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Presyncopal/Non-presyncopal Outcomes of Post Spaceflight Stand Tests are Consistent from Flight to Flight

DS Martin,[1] JV Meck[2]

[1]Wyle Life Sciences, Human Adaptation and Countermeasures Office, Houston, Texas 77058, [2]NASA/Johnson Space Center, Houston, Texas 77058

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Corresponding author:

Janice V. Meck, Ph.D.

Director, Cardiovascular Laboratory

SK/NASA Johnson Space Center

Houston, Texas 77058

Fax: 281-483-4181

Tel: 281-244-5405

Email: jmeck@ems.jsc.nasa.gov

ABSTRACT

INTRODUCTION The overall prevalence of orthostatic hypotension after short duration (6-18 d) spaceflight is 20% with existing countermeasures. However, it is not known if the outcomes of stand tests for orthostatic tolerance are consistent within individuals on subsequent flights, or if first time fliers are more (or less) likely to experience orthostatic hypotension and presyncope than are veteran astronauts.

METHODS Fifty astronauts were studied retrospectively. Stand test data, which had been collected before and after spaceflight, were compared from at least two flights for each astronaut. For twenty-five of these astronauts, their first flight in this database was also their first time to fly into space. For the remaining 25, their first flight in this database was their second, third or fourth flight, as data were available.

RESULTS No subject became presyncopal during preflight testing. Of the 50 subjects, 45 (90%) had the same outcome on their first and second flights of this study. Of 14 subjects on whom we had data from a third mission, 12 had the same stand test outcome on all three flights (86% same outcome across three flights). There was no correlation between flight duration and orthostatic tolerance ($r = 0.39$).

DISCUSSION These data support the idea that astronauts are predisposed to orthostatic tolerance/intolerance after spaceflight and that this predisposition is not altered by subsequent flights. Flight durations within this data set did not alter the likelihood of orthostatic intolerance and rookie fliers were no more likely to experience orthostatic intolerance than were veteran astronauts.

INTRODUCTION

The occurrence of postflight orthostatic hypotension is the most well documented manifestation of the cardiovascular adaptations to spaceflight. Symptoms of orthostatic hypotension may include: dimming of vision, nausea and lightheadedness (presyncope), or loss of consciousness (syncope). According to NASA protocol, an astronaut "passes" a stand or tilt test on landing day if he or she is able to remain asymptomatic in an upright position, without support and without moving, for 10 min. The number of crew members who are unable to meet these test criteria on landing day ranges from 10% to 80%, depending on the specific study (1,2,3,4,6). The preflight and postflight hemodynamic and neuroendocrine profiles that result in postflight orthostatic hypotension have been well characterized (1,3,5). However, it never has been determined if an astronaut's ability to pass a stand or tilt test after one flight will predict his or her ability to pass a stand or tilt test after a second or third flight, or, alternatively, if performance during stand or tilt tests might improve with additional flight experience. The benefit of this knowledge would be the ability to predict which second time fliers would most likely need medical attention upon landing or require additional assistance during postflight egress from the vehicle. This was a retrospective study to test the hypothesis that the occurrence of presyncope or syncope during a 10-min stand test on landing day is consistent in individuals from flight to flight.

METHODS

Data were analyzed from preflight and postflight stand tests (a medical requirement at the time) performed on 50 astronauts, 42 male and 8 female (ages 33.5 - 61.3 yr, mean 41.8 $\pm$

0.47 SE). Each flew on two or more U. S. Space Shuttle missions. For twenty-five of these astronauts, their first flight in this database was also their first (rookie) time to fly into space. For the remaining 25 their first flight in this database was their second, third or fourth flight, as data were available. The average time between the first and second flights in this database was 708 ± 26 d for the non-presyncopal subjects and 594 ±18 d for the presyncopal subjects.. No significant lifestyle changes, such as changes in exercise regimen or diet, were noted between flights. Data were analyzed from a total of 35 missions lasting from 6 to 18 d. Stand tests were performed approximately 10 d prior to flight and again within several hours of landing. Following landings, astronauts exit the shuttle after about 45 min to an hour. They ambulate, as able, in the clinic until the stand test is performed. There is a six min supine rest prior to the stand test. All subjects performed the mandatory oral fluid load, equivalent to isotonic saline at a rate of 15 ml/kg body weight within 2 h prior to landing. No subject had consumed caffeine, alcohol, or sleeping medications within 12 h prior to the test; none had consumed a heavy meal within 4 h or exercised at maximum heart rate within 24 h. Subjects were instrumented for electrocardiogram, manual arterial pressure, and beat-to-beat finger arterial pressure (Finapres, Ohmeda, Inglewood, CO). Measurements were taken each minute for 6 min supine and 10 min standing, unless symptoms necessitated a return to the supine position. Three people assisted the subjects to the standing position to minimize artifact due to contraction of skeletal muscle. One person lifted the astronaut's upper back from behind while another swept the astronaut's feet to the side of the bed. A third person also helped bring up and stabilize the astronaut's torso. A bed that was close to hip height was used to eliminate the need for the subject to stand up when getting off

the bed. If subjects developed presyncopal symptoms (systolic pressure lower than 70 mmHg or pressure rapidly falling, dizziness, lightheadedness, nausea, or sudden drop in heart rate) while standing then they were returned to the supine position immediately.

