Stroke: new technologies (FS-24)

Mindy F Levin (Canada)
Jane H Burridge (United Kingdom)
Sandeep K Subramanian (Canada)
John M Solomon (India)
Focused Symposium #FS-24

Stroke: New Technologies

BRAINTRAIN: Making the most of new technologies for stroke rehabilitation

Convener: Mindy F. Levin, PT, PhD, McGill University, Canada
Participants: Jane H. Burridge, PT, PhD, University of Southampton, UK
Sandeep K. Subramanian, PT, PhD, University of Montreal, Canada
John Solomon M, PT, PhD, Manipal University, India

WCPT 2015, LEVIN
## PROGRAMME
**Saturday, May 2, 2015, 13:45-15:15**

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>13:45-13:50</td>
<td>Levin</td>
<td>Introduction</td>
</tr>
<tr>
<td>13:50-14:05</td>
<td>Levin</td>
<td>New technologies for stroke rehabilitation</td>
</tr>
<tr>
<td>14:05-14:20</td>
<td>Burridge</td>
<td>FES + Robotics and Tele-CIMT</td>
</tr>
<tr>
<td>14:20-14:35</td>
<td>Subramanian</td>
<td>Virtual reality technologies</td>
</tr>
<tr>
<td>14:35-14:50</td>
<td>Solomon</td>
<td>Low-cost virtual reality technologies</td>
</tr>
<tr>
<td>14:50-15:15</td>
<td>Panel</td>
<td>General Discussion</td>
</tr>
</tbody>
</table>

WCPT 2015, LEVIN
Learning Objectives

To become familiar with

- principles of neuroplasticity, motor control and motor learning applicable to stroke rehabilitation;

- how technology can assist in application of principles in therapy

- examples of using technology in developed and developing countries; barriers and facilitators
Symposium will focus on: Upper Extremity Recovery after Stroke

- Up to 88% of patients show initial upper extremity sensorimotor dysfunctions that persist in 55 to 75% of patients for more than three months (Young and Forster, 2002)

- Poor recovery of the upper limb leads to limitations in ADL and quality of life
Mindy F. Levin, PhD, PT
Professor, School of Physical and Occupational Therapy, McGill University, Canada

Jane H. Burridge, PhD, PT
Professor in Restorative Neuroscience, Southampton University, UK

Sandeep K. Subramanian, PhD, PT
Postdoctoral Fellow, Dept. Neuroscience, University of Montreal, Canada

John Solomon M., PhD, PT
Associate Professor, Department of Physiotherapy, MCOAHS, Manipal University
New technologies for stroke rehabilitation

Mindy F. Levin, PT, PhD

Canada Research Chair in Motor Recovery and Rehabilitation
Stroke rehabilitation: How effective are we?

- **More effective acute management**, but number of stroke survivors needing long-term care or rehabilitation increasing — economic burden

- At 6 months post stroke, 50-70% continue to have arm motor deficits; 30% are unable to walk without assistance and 46% have cognitive deficits;  (*Young and Forster, 2002, Go et al., 2013, Amer Heart Association, 2014)*.

- Mounting evidence that recovery can extend beyond course of usual rehabilitation *(e.g., Cirstea and Levin 2007; Piron et al. 2010)*

- Motor recovery is attributable to adaptive plasticity and motor learning *(Nudo 2003)*
Ten principles of experience-dependent neural plasticity

1. Use it or Lose It
2. Use it and Improve It
3. Specificity
4. Repetition Matters
5. Intensity Matters
6. Time Matters
7. Salience Matters
8. Age Matters
9. Transference
10. Interference

Best recovery achieved through repetitive practice with appropriate feedback of functionally relevant tasks at the right time (i.e., ADLs, manipulation of objects, etc.). Need to strengthen key muscles and movements in task-relevant patterns (i.e., shoulder flexion with external rotation).
Links between Technology and Principles of Neuroplasticity and Learning

