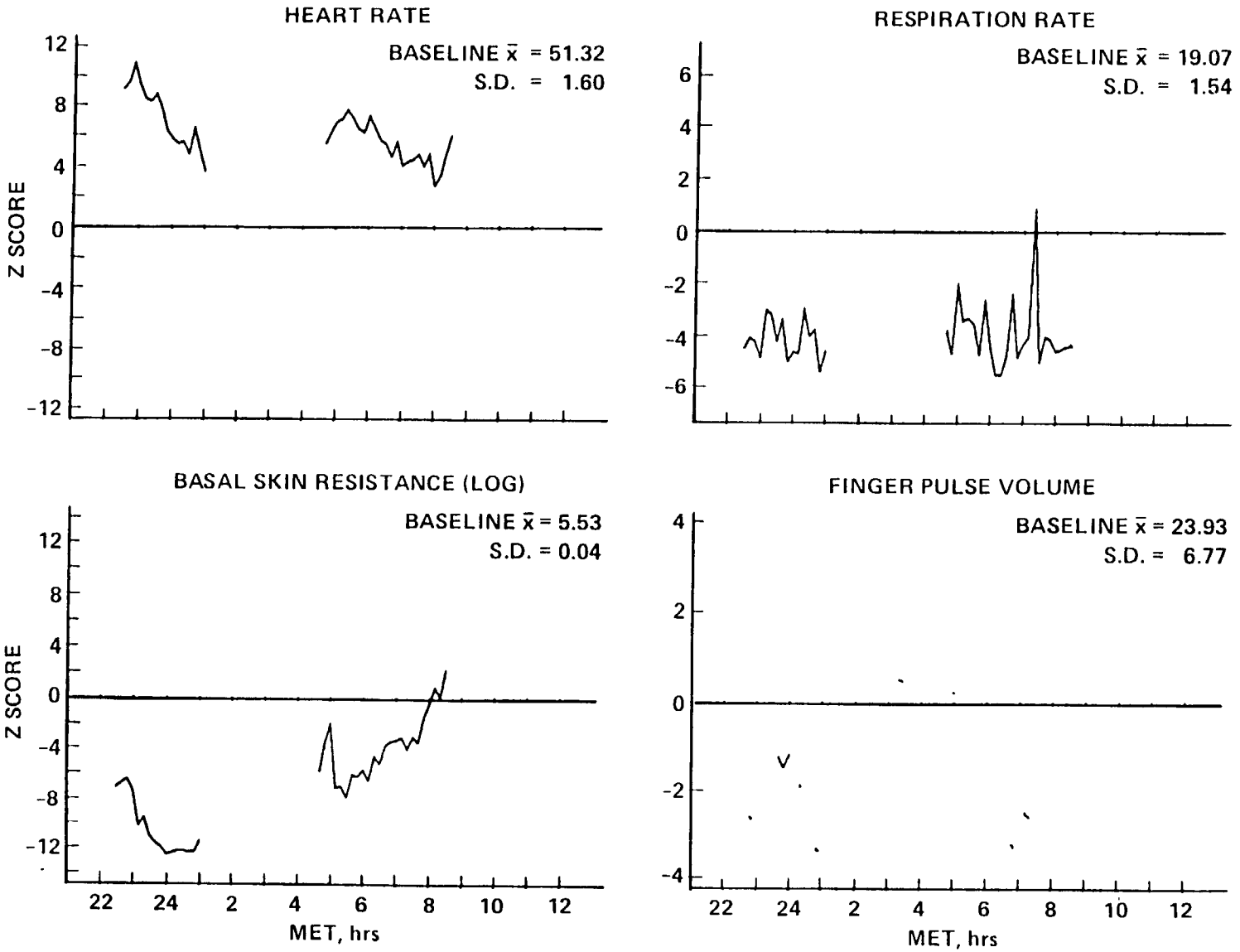



Figure 37.- Mission day 4: Crewmember D (10-min means).

Mission Day 6 Reentry- No physiological data were collected on any crewmembers on mission day 5. Data were collected on Crewmembers A and B only on mission day 6 during reentry.

Crewmember A: The sudden peak in HR, rise in RR, and decreases in both skin resistance and FPV may have occurred during reentry but no MET was recorded (fig. 38).

Crewmember B: The increase in HR and RR and the decrease in skin resistance may have occurred during reentry, but no MET was recorded (fig. 39).

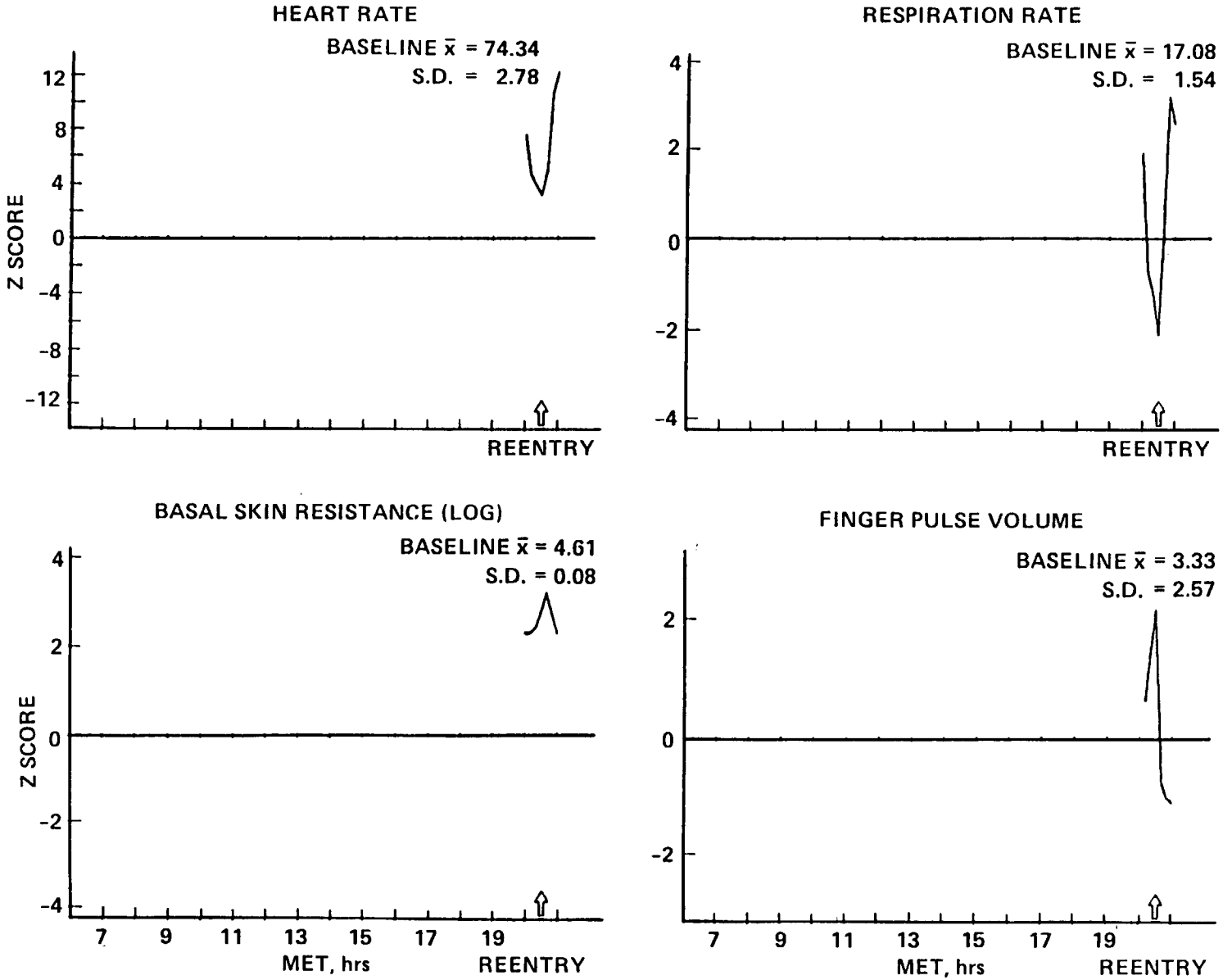



Figure 38.- Mission day 6: Crewmember A (10-min means).

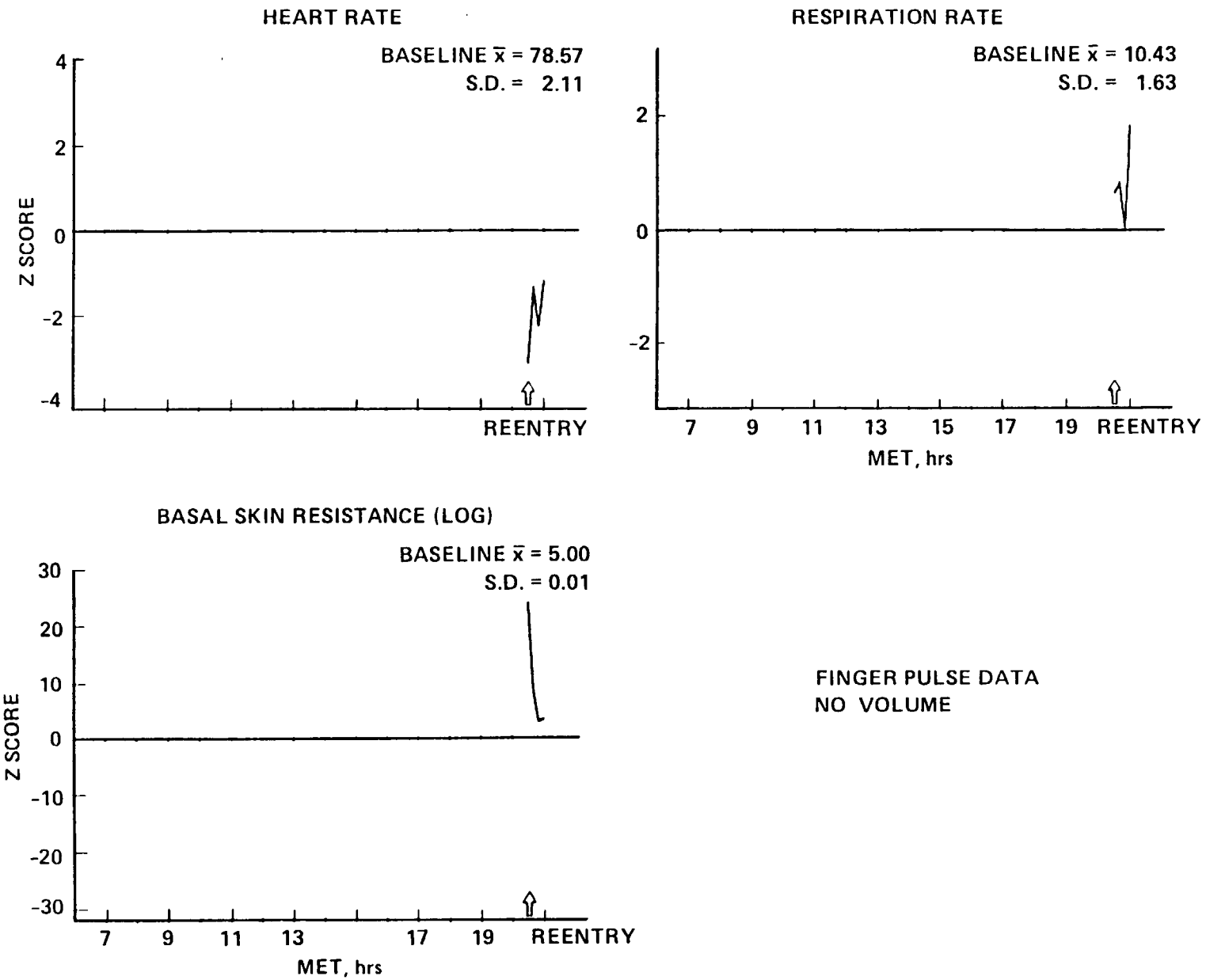



Figure 39.- Mission day 6: Crewmember B (10-min means).

# DISCUSSION

## Findings to Date

An important finding from this experiment is that Crewmember A, who showed the best preflight training performance, reported no severe malaise inflight. Further, all physiological response levels recorded for this crewmember throughout the mission indicated low sympathetic tone which suggests low stress.

Because continuous physiological monitoring of several parameters during waking hours had not been previously obtained (by NASA) on humans in space, the investigators did not really know what to expect. It was possible that the microgravity environment would produce a lower HR than typically observed on Earth. However, Crewmember D showed a higher HR on all mission days. Also, the positive fluid shift that results during exposure to microgravity might have produced lower levels of FPV. However, Crewmember A, who was successfully trained to regulate blood volume in his hands, showed consistently higher FPV throughout the mission than all other crewmembers.

Both Crewmembers C and D reported taking anti-motion-sickness medication on mission day 0, and this may have had an effect on their physiological response levels. However, despite taking medication, both individuals experienced SAS episodes on this mission day. In addition, Crewmember D showed elevated heart rate for all mission days while both crewmembers showed reduced skin resistance and finger pulse volume throughout the flight. For future flights, it would be very useful to obtain additional preflight data on the effects of various anti-motion-sickness drugs and dosages on physiological response levels. These data could then be compared to subsequent flight data for those crewmembers who take medication during the mission.

Continuous physiological monitoring inflight can be used to answer several other questions in addition to providing objective information on SAS. For example, by examining a given crewmember's Payload Crew Activity Plan (PCAP) for each mission day, the investigators can match the physiological data that is generated to known crew activities. Given this information, the effects of work load, fatigue, and disturbances in diurnal cycles on physiological response levels can be determined.

Many data epochs relevant to emetic episodes were lost during this mission because either the crewmember could not (or would not) wear the flight hardware at these times or because hardware malfunctioned. The efficacy of AFT as a treatment for SAS cannot be determined on the basis of data collected on only one mission. Additional flights will be required to obtain data on a total of 16 subjects. The investigators have concluded that if the physiological recordings and the other inflight requirements of the study are performed by the crew, it will then be possible to test the hypotheses of this experiment.

## Lessons Learned

Volunteer Crew Participation- During the mission, negative reporting by crewmembers is crucial. Investigators in the POCC should be informed of any failure to conduct specific payload requirements for any experiment. This procedure requires cooperation from crewmembers which can only be expected if crew participation in a given experiment is made on a voluntary basis. Therefore, we highly recommend that only volunteers be assigned as subjects in the future. Further, the principal investigator should be given the opportunity to discuss the objectives of the study and its procedures with the participants at the earliest possible time.

Preflight Schedule and Procedure Changes- The original AFT experiment protocols written to support STS 51-C and 51-B, defined the crew participation schedule to include 12 AFT sessions and 3 rotating chair tests conducted from 4 to 1 months prior to launch. However, because of launch delays for both missions, these sessions were distributed over a 7-month period. The result was that these subjects showed less effective control of their symptoms than subjects who were trained over shorter periods of time. To eliminate the effect of launch delays on training schedules for future missions, it is recommended that preflight AFT sessions be administered on 15 consecutive days at 1 year to 8 months prior to launch. Additionally, a minimum of 4 and a maximum of 8 AFT followup sessions (during 4 to 1 months prior to launch) will be required. The total number of followup sessions needed will be determined on an individual basis.

Several KC-135 flights have also been added to the protocol during both baseline and AFT followup sessions for two reasons. (1) One of the concerns of the 51-B crew was that rotating chair tests (conducted within 4 to 1 months prior to launch) produced residual symptoms over a 12-hr period which interfered with other payload training activities scheduled for the same day. However, KC-135 flights are often scheduled in this time period to enable crewmembers to practice various payload activities during microgravity periods. These flight tests have been substituted for rotating-chair tests, and will be used to assess each crewmember's ability to control his/her symptoms in this environment. Data from these tests will be used to determine the number of AFT followup sessions required for each individual. (2) It is necessary for crewmembers to practice some of the AFT inflight procedures (e.g., donning/doffing of flight hardware) in a micro-g environment.