Outcomes were classified as presyncopal if a subject was unable to complete 10 min standing without symptoms on landing day, or non-presyncopal if they were. The percent of the same flight-to-flight outcomes of all individuals was computed. In addition, a least squares regression analysis was performed between percentage of presyncopal subjects on each flight and flight duration to determine if flight duration was a confounding variable. A Chi-square analysis was used to determine if the incidence of presyncope was different between rookies and veterans.

RESULTS

(Fig. 1 here)

No subject became presyncopal during preflight testing. Figure 1 presents landing day stand test outcomes for the first and second flights in this database. Of the 50 subjects, 45 had the same outcome (presyncopal or non-presyncopal), on their first and second flights in this study (90% same outcome). Of 14 subjects on whom we had data from a third mission, 12 had the same stand test outcome on all three flights (86% same outcome across three flights, not shown). Regression analysis of percent of presyncopal subjects/flight versus flight duration showed no significant correlation ($r = 0.39$, $P = 0.24$). The Chi-square analysis showed that rookie astronauts were not more likely to become presyncopal after their first spaceflight than were veteran astronauts ($P > 0.25$). Heart rate and blood pressure changes between pre- and postflight (supine and standing)

for the two flights of each astronaut that were used in this study are depicted in Figure 2. There were no significant inter-flight differences.

(Fig. 2 here)

DISCUSSION

This is the first report of results from post spaceflight stand tests in the same subjects after two or more different flights aboard the Space Shuttle. These data show that the overwhelming number of astronauts have the same stand test outcomes (presyncopal or non-presyncopal) from flight to flight, suggesting that orthostatic tolerance after spaceflight is not "learned". Of the five astronauts who did not have the same outcome, there was no pattern of either improved or diminished orthostatic tolerance. Two were presyncopal on their first and non-presyncopal on their second flight of this study. Three were non-presyncopal on their first and presyncopal on their second flight of this study. Those astronauts who become presyncopal after their first flight are highly likely to need intervention with additional countermeasure(s) for their second flight, and those who do not experience orthostatic symptoms following their first flight are unlikely to need additional countermeasures. This finding is an important addition to the knowledge needed to understand and characterize spaceflight-induced presyncope.

We previously have reported that preflight hemodynamic responses to standing can predict which astronauts may become presyncopal during a stand test after flight. As a group, those crewmembers at risk for presyncope during a landing day stand test have lower preflight supine and standing vascular resistance and arterial pressures than those

who will not become presyncopal on landing day (3,5). This predictive information has allowed the possibility to begin development of individual countermeasure prescription for crewmembers before his or her rookie flight. No significant lifestyle changes,such as changes in exercise regimen or diet, were noted between flights. The addition of this new information may help flight surgeons to be proactive in their management and treatment of individual crewmembers on both their initial and subsequent flights.

In this study, the rate of presyncope after spaceflight was not related to mission duration. However, it is not possible to extrapolate these results to significantly longer missions. The rate of presyncope following flights of 4 to 6 mo has been reported at 83% (4). In that report of results from six astronauts, each of whom flew on a short (4–18 d) mission followed by a long (4–6 mo) mission, there was only 17% consistency in their stand test outcomes between the short and long duration flights. One of the six became presyncopal after the short flights, but five of the same six became presyncopal after the long flights (4).

In summary, we compared the outcomes (presyncope versus non-presyncope) during 10-min stand tests in 50 crewmembers who flew on two or more Space Shuttle missions. We found a 90% inter-flight consistency of outcomes when comparing .

LIMITATIONS

There are many variables that might have contributed to differences in results between flights in this retrospective analysis. Among these are differences in plasma volume losses, degree of fatigue, and in-flight changes in sleep/wake cycles, sleep architecture, diet, and exercise routines (5). Had it been possible to maintain all of these factors

constant, an even greater consistency in intra-subject postflight stand test results from flight to flight would be expected.

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FIGURE LEGENDS

Figure 1. The number of subjects who were non-presyncopal (NPS) and presyncopal (PS) is displayed by flight. Those subjects who had the same stand test outcome after the second flight are in shaded gray. The number of astronauts for whom the first flight in this database was also their first spaceflight is represented in parenthesis.

Figure 2. Heart rate and blood pressure, both supine and standing are displayed before and after spaceflight (mean ± SE). First flight is represented by a closed circle. The second flight is represented by an open circle.