EXTENDED DURATION ORBITER MEDICAL PROJECT

VARIABILITY OF BLOOD PRESSURE AND HEART RATE - STS-50/USML-1

Janice M. Fritsch-Yelle*, John B. Charles* and Sheila W. Boettcher+

*NASA JSC, Houston, Texas
+KRUG Life Sciences, Houston, Texas

ABSTRACT

Decreases in arterial baroreflex function after space flight may be related to changes in blood pressure and heart rate patterns during flight. Ambulatory blood pressure and heart rate was measured for 24-hours, in 14 astronauts on two occasions before flight, 2-3 occasions in flight, and two days after landing on Shuttle missions lasting 4 to 14 days. Blood pressure and heart rate were recorded every 20 minutes during awake periods and every 30 minutes during sleep. In pre- and postflight studies, the 24-hour ambulatory measurements were followed by studies of carotid baroreceptor-cardiac reflex responses. Carotid baroreceptors were stimulated using a sequence of neck pressure and suction from +40 to -65 mmHg.

Carotid baroreceptor-cardiac reflex responses were reduced postflight. The variability of blood pressure and heart rate are both reduced in flight. None of the changes in blood pressure and heart rate patterns in-flight related to postflight reductions in baroreflex parameters.

NOMENCLATURE

ABPM	Automatic Blood Pressure Monitor
Carotid Baroreceptors	Blood pressure sensors located in the neck region used to regulate blood pressure and heart rate.
Diastolic Blood Pressure	Amount of pressure in the arteries during the (mmHg) relaxation phase of the heart cycle.
Systolic Blood Pressure	Amount of pressure in the arteries during the (mmHg) contraction phase of the heart cycle.
Barocuff	Inflatable cuff applied to the neck. Pressure in the cuff can be increased and decreased according to the protocol.
Valsalva Maneuver	Forced exhalation against the mouthpiece preventing exhaled air from escaping.

Joint "L+1" Science Review for USML-1 and USMP-1 with the Microgravity Measurement Group, September 22-24, 1993, Huntsville, Alabama, USA.

INTRODUCTION

Postflight alterations in cardiovascular responses to exercise and standing are initiated during flight, however, they are not known to impair cardiovascular performance in space (2). Functional problems become apparent on landing day, when most crew members have reduced exercise capacity and orthostatic tolerance (1). The cause of the orthostatic intolerance may be partly related with loss of plasma volume during weightlessness (5). Blood pressure variations in flight may also contribute to the orthostatic intolerance on landing. Data received from crew members on shorter flight durations (4-5 days) demonstrated significant reductions in vagal control of the sinus node that may contribute in part to orthostatic intolerance (3).

This investigation measured the cardiovascular responses (heart rate and blood pressure) of 14 astronauts on Shuttle flights lasting 4-14 days. Blood pressure and heart rate were recorded every 20 minutes during wake periods and every 30 minutes during sleep. Data sessions included preflight, in-flight, and postflight. The pre and postflight activity involved 24-hour ambulatory monitoring followed by studies of carotid baroreceptor-cardiac reflex responses. Baroreflex testing occurred six times postflight for crew members on missions greater than 10 days. Carotid baroreceptors were stimulated using a sequence of neck pressure and suction from +40 to -65 mmHg.

The data from the two subjects from USML-1 will be analyzed with the other 12 subjects to maintain the privacy of their medical data.

I. RESULTS

Daily means and standard deviations of arterial pressure and heart rate were averaged. Carotid distending pressures (systolic - neck pressure) were plotted against R-R intervals. Calculated variables were minimum, maximum, and range of R-R interval responses, maximum slope, and operational point. Maximum slopes were identified with linear regression analyses applied to each set of three consecutive data pairs on the stimulus-response relation. Operational points were defined as [(R-R intervals at 0 mmHg neck pressure minus minimum R-R interval)/R-R interval range] x 100%.

