Analyzing the Effects of Virtual Reality and Treadmill Gait Training Following a Cerebrovascular Accident

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Introduction

Cerebrovascular accidents (CVAs) result in gait deficits that negatively impact community ambulation, specifically with regard to decreased gait velocity, stride length, cadence, joint power, and overall safety (Mirelman et al., 2010).

Treadmill training assists in decreasing energy expenditure and cardiovascular demands post-CVA (Lin et al., 2010). Virtual reality (VR) utilizes graphic images and simulated environments to provide continuous optic flow and visual feedback, allowing greater emersion into a protected environment. Benefits of VR include high dose of repetition, live feedback, ability to be individualized, and motivational factors.

Current literature has emphasized gait speed and balance as outcome measures with virtual reality research. In the present study, the researchers utilized clinical assessment tools aimed at measuring functional capacity and improvement. The researchers posed the following question: To what extent does dynamic environment training utilizing a treadmill and virtual reality (VR) environments improve gait function in a participant with chronic neurological impairments as a result of a cerebrovascular accident (CVA)?

The researchers hypothesized that VR-based environments designed to challenge and incorporate optic flow, used with treadmill training, will yield neuromuscular improvements in walking in a participant with chronic neurological impairments resulting from a CVA. They found improvements in Functional Gait Assessment (FGA), Six-Minute Walk Test (6MWT), and gait parameters. Further research is needed to determine feasibility of virtual reality treadmill training.

Objectives

- Pilot study to determine to what extent does dynamic environment training utilizing a treadmill and virtual reality environments improve gait function in a participant with chronic neurological impairment as a result of a CVA
- Contribute to existing limited data on VR in clinical rehabilitation
- Determine feasibility of use of VR in clinical setting
- Develop a protocol for larger studies in the future

Methods

- 24 year-old female, 13 months post-CVA
- 14-week study, 21 sessions total
- Two week training period of four sessions, participant was acclimated to VR and treadmill
  - Initial assessment data gathered: FGA, 6MWT, and Qualisys motion capture data (step length, stride length, cadence)
- 16 gait training sessions on modified belt-driven treadmill, Oculus Rift head-mounted stereoscopic display provided VR environment
  - Goal: attain 30 minutes of continuous gait training
- PT students provided manual facilitation to decrease hemiplegic inversion, increase dorsiflexion, and encourage greater step length
- Outcome data re-assessed every fourth session
- Two and four weeks post-gait training, follow-up assessments conducted to assess retention

Results

Figure 1. Functional Gait Assessment (FGA)

