Upper limb rehabilitation

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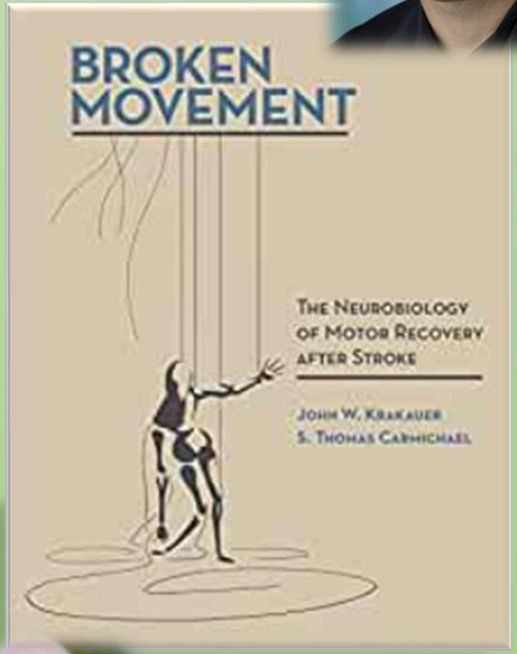
Outline

- Background- current status
- Recovery vs compensation
- Recovery theories + neural basis of motor Control
- Course of spontaneous recovery
- Interaction between spontaneous recovery & training
- How to implement the theory?



Upper limb (UL) paresis

2/3 unable to use UL for ADL
most are unable to carry out professional work
(Kwakkel et al., 2003, 2016)

50% of stroke survivors:
UL dysfunction 4 years post stroke
(Langhorne et al., 2009)

Severe arm paresis:
14% complete recovery
30% partial recover
(Nakayama et al., 1994)

Cochrane UL review:

"No evidence can be found for any interventions that are currently used as part of routine practice and evidence is insufficient to enable comparison of the relative effectiveness of interventions" (Pollock et al., 2014)

Only CIMT has a moderate effect

(Wolf et al., 2008, Huseyinsinoglu et al., 2012, Yadev et al., 2016, Hsieh 2016)

Possible explanations

Most RCT's – chronic phase

Walking + ADL

get more attention

Low therapy doses:

Average number of repetitions/session is 32 (Lang et al., 2009)

Spontaneous preference to use the unaffected limb

"learned non-use"

Current rehab practice:

achieving ASAP independence in B-ADL

Improved function
(compensation)

