The Role of Patient Mobility In the Recovery of the Neurologic Patient

Neural Stimulation through Mobilization
A Presentation in Conjunction with the

Patsy Getz Initiative

Mobility is Medicine
For those of you who were never fortunate enough to know Patsy, let me take a moment to honor her. Patsy was a Nurse who devoted her entire professional life to the quality of patient care here at Emory. As a Clinical Nurse Specialist in orthopedics and rehabilitation, Patsy was adamant about the necessity of early mobilization for the health and recovery of our patients. As one of the founding planners for the Center for Rehabilitation Medicine, Patsy put this sentiment into practice. It was in her honor, and now in her memory, that we initiate this mobility program.
Presentation

- Definition of Rehabilitation & Compensation
- Overview - Role of Brain Stimulation in Functional Recovery
- Functional MRI and New Evidence on Motor Recovery
- It’s as Simple as ROM
- The Virtual Body - the Brain’s Organization
- Consequences of Limited Brain Stimulation due to Lack of Movement
- How Fast Can the Brain Change?
- Summary
Definitions
“Rehabilitation”

• **re·ha·bil·i·tate**

• **To restore** to good condition, operation, or capacity.

• **Origin**

  Medieval Latin rehabilitāre, rehabilitāt-,* to restore to a former rank* : Latin re-, re- + Late Latin habilitāre, *to enable*
“Compensation”

• **compensation**

• Biology: the *improvement* of any defect *by* the excessive development or action of another structure or organ of the same structure.

• **Origin:**
  1350–1400; Medieval latin: *compensacioun*: equiv. to
Our Goal

To rehabilitate (enable/restore) function by stimulating the development of compensatory cells within the brain.

The question is: HOW?
Overview
The Role of Brain Stimulation in Functional Recovery
What do the studies show?
The study of neural plasticity has shown the remarkable ability of the developing, adult, and aging brain to be shaped by environmental inputs in the healthy state and after a lesion.

Neurons adjacent to a lesion in the sensori-motor brain areas become hyper-activated and can take over the functions previously performed by the damaged neurons.

The amount of the brain devoted to a body part can enlarge to bring in potentially useful neurons.

This reorganization largely underlies the clinical recovery of motor performances and sensori-motor integration after a stroke.
• Functional MRI (fMRI) demonstrates enhanced recruitment of the affected cortex, in 2 ways:
  – Recruitment of **Intact neurons around the lesion**, as in the case of **cortical** stroke (using new unassigned cells)
  – Recruitment of **Intact but deafferented cortex**, as in **sub-cortical** strokes (running wiring to intact but unwired cells)
Reinforcing the use of the affected side can cause activation to increase again in the affected side with a corresponding enhancement of clinical function.

AND (AMAZINGLY)

There is inter-hemispheric activity that underlies recovery- meaning that the stimulation of the unaffected side can facilitate reorganization of the affected hemisphere.
FUNCTIONAL IMPLICATIONS

After a lesion, the brain is still shaped by in-coming impulses

Undamaged cells surrounding the lesion become hyper activated and can be facilitated to assume the function of the damaged cells

Undamaged but deafferented cells surrounding the lesion become hyper-excited and can be recruited to assume the function of the damaged cells

Impulses act bilaterally, so unaffected hemisphere can input to affected side
FUNCTIONAL IMPLICATIONS

BOTTOM LINE
The sooner a patient experiences body movement, even on the unaffected side, the sooner we stimulate the brain, the sooner motor recovery begins

Bilateral stimulation is critical
Functional MRI and Motor Recovery
What We Now Know about Mobility and the Brain

New testing procedures have provided us with useful information on how sensory input effects the Brain and how it can influence its motor recovery.

We will specifically consider the research on Functional Magnetic Resonance Imagery (fMRI)
Functional MRI

• fMRI gives us the ability to observe which structures participate in specific functions

• This new ability to directly observe brain function advances our understanding of brain re-organization
WHAT IS fMRI?

• Neural activity in the brain causes local increased blood flow

• The increased blood flow results in a local decrease in deoxyhemoglobin

• Deoxyhemoglobin serves as the source of the signal for fMRI.
fMRI example

MULTI-STAGE ANALYSIS WITH COINCIDENCE

COINCIDENCE
Run 1 AND Run 2

Penfield’s Motor Homunculus

Left Hand: Finger Thumb Tapping
It’s as Simple as Range Of Motion
What do the studies show?
Motor homunculus: passive mapping in healthy volunteers by using functional MR imaging--initial results.


Kocak M, Ulmer JL, Sahin Ugurel M, Gaggl W, Prost RW.

Both **active and passive** movements of: hand, elbow, shoulder, ankle, knee, and hip produced activation of the primary motor cortex.
Altered cortical activation with finger movement after peripheral denervation: comparison of active and passive tasks. 
Reddy H, Floyer A, Donaghy M, Matthews PM. 
Exp Brain Res. 2001 Jun;138(4):484-91

• **Purpose**: Compare cortical activation during hand movements in profoundly weak patients with motor neuropathy and in normal controls, using fMRI

• **Healthy individuals**: patterns of brain activation during active and passive index finger movements:
  – activated neurons in the primary motor cortex contralateral to the hand moved (CMC) were **40% lower for the passive than for the active task**

• **Patients with severe distal sensory neuropathy**: No activation with passive movement was found. Increased activation with active motion.

• **Patients with severe pure motor neuropathies**: showed substantial increases in the amount of activation compared to controls for **both the active and passive tasks were similar**.
These results confirm passive and active motions can activate neurons outside the lesion zone for motor lesions.

In cases of severe sensory impairment, active motion must be used.
Identifying brain regions for integrative sensorimotor processing with ankle movements.
Ciccarelli O, Toosy AT, Marsden JF, Wheeler-Kingshott CM, Sahyoun C, Matthews PM, Miller DH, Thompson AJ.