Variability of blood pressure and heart rate were both reduced in flight. Carotid baroreceptor-cardiac reflex responses were reduced postflight. Preflight slope was 4.9 ± 0.3 msec/mmHg, range was 250 ± 22 msec, and operational point was 40.0 ± 3.8%. On landing day, slope was 3.9 ± 0.4, range was 180 ± 17 msec, and operational point was 27.8 ± 4.2% ($p < 0.05$ from preflight). Three days after landing the slope was 4.8 ± 0.6, range was 230 ± 22, and operational point was 35.2 ± 2.5%. No values three days after landing were different from preflight. None of the changes in blood pressure and heart rate patterns in flight related to postflight reductions in baroreflex parameters.

II. DISCUSSION

A series of measurements to assess autonomic control of the cardiovascular system on 14 astronauts were performed before and after Shuttle missions lasting 4-14 days. Resting vagal control of R-R intervals as estimated by power spectral analyses was not altered after space flight. The balance between sympathetic and vagal R-R interval control shifted toward greater sympathetic influences on landing day, and for several days after landing. Abnormalities of carotid baroreceptor-cardiac reflexes found after shorter duration missions (4-5 days) were also found after longer missions, but were not greater. In fact, reduction of baroreceptor slope was less after the longer flights. Reductions of range of the R-R interval response were similar after the short and long missions. Systolic and diastolic pressure reductions during, and increases after Valsalva straining were greater on landing day than preflight. In four astronauts, preflight and in-flight "square wave" blood pressure responses changed to sinusoidal patterns on landing day (Figure 4). Several astronauts had orthostatic intolerance both before leaving the Shuttle and later during the stand tests in the clinic. Postflight reductions in standing arterial pressures and postflight reductions in baroreflex operational points were significantly correlated.

The four subjects mentioned above routinely exercised (running 20 to 25 miles per week). It has been suggested that these subjects had expanded plasma volume before flight as a result of their normal daily intense aerobic exercise regimens (4), and the change to a sinusoidal response on landing day is at least partially due to loss of blood volume during flight. Recent studies by the investigator have demonstrated that normal responders become square-wave responders when blood volume is increased by intravenous saline. These same subjects develop exaggerated sinusoidal responses after dehydration. Postural changes reducing central blood volume could also contribute to this phenomena (6).

Twenty-five percent of the 14 crew members experienced severe orthostatic symptoms while in the Shuttle after wheels stop and/or during the stand test later in the clinic. Systolic pressures decreased dramatically with standing on landing day after the longer missions (10 - 14 days) unlike the non-significant changes seen after shorter flights. Changes in diastolic pressures were similar to the short flights.

CONCLUSIONS

While the variability of blood pressure and heart rate are both reduced in flight, those reductions did not relate to changes in baroreflex function after landing for crew members. While this study was useful in systematically documenting for the first time changes in blood pressure and heart during space flight, the original hypothesis of long duration flights reducing the variability was not proven. Blood pressure and heart rate exhibited diurnal variation in flight, however this variation was reduced from preflight data.

ACKNOWLEDGMENTS

The EDOMP team would like to thank the crew members of USML-1 who participated in this study, with the discomforts of 24-hour monitoring and neck suction. We appreciate your dedication to collecting this scientific data and your contribution to the future of long duration space flights. We also thank the personnel of Marshall Space Flight Center whose efforts on this investigation have contributed to the future of long duration space flights.

REFERENCES

1. Bungo, M. W., and P.C. Johnson, Jr. Cardiovascular examinations and observations of deconditioning during the space shuttle orbital flight test program. *Aviation Space Environmental Medicine* 54: 1001-1004, 1983.

2. Dietlein, L. F. Skylab: A Beginning. *In*: Biomedical Results from Skylab, edited by R. S. Johnston and L. F. Dietlein. Washington, DC; NASA, 1977, p. 408-418.

3. Fritsch, Janice M. , Charles, J.B., Bennett, B.S., Jones, M.M., and Eckberg, D.L., Short-duration spaceflight impairs human carotid baroreceptor-cardiac reflex responses. *Journal of Applied Physiology* 73(2): 664-671, 1992.

4. Green, H. G., J.R. Sutton, G. Coates, M. Ali, and S. Jones. Response of red cell and plasma volume to prolonged training in humans. *Journal of Applied Physiology* 70: 1810 - 1815, 1991.