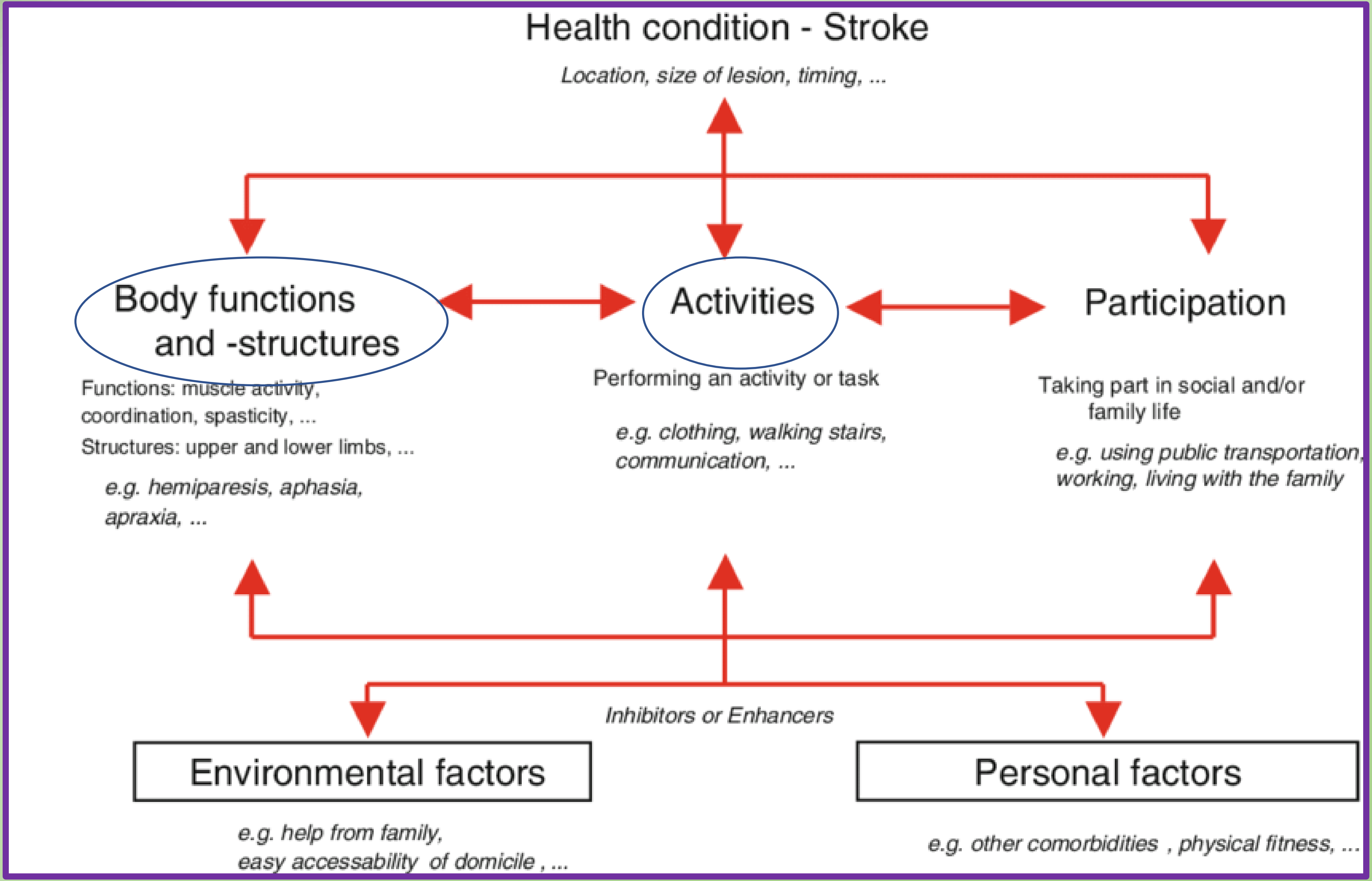
return to as close as normal

greater ability to cope with daily function tasks

restitution + reorganization

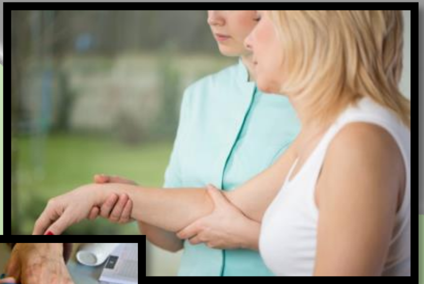
restitution + reorganization + compensation

ICF


Health condition - Stroke
Location, size of lesion, timing, ...
Body functions and -structures
Functions: muscle activity, coordination, spasticity, ...
Structures: upper and lower limbs, ...
e.g. hemiparesis, aphasia, apraxia, ...
Activities
Performing an activity or task
e.g. clothing, walking stairs, communication, ...
Participation
Taking part in social and/or family life
e.g. using public transportation, working, living with the family
Inhibitors or Enhancers
Environmental factors
e.g. help from family, easy accessability of domicile , ...
Personal factors
e.g. other comorbidities , physical fitness, ...