Flight Hardware Modifications- The most significant modification of future flight hardware, recommended by both the crewmembers and the investigators, is to reduce the instrument's size. A smaller instrument package will serve two purposes: (1) it can be worn on the body during launch, which would eliminate data loss on the critical mission day 0; and (2) the size reduction will facilitate crew mobility and comfort at critical activity periods during the mission. The feedback displays will also be reduced in size and will function more reliably than the previous flight hardware. A data playback system will be made available for use by the investigators before the start of preflight training activities.

Inflight Procedure Changes- Physiological monitoring requirments have been reduced to include only the first three mission days. Preliminary findings indicate

that SAS is most likely to occur during this time. Further, the proposed hardware modification described previously should eliminate the requirement for crewmembers to change cassette data tapes in the middle of a mission day.

## Status of Future Flights

When fabrication of the flight hardware is complete, this experiment may be repeated on any future NASA Shuttle flight as deemed appropriate by mission management.

APPENDIX A:

PREFLIGHT DATA OF BACKUP CREWMEMBERS

## Resting Baseline

Table A-1 is a summary of the preflight, resting baseline data for each crewmember. Means and standard deviations (SDs) were computed for each physiological variable from 60, which were collected during two 30-min sessions, at an average of 1/min.

TABLE A-1.- RESTING BASELINE DATA MEANS AND STANDARD DEVIATIONS OF EACH PHYSIOLOGICAL RESPONSE

| Crewmember | Finger pulse volume, units/min | Respiration rate, breaths/min | Heart rate, beats/min | Basal skin resistance, log kohm | Finger temperature, °F | |
|---|---|---|---|---|---|---|
| E | 13.6 | 15.3 | 63.0 | 4.491 | 88.2 | Mean |
| | 5.7 | 3.9 | 1.0 | 0.002 | 0.9 | SD |
| F | 4.1 | 14.0 | 62.9 | 4.790 | 78.0 | Mean |
| | 2.8 | 2.7 | 1.0 | 0.073 | 1.0 | SD |

## Baseline Motion Sickness Test

The physiological data of each crewmember recorded during his/her initial rotating-chair test are shown in figures A-1 and A-2. The four physiological variables selected for plotting were similar to those measured subsequently inflight with two exceptions. Skin conductance level, the reciprocal of BSR, is plotted and hand temperature has been substituted for finger pulse volume. The latter substitutions were necessary because the transducers, and/or electronics of the AFS were not functional at the time of these data collection sessions.

The X-axes on these graphs were divided into three segments: Baseline, minutes 1 through 10 which preceded the start of rotation; Test Minutes, the time during actual rotation which varied for each subject; and Baseline, 10 min immediately following the end of chair rotation.

## Autonomic Conditioning/Testing

Crewmember E- Figure A-3 shows the number of rotations tolerated by Crewmember E during all preflight rotating chair tests. Figure A-4 is a z-score graph of the physiological data collected during rotating chair tests before and after AFT.

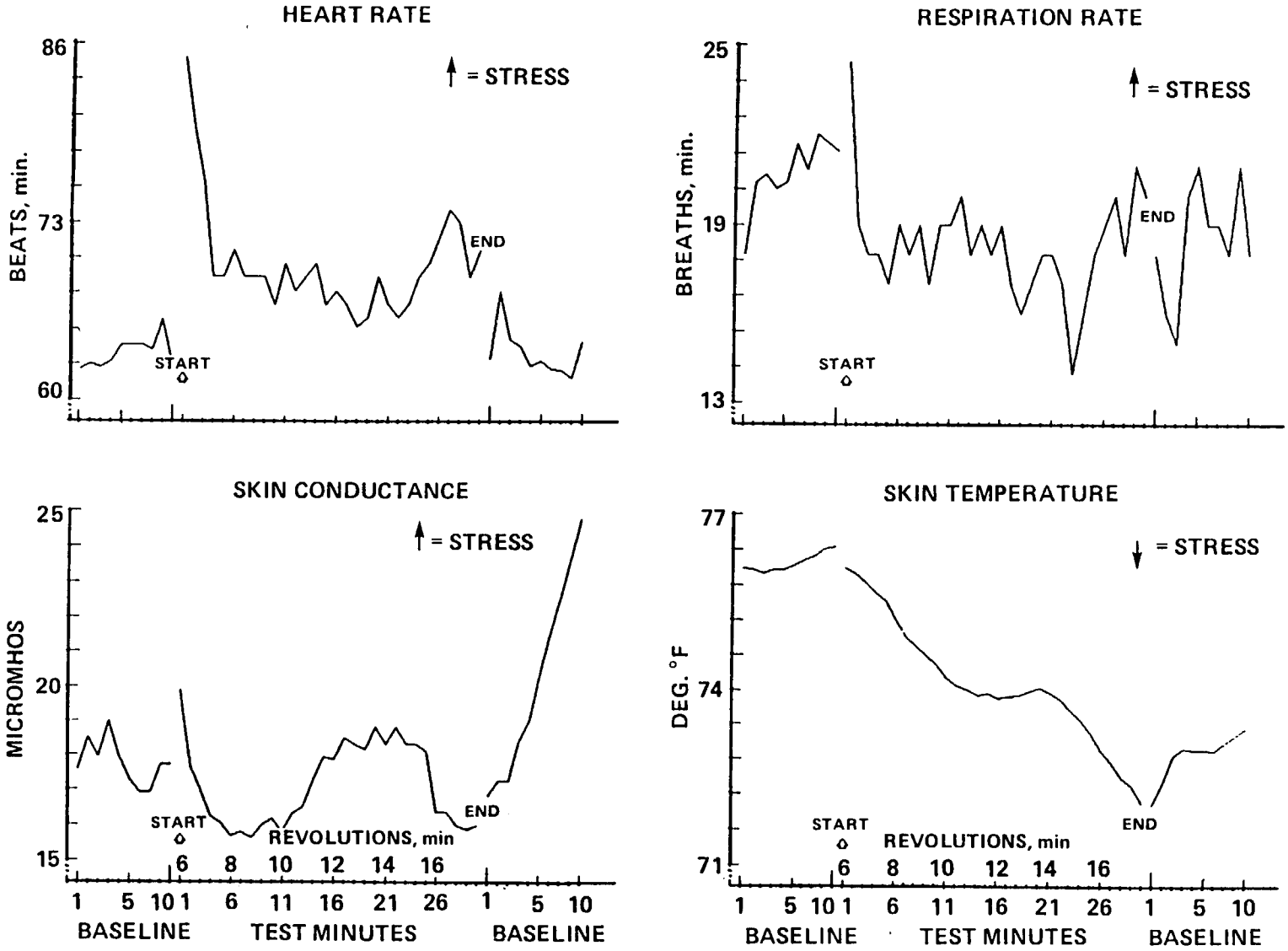



Figure A-1.- Baseline rotating-chair test: Crewmember E.

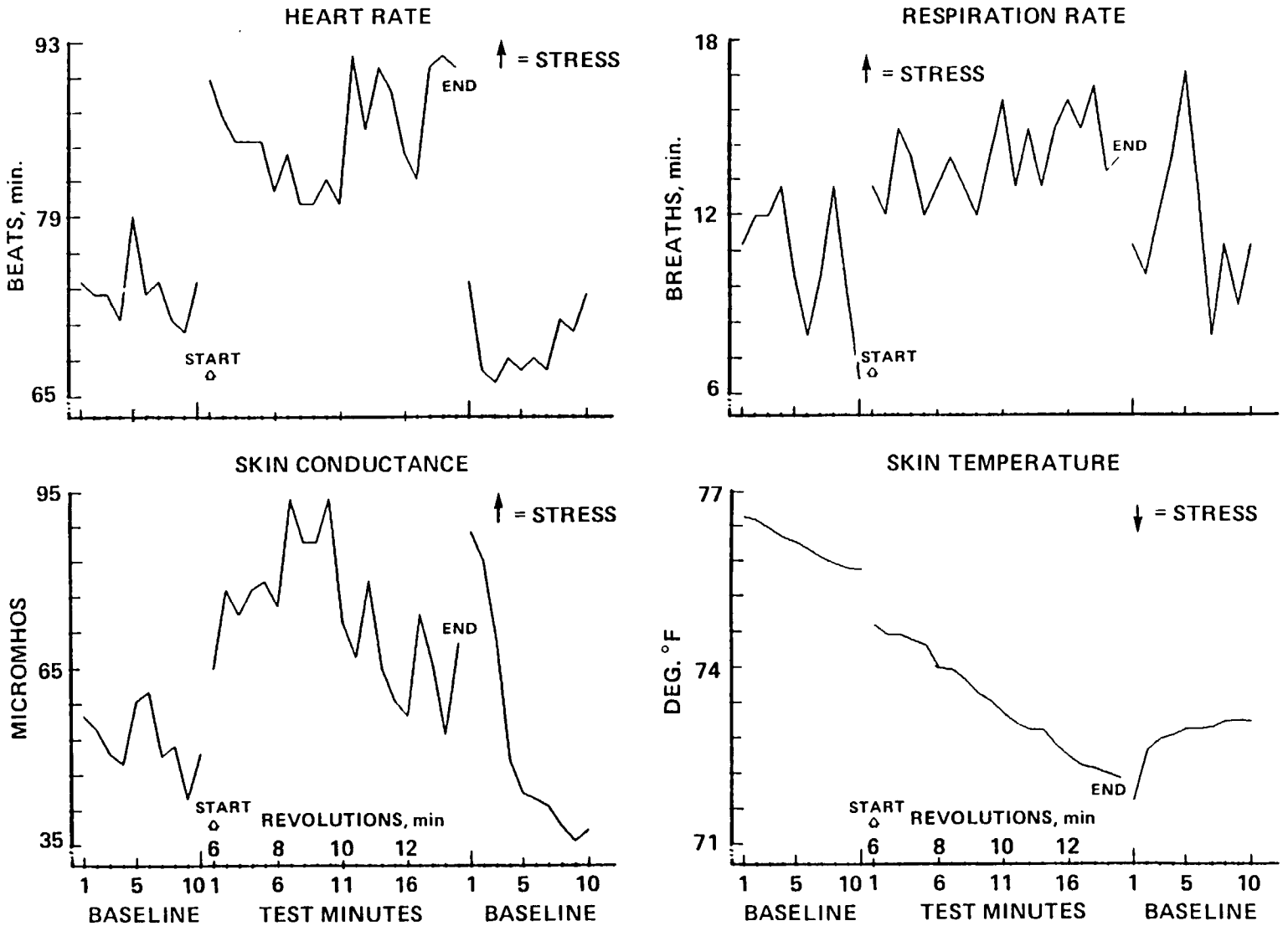



Figure A-2.- Baseline rotating-chair test: Crewmember F.

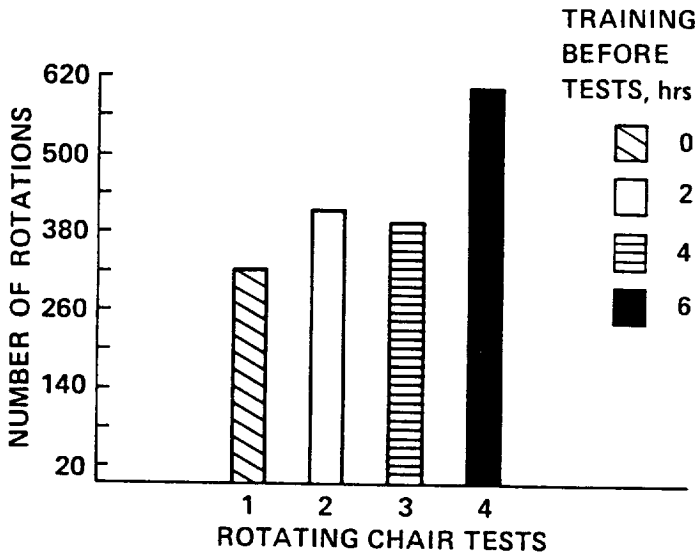



Figure A-3.- Motion sickness tolerance before, during and after training: Crewmember E.

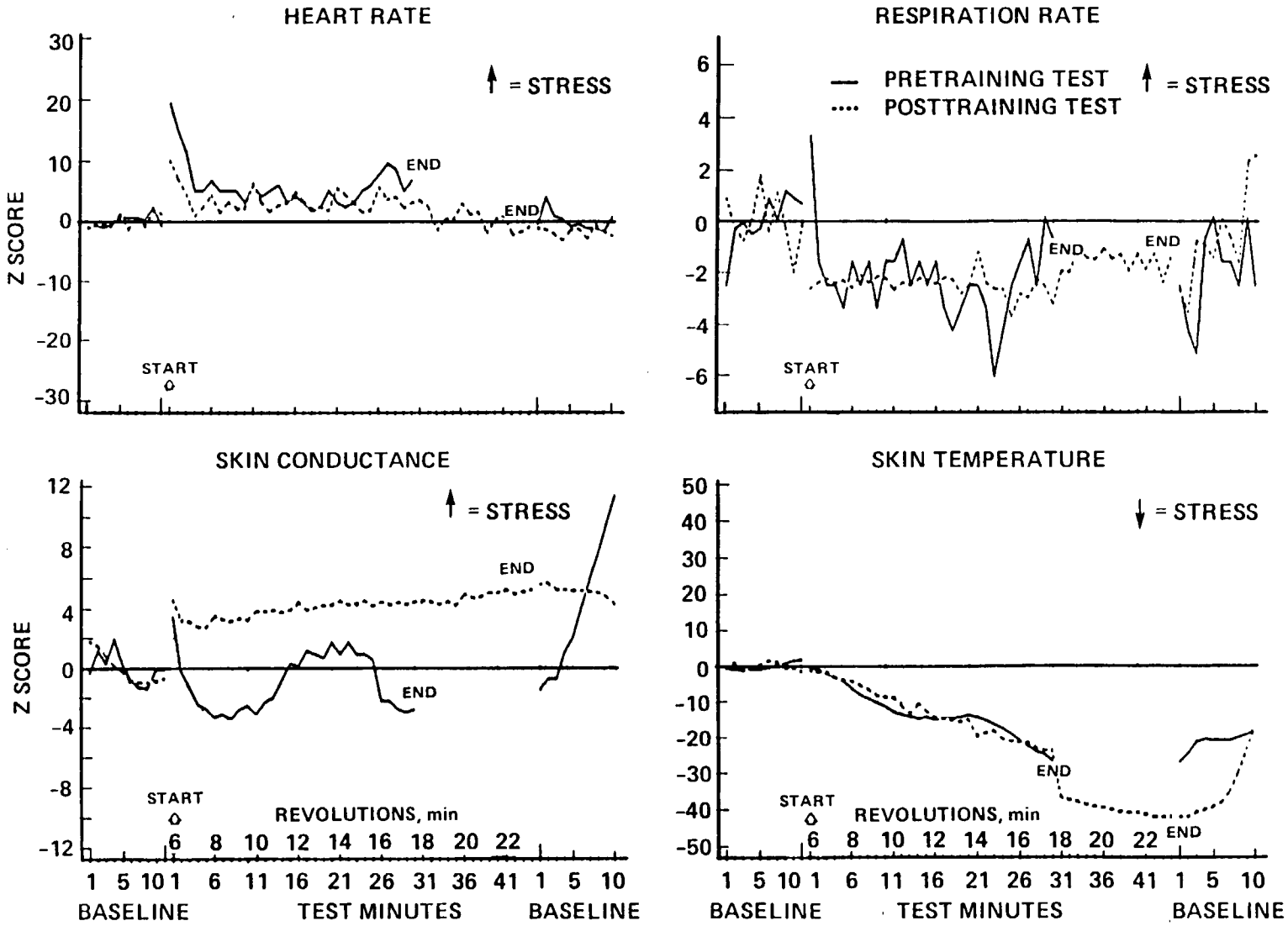



Figure A-4.- Physiological data during rotating-chair tests: Crewmember E.

This subject's susceptibility to motion sickness was moderate to low prior to training. Although he was highly motivated, his improvement in motion sickness tolerance following AFT was not as large as anticipated by the investigators for a "low susceptible" subject. This result may have been due to changes in the planned training schedule. Figure A-5 shows malaise levels reported before and after training.

