Robotics for Stroke Rehabilitation

Joel Stein, MD

Department of Rehabilitation Medicine
Columbia University College of Physicians and Surgeons
Weill Cornell Medical College
NewYork-Presbyterian Hospital
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- Funded Research
  - Tibion (funded research study)
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- Scientific Advisory Board
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Outline

- Stroke Recovery & Rehabilitation
- Newer approaches to treatment
  - Exercise therapy
  - Robotics
  - Virtual Reality
  - Brain Stimulation
  - Electrical Stimulation
  - Combination Therapy
Recovery & Rehabilitation

- Rehabilitation = Recovery + Compensation
How does recovery occur?
Cerebral Plasticity
Approaches to Enhance Recovery

- Exercise/Task Practice
- Brain Stimulation (Electrical, TMS)
- Sensory Enhancement or Stimulation (e.g. Vibratory, electrical, thermal, acupuncture)
- Medications (?amphetamines, SSRI’s)
- Growth Factors and Stem Cells
What do patients want from Rehabilitation?

With apologies to Sigmund Freud
What do patients want?

- Recovery!!
- Functionally meaningful improved motor function
- Durable response to therapy
- Engaging (fun) activities
- Efficient use of time
- Covered by insurance
What do clinicians want?

- Same as patients, plus:
- Patient compliance
- Affordable technology
- Efficient use of gym space
- Financially viable for institution
- An option for self-directed home-based therapy
- Generalization to other activities
The problem with exercise

15 minutes of cardio, 15 minutes of weights, and an hour of talking myself into it.
Mental Practice

Okay, think... and stop!
And think, ... and stop!
Stay with me, now!
Think harder!
Feel that burn!

Brain exercise video
What is the role of exercise in stroke rehabilitation?

1. Exercise helps in teaching compensatory techniques for rehabilitation
2. Exercise can stimulate the brain to recover lost function
3. Exercise's primary role is to distract the patient while recovery takes place
4. I'm not sure - it makes me tired to think about it
5. A & B

- 1: 15%
- 2: 8%
- 3: 0%
- 4: 0%
- 5: 77%
Exercise vs. Robotics: Man vs. Machine?
Why high-tech rehab?

- Often the only way to provide certain therapies and treatments
Why high-tech rehab?

* Labor saving – cost of personnel rising while the cost of technology is falling
Why high-tech rehab?

- Able to provide treatments repetitively without therapist fatigue
Why high-tech rehab?

- More interesting for the patient
Why high-tech rehab?

* Competitive marketing advantage
Robot-Assisted Rehabilitation
Robot Aided Rehabilitation

- Robot provides assistance in completing reaching tasks
- Assistance provided decreases as patient’s ability increases
- Suitable even for patients with severe weakness
- Both short (Aisen 1997) and long term (Volpe 1999) benefits demonstrated for treatment early after stroke
Motor function pre- and post-Robot Therapy

Scores

Fugl-Meyer
MSS (Shoulder and Elbow)
MSS (Wrist/Hand)
MRC motor power

Baseline
After Robot Therapy
InMotion3 Wrist Robot
VA Robot Study

- VA multicenter study
- 127 chronic (>6 months) hemiparetic stroke survivors
- 49 assigned to 12-week robot therapy, 50 to intensive therapist-assisted therapy, and 28 to usual care
- Robot Rx: 3 weeks each of Shoulder-Elbow, Vertical+Grasp, Wrist, and then combined

VA Robot Study

A Fugl-Meyer Assessment, Robot vs. Usual Care

Overall mean difference, 2.88 (95% CI, 0.57 to 5.18); P=0.02

B Fugl-Meyer Assessment, Robot vs. ICT

Overall mean difference, -0.58 (95% CI, -2.97 to 1.81); P=0.63

VA Robot Study: Conclusions

- Effects of robotic therapy were modest.
- Robotic therapy was similar in outcome to intensive human therapy.
- Robotic therapy was somewhat more expensive than comparable human therapy ($9,977 vs. $8,269).
- Patients receiving robotic therapy in the 2nd half of the study showed greater improvement on multiple measures (Staff experience).
Motorika Reo Go
Armeo Power
Partial Body-Weight Supported Treadmill Training

