VR and Serious Games for Rehabilitation of Balance, Mobility and Fitness of Persons Post-Stroke

Judith E. Deutsch PT PhD FAPTA
Professor and Director Rivers Lab
School of Health Professions, Rutgers
State of the Science 2017

Objectives

• Define VR and serious games
• Understand how VEs and serious games are used with persons post-stroke
  – Balance
  – Mobility
  – Fitness
• Offer Knowledge Translation and Technology Transfer solutions

Virtual Reality & Virtual Environments

• Definition: Computer generated interactive environment drawing on three primary senses
  – Visual
  – Auditory
  – Haptic

Presence and Immersion

Engagement: challenge, positive affect, endurability, aesthetic and sensory appeal, attention feedback and novelty variety, interactivity and perceived user control (Obrien 2008)

Disclosures

Patents:
VRACK and VSTEP

Funding:
QED Science Center

References

Stroke AND Virtual Reality Rehabilitation

Citations in Pub Med

“Serious Games”

November 22, 2005
November 4, 2010 (K)
June 16, 2011 (SDK)
February 1, 2012
November 22, 2013
November 2014

Serious Games

Reward
Challenge
Narrative Structure
Goal-Motivation

Garris et al, Simul Gaming 2002; Faria et al, ICDVRAT 2014;
Cristea et al, Stroke 2006; Von Ahn et al, Commun ACM 2008,
Gamito et al, Disabil Rehabil 2015

Stroke AND Rehabilitation AND Wii

Pub Med Citations Wii

Saposnik, 2010


Stroke AND Rehabilitation AND Kinect

Pub Med Citations Kinect

UL


VR Augmented Balance and Mobility Training Post-Stroke Outcomes

Deutsch_ State of the Science_ 2017
Virtual Reality Post-Stroke
Cochrane Review

Update to be Published in 2017

Technology Integrated with Practice

Exercise Type | Range of Motion | Resistance | Speed | Duration
--- | --- | --- | --- | ---
Warm Up | High | Low | Low | Low-Medium
Endurance | Medium | Low-Medium | Low-Medium | High
Strengthening | Variable | High | Variable | Low
Speed | Variable | Low | High | Low-Medium
Coordination | Variable | Low | Medium | Medium

Mirelman, Bonato, Deutsch, Stroke, 2009

Custom VR Improves Temporal & Spatial Parameters of Gait

- N = 16
- Mean gait speed: 0.64 m/s (.54–.84)
- Dose:
  - 1hr/3xweek
  - 12 hours
- Outcomes:
  - Gait speed
  - Endurance
  - Coordination
  - Community Ambulation

Mirelman, Bonato, Deutsch, Stroke, 2009
### Evidence

<table>
<thead>
<tr>
<th>N</th>
<th>VR-SG</th>
<th>Activity</th>
<th>Part-</th>
</tr>
</thead>
<tbody>
<tr>
<td>170</td>
<td>Nintendo Wii Postural Control</td>
<td>BFS, FAC, WMFT, TUG, FM</td>
<td>SIS</td>
</tr>
<tr>
<td>341</td>
<td>Treadmill + VR Nintendo Wii Customized VR</td>
<td>Kinematics Postural Control, FM, WOS</td>
<td>Gait Speed, 6MWT BBS, TUG, BI, FIM, FRT., ABC, WDQ Comm. Amb.</td>
</tr>
<tr>
<td>428</td>
<td>Treadmill + VR Nintendo Wii Customized VR</td>
<td>Postural Control Temporal Spatial</td>
<td>BBS, Tinnelt, TUG, FRT, ABC</td>
</tr>
<tr>
<td>522</td>
<td>Treadmill + VR Nintendo Wii Customized VR</td>
<td>Postural Control Temporal Spatial, FM, MMAS, Tardieu, Chedoke, Ashworth</td>
<td>Gait Speed, FAC, 6MWT, TUG BBS, WAQ, ABC, FRT, DIG</td>
</tr>
<tr>
<td>984</td>
<td>Nintendo Wii Fit Postural VR</td>
<td>Postural Control</td>
<td>BBS, TUG, FRT, 10MWT, 6MWT, Stair, Tinnelt,</td>
</tr>
</tbody>
</table>