Crewmember F- Changes in motion sickness tolerance for Crewmember F across all preflight rotating-chair tests are shown in figure A-6. For this crewmember we have provided two sets of data; the first compares the pretraining rotating-chair test to a test administered after 4 hr of training (figs. A-7 and A-8). The second set compares pretraining data with the final rotating-chair test when training was complete (figs. A-9 and A-10). On the day of the final test, this crewmember was suffering from gastrointestinal flu (diarrhea) but decided to proceed.

The first set of graphs (figs. A-7 and A-8) show the degree of control of this crewmember after 4 hr of training. The crewmember's heart rate was more stable after 4 hr of training than before. It is unlikely that the heart rate was influenced significantly by breathing since there is very little difference in respiration rate for the two tests.

During the posttraining test (figs. A-9 and A-10), it was immediately apparent that this subject showed less control of physiological responses than in the previous test. The bar graph of the diagnostic points suggests that as control of physiology began to decline, more malaise was experienced.

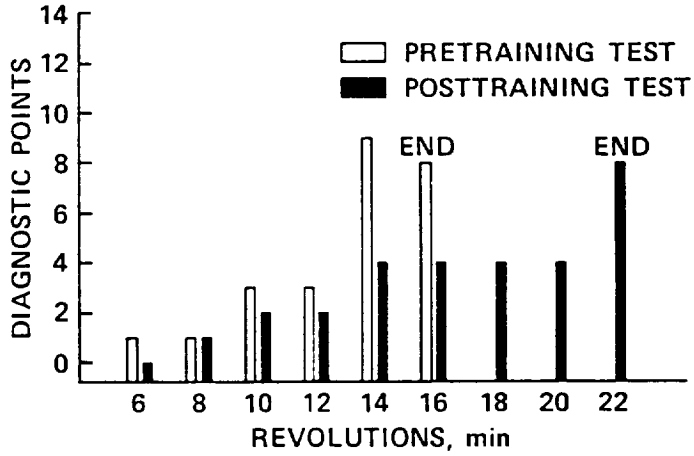



Figure A-5.- Malaise levels before and after training: Crewmember E.

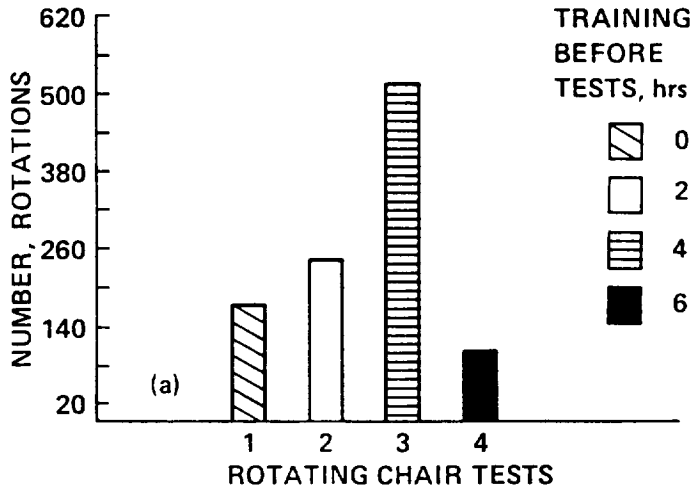



Figure A-6.- Motion sickness tolerance before, during and after training: Crewmember F.

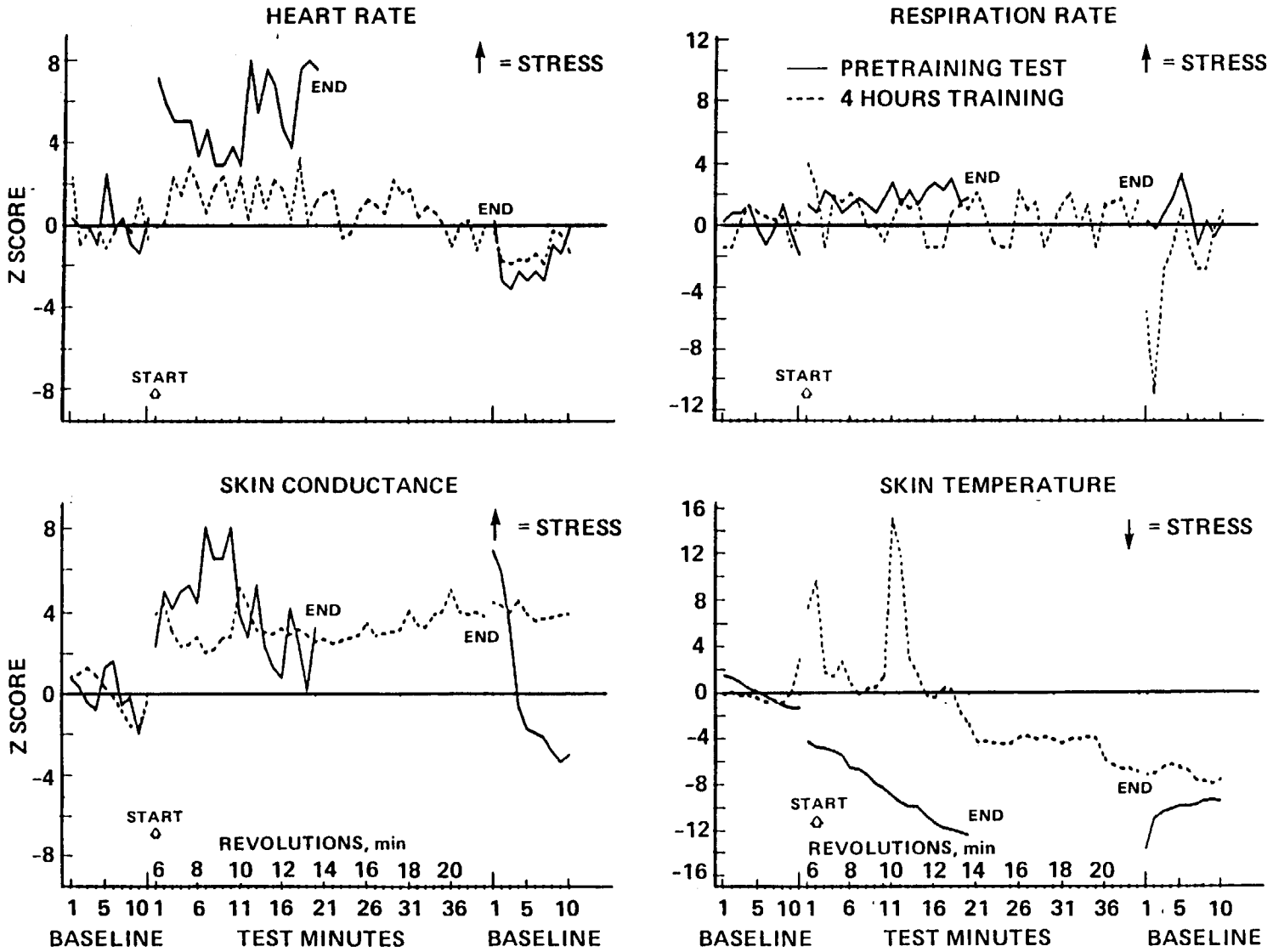



Figure A-7.- Physiological data during rotating-chair tests 1 and 3: Crewmember F.

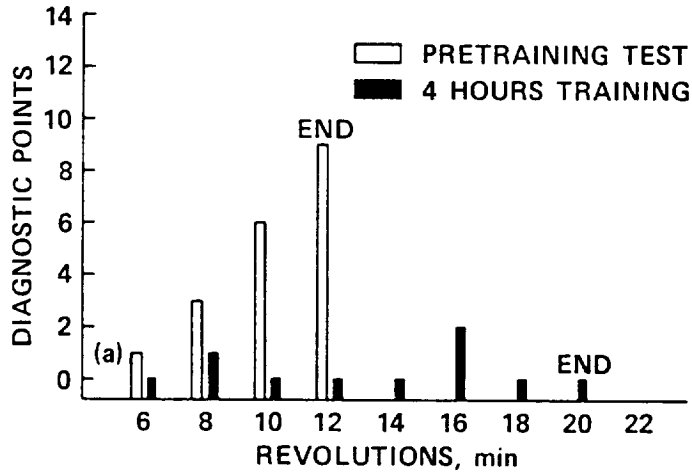



Figure A-8.- Malaise levels during tests 1 and 3: Crewmember F.

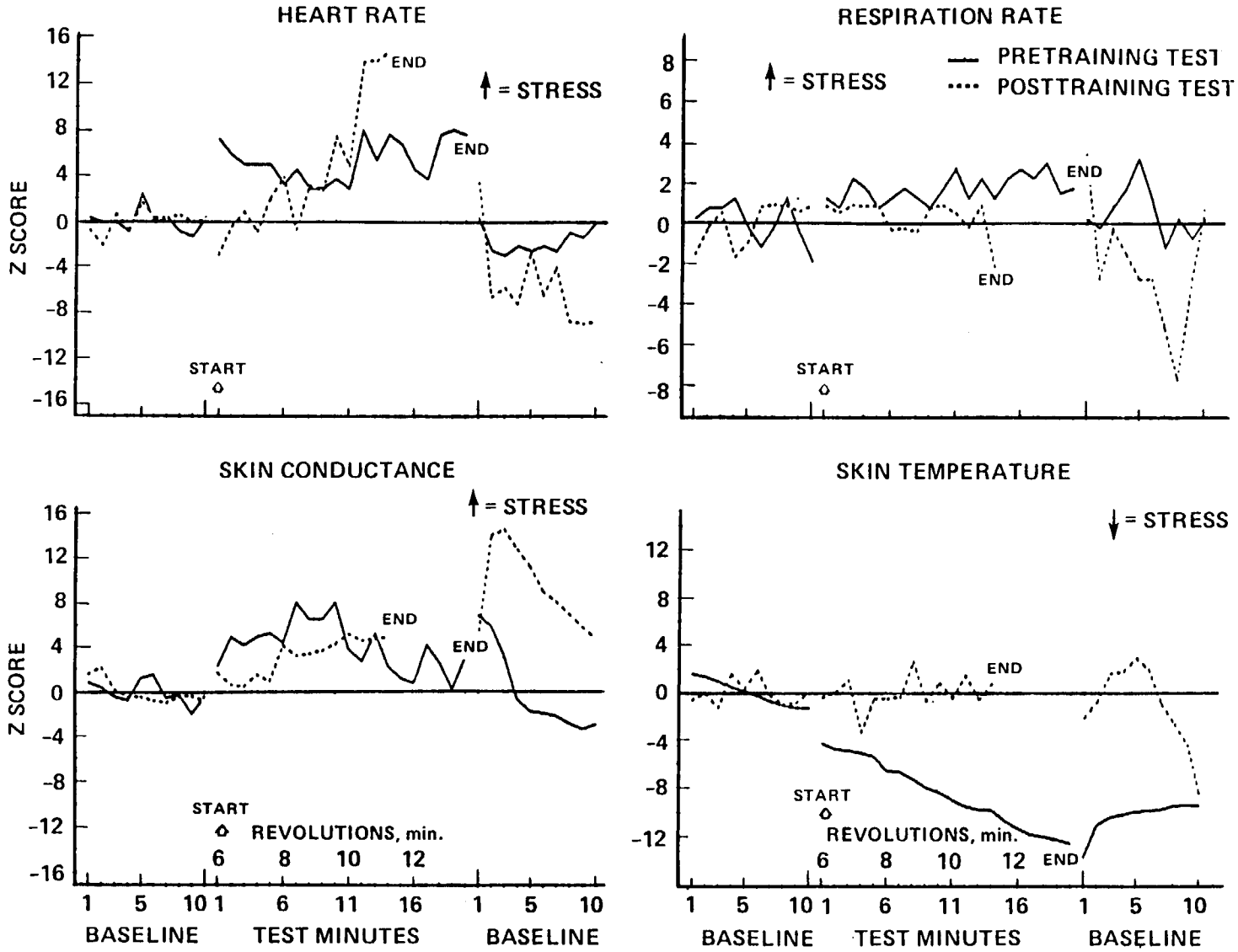



Figure A-9.- Physiological data during rotating-chair tests 1 and 4: Crewmember F.

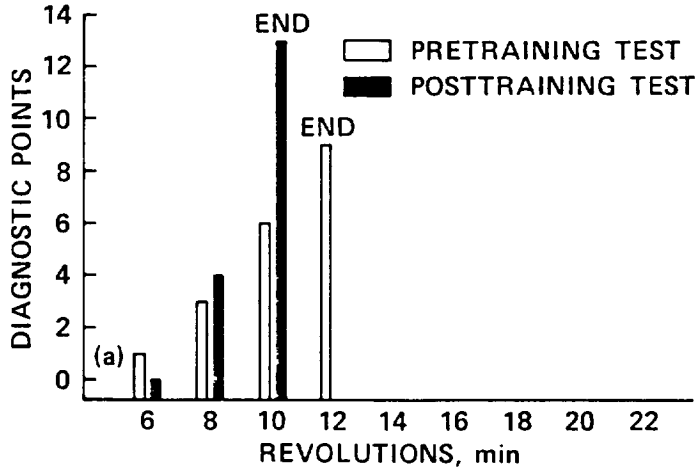



Figure A-10.- Malaise levels during tests 1 and 4: Crewmember F.

APPENDIX B:

AFT

3AFT23

PAYLOAD FLIGHT DATA FILE BOOK (PFDFB)

PFDFB is a manual prepared by Marshall Space Flight Center (MSFC) used by crewmembers during the mission. It contains instructions for performing the experiment.

SYSTEMS ANALYSIS AND INTEGRATION LABORATORY

OPERATIONS DEVELOPMENT DIVISION

SPACELAB MISSION 3

# AFT PAYLOAD OPERATING PROCEDURE

FINAL, REV A

MARCH 26, 1985

Prepared by:
Lybrease F. Woodard
Book Manager

Approved by:
Dr. Patricia S. Cowings
Principal Investigator

Dr. Mary Helen Johnston
SL-3 AFT Crew Lead

Carolyn S. Griner
Payload Operations

This document is under the configuration control of the MSFC Payload Flight Data File (PFDF) Change Control Board (CCB). All proposed changes must be submitted on standard MSFC Form 2327 (ECR) to EL03/C. Griner or C. Owen, Bldg. 4610, Room 2098, (205) 453-4735.

Comments concerning this document may be addressed to EL15/L. Woodard, Bldg. 4619, Room 107, (205) 453-5060.