- More Repetitions
- More Practice Time
- Adjustable Difficulty Level

Motivation

- Too hard
- Too easy
- Ideally difficulty progression

Feedback

Increasing difficulty

WCPT 2015, LEVIN

http://www.iisartonline.org
Rehabilitation Technology V.0

Training devices

Assistive devices

Measurement devices

WCPT 2015, LEVIN

http://www.iisartonline.org
Rehabilitation Technology V.1

**Robotics**
assist, enhance, intensify therapy

**Non-Actuator Devices**
(no motors) body weight support systems

**Functional Electrical Stimulation**
replace lost motor function

**Virtual Reality**
assist, enhance, intensify therapy feedback & motivation

**Sensor Technology**
motion tracking

**Brain Stimulation**
enhance recovery

WCPT 2015, LEVIN

http://www.iisartonline.org
Interventions for sensorimotor rehabilitation

Motor planning
Coordination
Force
Isolated mvt
Muscle tone
Reflexes

Task Performance

Sensorimotor approaches
Robotics

Mental practice

Task-specific
CIT
Virtual Reality

Neurodevelopmental approaches
TMS/tDCS
NMES/FES

WCPT 2015, LEVIN
Number of studies published between 2007 and 2013

Search key words: ‘rehabilitation’ with ‘virtual reality’ or “telerehabilitation” or ‘robotics’

WCPT 2015, LEVIN
Rehabilitation Gaming System (RGS) -

Task adjusted to user abilities by PTM that adapts difficulty of subsequent trial according to success rate of previous trials.
Video-capture VR environments

Patrice Weiss, Haifa; Dario Liebermann, BeerSheva; Heidi Sveistrup, Ottawa; Mindy Levin, McGill

Game-like

WCPT 2015, LEVIN

Liebermann, Berman, Weiss, Levin 2012
Tele-rehabilitation
Development of FES

Electronic personal stimulator
Wladimir Liberson

~1961

Parastep I

~ 1982

Freehand System

~1986

Bionic Glove

~ 1989

Handmaster NMS-1

~1993

Complex Motion

~1999

http://www.iisartonline.org

WCPT 2015, LEVIN
Handmaster NMS-1 (~ 1993)
http://www.bioness.com/H200_for_Hand_Paralysis.php

Characteristics

Bioness (formerly Neuromuscular Electrical Stimulation Systems Ltd.)

Lightweight, ergonomical arm-hand orthosis with integrated FES and separate, wireless control unit.

For reaching, grasping, opening and closing the hand
Characteristics

Electrostimulation device for muscle strengthening, arm and hand rehabilitation

NMES, EMG-triggered
Biofeedback
Development of Robotic Rehabilitation

http://www.iisartonline.org

1920
Movement therapy

1954
Unimate
First robotic arm

1975
Programmable
Universal
Manipulation Arm
(PUMA)

1979
Selective
Compliant
Articulated Robot Arm
(SCARA)

1991
MIT-Manus
First therapeutic arm robot

WCPT 2015, LEVIN
MIT-Manus (~1991)

http://interactive-motion.com/

Characteristics

Newman Laboratory for Biomechanics and Human Rehabilitation, Massachusetts Institute of Technology (MIT)

2-DoF end-effector type robot based on a selective compliance assembly robot arm (SCARA)
Assists shoulder and elbow movements in the horizontal plane

First upper limb therapeutic robotic device
Move, guide or perturb a patient’s limb
Measure position, velocity and forces applied
ArmeoSpring – Hocoma

- arm rehabilitation exoskeleton that combines arm weight-support with motivating exercise games in virtual reality.

http://www.hocoma.com/products/armeo/
Wearable Sensors
Arm Tutor (2004)
http://www.meditouch.co.il

Characteristics

MediTouch Ltd, Netanya, Israel

Elbow (wrist, finger, trunk) sensors provide accurate joint movement tracking and games in a VR environment

Exercises designed to train arm and hand function and reduce trunk compensation
Virtual Reality – UL ‘Function’
(related to time since stroke onset)


Review: Virtual reality for stroke rehabilitation
Comparison: 2 Upper limb function: subgroup analyses
Outcome: 2 Time since onset of stroke