5. Johnson, P. C., T. B. Driscoll, and A.D. Leblanc. Blood volume changes. *In*: Biomedical Results from Skylab, edited by R. S. Johnston and L. F. Dietlein. Washington, DC; NASA, 1977, p. 235-241.

6. Ten Harkel, A.D., J.J. Van Lieshout, E.J. Van Lieshout, and W. Wieling. Assessment of cardiovascular reflexes: influence of posture and period of preceding rest. *Journal of Applied Physiology* 68: 147-153, 1990.

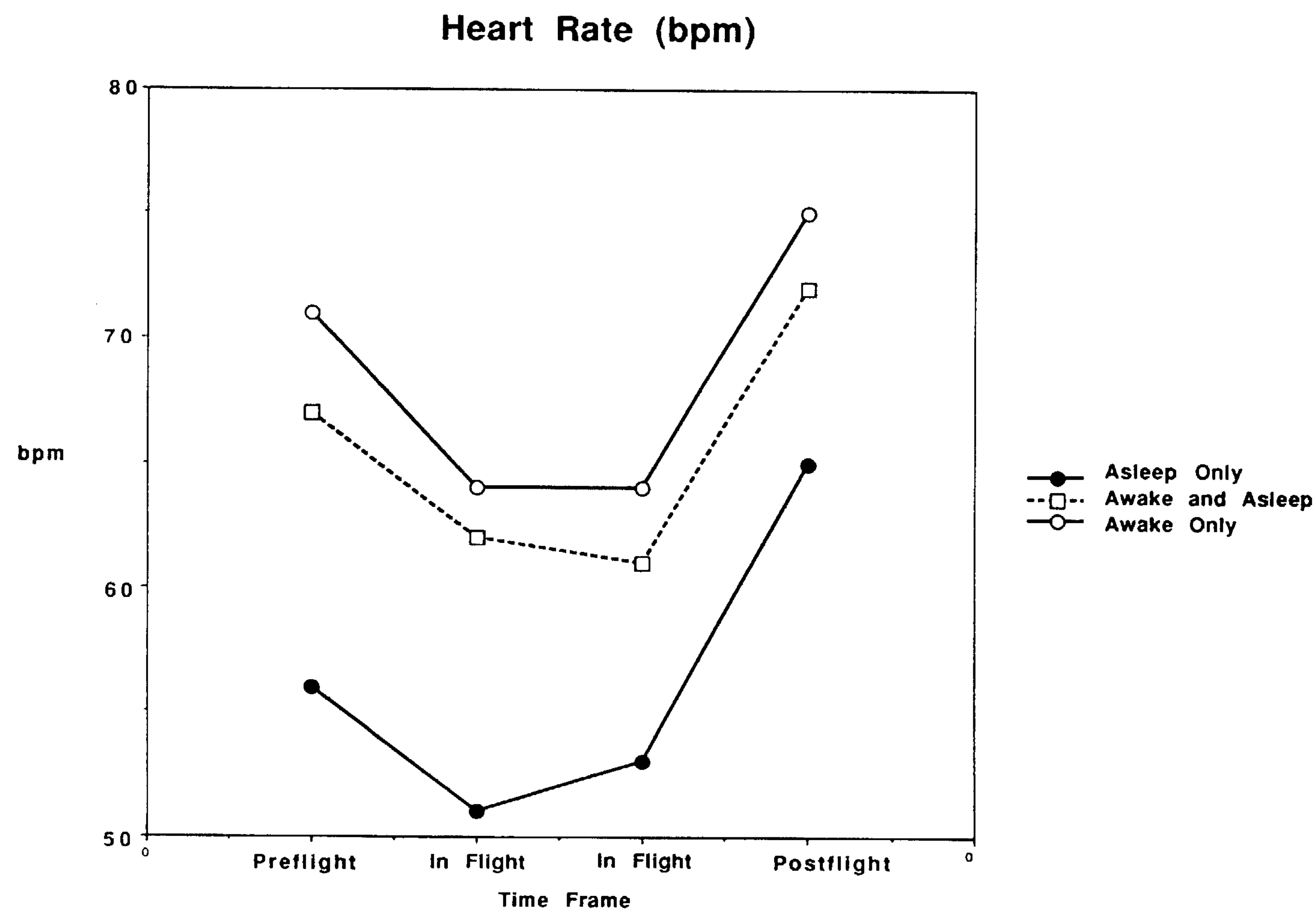

Figure 1 Heart rate variability in 14 astronauts on Shuttle flights of 4–14 days duration.