CHANGE CONTROL BOARD

SL-3 AFT PAYLOAD OPERATING PROCEDURE

| PFDF EDITION INCORPORATED | | | |
|---|---|---|---|
| CONTROL NO. | TITLE | DATE | DISPOSITION |
| N/A | PRELIMINARY | 9/21/83 | |
| CCBD-203-84-0127 | FINAL | 10/26/84 | APPROVED |
| CCBD-OPS-058 | FINAL, REV A | 3/26/85 | APPROVED |

AFT PAYLOAD OPERATING PROCEDURE
LIST OF EFFECTIVE PAGES
PRELIMINARY 9/21/83
FINAL 10/26/84
FINAL, REV A 3/26/85

| PAGE | ISSUE |
|---|---|
| i | AFT/SL-3/FIN A |
| ii | AFT/SL-3/FIN A |
| iii | AFT/SL-3/FIN A |
| iv | AFT/SL-3/FIN A |
| EO-1 | AFT/SL-3/FIN A |
| EO-2 | AFT/SL-3/FIN A |
| EO-3 | AFT/SL-3/FIN A |
| EO-4 | AFT/SL-3/FIN A |
| EO-5 | AFT/SL-3/FIN A |
| EO-6 | AFT/SL-3/FIN A |
| CL-1 | AFT/SL-3/FIN A |
| CL-2 | AFT/SL-3/FIN A |
| NOM-1 | AFT/SL-3/FIN A |
| NOM-2 | AFT/SL-3/FIN A |
| NOM-3 | AFT/SL-3/FIN A |
| NOM-4 | AFT/SL-3/FIN A |
| NOM-5 | AFT/SL-3/FIN A |
| NOM-6 | AFT/SL-3/FIN A |
| NOM-7 | AFT/SL-3/FIN A |
| NOM-8 | AFT/SL-3/FIN A |
| NOM-9 | AFT/SL-3/FIN A |
| NOM-10 | AFT/SL-3/FIN A |
| NOM-11 | AFT/SL-3/FIN A |
| NOM-12 | AFT/SL-3/FIN A |
| MAL-1 | AFT/SL-3/FIN A |
| MAL-2 | AFT/SL-3/FIN A |
| MAL-3 | AFT/SL-3/FIN A |
| MAL-4 | AFT/SL-3/FIN A |
| MAL-5 | AFT/SL-3/FIN A |
| MAL-6 | AFT/SL-3/FIN A |
| MAL-7 | AFT/SL-3/FIN A |
| MAL-8 | AFT/SL-3/FIN A |
| IFM-1 | AFT/SL-3/FIN A |
| IFM-2 | AFT/SL-3/FIN A |

CONTENTS



PRECEDING PAGE BLANK NOT FILMED



78

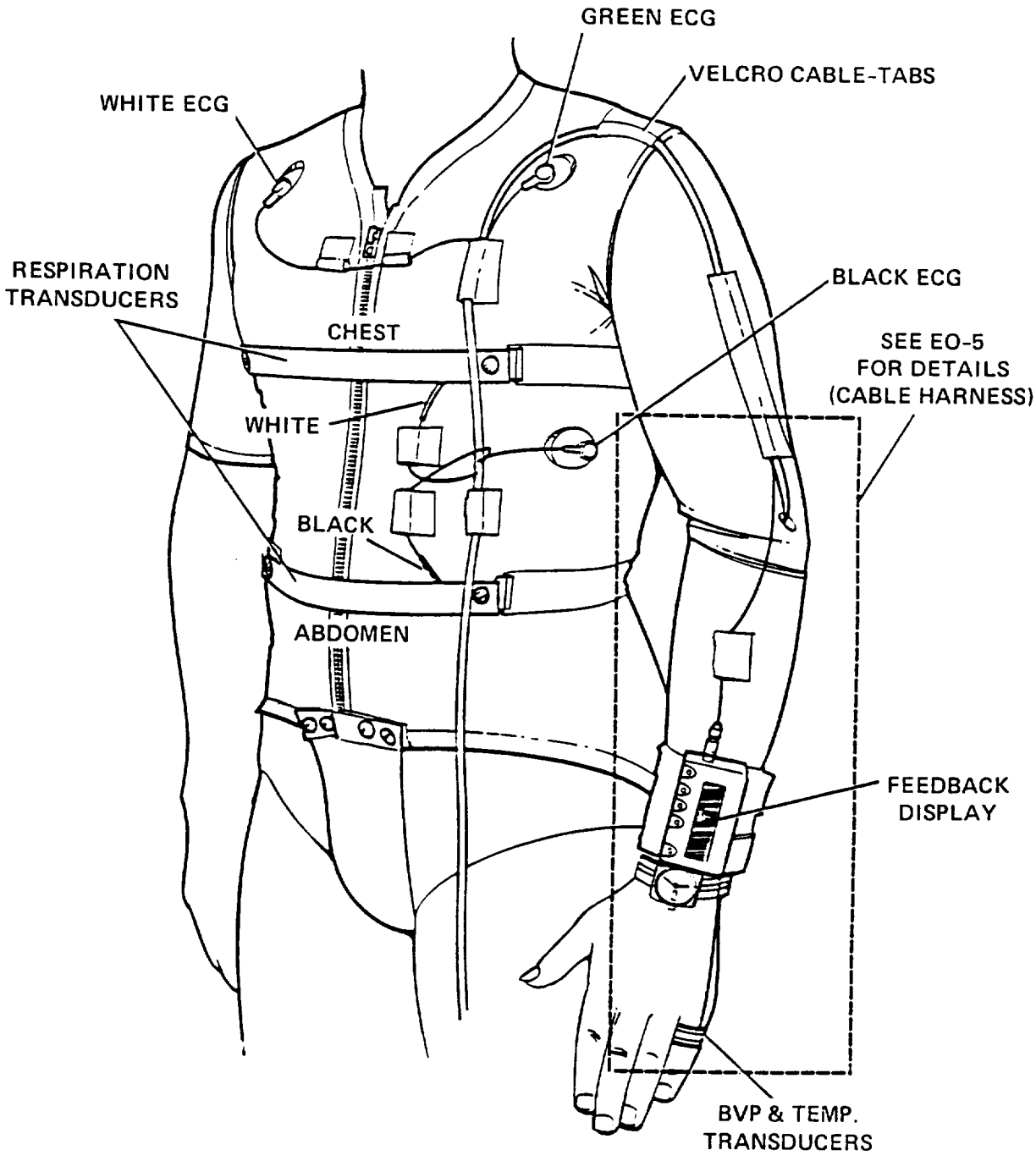
EXPERIMENT OVERVIEW

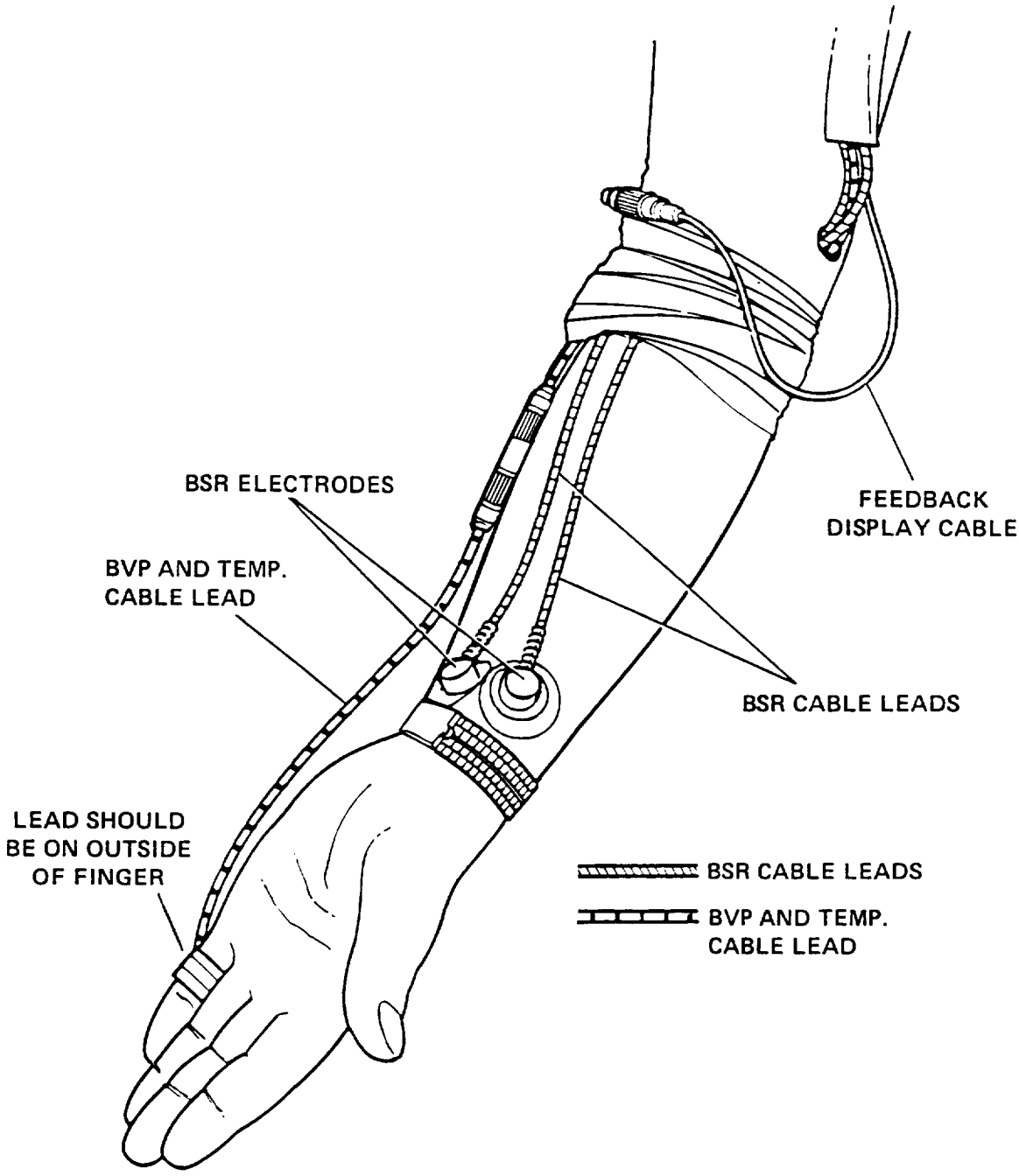
GENERAL INFORMATION

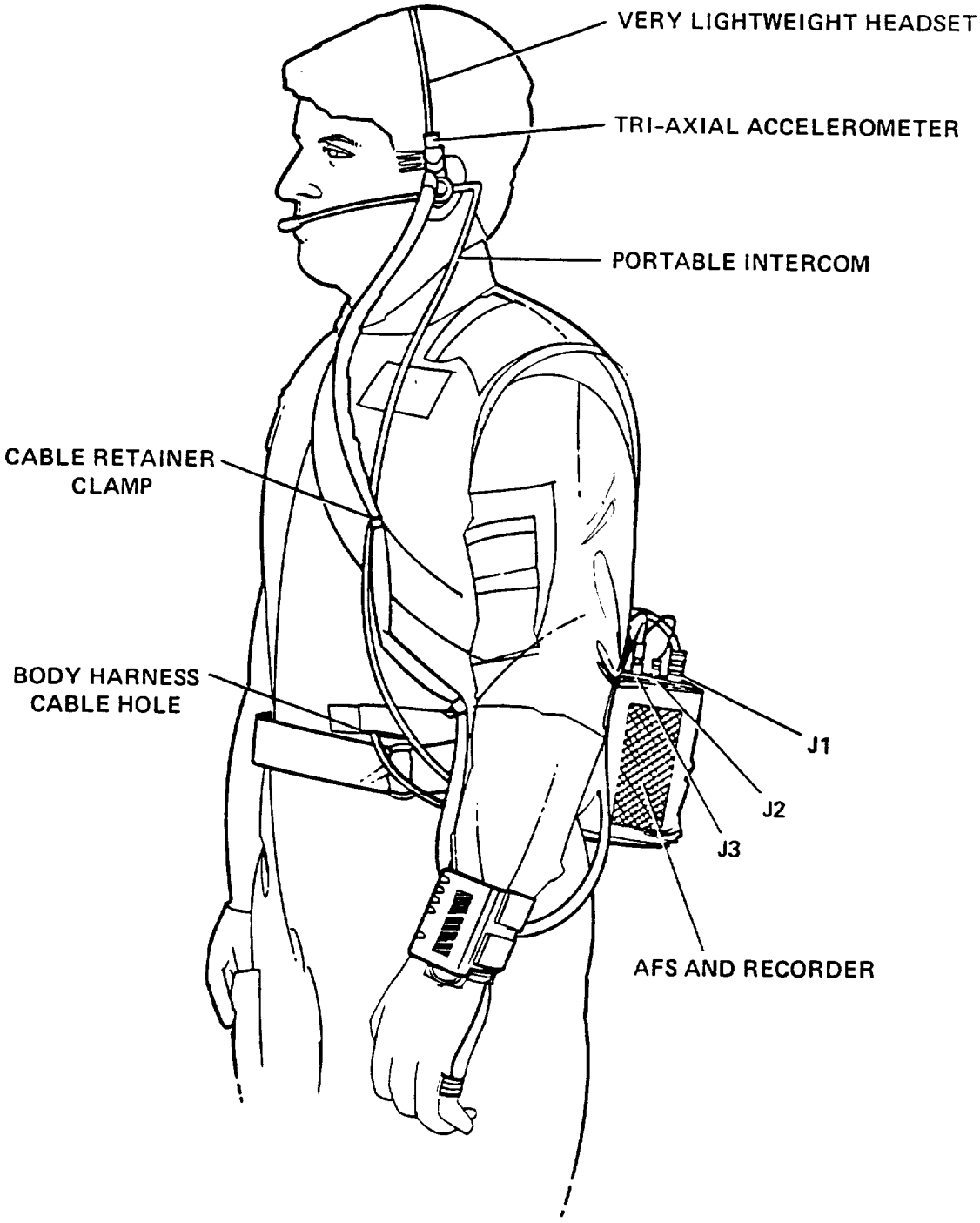
The Autogenic Feedback Training Experiment is designed to assist Shuttle crewmembers in countering the effects of Zero-Gravity Motion Sickness by the use of autogenic feedback methods. The experiment is separated into two major activities: An extensive preflight training activity and self-practice sessions, and the in-flight autogenic feedback activity performed both in timeline practice and symptom contingent modes. In addition, instrumentation will be attached to crewmembers for continuous monitoring of four (4) physiological parameters and acceleration.

Instrumentation for the AFT experiment will consist of electrodes attached to the crewman, a wire harness transmitting the signals from the transducers to the electronics system, a mesh undergarment used both for transducer placement and harness attachment, a belt to hold the electronics system, and a self-contained electronics system. The Autogenic Feedback System (AFS) consists of two (2) units: An analog signal conditioning front-end/cassette data tape recorder unit and a wristwatch feedback display.

CREWMEMBER ENTRY
LAUNCH
DON GARMENT, CONNECT ELECTRODES TO AFS AND INSERT CASSETTE
PROCEDURE 1
ACTIVATE AFS
PROCEDURE 2
REMOVE AFS FROM UNDER SEAT AND DON
PROCEDURE 2
DAILY ACTIVITY
ACTIVATE AFS
PERFORM DIAGNOSTIC SCALE (<1 HR OF RISING)
PROCEDURE 3
PREVENTIVE EXCERCISE SESSIONS (SUBJECTS ONLY)
PROCEDURE 4
CONTINUOUS DAYTIME MONITORING
CHANGE CASSETTE TAPE AFTER 7± 0.5 HRS
PROCEDURE 5
PERFORM DIAGNOSTIC SCALE AFTER CHANGING TAPE
PROCEDURE 3
CONTINUOUS DAYTIME MONITORING
DON GARMENT AND AFS. RECONNECT CABLES AND INSERT NEW CASSETTE
PROCEDURE 1
REPLACE BATTERIES (ODD # DAYS)
PROCEDURE 6
SLEEP
REMOVE TAPE DEACTIVATE AFS STOW
PROCEDURE 9
MET DAY 6 PS ONLY PREP FOR REENTRY
REENTRY
DON GARMENT, CONNECT ELECTRODES TO AFS INSERT CASSETTE AND MOUNT AFS UNDER SEAT
ZERO-G SYMPTOM CONTINGENY ACTIVITY
PUSH INDICATOR BUTTON
PERFORM DIAGNOSTIC SCALE
SYMPTOM CONTINGENT EXERCISES (SUBJECTS ONLY)
PERFORM DIAGNOSTIC SCALE (30 MIN LATER)
PROCEDURE 8


GREEN ECG
VELCRO CABLE-TABS
WHITE ECG
RESPIRATION TRANSDUCERS
BLACK ECG
CHEST
SEE EO-5 FOR DETAILS (CABLE HARNESS)
WHITE
BLACK
ABDOMEN
FEEDBACK DISPLAY
BVP & TEMP. TRANSDUCERS


BSR ELECTRODES
BVP AND TEMP.
CABLE LEAD
FEEDBACK
DISPLAY CABLE
BSR CABLE LEADS
LEAD SHOULD
BE ON OUTSIDE
OF FINGER
BSR CABLE LEADS
BVP AND TEMP.
CABLE LEAD


VERY LIGHTWEIGHT HEADSET
TRI-AXIAL ACCELEROMETER
PORTABLE INTERCOM
CABLE RETAINER CLAMP
BODY HARNESS CABLE HOLE
J1
J2
J3
AFS AND RECORDER

# CHECKLIST

## AFT CHECKLIST

Identical activities take place the first 5 days of the mission with the exceptions noted.