Restorative approach

- ✓ targeting impairment
- ✓ exercises aimed to restore normal operation of the motor system
- ✓ training aimed to restore isolated movement



Compensatory approach

- ✓ targeting activity, participation
- ✓ ADL training using aids & compensation

Measuring recovery & improved function

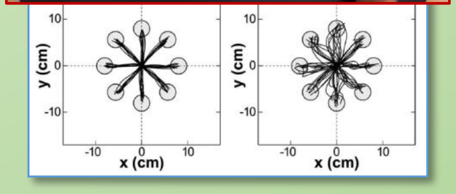
Recovery

Measuring should not be influenced by compensation

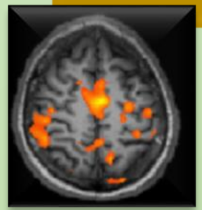
ICF domain=activity

Fugl-Meyer Assessment

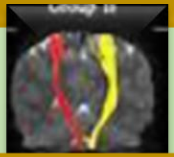
Kinematic measures



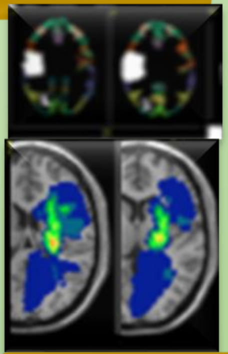
Functional/structural imaging



fMRI

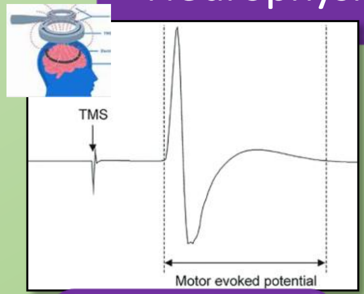


DTI (Diffusion Tensor Imaging)

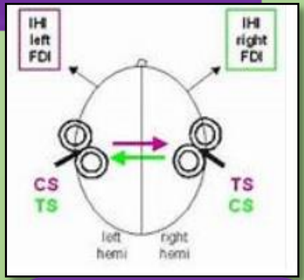


Lesion data

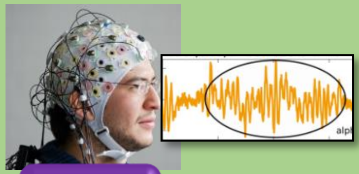
Neurophysiological measures



MEP (Motor evoked potential)



IHI Measures (Interhemispheric inhibition)



EEG

FIM
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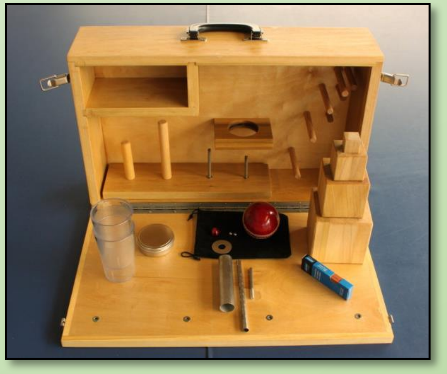
Improved function

