

DEVELOPMENT OF TRAINING PROGRAMS TO OPTIMIZE PLANETARY AMBULATION

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Astronauts experience disturbances in functional mobility following their return to Earth due to adaptive responses that occur during exposure to the microgravity conditions of space flight. Despite significant time spent performing in-flight exercise routines, these training programs have not been able to mitigate postflight alterations in postural and locomotor function. Therefore, the goal of our two inter-related projects (NSBRI-ground based and ISS flight study, “Mobility”) is to develop and test gait training programs that will serve to optimize functional mobility during the adaptation period immediately following space flight, thereby improving the safety and efficiency of planetary ambulation. The gait training program entails manipulating the sensory conditions of treadmill exercise to systematically challenge the balance and gait control system. This enhances the overall adaptability of locomotor function enabling rapid reorganization of gait control to respond to ambulation in different gravitational environments.

To develop the training program, we are conducting a series of ground-based studies evaluating the training efficacy associated with variation in visual flow, body loading, and support surface stability during treadmill walking. We will also determine the optimal method to present training stimuli within and across training sessions to maximize both the efficacy and efficiency of the training procedure.

Results indicate that variations in both visual flow and body unloading during treadmill walking leads to modification in locomotor control and can be used as effective training modalities. Additionally, the composition and timing of sensory challenges experienced during each training session has significant impact on the ability to rapidly reorganize locomotor function when exposed to a novel sensory environment. We have developed the capability of producing support surface variation during gait training by mounting a treadmill on a six-degree-of-freedom motion device. This hardware development will allow us to evaluate the efficacy of this type of training in conjunction with variation in visual flow and body unloading.

As part of the effort to evaluate gait adaptability training programs, we have collected pre and post flight locomotion data on crewmembers from ISS Expeditions 5-12 (Mobility). Locomotor function was assessed before and after space flight using two tests of gait function. The Integrated Treadmill Locomotion Test (ITLT) characterizes alterations in the integrated function of multiple sensorimotor sub-systems. Subjects walk on a motorized treadmill while we assess changes in postural stability, head-trunk coordination, dynamic visual acuity and lower limb coordination strategies. The Functional Mobility Test (FMT) provides a corresponding assessment of the functional and operational changes in locomotor function by testing subjects’ ability to negotiate an obstacle course placed over a medium-density foam floor. Using both tests we can map the relationship between functional capabilities and physiological changes.

Results from the FMT indicate that adaptation to space flight led to a 50% increase in time to traverse the obstacle course on R+1, and recovery of function took an average of 2 weeks after return. Results from the ITLT indicate that both head and torso movements during locomotion show postflight changes predominantly in the pitch and roll planes presumably due to the central reinterpretation of otolith information. Dynamic visual acuity was decreased followed by an improvement in performance during the post flight recovery period. Importantly, these alterations in kinematics and dynamic visual acuity were accompanied by commensurate changes in functional mobility.

This work supported by the National Space Biomedical Research Institute through NASA NCC 9-58 and by NASA ISS Experiment E120 “Mobility”