

A COMPARISON OF TANDEM WALK PERFORMANCE BETWEEN BED REST SUBJECTS AND ASTRONAUTS

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INTRODUCTION

Astronauts experience a microgravity environment during spaceflight, which results in a central reinterpretation of both vestibular and body axial-loading information by the sensorimotor system. Subjects in bed rest studies lie at 6° head-down in strict bed rest to simulate the fluid shift and gravity-unloading of the microgravity environment. However, bed rest subjects still sense gravity in the vestibular organs. Therefore, bed rest isolates the axial-unloading component, thus allowing for the direct study of its effects.

The Tandem Walk is a standard sensorimotor test of dynamic postural stability [1]. In a previous abstract [2], we compared performance on a Tandem Walk test between bed rest control subjects, and short- and long-duration astronauts both before and after flight/bed rest using a composite index of performance, called the Tandem Walk Parameter (TWP), that takes into account speed, accuracy, and balance control. This new study extends the previous data set to include bed rest subjects who performed exercise countermeasures. The purpose of this study was to compare performance during the Tandem Walk test between bed rest subjects (with and without exercise), short-duration (Space Shuttle) crewmembers, and long-duration International Space Station (ISS) crewmembers at various time points during their recovery from bed rest or spaceflight.

METHODS

All subjects provided written informed consent before participating in this study, which was approved in advance by the NASA Lyndon B. Johnson Space Center Institutional Review Board.

This study is part of a larger protocol that uses a suite of physiologic tests and functional tasks to relate physiologic changes to changes in functional performance of mission-critical tasks immediately postflight or after bed rest. Subjects groups included: (a) 10 bed rest controls, all of whom completed 70 days of 6-degrees head-down strict bed rest with no exercise countermeasure; (b) 17 bed rest exercisers, all of whom completed the same bed rest but with exercise countermeasures; (c) 6 short-duration crewmembers who completed Space Shuttle missions (12.9 ± 1.5 d) with in-flight exercise countermeasures, and (d) 13 long-duration crewmembers who completed missions aboard the ISS (151.6 ± 17.1 d) with in-flight exercise countermeasures. Data collection sessions occurred twice within a 2-month or 2-week time period before flight or bed rest, respectively (Pre), and four times after flight/bed rest: on the day of landing or end of bed rest (Post+0d), one day post (Post+1d), six days post (Post+6d) and a final session 10 days (bed rest) or 30 days (flight) post (Post+10/30). Due to logistical limitations, data could not be collected from long-duration crewmembers on landing day.

In the Tandem Walk test, the subjects walked in a heel-to-toe fashion at a self-selected speed for 10-12 steps with their arms crossed on their chests and their eyes closed. A spotter walked next to the subject to ensure safety and to monitor the step

count. Three Tandem Walk trials were performed per session.

Torso and head linear accelerations (relative to their respective local coordinate systems) were recorded at 50 Hz using triaxial inertial measurement units (Xsens, North America Inc., Culver City, CA). During the analysis, the start and end of the trials were manually selected by inspection of a plot of the vertical head acceleration to get the total trial time. The gravitational acceleration was removed from the Z-component of the torso acceleration. The root-mean-square (RMS) of the resultant linear torso accelerations (TorsoAccR) over the trial was then computed. Video of the trials were reviewed to determine the percentage of heel-to-toe (“correct”) steps during the task. The TWP was then computed for each session as follows:

$$TWP = \ln \left(1 + \frac{PctCorrectSteps}{TotalTime * RMS(TorsoAccR)} \right)$$

The log transformation was used to prevent extreme values from dominating the data analysis. Larger values of TWP reflect better overall performance.

A separate analysis revealed no significant difference between the two Pre sessions, so their data were pooled in the subsequent analysis. A linear mixed model with TWP as outcome and random subject effects was used to estimate group-by-session means and test for pre-post differences between groups for each post session. P-value thresholds for reporting significance were calculated using the Hochberg multiple-comparison procedure [3] to control the family-wise Type I error rate to 0.05.

RESULTS AND DISCUSSION

All groups exhibited lower TWP values (i.e., increased instability) during Tandem Walk immediately after flight/bed rest (Figure 1). Thus, axial-unloading alone – as is the case in bed rest – resulted in decreased Tandem Walk performance immediately after flight/bed rest.

The multiple-comparison analysis of the pre- to postflight/bed rest difference estimates showed that

the *change* in TWP for the bed-rest exercise subjects was: (a) significantly less than that of the bed rest controls for Post+0d and Post+1d, (b) significantly less than the long-duration flight group for Post+1d, and (c) significantly more than the short-duration flight group for Post+6d. Thus changes in TWP in the bed rest exercise group were similar to short-duration astronauts for Post+0d and Post+1d, but similar to the long-duration astronauts at Post+6d. Therefore, exercise countermeasures helped mitigate some of the decrement in TWP after bed rest (exercise vs. control). However, additional balance and/or coordination training during flight/bed rest may be required to maintain TWP at Pre levels on Post+0d.

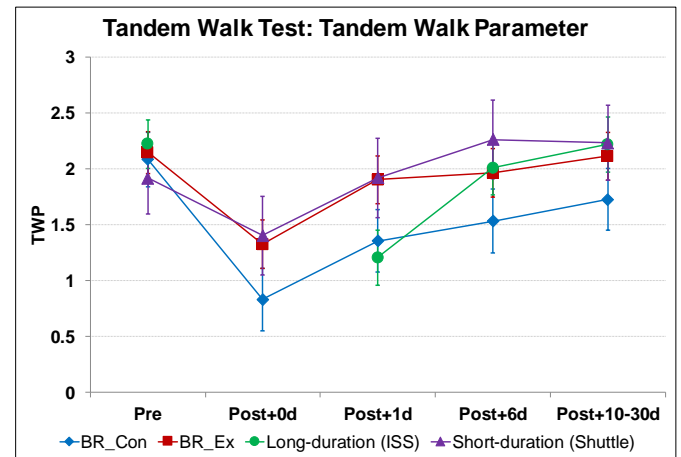


Figure 1: Tandem Walk Parameter (± 2SE)

CONCLUSIONS

Exercise countermeasures during space flight or bed rest helped mitigate some of the decrements in tandem walk performance immediately after flight/bed rest. But performance deficits remained, thus suggesting an additional sensorimotor countermeasure may be necessary to maintain tandem walk performance on Post+0d at preflight/bed rest levels.

REFERENCES

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