MET day 0: The equipment is donned prior to launch with the exception of the headset, which is donned after launch.

MET day 4: The equipment is removed at the end of the day and stowed

Re-entry day: Payload Specialists only -- the equipment is donned and AFS unit mounted under the seat

1 Upon arising on MET days 1 and 3, change batteries (Procedure 6), don equipment (Procedure 1), and activate AFS unit (Procedure 2). On MET day 2, don equipment and activate AFS unit.

2 Perform diagnostic scale (Procedure 3).

3 SUBJECTS ONLY - Perform preventative session (Procedure 4).

4 Record continuously the physiological responses on each crewmember's cassette tape recorder for 7.5 hours during normal activities.

5 Change tape cassette (Procedure 5).

6 Perform diagnostic scale (Procedure 3).

7 Continuously record activities for additional 7.5 hours. When tape is full, deactivate electronics.

8 Upon retiring each day, remove and stow both used tapes and equipment (Procedure 9).

NOTE

Should symptoms of Space Adaptation Syndrome appear, the subject crewmembers should perform Procedure 8. The control crewmembers should perform Procedure 3.

---

## AUTOGENIC EXERCISES

EXERCISE #1: MUSCLE
EXERCISE #2: WARMTH
EXERCISE #3: CARDIAC
EXERCISE #4: RESPIRATION
EXERCISE #5: ABDOMEN
EXERCISE #6: FOREHEAD

NOMINAL PROCEDURE

1 - AFS EQUIPMENT PLACEMENT AND CONNECTION

| INITIAL CONDITIONS | | | CREW NOTES |
|---|---|---|---|
| | 1 | Verify electrodes are securely attached to body<br><br>*If not, *<br>* perform ELECTRODE REPLACEMENT *<br>* (PROCEDURE-7, pg. NOM-10) * | |
| MF71M | 2 | Open stowage locker | |
| | 3 | Unstow garment | |
| | 4 | Don garment, centering holes over electrodes | |
| | 5 | Unstow respiration transducers and snap on garment | Connectors should face each other on the left side of body |
| | 6 | Unstow cable harness | |
| | 7 | Unstow BVP ring and attach cable connector to harness | |
| | 8 | Extend harness up body and down left arm | |
| | 9 | Retain harness by fastening Velcro clamps around cables | |
| | 10 | Feed BSR and BVP cables through hole on left sleeve | |
| | 11 | Snap cable ECG leads onto correct body electrodes | Green lead - left shoulder<br>White lead - right shoulder<br>Black lead - left side |
| | 12 | Connect harness to respiration transducers | Chest transducer mates to white harness connector. Abdomen transducer mates to black harness connector |
| | 13 | Snap cable leads to BSR electrodes | |
| | 14 | Place BVP ring on finger and secure with tape | |
| | 15 | Close zipper on left sleeve | |

| INITIAL CONDITIONS | | CREW NOTES |
|---|---|---|
| 16 | Unstow and don outer garment | |
| 17 | Bring harness connectors out through hole in outer garment | |
| 18 | Unstow display unit and secure display Velcro band around wrist | |
| 19 | Connect display to harness and restrain display cable with Velcro on left sleeve | |
| 20 | Unstow belt and pouch containing AFS unit | |
| 21 | Unstow cassette tapes (two) Place cassette 'B' in pouch pocket | Cassettes are labeled by mission day. |
| 23 | Connect harness to AFS connector No. J1 and J2 | |
| 24 | Unstow log book and place in belt pouch or in pocket of outer garment | |
| 25 | Close stowage locker | |
| 26 | Remove Lightweight Headset from stowage and place on head | |
| 27 | Connect accelerometer cable (tied to headset cable) to AFS connector No. J3 | |
| 28 | Proceed to AFS ACTIVATION (PROCEDURE-2, pg. NOM-4) | |

| INITIAL CONDITIONS | CREW NOTES |
|---|---|
| 1 AFS POWER sw - ON<br>Wrist display reads:<br><br>AFS<br>CREW ID = 0 V1.4 | NOTE: V1.4 refers to the software version in use. Crewmembers should ignore. |
| 2 Push INC or DEC keys to set assigned crew i.d. number | MS-1 ID=2<br>INC = Increment MS-3 ID=4<br>DEC = Decrement PS-F ID=3<br>PS-M ID=5 |
| 3 Push MODE key once<br>Wrist display reads:<br><br>Tape ID = 0A | The first digit refers to MET day: 0-9; the second digit refers to first or second tape of the day: A or B, respectively |
| 4 Push INC or DEC keys to set tape i.d. | |
| 5 Push MODE key once<br>Wrist display reads:<br><br>SUBJECTS CONTROLS<br><br>HR=60* BVP=500 HR= * BVP=<br>RR=12 BSR=500 RR= BSR= | Now in EQUIPMENT CHECKOUT Mode<br><br>The numbers shown on the SUBJECT display are typical values. The data fields on the CONTROL display will be blank unless there is an error message |
| 6 Verify that no errors appear on the display<br>* If 'HI', 'LO', '0' appears in data *<br>* fields, OR if 'X', 'Y', 'Z', or 'T' *<br>* appears before the BSR field, *<br>* Go to MAL procedures * | |
| 7 Push MODE key once<br>✓'*' disappears<br><br>NOTE<br>Transient errors may occur at this time. If error remains displayed for more than 1 minute, go to MAL procedures. | Now in DATA COLLECTION Mode |
| 8 Record MET in DIAGNOSTIC SCALE log book | |
| 9 Go to SELF-ADMINISTERED DIAGNOSTIC SCALE (PROCEDURE-3, pg. NOM-5) | |

## 3 - SELF-ADMINISTERED DIAGNOSTIC SCALE

| INITIAL CONDITIONS | CREW NOTES |
|---|---|
| . . . . . .SYMPTOM CONTINGENT OPS . . . . . | |
| . 1 Push EXEC key twice<br>. Display will blink off, then on again | Marks the start of<br>the procedure on tape |
| 2 Note in log book:<br>ID number and on relative rating scales, check off the level of each class of symptom indicating your present condition and any pertinent commentary | |
| . . . . . .SYMPTOM CONTINGENT OPS . . . . . | |
| . 3 Push EXEC key twice<br>. SUBJECTS CONTROLS<br>. HR=60* BVP=500 HR= * BVP=<br>. RR=12 BSR=500 RR= BSR= | Indicates end of<br>procedure |

## SUMMARY OF DIAGNOSTIC SCALE

CREWMEMBER _____ MISSION DAY _____ TIME _____

DIAGNOSTIC CRITERIA SCALE – SPACE ADAPTATION SYNDROME

| MALAISE LEVEL | POINTS | VMT | TMP | DIZ | HAC | DRZ | SWT | PAL | SAL | NSA | ED | EA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PATHOGNOMIC | 16 | I | | | | | | | | | | |
| MAJOR | 8 | | | | | III | III | III | III | II,III | | |
| MINOR | 4 | | | | | II | II | II | II | I | | |
| MINIMAL | 2 | | | | | I | I | I | I | | I | |
| AOS | 1 | | I,II | I,II | I | | | | | | | I |

This section is a shorthand description of the criteria used in assigning levels of malaise

LEVELS OF SEVERITY IDENTIFIED BY TOTAL POINTS SCORED

| FRANK SICKNESS (S) | SEVERE MALAISE (MIII) | MODERATE A (MIIA) | MODERATE B (MIIB) | SLIGHT MALAISE (MI) |
|---|---|---|---|---|
| 16 POINTS | 8-15 POINTS | 5-7 POINTS | 3-4 POINTS | 1-2 POINTS |

This section is the working section to be used for two events per sheet

| | TIME-LINED | SYMP CONT. | SYMPTOMS OBSERVED VMT | TMP | DIZ | HAC | DRZ | SWT | PAL | SAL | NSA | ED | EA | TOTAL POINTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| * | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | |
| | | | | | | | | | | | | | | |

COMMENTS: _____

* Box 1 or 2 - Should be checked to determine whether the session is a timelined activity or a symptom contingent one

Box 3 'VMT' - VOMITING is not differentiated with respect to level, if symptom is observed, record 'I'

Box 4 'TMP' - INCREASED BODY TEMP is reported in two levels. Record 'I' for mild-to-moderate or 'II' for moderate-to-severe

Box 5 'DIZ' - DIZZINESS/VERTIGO is reported in two levels. Record 'I' for mild-to-moderate or 'II' for moderate-to-severe

Box 6 'HAC' - HEADACHE is reported to two levels. Record 'I' for mild-to-moderate or 'II' for moderate-to-serve

Box 7 'DRZ' - DROWSINESS is reported as 'I' - mild, 'II' - moderate, or 'III' - severe

Box 8 'SWT' - SWEATING is reported as 'I' - mild, 'II' - moderate, or 'III' - severe

Box 9 'PAL' - FACIAL PALLOR is reported as 'I' - mild, 'II' - moderate, or 'III' - severe

Box 10 'SAL' - INCREASED SALIVATION is reported as 'I' - mild, 'II' - moderate, or 'III' - severe

Box 11 'NSA' - NAUSEA is reported as 'I' - mild, 'II' - moderate, or 'III' - severe

Box 12 'ED' - EPIGASTRIC DISCOMFORT describes the symptoms as not nausea, but increased sensations in the stomach. It is not considered uncomfortable (e.g., pressure or fullness in stomach). Record 'I' if this symptom is present

Box 13 'EA' - EPIGASTRIC AWARENESS describes the symptoms as not nausea, but becoming uncomfortable (e.g., lump in throat, knot in stomach). Record 'I' if this symptom is present

## 4 - PREVENTIVE AFT EXERCISE SESSION

| INITIAL CONDITIONS<br>Only the SUBJECT group crewmembers are required to perform this procedure | | CREW NOTES |
|---|---|---|
| | NOTE<br>AFT EXERCISE SESSION should be performed in an area providing minimal distractions | |
| 1 | Secure self in a stationary position such that no muscle tension is needed to maintain posture | Strap into bunk if possible |
| 2 | Push EXEC key twice<br>Display will blink off, then on again | Marks start of procedure |
| 3 | Using display unit,<br>Regulate autonomic reponse levels in manner prescribed during preflight training | |
| 4 | At end of session,<br>Push EXEC key twice | Marks end of procedure |

## 5 - CASSETTE TAPE CHANGEOUT

| INITIAL CONDITIONS | CREW NOTES |
|---|---|
| Make sure display is connected to cable harness before proceeding with tape changeout. | |
| 1 Push MODE key<br>Display reads:<br><br>CHANGE TAPE?<br>MODE = YES | |
| 2 Push MODE key<br>Display reads:<br><br>TAPE ID = XX | Tape has now stopped<br><br>Display will show the last tape ID entered |
| 3 Open pouch flap | |
| 4 Lift AFS access cover | |
| 5 Rotate head lever ccw to retract heads | |
| 6 Remove 'used' tape, Temporarily tuck in belt | |
| 7 Remove 'new' tape from pocket on AFS pouch and install in AFS | |
| 8 Rotate head lever cw to reposition heads | |
| 9 Close AFS access cover | |
| 10 Close pouch flap | |
| 11 Stow 'used' tape in pocket on AFS pouch | |
| 12 Reactivate AFS (PROCEDURE-2, pg. NOM-4, step 4) | |

## 6 - BATTERY REPLACEMENT

| INITIAL CONDITIONS | | CREW NOTES |
|---|---|---|
| MF71M | 1 Open stowage locker | |
| | 2 Obtain AFS | |
| | 3 /AFS POWER sw - OFF | |
| | 4 Remove AFS from belt pouch | |
| | 5 Unscrew battery retaining screws (four) | |
| | 6 Remove battery pack from AFS and disconnect cable | |
| | 7 Unstow new battery and stow expended battery in vacant slot in locker | |
| | 8 Remove new battery from sealed bag | |
| | 9 Discard bag in S/L trash | |
| | NOTE<br>When installing battery, writing on connector should be showing | |
| | 10 Connect battery cable and insert fresh battery pack into AFS | |
| | 11 Tighten battery retaining screws (four) | |
| | 12 Replace AFS in belt pouch and temporarily restow in stowage locker | |
| | 13 Proceed to AFS EQUIPMENT PLACEMENT AND CONNECTION (PROCEDURE-1, pg. NOM-2) | |

## 7 - ELECTRODE REPLACEMENT

| INITIAL CONDITIONS | | CREW NOTES |
|---|---|---|
| 1 | Remove loose electrode(s) and discard in S/L trash | |
| 2 | Open AFT stowage locker | BSR ELECTRODES STWG - MF710<br>ECG ELECTRODES STWG - MF71M |
| 3 | Unstow packet of DIAGNOSTIC ECG ELECTRODES used for BSR or QUICK PREP ECG electrodes and alcohol wipes | Use alcohol wipes to clean skin before replacing ECG electrodes. DO NOT clean skin on wrist before replacing BSR electrodes. |
| 4 | Slide card of electrodes from packet | |
| 5 | Remove electrode from card | |
| 6 | Place on desired location | |
| 7 | Restow packet of electrodes | |
| 8 | Close AFT stowage locker | |