<table>
<thead>
<tr>
<th>Study</th>
<th>VR</th>
<th>Comparison</th>
<th>Std. Mean Diff</th>
<th>Weight</th>
<th>Std. Mean Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean (SD)</td>
<td>N</td>
<td>Mean (SD)</td>
<td>N, Fixed, 95% CI</td>
</tr>
<tr>
<td>&lt; 6 months</td>
<td>9</td>
<td>-19.8 (3.4)</td>
<td>7</td>
<td>-27.4 (8.7)</td>
<td>6.8%</td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td>34</td>
<td></td>
<td></td>
<td></td>
<td>24.0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heterogeneity: Chi^2 = 0.68, df = 1 (P = 0.41); P = 0.0% Test for overall effect: Z = 2.58 (P = 0.010)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 6 months</td>
<td>9</td>
<td>52.8 (6.9)</td>
<td>9</td>
<td>50.2 (18.9)</td>
<td>9.4%</td>
</tr>
<tr>
<td>Housman 2009</td>
<td>14</td>
<td>24.9 (7.4)</td>
<td>14</td>
<td>19.6 (6.7)</td>
<td>13.6%</td>
</tr>
<tr>
<td>Piron 2009</td>
<td>18</td>
<td>53.6 (7.7)</td>
<td>18</td>
<td>49.5 (4.8)</td>
<td>17.9%</td>
</tr>
<tr>
<td>Piron 2010</td>
<td>27</td>
<td>49.7 (10.1)</td>
<td>20</td>
<td>46.5 (9.7)</td>
<td>23.8%</td>
</tr>
<tr>
<td>Sugar 2009</td>
<td>11</td>
<td>30 (12.4)</td>
<td>11</td>
<td>26.36 (2.33)</td>
<td>11.3%</td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td>72</td>
<td></td>
<td></td>
<td></td>
<td>76.0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heterogeneity: Chi^2 = 1.32, df = 4 (P = 0.86); P = 0.0% Test for overall effect: Z = 2.75 (P = 0.0060)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>113</td>
<td>92</td>
<td></td>
<td></td>
<td>100.0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heterogeneity: Chi^2 = 2.81, df = 5 (P = 0.83); P = 0.0% Test for overall effect: Z = 3.66 (P = 0.00025) Test for subgroup differences: Chi^2 = 0.81, df = 1 (P = 0.37), P = 0.0%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

WCPT 2015, LEVIN
Robot-assisted therapy trials – UL movement

SES = summary effect size = 0.65, 0.13

Effects of Robot-Assisted Therapy on Upper Limb Recovery After Stroke: A Systematic Review
Gert Kwakkel, Boudewijn J. Kollen and Hermano I. Krebs
Neurorehabil Neural Repair 2008 22: 111 originally published online 17 September 2007

Fugl-Meyer (mean and 95% CI)

Functional Independence Measure (mean and 95% CI)

Favours alternative Favours Robotics

N=218

N=118

Favours alternative Favours Robotics

WCPT 2015, LEVIN
Conclusions

- Improvement in methodological quality of research is still necessary before effects of technology-based interventions can be fully assessed.
- Lack of evidence reflects relative immaturity of discipline.
- Growing field of research with promising early results.
- Variable translation to clinical practice.
Technology-Based Rehabilitation
Technology Hype-Cycle

Gartner Group (www.gartner.com)
New Technologies 1
FES + Robots
CIMT + Telerehab (LifeCIT)

Jane Burridge
jhb1@soton.ac.uk
Twitter@janeburridge2
‘The difficulty lies, not in the new ideas, but in escaping from the old ones…’

John Maynard Keynes
Performance driven FES using robots and sensors

- Progression from planar to 3D robots to Functional tasks
- Iterative Learning Control Algorithms to modulate FES
- Movement trajectories monitored by wearable and remote sensors (MS Kinect and Leap Motion)
- Wearable FES arrays to give targeted stimulation
- Practice everyday tasks
Turning on a light switch (SaeboMAS only)
Turning on a light switch with ILC/FES
Some results from our most recent study

Meadmore et al. The application of precisely controlled functional electrical stimulation to the shoulder, elbow and wrist for upper limb stroke rehabilitation: A feasibility study Journal of NeuroEngineering and Rehabilitation. In Press
## Clinical Results