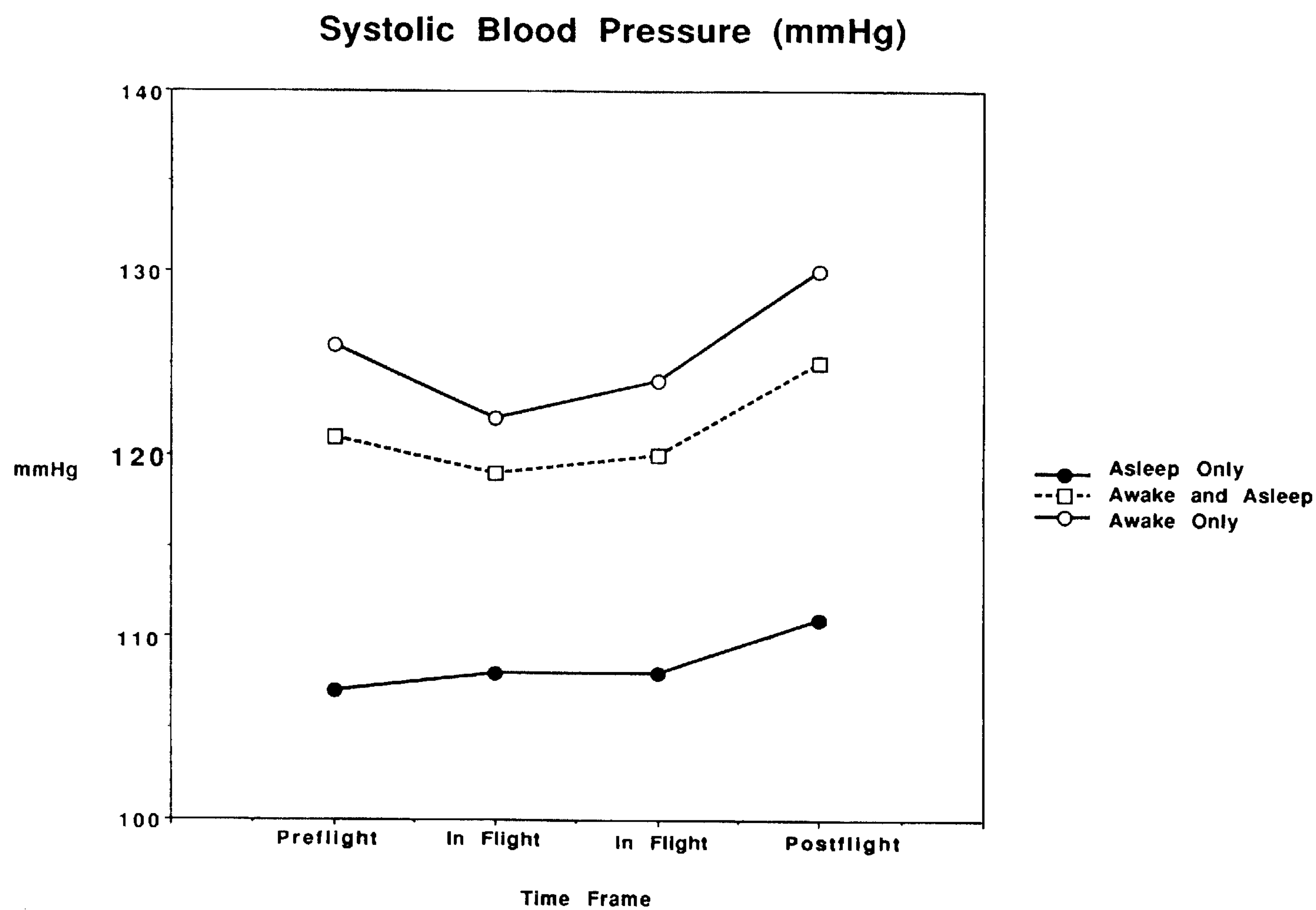

Figure 2 Systolic blood pressure variability in 14 astronauts on Shuttle flights of 4–14 days duration.