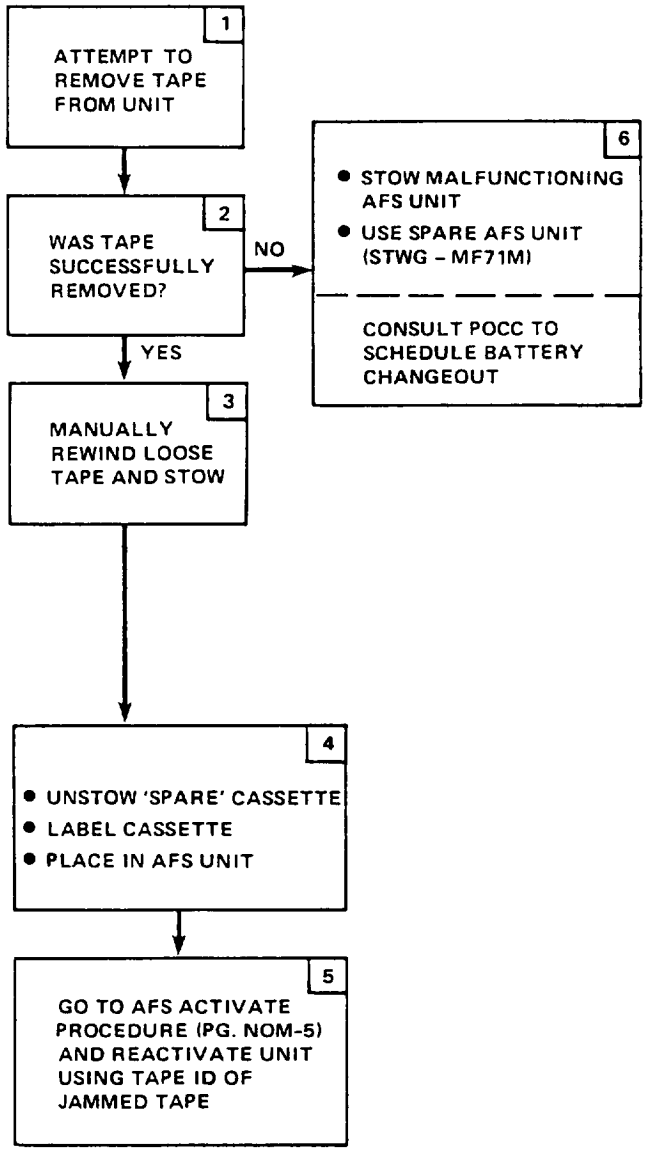
## 8 - SYMPTOM CONTINGENT COUNTERACTIVE AFT SESSIONS

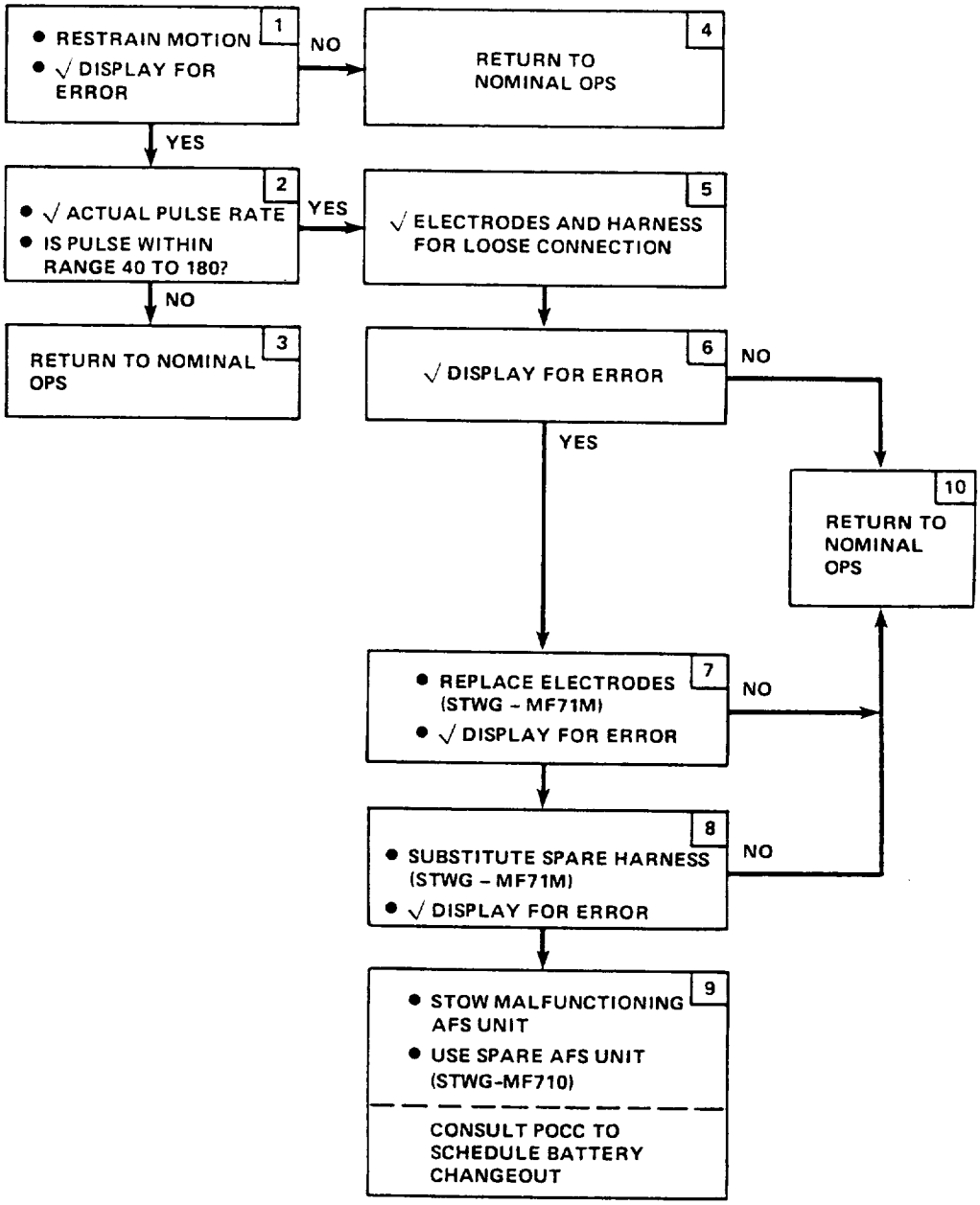
| INITIAL CONDITIONS | CREW NOTES |
|---|---|
| Only the SUBJECT group crewmembers are required to perform this procedure | |
| NOTE<br>SYMPTOM CONTINGENT COUNTERACTIVE AFT SESSIONS should be performed (if possible) in an area providing minimal distractions | If necessary, this session can be performed while mission ops activity is in progress |
| 1 Secure self in a stationary position such that nomuscle tension is required to maintain posture | |
| 2 Perform SELF-ADMINISTERED DIAGNOSTIC SCALE (PROCEDURE-3, pg. NOM-5) | |
| 3 Using display unit,<br>Regulate autonomic response levels in manner prescribed during preflight training | |
| 4 After 30 minutes or at cessation of symptoms (whichever occurs first), Perform a second SELF-ADMINISTERED DIAGNOSTIC SCALE (PROCEDURE-3, pg. NOM-5) | |

## 9 - AFS EQUIPMENT REMOVAL AND STOWAGE

| INITIAL CONDITIONS | | | CREW NOTES |
|---|---|---|---|
| | 1 | AFS POWER sw - OFF | |
| MF71M | 2 | Open stowage locker | |
| | 3 | Open cassette pocket on the pouchand remove used tape | |
| | 4 | Stow cassette tape in sequence | |
| | 5 | Disconnect AFS from harness and accelerometer | |
| | 6 | Remove and stow Lightweight Headset according to usual procedures | |
| | 7 | Remove belt/pouch with AFS from body | |
| | 8 | Open pouch flap | |
| | 9 | Lift AFS access cover | |
| | 10 | Remove cassette tape | |
| | 11 | Stow cassette tape in sequence | |
| | 12 | Rotate head lever ccw to retract heads | |
| | 13 | Insert cassette 'A' for next day | |
| | 14 | Rotate head lever cw to reposition heads | |
| | 15 | Close access cover | |
| | 16 | close pouch flap | |
| | 17 | Fold and stow belt with pouch containing AFS in stowage locker | |
| | 18 | Unfasten wrist display unit<br>Fold and stow display unit | |
| | 19 | Remove outer garment and secure | |
| | 20 | Remove BVP transducer from finger | |
| | 21 | Disconnect BVP transducer from harness and stow | |

| INITIAL CONDITIONS | | CREW NOTES |
|---|---|---|
| 22 | Disconnect harness from remaining transducers and electrodes | |
| 23 | Unfasten Velcro harness retainers | |
| 24 | Remove harness | |
| 25 | Fold and stow harness | |
| 26 | Unsnap and stow respiration transducers | |
| 27 | Remove, fold, and stow garment | |
| 28 | Close stowage locker | |

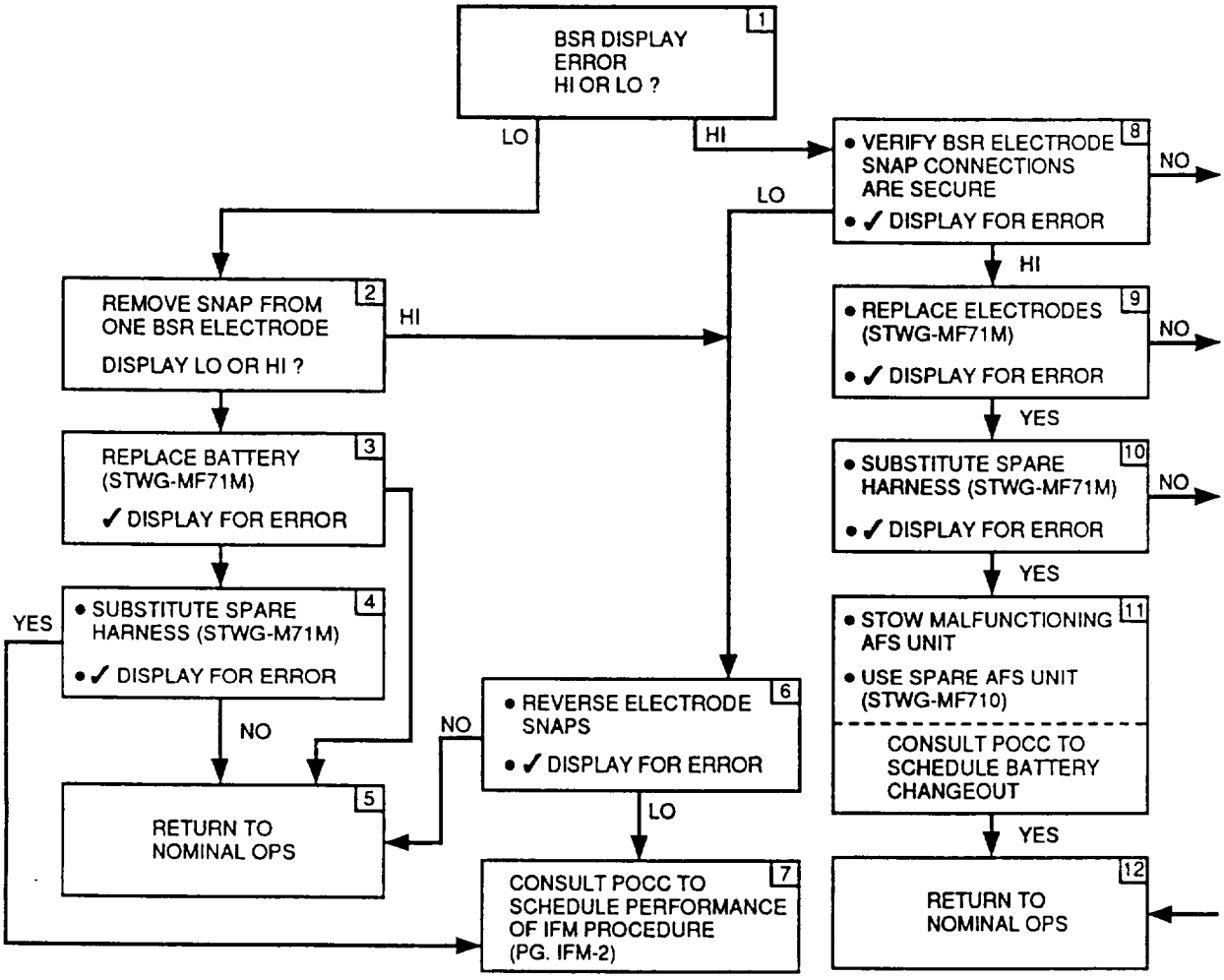

1
ATTEMPT TO REMOVE TAPE FROM UNIT
2
WAS TAPE SUCCESSFULLY REMOVED?
NO
YES
6
• STOW MALFUNCTIONING AFS UNIT
• USE SPARE AFS UNIT (STWG – MF71M)
CONSULT POCC TO SCHEDULE BATTERY CHANGEOUT
3
MANUALLY REWIND LOOSE TAPE AND STOW
4
• UNSTOW 'SPARE' CASSETTE
• LABEL CASSETTE
• PLACE IN AFS UNIT
5
GO TO AFS ACTIVATE PROCEDURE (PG. NOM-5) AND REACTIVATE UNIT USING TAPE ID OF JAMMED TAPE

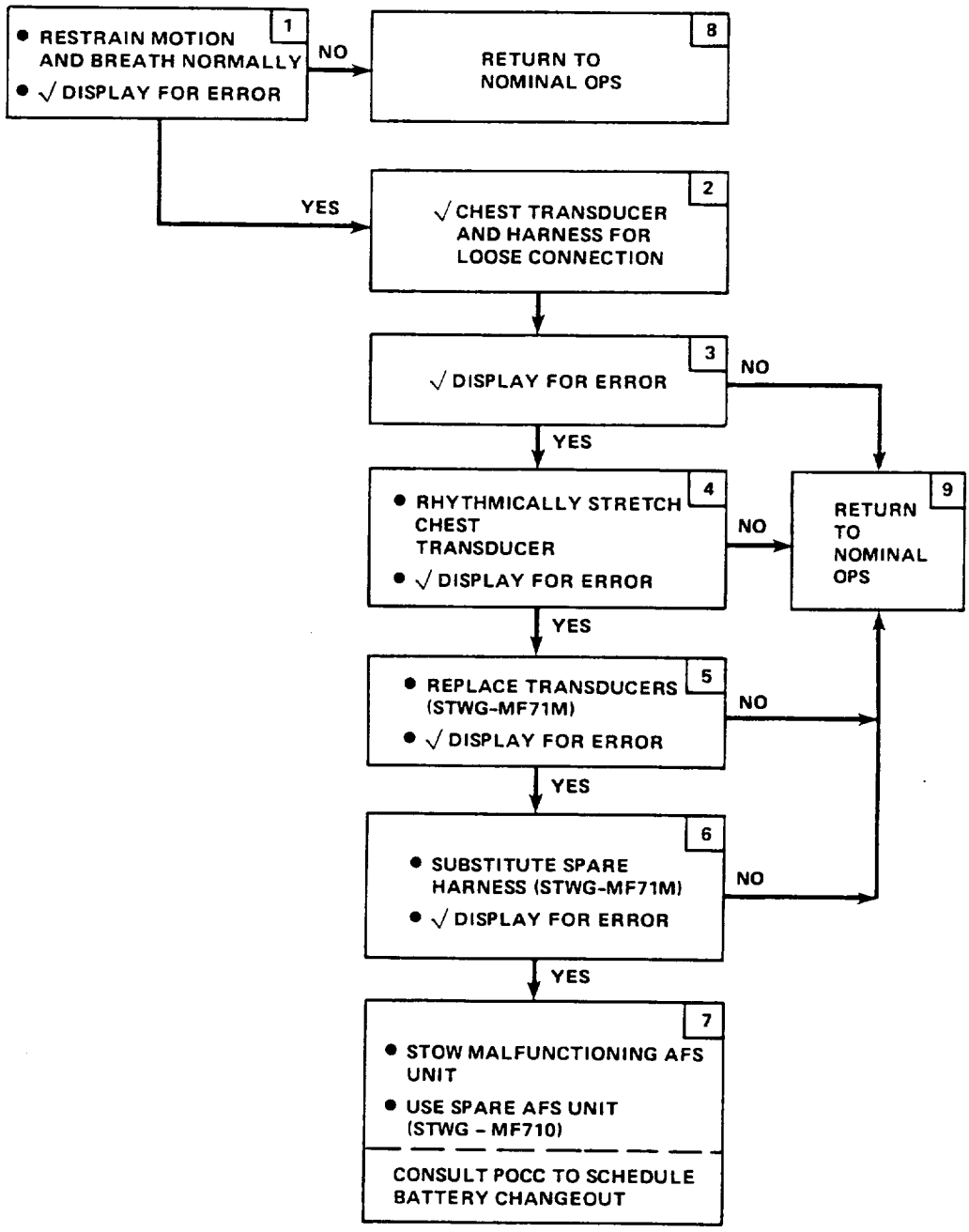

1
• RESTRAIN MOTION
• √ DISPLAY FOR ERROR
NO
4
RETURN TO NOMINAL OPS
YES
2
• √ ACTUAL PULSE RATE
• IS PULSE WITHIN RANGE 40 TO 180?
YES
5
√ ELECTRODES AND HARNESS FOR LOOSE CONNECTION
NO
3
RETURN TO NOMINAL OPS
6
√ DISPLAY FOR ERROR
NO
YES
10
RETURN TO NOMINAL OPS
7
• REPLACE ELECTRODES (STWG - MF71M)
• √ DISPLAY FOR ERROR
NO
8
• SUBSTITUTE SPARE HARNESS (STWG - MF71M)
• √ DISPLAY FOR ERROR
NO
9
• STOW MALFUNCTIONING AFS UNIT
• USE SPARE AFS UNIT (STWG-MF710)
CONSULT POCC TO SCHEDULE BATTERY CHANGEOUT