<table>
<thead>
<tr>
<th>ID</th>
<th>ARAT (57)</th>
<th></th>
<th>F-M Motor (66)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>Post-</td>
<td>Baseline</td>
<td>Post-</td>
</tr>
<tr>
<td>01</td>
<td></td>
<td></td>
<td>15</td>
<td>24</td>
</tr>
<tr>
<td>02</td>
<td></td>
<td></td>
<td>19</td>
<td>24</td>
</tr>
<tr>
<td>03</td>
<td></td>
<td></td>
<td>17</td>
<td>21</td>
</tr>
<tr>
<td>04</td>
<td></td>
<td></td>
<td>21</td>
<td>27</td>
</tr>
<tr>
<td>05</td>
<td></td>
<td></td>
<td>22</td>
<td>20</td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>2.6 (1.52)</td>
<td>7 (1.22)</td>
<td>18.8 (2.86)</td>
<td>23.2 (2.77)</td>
</tr>
<tr>
<td>z-test:</td>
<td>$t(4) = -2.44, p = .036$</td>
<td></td>
<td>$t(4) = -4.49, p = .005$</td>
<td></td>
</tr>
</tbody>
</table>
CIMT and tele-rehab - LifeCIT

A web-based support programme for people using Constraint Induced Movement Therapy (CIMT) at home

Jane Burridge, Lucy Yardley, Ann-Marie Hughes, Sebastien Pollet and Claire Meagher

This presentation reports independent research funded by the National Institute for Health Research (NIHR) under its Research for Patient Benefit (RFPB) Programme (Grant Reference Number PB-PG-0909-20145). The views expressed are those of the author(s) and not necessarily those of the NHS, the NIHR or the Department of Health.
The LifeCIT concept

- Forced use therapy – 3 weeks
- Interactive website
- Motivating support and feedback
- Exercises and games
- Minimal cost: £50 for the constraint mitt

The C-Mit
www.odstockmedical.com
LifeCIT: Philosophy

- **NOT:** Giving instructions – therapist in charge - ‘This is what you need to do....’

- **BUT:** Enabling the patient to take the lead – with support and guidance - ‘What do you want to be able to do?’

- Encourages self-efficacy and independence rather than compliance and dependence
Phases of the study

- Phase 1: development (18 months) (2011-2012)
- Phase 2: multi-centre pilot RCT (24 months) (2012-2014)
Phase 1: Development of the web-pages

- Mock-ups with therapists, patients and carers
- Think-aloud studies with 9 chronic stroke patients and 12 sub-acute (<12 weeks) patients in hospital and home
Developments based on observed patients’ behavior navigating the website and simultaneous oral feedback

- Website navigation:
  - avoid multiple menu options - linear progression through the pages
  - no scrolling – all information on one page

- Clarity of instructions:
  - minimal text and avoiding ambiguity
  - motivational language and illustrations e.g. ‘congratulations’ ‘how to get the most out of LifeCIT’
  - Instructions via video with a voice-over rather than text
Welcome to LifeCIT

If this is the very first time on the LifeCIT website then click here:

This is the first time I am using LifeCIT

If you already registered with LifeCIT then click here:

I've used LifeCIT before

If an existing LifeCIT user has given you their user name to view their progress, click this button:

View user progress
How can I get the most out of LifeCIT?

- **Wear the mitt** for up to 9 hours a day. The longer you wear it, the better the chances of improving.

- **Log onto LifeCIT each morning** and plan daily activities that you can do using your stroke arm.

- **Log on later in the day** to tell LifeCIT what you have been doing.

- Play LifeCIT **computer games** and do some LifeCIT **arm exercises**.

Click here to continue:  

Set your goals for this week

Select goals by clicking on the small grey circles:

I will wear the mitt for:

1 2 3 4 5 6 7 8 9 10 hours a day

I will do activities for:

1 2 3 4 5 6 7 8 9 10 hours a day

I will play LifeCIT computer games for:

0 15 30 45 60 minutes, twice a day

The numbers in orange are our suggestions for a goal, but you can choose what is realistic for you this week.
Final Version of the Website

• Provides personalized advice on request
• Has an embedded assessment based on the Motor Activity Log (MAL)
• Invites users to set targets, goals and a program of Mitt wear, exercises and tasks each day
• Gives visualizations of exercises and specially designed computer games
• Provides feedback on progress
• If progress is not as hoped it provides advice on how to adapt behavior
• Includes links with therapists and ‘supporters’

https://pips.ecs.soton.ac.uk/player/play/LifeCIT_demo1

Requires Username: 2 letters and 2 numbers and Password: free choice
Phase 2: Does a 3-week LifeCIT intervention improve upper limb function - maintained at six-months?