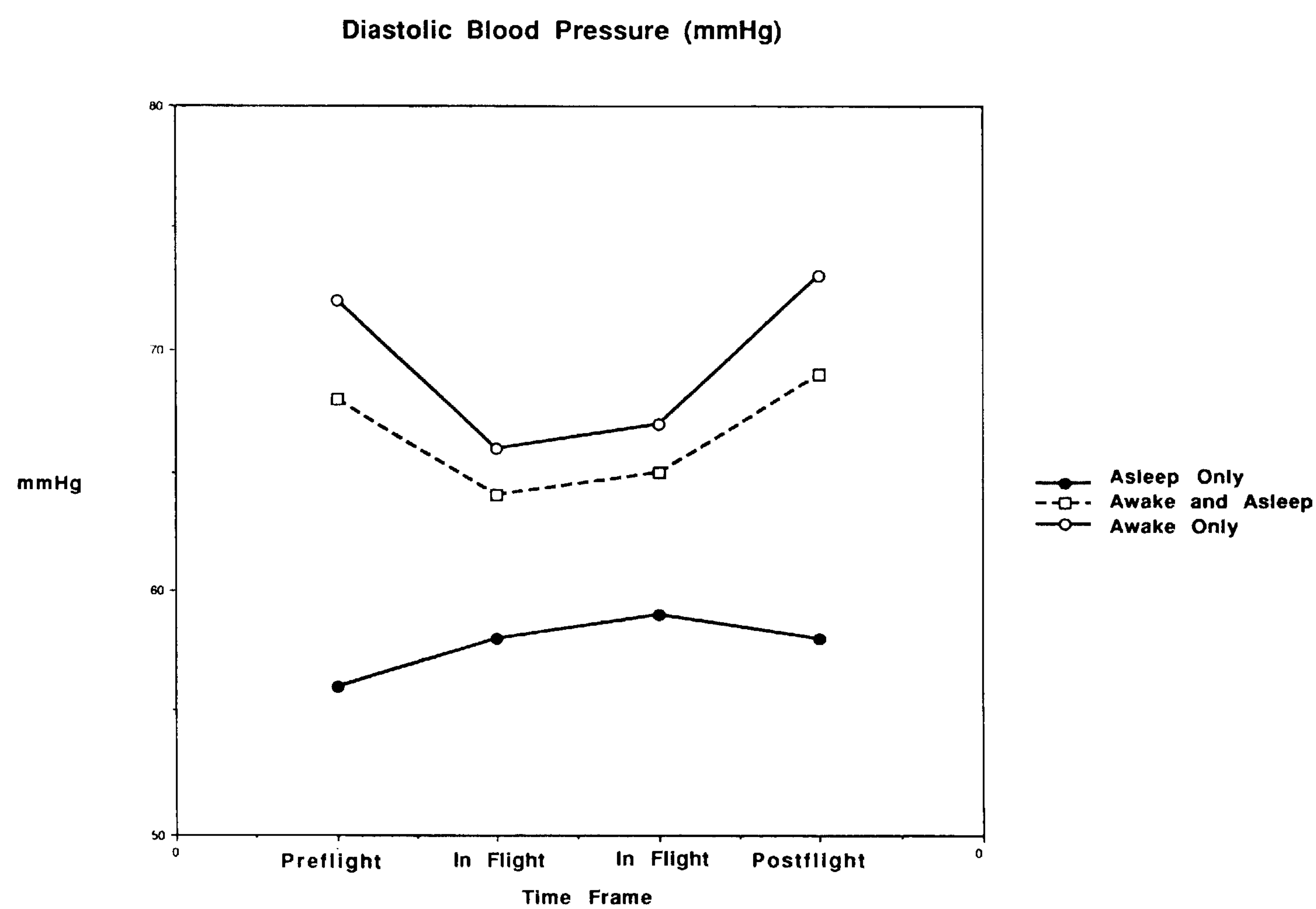

Figure 3 Diastolic blood pressure variability in 14 astronauts on Shuttle flights of 4–14 days duration.