Improving Stepping-Over Responses in the Elderly using Simulated Obstacles

David L. Jaffe, MS, Ellie Buckley, MS PT, Cheryl D. Pierson-Carey, PT MS

David A. Brown, PT PhD

Rehabilitation Research & Development Center
VA Palo Alto Health Care System
Palo Alto, CA 94304

Programs in Physical Therapy
Northwestern University Medical School
Chicago, IL 60611

Introduction

The United States Public Health Service considers the reduction of falls as a national health priority in it's "Healthy People 2000: National Health Promotion Disease Prevention Objectives". Ability to step over objects is essential for safe ambulation. Inability to step over objects result in collisions that may induce tripping and falling. The frail elderly, a growing Veteran population, are at high risk for falling. This research will identify efficacious approaches to teaching these individuals how to successfully step over objects, thus reducing falls and the injuries that may result.

Objective

The goal of this project is to design and evaluate clinical interventions to train elderly veterans at high risk for falling by using simulated objects and real objects. The interventions all employ techniques that allow people to practice difficult walking tasks more safely. The specific objective is to demonstrate the clinical efficacy of a simulated object training system in a randomized, controlled intervention study.

Methods

Subjects participate in one of three interventions:

▶ Real Objects Intervention - Subjects are asked to practice stepping over a course of ten foam obstacles of challenging height and length, or

▶ Imaginary Objects Intervention - Subjects are repetitively instructed to "step higher" and "step longer" while walking on a motorized treadmill, or

▶ Simulated Objects Intervention - A composite video image of the subjects' lower body and simulated obstacles is presented via a head-mounted display. Subjects are asked to step over the simulated obstacles while walking on a motorized treadmill. Shoe-mounted vibro-tactile stimulators provide feedback of "collisions" with the simulated obstacles.

Walking speed is measured before and after a 2 and 4 week trial of these interventions during comfortable and fast speed walking over 100 feet and over a 10 object obstacle course.

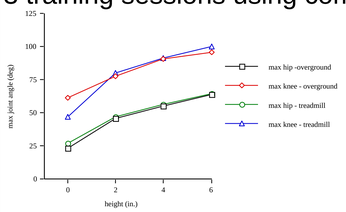
Also, the 6 minute walk test is used to assess endurance.

The evaluation procedures provide important outcome measures. The number of collisions as well as time over the courses are recorded. Measurements are taken pre-intervention, interim (after 6 sessions intervention), post-intervention (after 12 sessions intervention), and 1-month post completion of intervention.

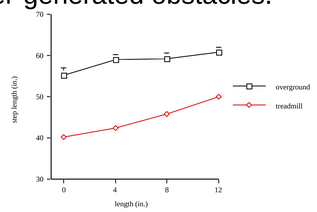
Results

To date, the pilot work has led to the following preliminary results:

- The most successful technique for presenting simulated objects involves displaying a side-view of stepping on a treadmill while the subject repeatedly negotiates computer-generated obstacles.
- Similar stepping strategies are employed for simulated and real obstacles over comparable size and shape.
- A small group of elderly subjects with post-stroke hemeiparesis were better able to negotiate an overground obstacle course after 3 training sessions using computer-generated obstacles.



Increase in maximum hip and knee flexion with increased obstacle height during overground and treadmill with simulated objects SORs for 5 young, healthy individuals.



Increase in step length with increased obstacle length during overground and treadmill with simulated objects SORs for 5 young, healthy individuals.

Status

Clinical trials are currently underway with a population of Veterans over the age of 60 who have mild to moderate COPD and are unable to negotiate an obstacle course without collision. The completed study will identify the relative merits of the three interventions with this population.

Planned

Future work on this project may explore simulation techniques with walking aids such as canes and crutches. Other potential areas of research include the study of improvements in fitness and gait through simulation of walking situations. The system could augment gait training by using visual feedback for persons with gait deviations. The system could potentially provide an enjoyable and safe environment for general exercise, a safe setting for "wanderers", or a simulated practice session for way-finding and familiarization of nursing home patients with their facility.

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Photos

Subject shown negotiating a foam obstacle from an initial evaluation session.

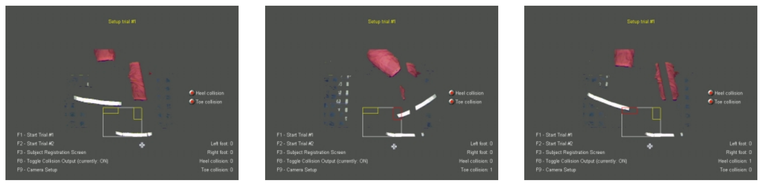
Subject (on right) stepping over a series of foam obstacles during an evaluation session. The LEDs on the subject indicate heel strike, while the LEDs on the therapist are lit when a collision is observed. All evaluation sessions are videotaped to provide timing information.

Subject stepping over a series of foam obstacles in the Real Objects Intervention.

Subject wearing overhead safety harness while being encouraged to “step higher and longer“ on a motorized treadmill during the Imaginary Objects Intervention.

Subject wearing head-mounted display and overhead safety harness while stepping over simulated objects on a motorized treadmill during the Simulated Objects Intervention.

Elements of the vibro-tactile feedback system. Vibrators (left figure) are placed in contact with heel and toe of each foot. The foot-switches (middle figure) sense which foot is off the ground. The interface box (right figure) receives collision information from the computer system and provides a 250ms vibration cue to the heel or toe of the foot involved in a collision.



Three views through the head-mounted display showing subjects' feet in relationship with a simulated obstacle. In the figure on the left, the subject has successfully cleared the obstacle, while the center and right figures show collisions with the toe and heel respectively.

Contributing Companies: VividGroup, Inc., Computer Modules Inc., and Biodex Corp.