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<thead>
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<tr>
<td>21</td>
<td>Treadmill + VR Nintendo Wii Customized VR</td>
<td>Postural Control Gait Kinematics Time Stride Analysis</td>
<td>Gait Speed, 6MWT BBS, TUG, BI, FIM, FRT., ABC, WDQ, POMA, Brunel</td>
</tr>
</tbody>
</table>

### Custom for Rehab

Berg Balance Scale

Llorens et al Clinical Rehabilitation 2014, Archives PMR 2016

Custom for Rehab

Gosine, Damodaran & Deutsch ICVR 2015
VR and SG for Rehabilitation of Persons
Post-Stroke

**VR and serious games for fitness**

- Custom
- Off-the-shelf

**VRACK**

- Ranky et al. JNER, 2014; Deutsch et al. JNPT 2013

**VR and serious games for fitness**

- Custom
- Off-the-shelf

**Serious Games for Fitness or Wellness?**

- Wii Sports™ / Xbox Boxing
- UE activity
- Mobility activity

- Rest
- Gaming-Free Run
- Rest
- Gaming-Penguin
- Rest
- Gaming-Boxing

- 10 min.
- 10 min.
- 8-10 min.
- 8 min.
- 8-10 min.
- 10 min.

Kafri et al. Neurorehabil Neural Repair. 2013 Jul 29. [Epub ahead of print]
VR and SG for Rehabilitation of Persons Post-Stroke

Use of VR and Video Games in Practice

<table>
<thead>
<tr>
<th>Barriers</th>
<th>Actual Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>lack of age appropriateness</td>
<td>62.5% System at work</td>
</tr>
<tr>
<td>privacy issues</td>
<td>Nintendo Wii-Wii Fit (73%)</td>
</tr>
<tr>
<td>limited transfer of training, lack of accessibility of current systems</td>
<td>Microsoft Kinect; 7%</td>
</tr>
<tr>
<td></td>
<td>Other &lt; 3% of respondents had experience with rehabilitation-specific systems (e.g. GestureTek, Jintronix, CAREN)</td>
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<tr>
<td>Cost, time, learning needs and lack of fit with patients</td>
<td></td>
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</tbody>
</table>

Translate Knowledge?

KINECTING CLINICIANS

Levac, Espy, Fox, Pradhan
Deutsch Phys Ther March 2015

Appendix 1. Rating with Clinicians (SWIC) Resource

Levac, Espy, Fox, Pradhan
Deutsch Phys Ther March 2015
Challenges and Opportunities

- Technology will outpace research
- Commercial products will be developed that may not meet the rehab needs
- Technology innovation will not transfer to the clinic
- Standards for adopting and many case reports
- Collaboration between industry partners and clinician scientists involving end-users
- Collaborate globally to share technology

Technology Transfer

Collaborators

Open Rehab Initiative
Roberto Llorens PhD
Sergi Bermudez PhD

KWIC
Debbie Espy PT PhD
Emily Fox PT PhD
Daniele Levac PT PhD
Sujata Pradhan PT PhD

Collaborators:

MJ Myslinski PT EdD
Anat Mirelman PT PhD
Phyllis Bowlby PT EdD
Rose Gallagher, DPT
Harish Damodaran BME
Rob Gosine BME, PhD
VRLab Rutgers
Greg Burdea PhD
Rares Boian PhD
Michael Girone, ME
Jason Latonio, BSE

NJCST R & D Excellence Grant  NSF BES -0221687  NIH R41 HD054261
*AHA Founders Post-Doctoral Fellow, QED Science Center