- Pragmatic RCT
- Patients recruited on discharge from hospital 7 days to 3 months post stroke and a second cohort of chronic stroke patients
- Selection criteria included safety using CIT at home, >10° wrist movement, grasp task, and <5 on the MAL
- Main outcome measures: WMFT and MAL (Baseline, post intervention and six-month follow up)
- Post treatment interviews with the patients who used LifeCIT
Participants

- Screened: N=83 (64 – not meeting inclusion criteria 18 declined (3 could not use a computer)
- Recruited:
  - Control N=8  Treatment N=11
  - Sub-acute N=4 Post 16 weeks N=15
- Drop-outs: n=1 (frozen shoulder) – missed 6-month assessment
## Between Group differences - main outcomes

<table>
<thead>
<tr>
<th>Outcome Measure</th>
<th>Mean difference between groups</th>
<th>ANCOVA P-Value (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAL / AOU Baseline to end of treatment Score - 0-5</td>
<td>1.00*</td>
<td>&lt;0.003** (0.43-1.57)</td>
</tr>
<tr>
<td>MAL / AOU Baseline to follow-up</td>
<td>0.25</td>
<td>0.64 (0.95-1.44)</td>
</tr>
<tr>
<td>MAL / QOU Baseline to end of treatment Score 0-5</td>
<td>0.89*</td>
<td>&lt;0.003** (0.36-1.40)</td>
</tr>
<tr>
<td>MAL / QOU Baseline to follow-up</td>
<td>0.46</td>
<td>0.42 (0.80-1.71)</td>
</tr>
<tr>
<td>WMFT (FAS) Baseline to end of treatment Score 0-5</td>
<td>0.45*</td>
<td>&lt;0.001** (0.24-0.65)</td>
</tr>
<tr>
<td>WMFT (FAS) Baseline to follow-up</td>
<td>0.50*</td>
<td>0.15 (-0.24-1.24)</td>
</tr>
</tbody>
</table>

*Minimum Clinically Important Differences (MCID):**
- **between group sig P<0.05**
- MAL: 10% (i.e. 0.5) (Van der Lee Stroke 2003)
- WMFT (FAS) 0.2-0.4 (Keh-chung NNR 2009)
Summary of adherence data recorded on the LifeCIT Website

<table>
<thead>
<tr>
<th>Activity</th>
<th>Mean (SD) Min–Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time the Mitt was worn each day (hours)</td>
<td>4.8 (2.6) 1.4–8.4</td>
</tr>
<tr>
<td>Total reported activity time / day (hours)</td>
<td>3.2 (1.7) 0.6–5.9</td>
</tr>
<tr>
<td>Number of activities completed / day</td>
<td>8.9 (4.9) 2.5–15.6</td>
</tr>
<tr>
<td>Days activity reported (max 21, target 15)</td>
<td>13.6 (2.1) 11-18</td>
</tr>
</tbody>
</table>
Post-treatment Interviews with LifeCIT participants

Recorded on audio-tape, transcribed and analyzed using thematic analysis. The views expressed were overwhelmingly positive.....

• ‘...you know I was computer illiterate... and now I am starting on the 5th, I’ll be doing computer lessons at the library’

• ‘It also showed you your achievement at the end of each week so you could see where you were going with it... I found it all really good.’

• ‘[before the treatment] I had hardly any [function] really... I’ve definitely ... improved over 50 % using the mitt, definitely and everyone said the same thing.’
Conclusions

The use of FES+Robots is feasible and, when stimulation of wrist extension hand opening is included, function may be improved.