Scoring is sensitive to restitution and compensation

ICF domain=activity

ARAT
Action Research
Arm Test



19 items
grasp, grip, pinch,
gross motor
movement

WMFT
Wolf Motor
Function Test

17 items
Timed functional tasks
Strength tasks
Movement quality

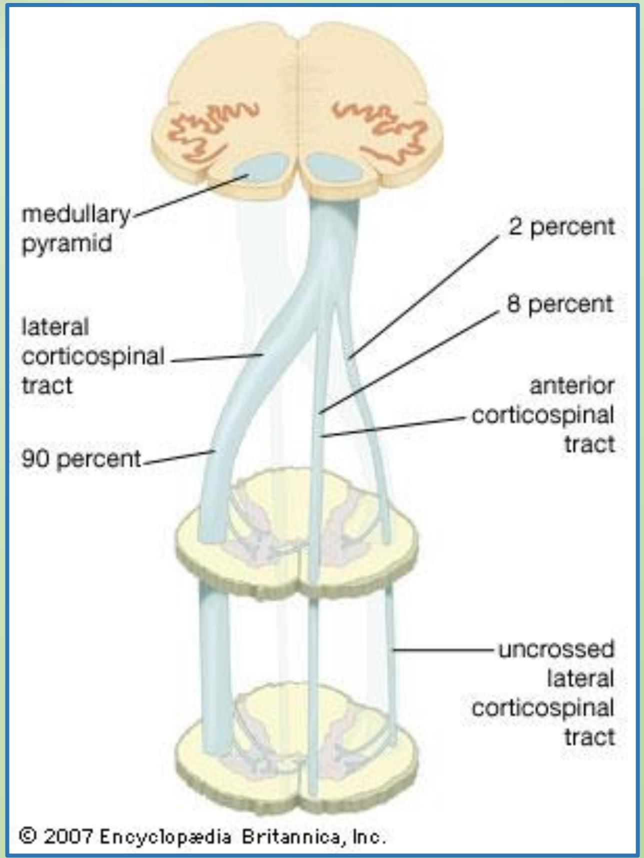
JTT
Jebson Taylor Test

7 items
Timed functional tasks

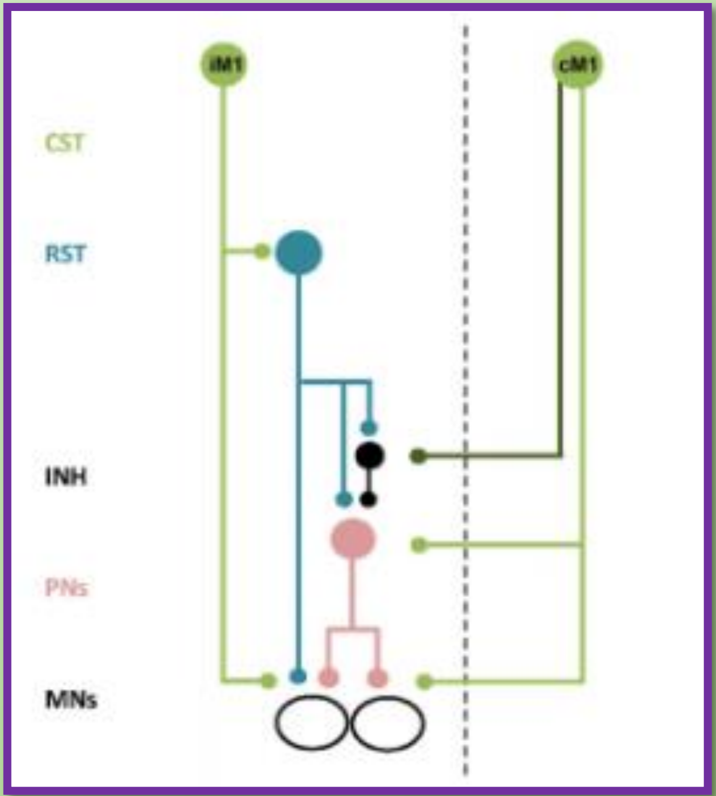
Box & Blocks

Neural basis of motor control