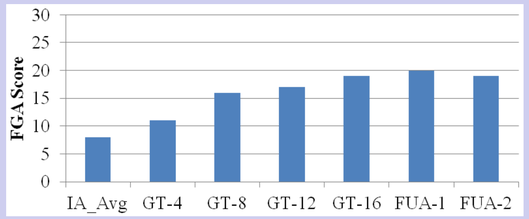


Figure 2. FGA Scores by Task

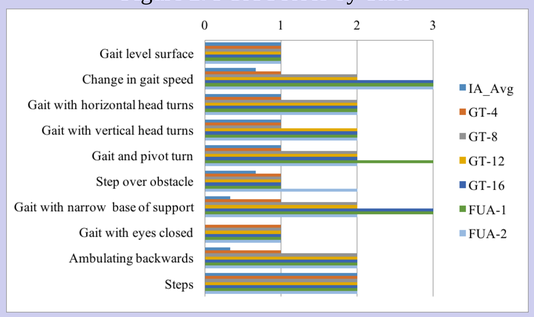


Figure 3. Oculus VR Headset & Environments

Figure 4. Six-Min. Walk Test Distance

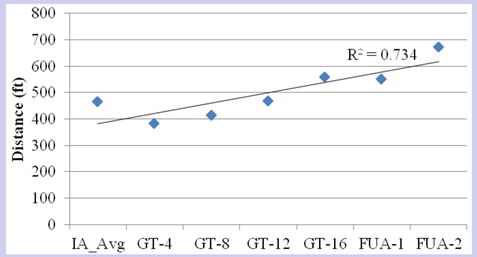


Figure 5. Right and Left Step Length

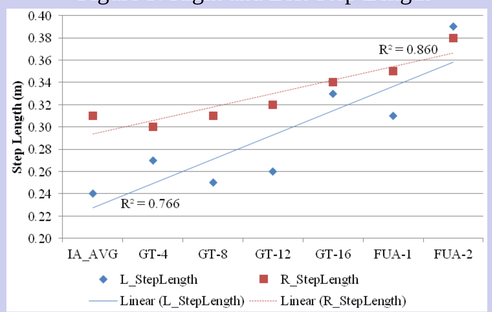
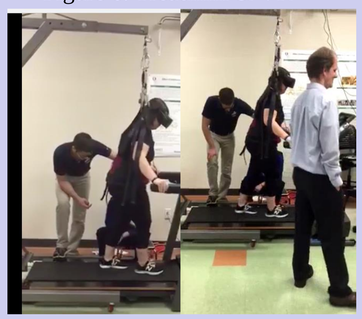


Figure 6. Treadmill & VR



Key: IA_Avg: average of first 3 initial assessments; GT: gait training session #; FUA: follow-up assessment #

FGA: There was a 12-point change in FGA scores from initial assessment to follow up assessment 1, meeting the minimal detectable change (MDC) of 4.2 points, and representing a 150% increase. The Pearson Correlation Coefficient r was calculated to be of 0.918, indicating significant improvement in functional gait.

6MWT: Distance covered from IA to FUA increased 207 feet or 20% and met the MDC of 112.8ft with a Pearson Correlation Coefficient of 0.856. Velocity improved 44.5% to 0.568 m/s with a Pearson Correlation Coefficient of 0.857 but was still well below the normative community ambulation speed of 1.3 m/s.

Spatiotemporal Parameters: Left step length increased 62.5% increase between the initial assessment average and follow-up assessment 2, while right step length increased 22.6% between the initial assessment average and follow-up assessment 2. Improvements in both right and left step length were remarkably steady and consistent, as evidenced by R^2 values of 0.766 and 0.860 for right and step length data respectively.

Data Analysis

- Mean values of each of the outcome measures (FGA, 6MWT, and Qualisys Motion Capture system data) obtained at three initial assessments. These were compared to four subsequent assessment values taken every 2 weeks, as well as two follow up assessment values
- Pearson Correlation Coefficient (r) calculated, compared to statistically significant r-value of 0.729
- Percentage differences calculated between initial and final assessments to determine magnitude of change
- Pre- and post-intervention FGA and 6MWT assessment values calculated to compare values to minimum detectable change (MDC) normative data

Discussion

Six-Minute Walk Test: Participant was able to meet the MDC, showed significant improvement in 6MWT distance covered, velocity, and gait quality.

Functional Gait Assessment: Improvement in overall score meeting MDC. Several subscores had the potential for improvement based on quality of performance, but due to the time to complete the task participant was unable to increase score.

Cadence: Heavy emphasis from researchers between gait training sessions 4 and 8 on quality of stepping versus rate of stepping. Reduction in cadence from 79.07 steps per minute as assessed at gait training session 4, to 68.81 steps per minute as assessed at gait training session 8.

Spatiotemporal parameters: Improved dorsiflexion and eversion of the left foot between gait training sessions, especially between sessions 3 through 7, with increased carryover between sessions and less manual facilitation required from researchers.

Endurance: Improved endurance with reduced HR overall and increased distance during 6MWT. Participant initially exhibited signs of fatigue during the first three gait training sessions. By the fourth and fifth gait training sessions, participant demonstrated improved endurance with ambulation and time on treadmill.

Conclusions

Researchers noted the following with regard to the participant's gait as compared to initial assessments:

- Increased gait velocity and narrower base of support
- More symmetrical step length, improved foot clearance via dorsiflexion control of the left foot
- Decreased incidence and amplitude of left knee hyperextension through terminal stance
- Improved control of left foot inversion throughout the swing phase

Positive results obtained from this study indicate a strong need for further research incorporating VR with treadmill training over larger participant groups. Future studies to include more comparative studies with appropriate control group.

Note: This project was approved by the FGCU IRB #2016-48

References: See handout with reference list