Changes in Locomotor Stability After Exposure to a Viscous Force Field

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1 Introduction

All strategies for stabilizing gait are not equal. Individuals with neurologic impairments rely heavily on general stabilization strategies that are present every step to resist and respond to any potential perturbation. General stabilization strategies (e.g. increasing step width and percent time in double support) decrease the necessity of sensing and responding to specific perturbations but inherently limit maximum walking speed, increase the metabolic cost of transport and decrease maneuverability. Training individuals to utilize specific stabilization strategies (e.g. corrective steps, anticipatory postural adjustments) that are present only when needed could improve gait stability, speed, efficiency and adaptability. However, engaging individuals in task specific practice of specific stabilization strategies is very difficult because general stabilization strategies act as a physiologic crutch that can override the requirement for individuals to practice making specific corrective actions when practicing walking in a balance challenging environment.

The purpose of this study was to try and induce a temporary after-effect of reduced reliance on general stabilization strategies during gait in ambulatory individuals with incomplete spinal cord injury by exposing them to a brief period of walking with external lateral stability.

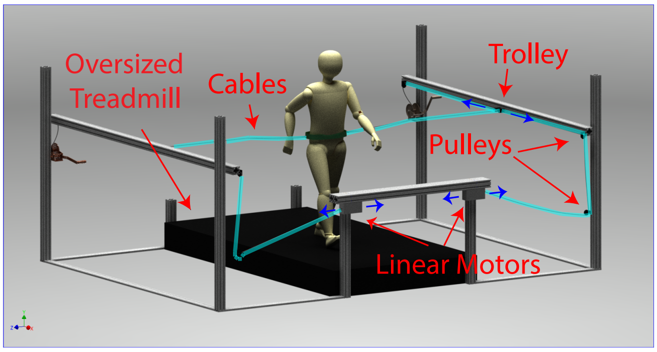

Figure 1: Subjects walk on an over-sized treadmill while being subjected to viscous lateral forces applied bilaterally via two linear motors.

2 Methods

Two ambulatory subjects with chronic, AIS (American Spinal Injury Association Impairment Scale) D, spinal cord injury, completed 600 steps of treadmill walking at their preferred speed. The first 200 steps were to get a **Baseline** measure of how subjects walked with no external assistance. The next 200 steps were done in the presence of an added **Viscous lateral force field**. After 200 steps, the force field was turned off and the subject continued to walk for another 200 steps to measure the presence of **After Effects**. The forces were applied via a cable/pulley system attached to the subjects' hips and driven by two brushless AC linear motors (Baldor, USA). Force control was maintained using feedback from load cells placed between the subject and the pulleys. An illustration of the robotic system is shown in Figure 1. The applied forces consisted of a baseline force of 15 lbs applied bilaterally to the subject with additional variable force proportional to the subject's lateral center of mass velocity. The effect of the viscous field was to resist subject's lateral motion. Motion capture cameras were used to measure mediolateral pelvis kinematics and foot placement variability.

3 Results

As shown in Figures 2 and 3, during the after-effects period subjects demonstrated an increase in mediolateral center of mass motion, step width variability (100% - 300% increase), and minimum lateral margin of stability variability (20% - 350% increase) when compared with baseline walking. Step width mean and margin of stability mean both tended to decrease (10% - 50%). These results are suggestive of a decrease in reliance on general stabilization strategies during the after-effects period when compared to baseline.

4 Discussion

A temporary period of reduced reliance on general stabilization strategies during gait can be induced in individuals with incomplete spinal cord injury by exposing them to a brief period of walking with external lateral stabilization. We believe that external stabilization can be used to prime the motor system for acquiring specific stabilization strategies during targeted gait rehabilitation interventions by temporarily decreasing an individual's reliance on the physiologic crutch of general stabilization strategies.

5 Acknowledgments

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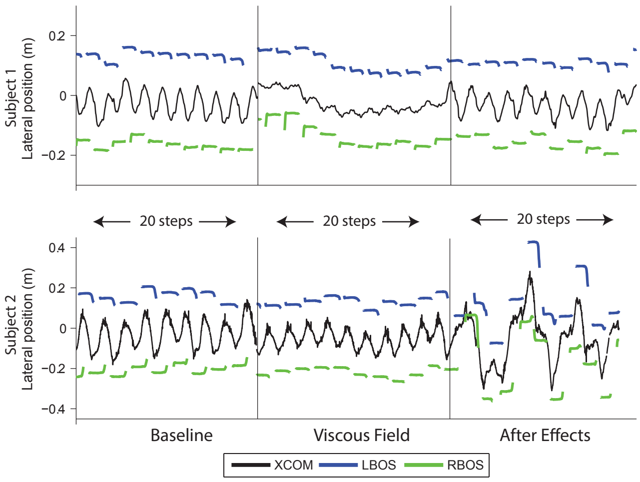

Figure 2: Extrapolated center of mass (XCOM), left base of support (LBOS), and right base of support (RBOS) data for two subjects walking during baseline, exposure to a viscous lateral force field, and the after-effects just after removing the forces. Data shown is for the last 20 steps of the baseline and viscous field trials, and the first 20 steps during the after-effects period.

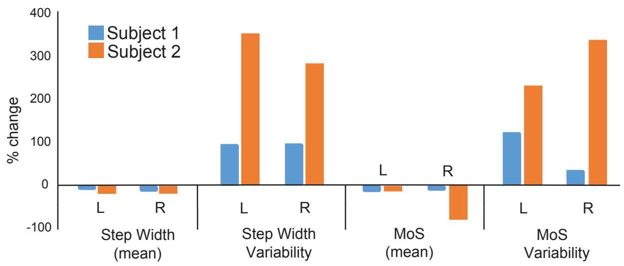

Figure 3: Percent change of kinematic measures from baseline walking to the period of after-effects created from exposure to the force field. Mean and variability of step width and margin of stability (MoS) are shown for both feet of each subject.