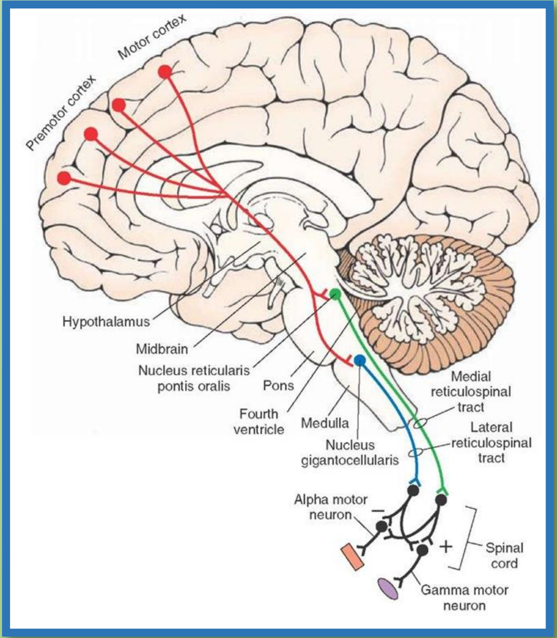
Corticospinal tract-CTS



Bilateral neural control

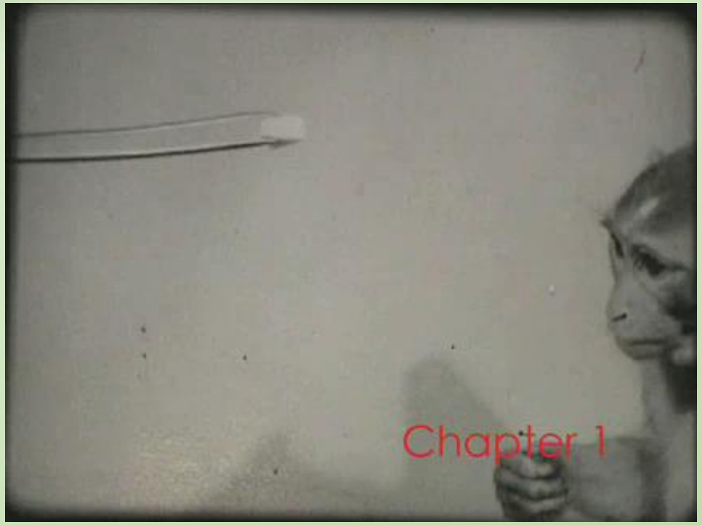


Reticulospinal tract



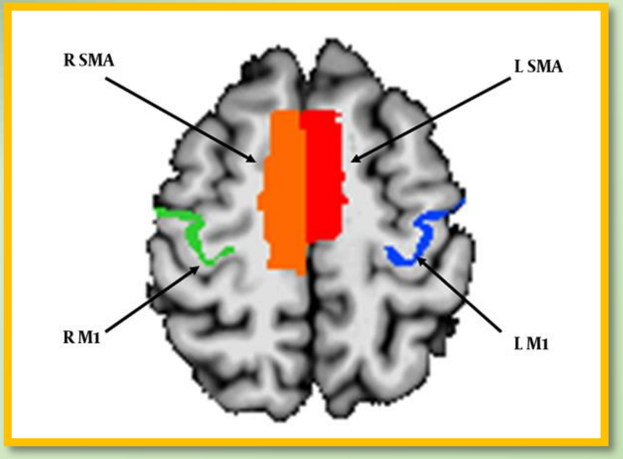
Normal reaching

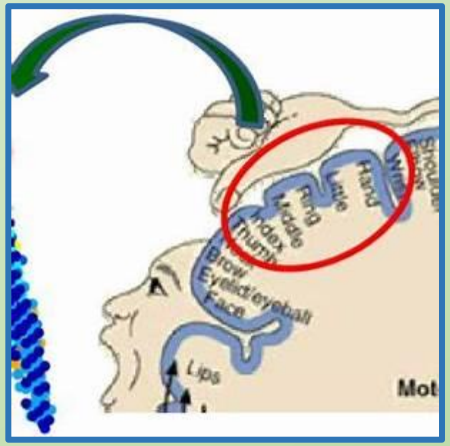
Full lesion to CTS



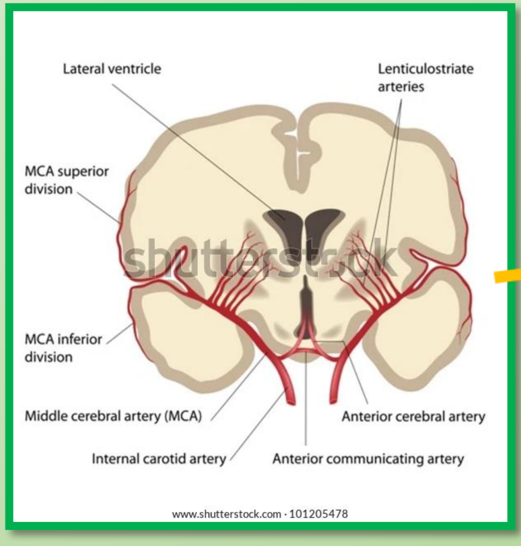
Lawrence and Kuypers (1968a,b) revisited: copies of the original filmed material from their classic papers in Brain

