Influence of Vibrotactile Feedback on Controlling Tilt Motion After Spaceflight

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INTRODUCTION. We hypothesize that adaptive changes in how inertial cues from the vestibular system are integrated with other sensory information leads to perceptual disturbances and impaired manual control following transitions between gravity environments. The primary goals of this ongoing post-flight investigation are to quantify decrements in manual control of tilt motion following short-duration spaceflight and to evaluate vibrotactile feedback of tilt as a sensorimotor countermeasure. METHODS. Data is currently being collected on 9 astronaut subjects during 3 preflight sessions and during the first 8 days after Shuttle landings. Variable radius centrifugation (216 deg/s, <20 cm radius) in a darkened room is utilized to elicit otolith reflexes in the lateral plane without concordant canal or visual cues. A Tilt-Translation Sled (TTS) is capable of synchronizing pitch tilt with fore-aft translation to align the resultant gravitoinertial vector with the longitudinal body axis, thereby eliciting canal reflexes without concordant otolith or visual cues. A simple 4 tactor system was implemented to provide feedback when tilt position exceeded predetermined levels in either device. Closed-loop nulling tasks are performed during random tilt steps or sum-of-sines (TTS only) with and without vibrotactile feedback of chair position. RESULTS. On landing day the manual control performance without vibrotactile feedback was reduced by >30% based on the gain or the amount of tilt disturbance successfully nulled. Manual control performance tended to return to baseline levels within 1-2 days following landing. Root-mean-square position error and tilt velocity were significantly reduced with vibrotactile feedback. CONCLUSIONS. These preliminary results are consistent with our hypothesis that adaptive changes in vestibular processing corresponds to reduced manual control performance following G-transitions. A simple vibrotactile prosthesis improves the ability to null out tilt motion within a limited range of motion disturbances.

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