Findings:
• Both cortical and subcortical structures activated during both active and passive movements of the ankle:
  – Both passive and active movements activated the same cortical regions that are used in walking (active more than passive)
  – Active movements of both feet generated greater activation than passive movements in regions important for motor planning.
  – Areas activated (by AROM and PROM)
    • contralateral primary motor and sensory cortices
    • premotor cortical regions (such as the bilateral rolandic operculum and contralateral supplementary motor area)
    • subcortical regions (such as the ipsilateral cerebellum and contralateral putamen)
• Passive and active movements fire cortical and sub-cortical neurons (the 2 areas we can effect!!)
• Passive and active movements can fire the brain in a functional pattern (like as in walking)
• Active is better than passive
• Bilateral is better than unilateral (like in dangling and transfers)
• Multiple regions of the brain are stimulated at the same time through the simple application of movement, (just as they do during function)
The Virtual Body - the Brain’s Organization
The “Homunculus”

- Meaning “little man”
- Gives us a visual way to remember how cells are clustered in the brain
- Every part in the body is represented in the sensory regions of the brain AND in the motor regions of the brain
- The size of each virtual body part is based on the sensitivity of the actual part
- This organization allows the brain to know where impulses are coming from and to produce a response in the right places
Contrary to what we may have been taught, we do not have just one “homunculus”, or “virtual body” representation in the brain.
We have dozens
(and they “talk” to each other)
The Virtual Bodies signal in different ways

**ONE**

Multiple motor homunculi’s output can converge on ONE muscle
The Virtual Bodies signal in different ways

TWO

A single motor homunculi’s output can diverge to multiple muscles
The Virtual Bodies signal in different ways

THREE

Multiple horizontal interconnects exist among homunculi as much as 8 mm apart.
Consequences of Limited Brain Stimulation due to Lack of Movement

“Smudging” and “Disconnect”
Definitions

• Smudging:
  ❖ Loss of specificity in structure representation, i.e. regions blur so that impulses can be mis-interpreted by the cortex as being from a different location
  ❖ Loss of Lateralization, i.e. mis-interpretation by the cortex on the side of the impulses

• Disconnection:
  ❖ Loss of cortical activation in a region due to lack of use in a portion of the range of motion so that the patient perceives weakness or loss of range in that region
The efficient state = impulses in and Reaction out
Normal Sensory - Motor Route

Efficient BRAIN
Knows EXACTLY where the impulse is from AND what to do about it!
The quality and specificity of this relay system relies on “sharpening the system” through using the body.
“Smudging”: Loss of specific region recognition

Brain not able to correctly locate where impulses are coming from, so cannot determine what to move=

Pt appears unable to move
Rx Loss of Region Recognition with **Movement**

Cortex can be “refreshed”

Through movement

(remember that passive and active ROM or a functional activity like getting patient OOB send impulses to the brain!)
“Smudging”: Loss of Lateralization

Brain not able to correctly locate which SIDE the impulses are coming from, so cannot determine what to move=
Pt appears unable to move
Rx Loss of “Lateralization” with Movement and Education

"Watch your Left leg as I move it- This is your left leg. Which foot is this?"
Disconnection: Loss of Cortical Activity in a Region

Hasn’t moved hand, Homunculus still has the cells but the brain doesn’t perceive impulses from the unused body part.
Bombarding the region with impulses causes the brain to reconnect with the region.
How Fast Can the Brain Change?
What do the studies show?
Temporal dynamics of plastic changes in human primary somatosensory cortex after finger webbing.

Stavrinou ML, Della Penna S, Pizzella V, Torquati K, Cianflone F, Franciotti R, Bezerianos A, Romani GL, Rossini PM.

Cereb Cortex. 2007 Sep;17(9):2134-42. Epub 2006 Nov 16

1.

Protocol: a temporarily webbed condition of 4 fingers (index to little finger) was used to simulate an artificial syndactyly and was maintained for about 5 h during which finger somatotopy in the somatosensory cortex was monitored. Experimental and control group) Overall time frame: 5.5 hours.

Compared Pre and Post sensory cortex activation “hot spots” for index and little finger, measured:

✓ BEFORE taping on dominant hand
✓ After 30 minutes of being “webbed”
✓ After 1 hour and every hour for 3 more hours
✓ 30 minutes after the taping was removed
RESULTS:

The brain changed its activation pattern from demonstrating impulses consistent with 5 fingers, to impulses consistent with 2 fingers (one finger and a thumb) in as little as 30 minutes of the experience. (No testing was done in less than 30 minutes)

Other studies have shown a change in as little as a few minutes!
Functional Implications of the Study

The brain is a plastic organ with the ability to rewrite/refresh itself in minutes to days.
SUMMARY

The Role of the Bedside Caregiver
What We Can All do to Facilitate the BEST Functional Outcome

• Remember that the brain is changed by input: passive, active, one sided or bilateral
• Remember that active and bilateral produce more positive input than passive and one sided
• Remember that the brain can be changed in minutes to days
• Remember that the lack of movement (even passive) negatively effects the brain’s ability to create a motor response.
• Functional Activities produce the greatest positive input to the brain: getting up, dangling, getting out of bed, and participating in ADL
What We Can All do to Facilitate the BEST Functional Outcome

Functional Activities produce the greatest positive input to the brain:

getting up, dangling, getting out of bed, and participating in ADL bombards the brain with the impulses it needs to begin rehabilitation of the cortical and sub-cortical structures.
Mobility is Medicine

“He who rests, rots.”
Arthur Fiedler, Conductor of the Boston Pops Symphony Orchestra, at age 82

For the patient’s sake, all of us must play an active role in the frequent and early mobilization of the patient