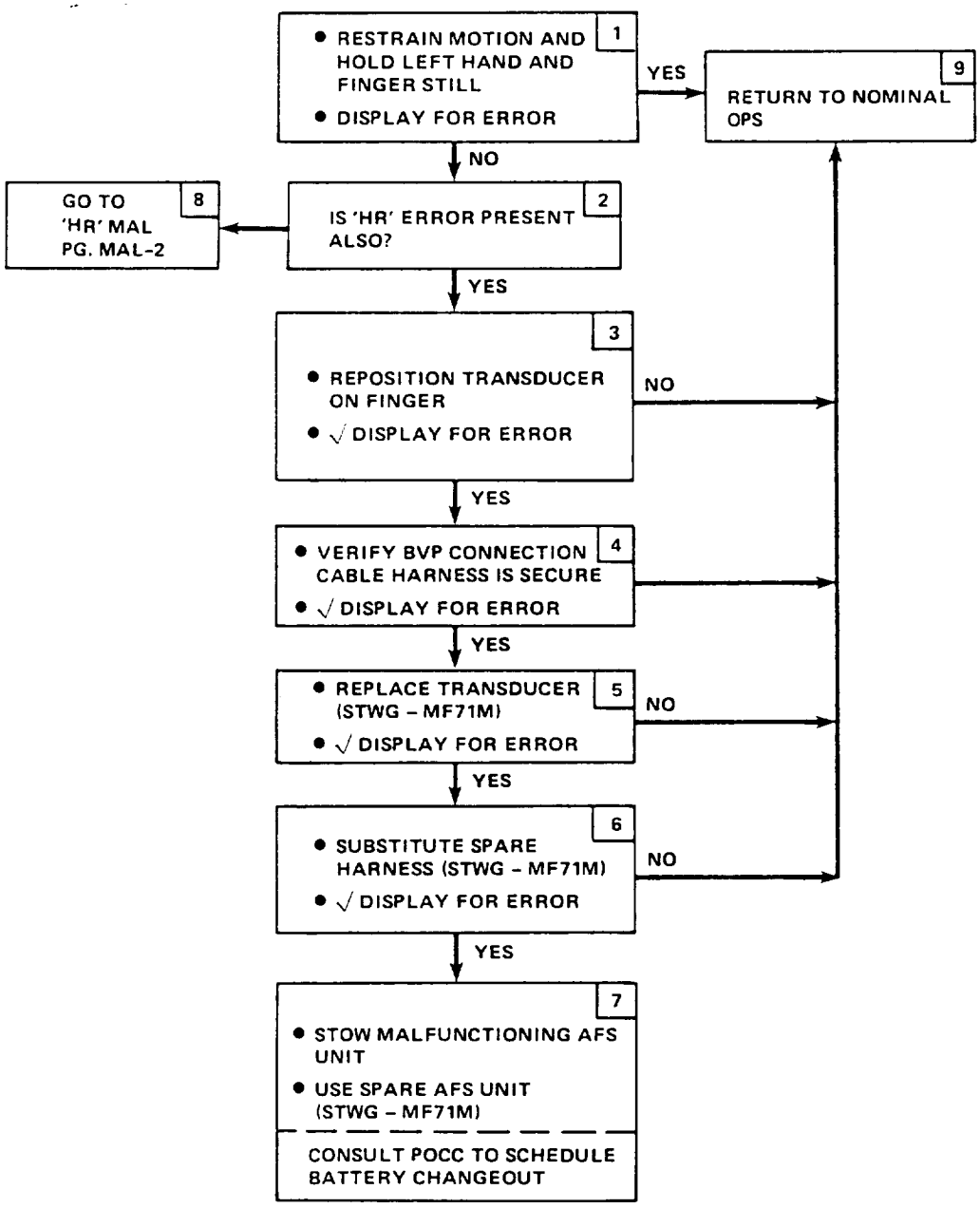
# BSR = HI OR LO

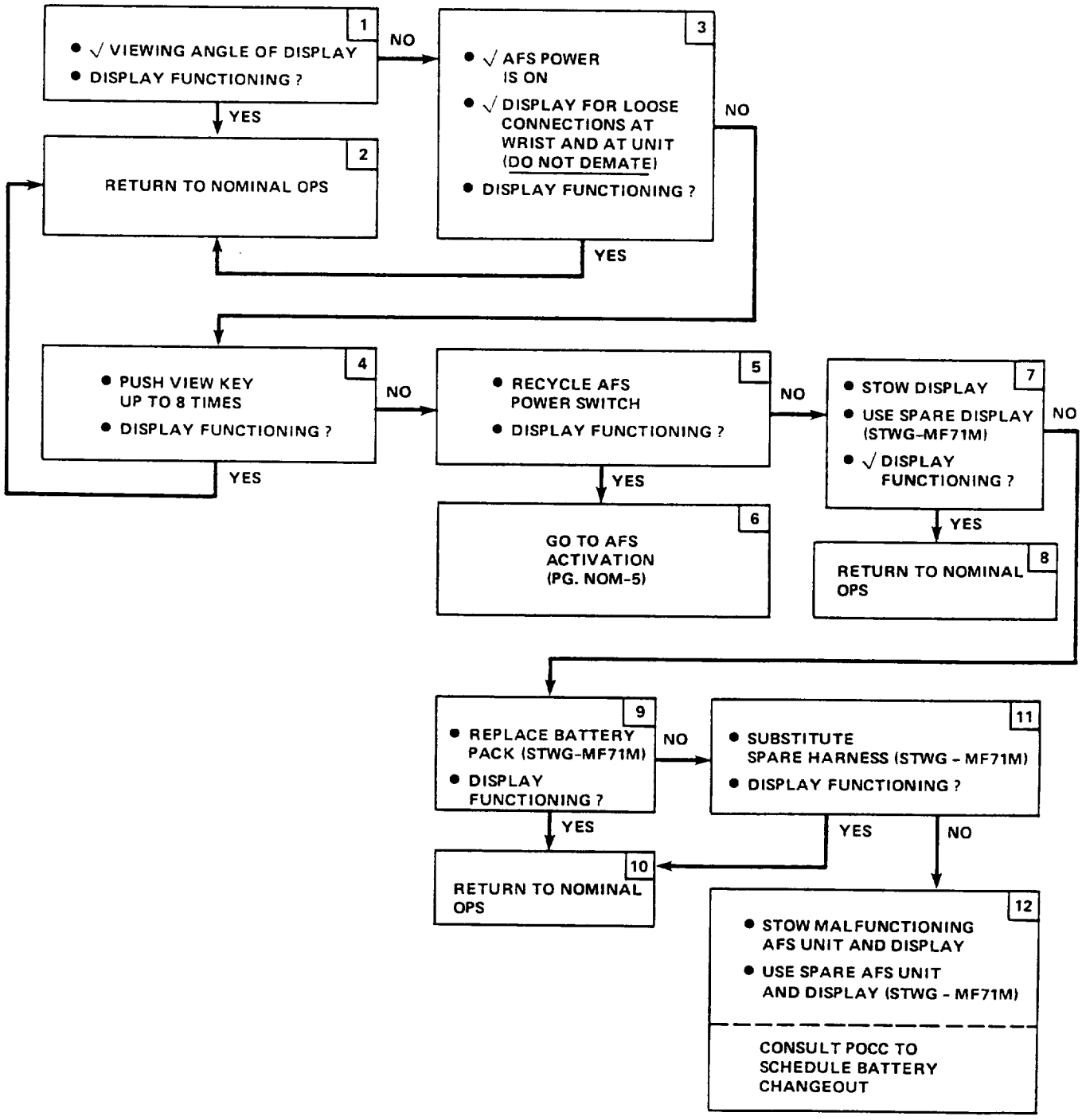
SYMPTOM: BSR SIGNAL RECOGNIZED AS INCORRECT

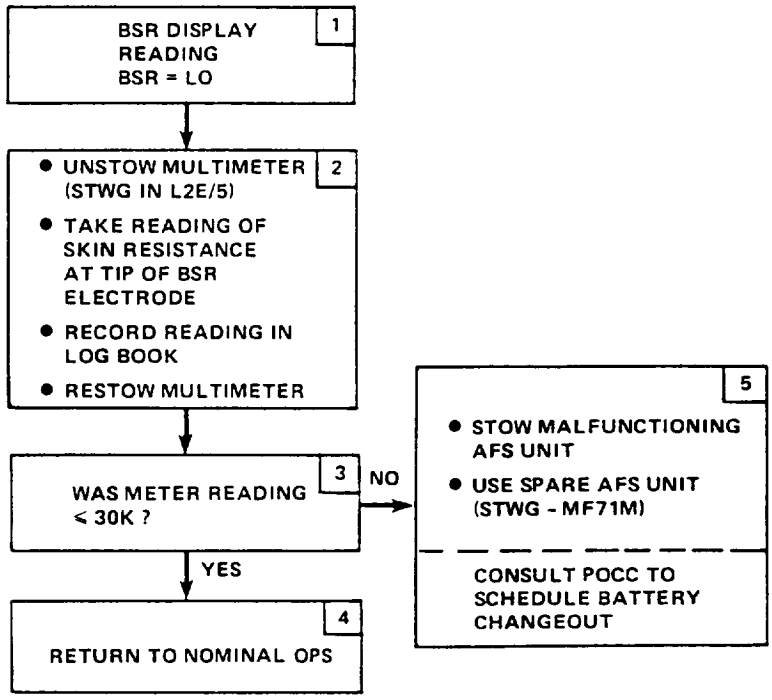
CREW RESPONSE:

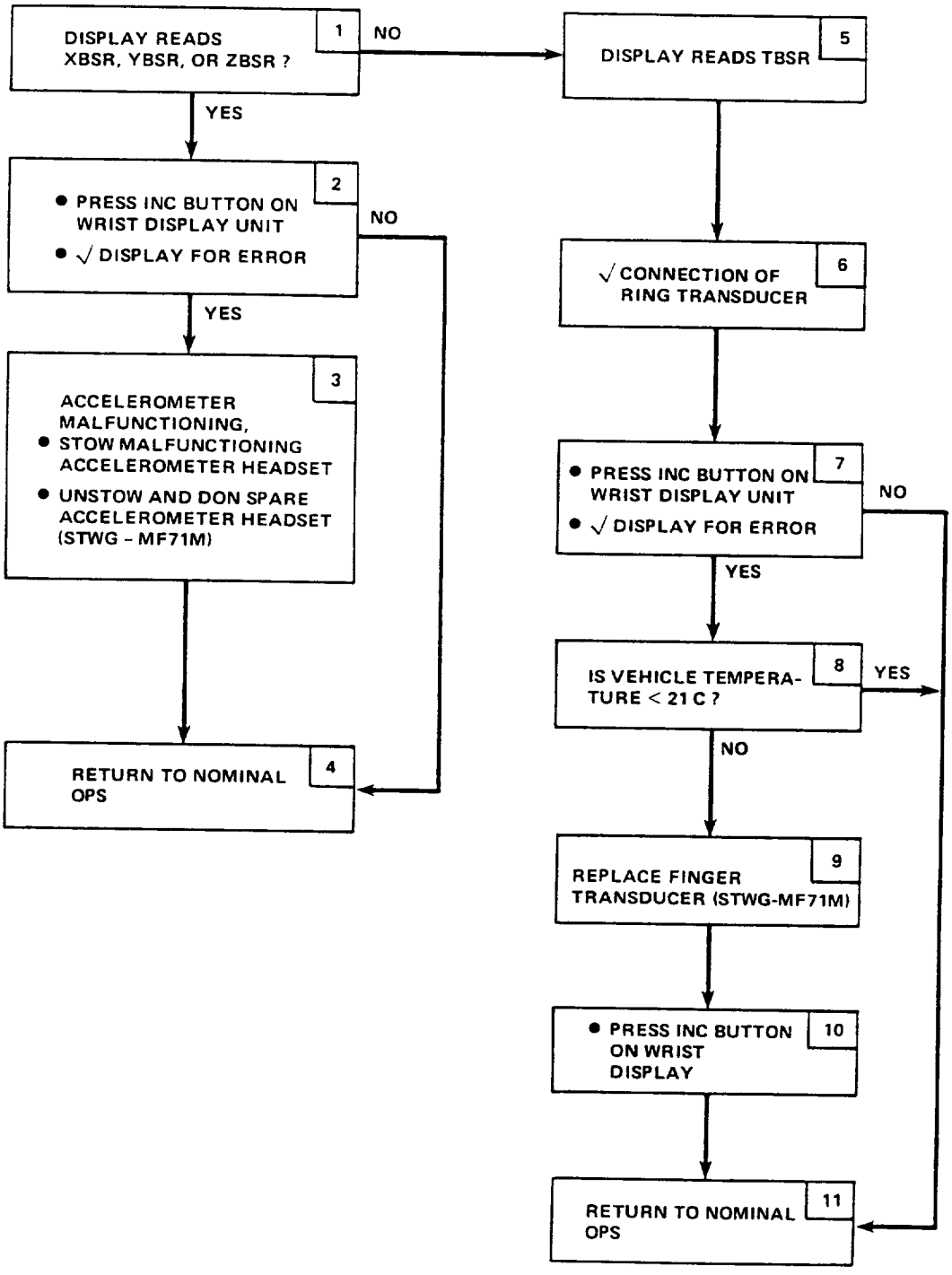



1
• RESTRAIN MOTION AND BREATH NORMALLY
• √ DISPLAY FOR ERROR
NO
8
RETURN TO NOMINAL OPS
YES
2
√ CHEST TRANSDUCER AND HARNESS FOR LOOSE CONNECTION
3
√ DISPLAY FOR ERROR
NO
YES
4
• RHYTHMICALLY STRETCH CHEST TRANSDUCER
• √ DISPLAY FOR ERROR
NO
9
RETURN TO NOMINAL OPS
YES
5
• REPLACE TRANSDUCERS (STWG-MF71M)
• √ DISPLAY FOR ERROR
NO
YES
6
• SUBSTITUTE SPARE HARNESS (STWG-MF71M)
• √ DISPLAY FOR ERROR
NO
YES
7
• STOW MALFUNCTIONING AFS UNIT
• USE SPARE AFS UNIT (STWG - MF710)
CONSULT POCC TO SCHEDULE BATTERY CHANGEOUT


1
• RESTRAIN MOTION AND HOLD LEFT HAND AND FINGER STILL
• DISPLAY FOR ERROR
YES
9
RETURN TO NOMINAL OPS
NO
8
GO TO 'HR' MAL PG. MAL-2
2
IS 'HR' ERROR PRESENT ALSO?
YES
3
• REPOSITION TRANSDUCER ON FINGER
• √ DISPLAY FOR ERROR
NO
YES
4
• VERIFY BVP CONNECTION CABLE HARNESS IS SECURE
• √ DISPLAY FOR ERROR
YES
5
• REPLACE TRANSDUCER (STWG – MF71M)
• √ DISPLAY FOR ERROR
NO
YES
6
• SUBSTITUTE SPARE HARNESS (STWG – MF71M)
• √ DISPLAY FOR ERROR
NO
YES
7
• STOW MALFUNCTIONING AFS UNIT
• USE SPARE AFS UNIT (STWG – MF71M)
CONSULT POCC TO SCHEDULE BATTERY CHANGEOUT


1
• √ VIEWING ANGLE OF DISPLAY
• DISPLAY FUNCTIONING ?
NO
YES
2
RETURN TO NOMINAL OPS
3
• √ AFS POWER IS ON
• √ DISPLAY FOR LOOSE CONNECTIONS AT WRIST AND AT UNIT (DO NOT DEMATE)
• DISPLAY FUNCTIONING ?
NO
YES
4
• PUSH VIEW KEY UP TO 8 TIMES
• DISPLAY FUNCTIONING ?
NO
YES
5
• RECYCLE AFS POWER SWITCH
• DISPLAY FUNCTIONING ?
NO
YES
6
GO TO AFS ACTIVATION (PG. NOM-5)
7
• STOW DISPLAY
• USE SPARE DISPLAY (STWG-MF71M)
• √ DISPLAY FUNCTIONING ?
NO
YES
8
RETURN TO NOMINAL OPS
9
• REPLACE BATTERY PACK (STWG-MF71M)
• DISPLAY FUNCTIONING ?
NO
YES
10
RETURN TO NOMINAL OPS
11
• SUBSTITUTE SPARE HARNESS (STWG - MF71M)
• DISPLAY FUNCTIONING ?
YES
NO
12
• STOW MALFUNCTIONING AFS UNIT AND DISPLAY
• USE SPARE AFS UNIT AND DISPLAY (STWG - MF71M)
CONSULT POCC TO SCHEDULE BATTERY CHANGEOUT