Using an intensively co-designed web-supported programme may be a cost-effective way to deliver CIMT (and potentially other interventions) at home.
Thank you for your attention

Jane Burridge
jhb1@soton.ac.uk
Twitter@janeburridge2
Virtual Reality Technologies

Sandeep K. Subramanian, PT, PhD
Department of Neurosciences,
University of Montreal, Canada
Motor Learning

What are we learning

- **Recovery** – accomplishing a movement or task the same way as it was done before. - also called ‘restitution’

- **Compensation** – accomplishing a movement or task in a different way than how it was done before. Other terminology: ‘adaptation’, ‘substitution’ e.g. use of trunk to extend the reach of the UL (Levin et al., 2009)

Motor performance (e.g. movement precision, speed)

Movement pattern (e.g. joint ROM, trunk movement)
Virtual Reality

- VR technical assembly that allows users to interact with objects or events in a virtual environment (VE; computer software generated simulation; Wilson et al., 1997).

- Interaction in a VE similar to real world physical environments (PEs).
Factors to consider in the use of VR

- **Level 1a evidence** (Sackett’s levels) on use of VR for upper limb rehabilitation *(EBRSR.com, accessed on April 19, 2015).*
- Optimal practice parameters need to be identified.
- High intensity practice → better outcomes.

Intensity

- Duration
- Numbers of repetitions
Study Objective, Question and Hypotheses

- **Study Objective:** Dose matched practice with feedback

\[ \text{VE} > \text{or} = \text{PE} \]

- **PICO Question:** “In subjects with post-stroke upper limb hemiparesis, does dose-matched practice with provision of feedback in a VE compared to a PE, result in similar or better arm motor recovery?”

- **Hypotheses:**
  After task practice in VE compared to PE, there will be greater improvements in
  i) UL motor impairment levels and
  ii) clinical measures of UL activity and arm use
# Participation schedule

<table>
<thead>
<tr>
<th>Pre-test</th>
<th>Intervention</th>
<th>Post-Test</th>
<th>Follow-up (3 months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
<td>Weeks 2 - 5</td>
<td>Week 6</td>
<td>Week 18</td>
</tr>
<tr>
<td>Clinical evaluations (FMA, RPSS, WMFT, MAL)</td>
<td>Three 1-hour sessions /wk, 4 weeks (72 trials/session, 3 blocks x 24 trials)</td>
<td>Clinical evaluations (Motivation Questionnaire)*</td>
<td>Clinical evaluations</td>
</tr>
<tr>
<td>Kinematic recording</td>
<td>Group 1 - PE</td>
<td>Kinematic recording</td>
<td>Kinematic recording</td>
</tr>
<tr>
<td>Kinematic recording</td>
<td>Group 2 - VE</td>
<td>Kinematic recording</td>
<td>Kinematic recording</td>
</tr>
</tbody>
</table>

(FMA: Fugl-Meyer Assessment; RPSS: Reaching Performance Scale in Stroke; WMFT: Wolf Motor Function Test; MAL: Motor Activity Log)
Feedback – Knowledge of results
(motor performance variables)

• **Positive feedback** - movement is both temporally and spatially successful (high pitched ‘ping’ sound, target turns green)

• **Negative feedback** - movement is not rapid and/or precise enough (buzzer sound, color of the target does not change)
Feedback – Knowledge of performance (movement pattern variables)

- Excessive trunk motion – 3\textsuperscript{rd} sound emitted (‘whoosh’), target turns \textbf{red} (even if the subject’s movement was accurate and precise enough)

- Default value for permissible trunk displacement \textit{tolerance} adjustable (i.e. 5 cm; Subramanian et al., 2010)
n=16 in each group (single unilateral stroke ≥6 mos and <5 yrs)

Participants matched in terms of FMA scores, age and chronicity.

Both groups further divided into sub-groups based upon FMA scores as mild (≥50/66) and moderate to-severe (≤49/66).
Effects of training environment

Greater improvements in shoulder horizontal adduction and flexion ranges of motion in the VE group

