FES-enhanced Training on a Tele-Rehabilitation workstation improves Tetraplegic Hand Function

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FES-assisted exercise following a SCI is effective in improving muscle strength, preventing injury and increasing independence in all phases of rehabilitation.

Access to FES devices is limited and they continue to be expensive.

Spinal Cord Injury Rehabilitation Evidence
www.scireproject.com/rehabilitation-evidence/upper-limb/key-points
So FES combined with exercise training produces results

BUT

How can it be delivered cost-effectively?

surface FES stimulators

Medtronic Respond 1970s

Neuromove 1980s

Bioness H200, 1990s

Bionic Glove 1990s

Rehabtronsics Hand Stimulator 2014
7 C5-6 SCI subjects
Significant improvements in:
• grip strength (0.6N to 16.5N)
• finger motion
• Fugl-Meyer scores

Alon & McBride 2003
Toothclick triggering

Vibration sensor & transmitter

Electrode cuff

Receiver/stimulator

US 6,961,623 (2005)

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Toothclick triggering

Prochazka et al 2007

Gan et al 2011
Head nod triggering: Rehabtronics Hand Stimulator

- Regulatory submissions underway
- Available mid-2015
- Cost ~$2K
Conventional exercise tasks are boring. How can we improve interest and adherence?

Computer gaming with robots?

- IMT Inmotion
- MIME
- Hocoma Armin
- Motorika Reo

- Cost………………………~$100K
- ROM………………………partial
- Dextrous manipulation……no
- Weight support.............yes
- Games.........................some
- Tele-supervision..............no
- UL function test.............Kinarm
**Small rehab robots**

- **Cost**: ~$10K
- **ROM**: limited
- **Dextrous manipulation**: no
- **Weight support**: yes
- **Tele-supervision**: no
- **Games**: yes
- **Hand function test**: yes

**Rehab robots: conclusions**

- Robots are very costly
- It’s what the participant tries to do that’s important, not robotic assistance
<table>
<thead>
<tr>
<th>passive exercise devices</th>
<th>Biometrics e-link</th>
<th>Hocoma Armeo Spring</th>
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<tr>
<td></td>
<td>Cost...............~$20K</td>
<td>Cost...............&gt;~$60K</td>
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<tr>
<td></td>
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<td>ROM.......................partial</td>
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<td></td>
<td>Games........................no</td>
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<tr>
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<td>Validated UL function test...no</td>
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<table>
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<tr>
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<th>Nintendo Wii</th>
<th>Jintronix Kinect system</th>
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<td>Hand function test..............no</td>
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ReJoyce system

10 games

tele-coaching enabled

ReJoyce automated hand function test

- Quantitative, standardized
- Tests ROM and dexterity
- Takes ~4 min
- Generates log automatically
- Calibrates game difficulty
• Criterion validity: correlation with ARAT $r^2 = 0.88$
• Responsiveness: effect size in RCT = 1.8.
• Test–retest difference: 0.67% ± 3.6%

Buick et al. J. Motor Behav. 2015

Standardized outcome evaluation across centers
Results

13 C5/6 subjects, 18 hands

ARAT

RAHFT

Task-specific scores

RAHFT Conventional Treatment Improvements

RAHFT ReJoyce Treatment Improvements
Best improvements were in medium-functioning subjects

3-centre RCT

- RCT in Vancouver, Toronto, Montreal
- 8 wks of IHT/FES-ET, 1 hr/day, 5 days/wk on a ReJoyce workstation.
- 14 participants block-randomized: tele-supervision 1 day/wk or 5 days/wk
ReJoyce arm hand function test

<table>
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<th>% change</th>
<th>Toronto RAHFT no FES</th>
<th>Vancouver RAHFT no FES</th>
<th>Toronto RAHFT with FES</th>
<th>Vancouver RAHFT with FES</th>
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</table>

% of able-bodied function

Why did the Vancouver group do better?

- Mean baseline scores Toronto 25%, Vancouver 40%
- Vancouver group benefited from FES, Toronto didn’t
Chronic stroke study, Edmonton, Belfast
6w, 1h/d, 5 d/w ReJoyce + FES + telerehab, n=11

Clients with mild to moderate hand function at baseline

ARAT % change

baseline  week 3  week 6

Reported Improvements in ADLs

- Grooming (combing hair, brushing teeth)
- Opening fridge door
- Picking up and holding heavier objects
- Opening doors with spherical knobs
- Lifting books down from shelves
- Holding phone handsets for longer periods
- Pulling files
- Picking things up from the floor
- Using tools such as hammers
- Selecting grocery items from supermarket shelves
- Holding cooking utensils
- Opening jar lids, pill containers
Tele-rehab

- The technology is commercially available
- The clinical trials have shown efficacy and feasibility
- Yet uptake has been slow......Why?

Tele-rehab: barriers

- More research evidence needed
- Reimbursement
- Licensure Portability
- Privacy: HIPAA Compliance

Pittsburgh Telerehab RERC, Ellen Cohn 2011

- Therapists prefer “hands-on”
- Busy therapists don’t have time for techno-gadgets unless they’re effective, turn-key and reliable
- Rehab chains may see tele-rehab as a threat to in-clinic clients
- Industry: unproven profit model

Rehabtronics, U of Alberta
Google, Scripps Health and One Medical are testing “Talk with a Doctor” tele-medicine.

Forbes article 15 Oct 2014: “some startups already offer telemedicine services: Amwell, Ringadoc, Teladoc, Doctor on Demand….but telemedicine through Google would be a game-changer because billions of people use Google every day and a large portion of those queries are health-related.

- Tele-rehab is sure to follow
- The technology is clinically tested, FDA-compliant and readily available
- So what’s needed?
- Therapist champions seizing the opportunity and ownership

Conclusions

- Clinically important improvements in UL function after 6 weeks of 1 h/day FES-ET
- VR training devices encourage adherence. Low-cost passive devices suffice
- Quantitative UL function tests allow standardized comparisons
- In-home tele-coaching proven in trials, now needs champions.
• Jan and Toni Kowalczewski
• Michel Gauthier
• Natalie Ravid
• Andy Prochazka (Rehabtronics)

• Tania Lam
• Jennifer Loffree
• John Steeves
• Milos Popovic
• Vera Zivanovic
• Naaz Desai

• CIHR
• AIHS
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• Victorian Neurotrauma Institute
• Rick Hansen Institute
• NIH