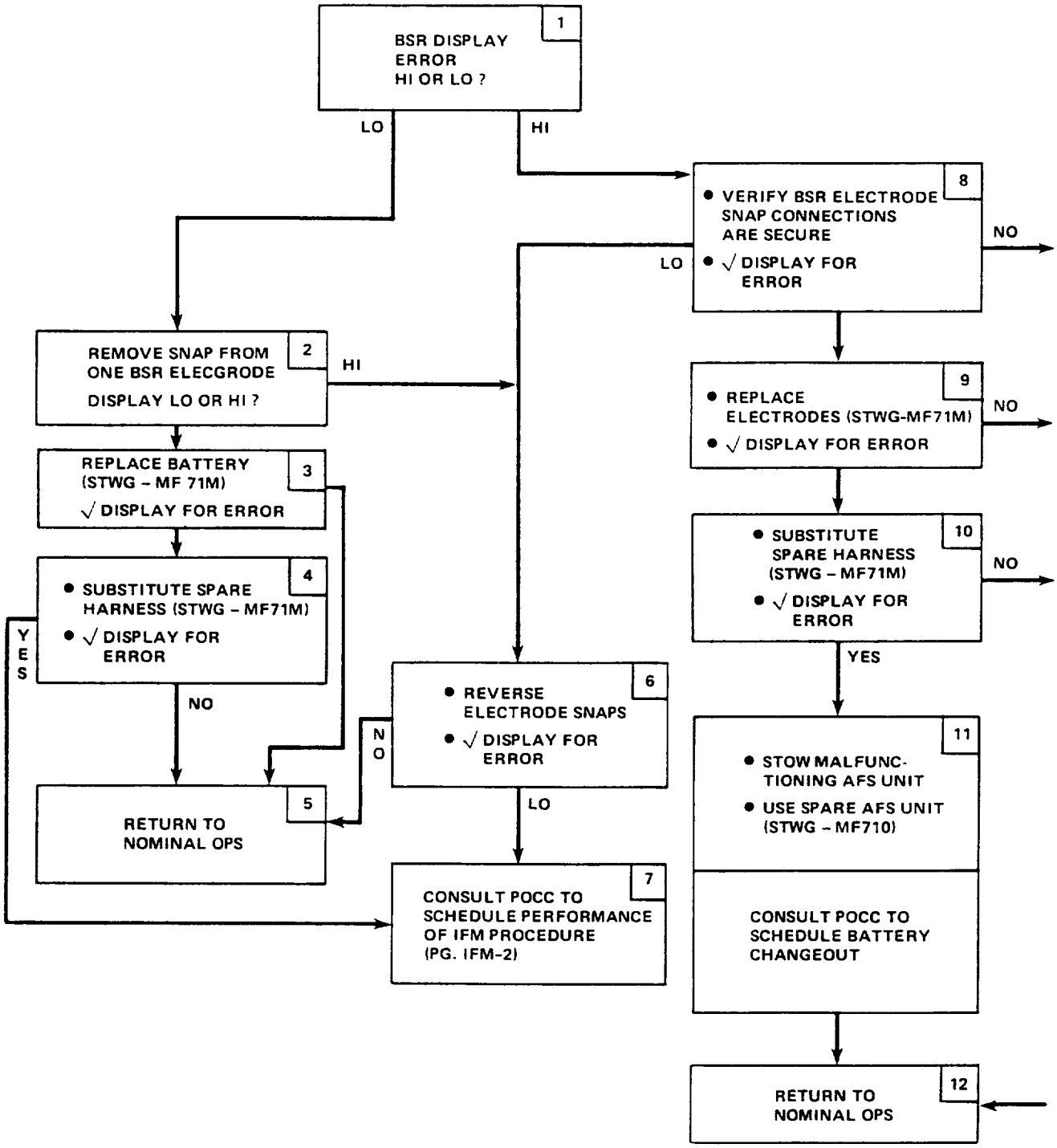

BSR DISPLAY READING BSR = LO
1
• UNSTOW MULTIMETER (STWG IN L2E/5)
• TAKE READING OF SKIN RESISTANCE AT TIP OF BSR ELECTRODE
• RECORD READING IN LOG BOOK
• RESTOW MULTIMETER
2
WAS METER READING ≤ 30K ?
3
NO
YES
RETURN TO NOMINAL OPS
4
• STOW MALFUNCTIONING AFS UNIT
• USE SPARE AFS UNIT (STWG - MF71M)
CONSULT POCC TO SCHEDULE BATTERY CHANGEOUT
5


1
DISPLAY READS XBSR, YBSR, OR ZBSR ?
NO
YES
2
• PRESS INC BUTTON ON WRIST DISPLAY UNIT
• √ DISPLAY FOR ERROR
NO
YES
3
ACCELEROMETER MALFUNCTIONING,
• STOW MALFUNCTIONING ACCELEROMETER HEADSET
• UNSTOW AND DON SPARE ACCELEROMETER HEADSET (STWG - MF71M)
4
RETURN TO NOMINAL OPS
5
DISPLAY READS TBSR
6
√ CONNECTION OF RING TRANSDUCER
7
• PRESS INC BUTTON ON WRIST DISPLAY UNIT
• √ DISPLAY FOR ERROR
NO
YES
8
IS VEHICLE TEMPERATURE < 21 C ?
YES
NO
9
REPLACE FINGER TRANSDUCER (STWG-MF71M)
10
• PRESS INC BUTTON ON WRIST DISPLAY
11
RETURN TO NOMINAL OPS

IN-FLIGHT MAINTENANCE

NOTE:

APPROVAL TO PERFORM IFM PROCEDURES AND THE SCHEDULING OF THE IFM PERFORMANCE MUST BE RECEIVED FROM POCC/MCC PRIOR TO PROCEEDING


1
BSR DISPLAY ERROR HI OR LO ?
LO
HI
8
• VERIFY BSR ELECTRODE SNAP CONNECTIONS ARE SECURE
• √ DISPLAY FOR ERROR
NO
LO
2
REMOVE SNAP FROM ONE BSR ELECGRODE
DISPLAY LO OR HI ?
HI
9
• REPLACE ELECTRODES (STWG-MF71M)
• √ DISPLAY FOR ERROR
NO
3
REPLACE BATTERY (STWG - MF 71M)
√ DISPLAY FOR ERROR
10
• SUBSTITUTE SPARE HARNESS (STWG - MF71M)
• √ DISPLAY FOR ERROR
NO
4
• SUBSTITUTE SPARE HARNESS (STWG - MF71M)
• √ DISPLAY FOR ERROR
YES
YES
NO
6
• REVERSE ELECTRODE SNAPS
• √ DISPLAY FOR ERROR
NO
11
• STOW MALFUNCTIONING AFS UNIT
• USE SPARE AFS UNIT (STWG - MF710)
5
RETURN TO NOMINAL OPS
LO
7
CONSULT POCC TO SCHEDULE PERFORMANCE OF IFM PROCEDURE (PG. IFM-2)
CONSULT POCC TO SCHEDULE BATTERY CHANGEOUT
12
RETURN TO NOMINAL OPS

APPENDIX C

PROCEDURES FOR SELF-ADMINISTERING DIAGNOSTIC SCALE INFLIGHT

Note: This procedure is identical for time-lined and symptom-contingent sessions.

1. Crewmember removes diagnostic booklet (3" X 5" spiral notepad) and pencil from pocket and opens to a blank page. Each page in this diagnostic booklet will be printed as follows:

MISSION

CREWMEMBER---------- DAY ---------- TIME ----------

DIAGNOSTIC CRITERIA SCALE - SPACE ADAPTATION SYNDROME

| MALAISE LEVEL | POINTS | VMT | TMP | DIZ | HAC | DRZ | SWT | PAL | SAL | NSA | ED | EA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PATHOGNOMIC | 16 | I | | | | | | | | | | |
| MAJOR | 8 | | | | | III | III | III | III | II,III | | |
| MINOR | 4 | | | | | II | II | II | II | I | | |
| MINIMAL | 2 | | | | | I | I | I | I | | I | |
| AQS | 1 | | I,II | I,II | I | | | | | | | I |

Levels of Severity Identified by Total Points Scored

| FRANK SICKNESS (S) | SEVERE MALAISE (MIII) | MODERATE-A (MIIA) | MODERATE-B (MIIB) | SLIGHT MALAISE (MI) |
|---|---|---|---|---|
| 16 points | 8-15 points | 5-7 points | 3-4 points | 1-2 points |

| TIME-LINED | SYMP CONT. | SYMPTOMS OBSERVED | | | | | | | | | | | TOTAL POINTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | VMT | TMP | DIZ | HAC | DRZ | SWT | PAL | SAL | NSA | ED | EA | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

COMMENTS:

2. Before writing on diagnostic sheet, push event button on ambulatory monitoring package to indicate start of session.

3. Indicate type of session by checking box maked "TIME-LINED" or "SYMP CONT." (symptom contingent). There are two rows provided on each page for those sessions

requiring that diagnostic be performed twice (i.e., before and after symptom contingent AFT sessions).

4. If vomiting has occured, print the letter "I" in the box marked "VMT".

5. Very minor symptoms of motion sickness are listed in this diagnostic scale as "AQS" - Also Qualifying Symptoms. Included in this symptom category are:

a. Increased body temperature - "TMP"
b. Dizziness/vertigo - "DIZ"
c. Headache - "HAC"

The subject has the option of reporting two levels of increased temperature and dizziness (mild-moderate "I" or moderate-severe "II"). Level of headache is not differentiated. If ANY degree of headache is experienced, the subject prints the letter "I" in the box marked "HAC".

6. Remaining symptoms of motion sickness (not including Nausea) are :

a. Drowsiness - "DRZ"
b. Sweating - "SWT"
c. Facial Pallor - "PAL"
d. Increased Salivation - "SAL"

Each of these symptoms can be described as mild, moderate or severe by writing in the appropriately marked box, "I" , "II" or "III", respectively. Note: The degree a facial pallor can be assessed by providing the crewmember with a "mirror" (plastic), glued to the back cover of the diagnostic booklet.

7. Symptoms of nausea or any sensations associated with the "gut" can be reported as five separate levels.

a. Epigastric Awareness - "EA"
This is described as increased sensations for the stomach but not considered uncomfortable. Reported by marking "I" in the box beneath "EA".

b. Epigastric Discomfort - "ED"
This is described as NOT nausea, but becoming uncomfortable (e.g., lump in throat, knot in stomach). Reported by marking "I" in the box beneath "ED".

c. Nausea - "NSA"
Reported as mild , moderate or severe by entering "I", "II" or "III", respectively.

8. Entering point values in the box marked "TOTAL POINTS" can be done if crewmember wishes but is not critical for this inflight procedure (can be done post-flight).

An example of a diagnostic report of a crewmember who experiences an increase in body temperature, some dizziness, moderate sweating and mild nausea is printed below:

CREWMAN ---------- DATE ---------- TIME ----------

DIAGNOSTIC CRITERIA SCALE - MOTION SICKNESS TEST

| MALAISE LEVEL | POINTS | VMT | TMP | DIZ | HAC | DRZ | SWT | PAL | SAL | NSA | ED | EA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PATHOGNOMIC | 16 | I | | | | | | | | | | |
| MAJOR | 8 | | | | | III | III | III | III | II,III | | |
| MINOR | 4 | | | | | II | II | II | II | I | | |
| MINIMAL | 2 | | | | | I | I | I | I | | I | |
| AQS | 1 | | I,II | I,II | I | | | | | | | I |

Levels of Severity Identified by Total Points Scored

| FRANK SICKNESS (S) | SEVERE MALAISE (MIII) | MODERATE-A (MIIA) | MODERATE-B (MIIB) | SLIGHT MALAISE (MI) |
|---|---|---|---|---|
| 16 points | 8-15 points | 5-7 points | 3-4 points | 1-2 points |

| TIME-LINED | SYMP CONT. | SYMPTOMS OBSERVED | | | | | | | | | | | TOTAL POINTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | VMT | TMP | DIZ | HAC | DRZ | SWT | PAL | SAL | NSA | ED | EA | |
| | X | | I | I | | | II | | | I | | | 10 |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

COMMENTS:

By referring to the KEY listed on the top of the pge, it can be seen that the symptoms of:

| | | | | |
|---|---|---|---|---|
| | "increased temperature" | = | 1 | diagnostic point; |
| | "some dizziness" | = | 1 | diagnostic point; |
| | "moderate sweating" | = | 4 | diagnostic points; |
| and | "mild nausea" | = | 4 | diagnostic points. |
| | TOTAL POINTS | = | 10 | |

The experimenters would rate this subject as having experienced "SEVERE MALAISE" or Malaise Level III (MIII).

9. COMMENTS: Because this is a subjective scale, a COMMENT section has been provided at the bottom of each diagnostic sheet so that the crewman may qualify his

report if he wishes. For example, the crewman may experience severe headache and this is his only symptom. Although the report of headache would result in TOTAL POINTS = 1 (or SLIGHT MALAISE), the crewmember may wish to indicate in the COMMENT section that the headache he is experiencing is severe (i.e., "This feels like a bad sinus headache" or "This feels like a migraine headache"). The COMMENT section might also be used by the subject to offer his personal evaluation of the effectiveness of the treatment. (e.g. "After the practice AFT session, I felt better"; or "I don't really notice any difference in symptoms after treatment"). Consequently, the information entered in the COMMENT section may be very useful for evaluating the effectiveness of AFT as a treatment and for elucidating descriptions of the nature of Space Adaptation Syndrome.

10. End of session - Crewmember presses the event button on his ambulatory monitoring package and replaces diagnostic booklet and pencil in pocket.

NASA
National Aeronautics and Space Administration

# Report Documentation Page

| 1. Report No. | 2. Government Accession No. | 3. Recipient's Catalog No. |
|---|---|---|
| NASA TM-89412 | | |

**4. Title and Subtitle**
Final Report
Spacelab 3 Flight Experiment #3AFT23: Autogenic-Feedback Training as a Preventive Method for Space Adaptation Syndrome

**5. Report Date**
October 1988

**6. Performing Organization Code**

**7. Author(s)**
Patricia S. Cowings, William B. Toscano and Joe Kamiya (University of California, San Francisco, CA), Neal E. Miller (Yale University, New Haven, CT), and Joseph C. Sharp

**8. Performing Organization Report No.**
A-87034

**10. Work Unit No.**
199-22-22-32

**9. Performing Organization Name and Address**
Ames Research Center
Moffett Field, CA 94035

**11. Contract or Grant No.**

**13. Type of Report and Period Covered**
Technical Memorandum

**12. Sponsoring Agency Name and Address**
National Aeronautics and Space Administration
Washington, D.C. 20546-0001

**14. Sponsoring Agency Code**

**15. Supplementary Notes**

Point of Contact: Patricia S. Cowings, Ames Research Center, MS 239A-2,
Moffett Field, CA 94035
(415) 694-5724 or FTS 464-5724

**16. Abstract** Space adaptation syndrome is a motion sickness-like disorder which affects up to 50% of all people exposed to microgravity in space. This experiment tested a physiological conditioning procedure (Autogenic-Feedback Training, AFT) as an alternative to pharmacological management. Four astronauts participated as subjects in this experiment. Crewmembers A and B served as treatment subjects. Both received preflight training for control of heart rate, respiration rate, peripheral blood volume, and skin conductance. Crewmembers C and D served as controls (i.e., did not receive training). Crewmember A showed reliable control of his own physiological responses, and a significant increase in motion sickness tolerance after training. Crewmember B, however, demonstrated much less control and only a moderate increase in motion sickness tolerance was observed after training. The inflight symptom reports and physiological data recordings revealed that Crewmember A did not experience any severe symptom episodes during the mission, while Crewmember B reported one severe symptom episode. Both control group subjects, C and D (who took antimotion sickness medication), reported multiple symptom episodes on mission day 0. Both inflight data and crew reports indicate that AFT may be an effective countermeasure. Additional data must be obtained inflight (a total of eight treatment and eight control subjects) before final evaluation of this treatment can be made.

| 17. Key Words (Suggested by Author(s)) | 18. Distribution Statement |
|---|---|
| Autogenic-feedback training<br>Instrumental training<br>Biofeedback<br>Space adaptation syndrome | Unlimited - Unclassified<br><br>Subject Category: 52 |

| 19. Security Classif. (of this report) | 20. Security Classif. (of this page) | 21. No. of pages | 22. Price |
|---|---|---|---|
| Unclassified | Unclassified | 116 | A06 |