* p<0.05, ** p<0.01
Effects of Severity - kinematic outcomes

**Moderate-to-severe (FMA ≤49/66) PE subgroup:** Better improvement in elbow extension, but more compensation

**Mild (FMA ≥50/66) VE subgroup:** Better improvement in elbow extension without compensation

*p<0.05, **p<0.01
Effects of Severity - clinical outcomes

Change in moderate –to–severe VE group: MCID value

*p<0.05
Motivation questionnaire

**Perceived competency**

- I think I am pretty good at this activity

**Pressure/Tension**

- I was anxious while working on this task

---

More competency in PE

Score ≥ 4  Score ≤ 3

More enjoyment in VE

*p<0.05, **p<0.01*
Salient results

- Dose matched task practice in VE led to greater improvements in arm-motor impairment levels (greater ROM of shoulder horizontal adduction and flexion).
- Levels of severity influenced the outcomes: more elbow extension ROM with greater compensations in the moderate-to-severe PE and without compensation in the mild VE subgroups.
- Improvements in the VE group can be attributed to factors including better use of KP and greater enjoyment.
- Dose-matched practice in a VE lead to a more adaptive pattern of arm motor recovery as compared to a PE in subjects with chronic post-stroke upper limb hemiparesis.
Influence of cognitive deficits

Improvements in VE with feedback provision were related to better memory and executive functioning (problem solving and cognitive flexibility) abilities (Mullick et al., 2015)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Target</th>
<th>Assessment</th>
<th>Verbal memory</th>
<th>Problem solving</th>
<th>Cognitive flexibility</th>
<th>Visuo-perception</th>
<th>Depression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focalize</td>
<td>LM</td>
<td>Post</td>
<td>RAVLT_DR</td>
<td>TOL_Moves</td>
<td>WCST_categories</td>
<td>ROCF_copy</td>
<td>BDI-II scores</td>
</tr>
<tr>
<td>Shld Hor Add</td>
<td>UI</td>
<td>RET</td>
<td>-0.685 *</td>
<td>-0.716_b</td>
<td>0.703_b</td>
<td></td>
<td>0.677_a *</td>
</tr>
<tr>
<td>Shld Flx</td>
<td>UI</td>
<td>RET</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.600_a *</td>
</tr>
<tr>
<td>Elb Ext</td>
<td>UI</td>
<td>Post</td>
<td></td>
<td></td>
<td></td>
<td>-0.754_a **</td>
<td></td>
</tr>
</tbody>
</table>
Influence of depression

Presence of depressive symptoms after stroke influences use of feedback for motor improvements (kinematic and clinical)

* p<0.05, ** p<0.01
Clinical implications

- Better recovery of post-stroke arm motor impairment and function may be ensured by incorporation of:
  - the basic elements identified as pertinent to optimize motor learning and recovery into task practice
  - appropriate feedback,
  - adequate attention to movement quality
  - knowledge of the presence of cognitive and mood deficits
Acknowledgements

- Dr. Mindy Levin
- The participants
  - Ruth Danennbaum, Rhona Guberek, Eric Johnstone, Christian Beaudoin, Vira Rose and Dr. Anatol Feldman
- Maria Fraraccio and Dr. Joelle Crane
- Gevorg Chilingaryan and Dr. Heidi Sveistrup
- Focus on Stroke Initiative and McGill Faculty of Medicine
BRAINTRAIN: Making the most of new technologies for stroke rehabilitation

Low cost technologies

John Solomon M, PT, PhD,
Associate professor, Dept of Physiotherapy, SOAHS, Manipal University, India
Stroke in India

Prevalence rate:
• 84-262/100,000 in rural and 334-424/100,000 in urban areas.

Incidence rate:
• 119-145/100,000
• Very few centers in the country have organized in-hospital and outpatient rehabilitation facilities

(Pandian JD et al, 2013)
Burden in developing and low income countries

- Awareness
- Early discharge
- Lack of adequate rehabilitation centers
- Financial constraints
Effect of a low-cost modified peripheral input device for training upper limb function in patients with stroke using computer games

John Solomon M, Manikandan N, Ritu Shroff, Sowmya Bhat

Objectives of the study:

- To design a low-cost modification to the mouse for facilitating computer exergaming in patients with hemiplegia
- To analyse the feasibility and effects of training on U.L functions following modified exergaming.
<table>
<thead>
<tr>
<th>Participant</th>
<th>Pre</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant 1</td>
<td>24</td>
<td>26</td>
</tr>
<tr>
<td>Participant 2</td>
<td>40</td>
<td>44</td>
</tr>
<tr>
<td>Participant 3</td>
<td>24</td>
<td>25</td>
</tr>
<tr>
<td>Participant 4</td>
<td>36</td>
<td>38</td>
</tr>
<tr>
<td>Participant 5</td>
<td>20</td>
<td>25</td>
</tr>
</tbody>
</table>

