A DUAL TRACK ACTUATED TREADMILL IN A VIRTUAL REALITY ENVIRONMENT AS A COUNTERMEASURE FOR NEUROVESTIBULAR ADAPTATIONS IN MICROGRAVITY

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INTRODUCTION

The neurovestibular system is primarily responsible for balance and stabilization and relies on vestibular, visual and proprioceptive cues. The microgravity environment alters these cues, resulting in sensory conflicts that cause crew members to experience gait and postural instabilities when returning to gravity environment. Longer durations in microgravity cause the adaptation process to be longer and more difficult [1]. During re-entry and post-flight, crew members suffer from disabling vertigo, oscillopsia, sudden loss of orientation, impaired coordination, sudden loss of postural ability, and overall decreased ability in standing and gait performance [2,3].

Travel to distant planets and extended durations of time aboard the International Space Station have made it necessary to develop effective countermeasure to aid in the adaptation process. The aim of this study was to determine if the dual-track actuated treadmill in a virtual reality environment significantly stimulates the neurovestibular system such that it would alleviate adverse adaptations.

METHODS

Subjects walked on the treadmill at a speed of 3.5 mph in one of three conditions:

1. Visual Only: There was a visual display and the left and right treadmill tracks were the same as the Control condition.
2. Treadmill Only: There was no visual display and the treadmill tracks raised and lowered vertically, inclined and declined, and changed speeds.
3. Treadmill and Visual: There was a visual display that coincided with the treadmill tracks as they performed like the Treadmill Only condition.

Data were collected for ten seconds both in the first and last five minutes of the 30-minute trial during the simulated activities of walking straight, around curves, uphill and downhill. Measurements were also made in control conditions before and after testing in which there was no visual display and both treadmill tracks remained the same speed and height.

Electromyography of the neck as well as and head/trunk kinematics were measured. Head acceleration was measured by a head mounted tri-axial accelerometer. Footswitches fixed to the bottom of the shoe were used to determine gait events.

RESULTS AND DISCUSSION

Results for head acceleration were analyzed to determine if the virtual reality treadmill alters the response to shock transients through the body. The resultant acceleration of the head was calculated and peak values were determined for each stride at heel strike. Accelerations were normalized by subtracting the peak values found in the initial control condition (Figure 1).

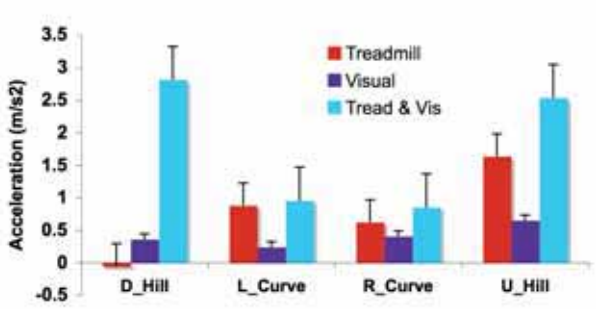

Figure 1: Normalized Head Acceleration During Five Activities By Experimental Condition

Acceleration for each activity was highly correlated to the control condition. Normalized accelerations of the head increased while walking on the dual-track treadmill compared to normal treadmill walking. Similarly, no significance was found when using paired t tests to compare the data across conditions. This can be attributed to the large variability between subjects. Treadmill and Visual trials showed significantly larger acceleration than the Visual Only trials indicating the importance of actuated belts with regard to neurovestibular stimulation. Of particular interest is the fact that the accelerations remained elevated in the final Control Condition as seen in Figure 1.

CONCLUSIONS

By increasing the input stimulus to the body, specifically the shock to the head, the treadmill forces the user to consistently activate their balance reflexes to maintain a consistent gait. This illustrates the potential for the dual track, actuated treadmill device with virtual reality to be an effective counter measure to alleviate the postural and balance distirbances after exposure to microgravity. Analysis of the muscle activation patterns and the head/neck coordination will further clarify the extent to which the treadmill stimulates the neurovestibular system.

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