Video courtesy of Hocoma, Inc.
Lokomat System

Video courtesy of Hocoma, Inc.
It’s not just the amount of Exercise: Robot vs. Human Gait training

Changes in gait speed at post- and F/U assessments at self-selected velocity (SSV; A) and fast velocity (FV; B)

Hornby, T. G. et al. Stroke 2008;39:1786-1792
Anklebot
Tibion “Bionic Leg”

1. Sensors in the device and inside the shoe detect user action (for example, sitting, standing, climbing stairs).
2. Microprocessors in the device analyse this information.
3. Device provides external force to supplement muscle strength.
Tibion device: Walking
Exoskeletal Robots
SCI - Unassisted

Unassisted Motion
Motor Impairment

Upper Extremity Fugl-Meyer Scores

Subject 1
Subject 2
Subject 3
Subject 4
Subject 5
Subject 6
Hand Robot - Amadeo
Amadeo games
Increased AROM after Training
Why use robots in stroke rehabilitation?

1. Robots are sophisticated exercise machines that provide repeated exercises in a reliable and reproducible manner.

2. Robots can be helpful around the house, serving drinks, fetching slippers, and straightening up before guests arrive.

3. Robots can incorporate virtual reality or games to make exercises more engaging for the patient.

4. Robots offer a type of therapy that is unique and entirely distinct from exercise therapy.

5. A&C
What is the role of robots in stroke rehabilitation in 2011?

1. Robots should be routinely used and are considered "standard of care"
2. Robots represent an entirely new approach to therapy that is vastly superior to traditional human-delivered therapy
3. Robots are capable of supplementing traditional therapy, but their role in routine clinical rehabilitation remains uncertain
4. Robots are evil and likely to take over the world if we don't take immediate and drastic action.
Virtual Reality vs. Robotics

- Less well-studied than robot-aided rehabilitation
- Use of virtual environment allows real-time visual or auditory feedback for motor task training
- Some systems provide haptic (force/touch) feedback (e.g. Rutger's Ankle)
- Consumer devices both sophisticated and inexpensive
- Which patient populations are right for this technology?
Rutger's Ankle VR system
Consumer Market Virtual Reality/Gaming Devices

Xbox Kinect
USE YOUR WHOLE BODY
There's an app for that...

PocketSLP
The Digital SLP Assistant

Welcome to PocketSLP Articulation

$29.99
Click Here for a Demo
Virtual reality and gaming are promising tools for rehabilitation because:

1. They replace the need for conventional PT and OT
2. Staff can use them during lunch breaks to play virtual soccer tournaments
3. They are fun and engaging methods of encouraging patients to exercise and perform task-practice
4. We are living in the Matrix, and these tools give us access to the source code so we can change reality
Transcranial Magnetic Stimulation (TMS)
Transcranial Direct Current Stimulation (TDCS)
Therapeutic Electrical Stimulation

Neuromove – EMG triggered Therapeutic Electrical Stimulation

Bioness Therapeutic Electrical Stimulation System
Saeboflex & SaeboReach
Lower Limb FES

Bioness L300

Walk-aide
Implantable FES: Neurostep
Combination Therapy

Combining two or more treatments concurrently or consecutively to maximize recovery

Types of treatments

- Therapeutic Exercise/Task Practice
- Limb stimulation (electrical, acupuncture)
- Brain stimulation
- Medications
- Growth Factors
- Stem Cells
- Others?
Are effects additive, synergistic, or zero-sum?

* If therapies “A” and “B” each provide 10% benefit individually, will combining them provide:

a) 20% benefit (Additive)

b) 30% benefit (Synergistic)

c) 10% benefit (Zero-sum)

d) 5% benefit (Interfering)

e) Unknown

Answer: (e) Unknown
Conclusions

- Exercise remains our primary method for enhancing motor recovery after stroke, as well as for teaching compensatory strategies.
- Effect size of existing therapies are insufficient to substantially impact disability.
- Technology will play an expanding role in rehabilitation in the near future, including robotic and/or virtual reality-aided therapy.
- Combination therapies are likely to be useful (especially involving exercise).