**Fugl Meyer Upper Extremity Scale score (66)**
Commercially available VR game systems

Wii

Xbox 360- Kinect

Sony Eye toy
Commercially available VR game systems

• Advantages
  – Availability
  – Low cost
  – Home based use
  – Fun to use
  – May involve family members

• Disadvantages
  – Not specific to the motor dysfunction
  – Level of activity may not be appropriate
  – Patients may get uninterested sooner
Evidence for effectiveness of commercial devices in stroke rehabilitation


Effect size in body structure domain

<table>
<thead>
<tr>
<th>Study</th>
<th>Effect Size (G)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kim, 2012</td>
<td>0.52 [-0.42, 1.46]</td>
</tr>
<tr>
<td>Saposnik, 2010</td>
<td>0.12 [-0.76, 1.00]</td>
</tr>
<tr>
<td>Yavuzer, 2008</td>
<td>1.73 [0.72, 2.73]</td>
</tr>
</tbody>
</table>

Summary G: (RE Model)

Effect size in activity domain

<table>
<thead>
<tr>
<th>Study</th>
<th>Effect Size (G)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GillGomez, 2011</td>
<td>0.90 [-0.07, 1.86]</td>
</tr>
<tr>
<td>Kim, 2012</td>
<td>0.31 [-0.61, 1.24]</td>
</tr>
<tr>
<td>Saposnik, 2010</td>
<td>-0.25 [-1.13, 0.64]</td>
</tr>
<tr>
<td>Yavuzer, 2008</td>
<td>2.19 [1.11, 3.27]</td>
</tr>
</tbody>
</table>

Summary G: (RE Model)

Jintronix rehabilitation system

- Consists of a computer interface with a Kinect camera to track upper body movements
- 3 unilateral and 2 bilateral activities
- Participants reach for, transport and release objects or move the arm through a prescribed trajectory
Virtual reality stroke rehabilitation

Philippe Archambault, Mindy F. Levin, John Solomon M

➢ Objectives of the Study
  • To assess the usability of the Jintronix VR rehabilitation system by clinicians and patients with hemiparesis due to stroke.
  • To develop clinical guidelines for using this system
Methodology

• Hemiparetic patients between 30 to 65 years of age participated in the study

• Seventeen stroke patients in sub-acute phase were recruited and participated in a three session trial

• Seven therapists with at least one year of experience in neurorehabilitation
Perceived Usefulness of VR training

Participants with stroke

Clinicians

Perceived Usefulness

- positive
- negative
- neutral
Effect of virtual reality training on trunk control in patients with stroke

John Solomon M, Xina Quadros, Senthilkumaran D, Philippe Archambault, Mindy F. Levin,
141 Subjects with stroke were screened

Excluded (n=115)
Reasons for exclusion:
- Refused consent = 12
- Low GCS = 10
- <28 MMSE = 2
- Global aphasia = 12
- Vestibular = 7
- Visual = 3
- Associated medical conditions/medically unstable = 33
- Early discharge = 15
- Functionally independent = 15
- Chronic stroke = 6

26 subjects were included and written informed consent obtained

Block randomization

Experimental group (n=13)
Control group (n=13)

Baseline assessment by blinded rater

Intervention (6 sessions): conventional PT + Kinect based trunk training via the JRS

Intervention (6 sessions): conventional PT + computer based gaming with mouse

Experimental group (n=13)
Control group (n=13)
Comparison of trunk impairment scale scores between the groups (n=26)

Comparison of sit and reach distances between the groups (n=26)

Statistically significant difference was found on comparison between groups (p=0.001)

Statistically significant difference was found on comparison between groups (p=0.009)
Clinical message

• Low-cost VR devices are effective in improving motor functions in stroke patients

• Patient motivation to participate and acceptance of VR technology are high

• This technology could be used for home-based programs
Thank You!
Drivers of change in clinical practice...

• Economics – need for cost effective treatments
• Clinical evidence
• Basic science
• Technology