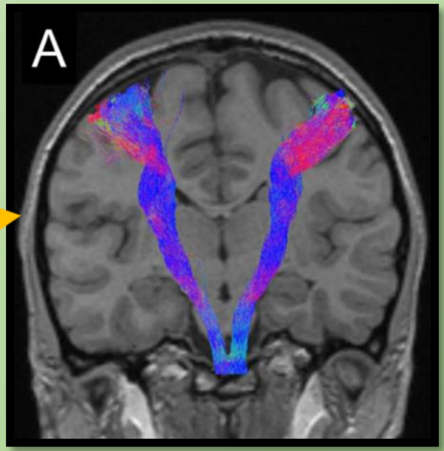
The anatomy of hemiparesis





Rate of M1 hand area involvement < 30%





Hemiparesis is largely a result of damage to descending motor pathways-

Upper limb MCA territory

Recovery is attributed to neuronal reorganization
(Kwakkel et al. 2002, Gerloff et al. 2006 Grefkes et al. 2008)

Vicariation
An intact cortical area taking on a function previously performed by the lesioned area

Perilesional areas

Homologous areas of the non-lesioned hemisphere

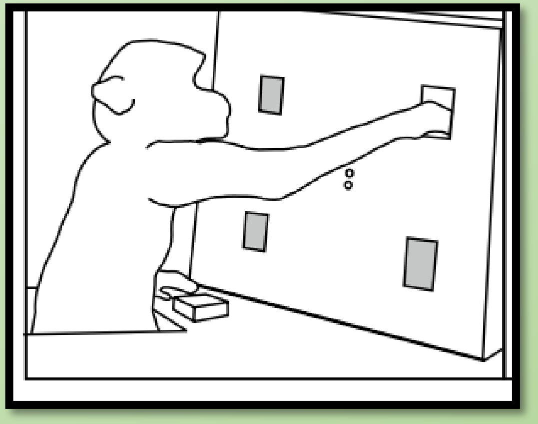
Evidence for a role of the reticulospinal system in recovery of skilled reaching after cortical stroke (Herbert et al., 2015)

Subject 1- small lesion M1

Subject 2- large lesion M1

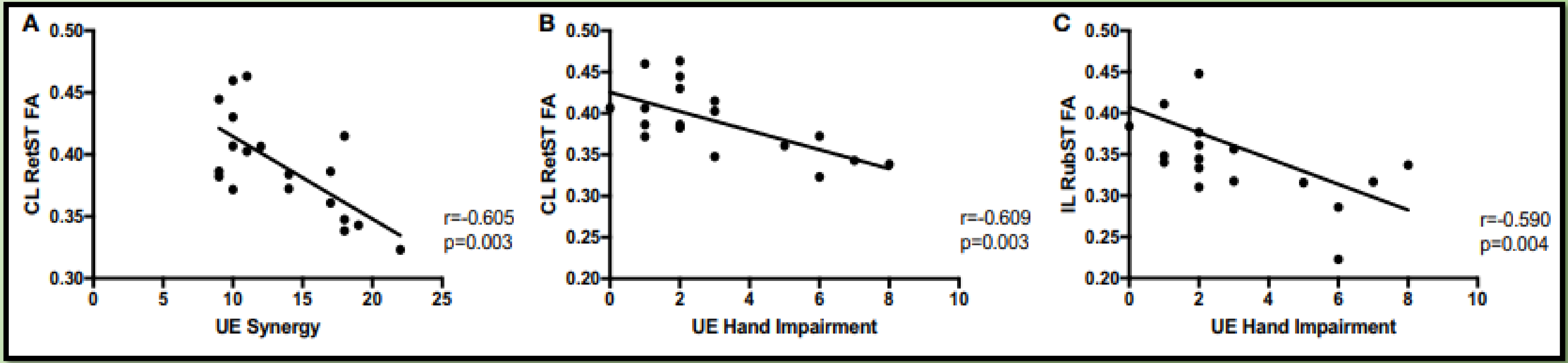
- Reaching-mildly impaired
- reduction in the area of shoulder/elbow representation in the lesioned M1
- Small change in contralesional response

- Reaching-severly impaired
- shoulder/elbow representation absent
- Output from contralesional reticularspinal pathways



upper limb motor outputs from right and left cortical motor areas and from the pontomedullary reticular formation

The contra-lesional Reticulospinal tract and the ipsilesional Rubrospinal tracts are important for recovery among severe chronic patients
(Owen et al., 2017)

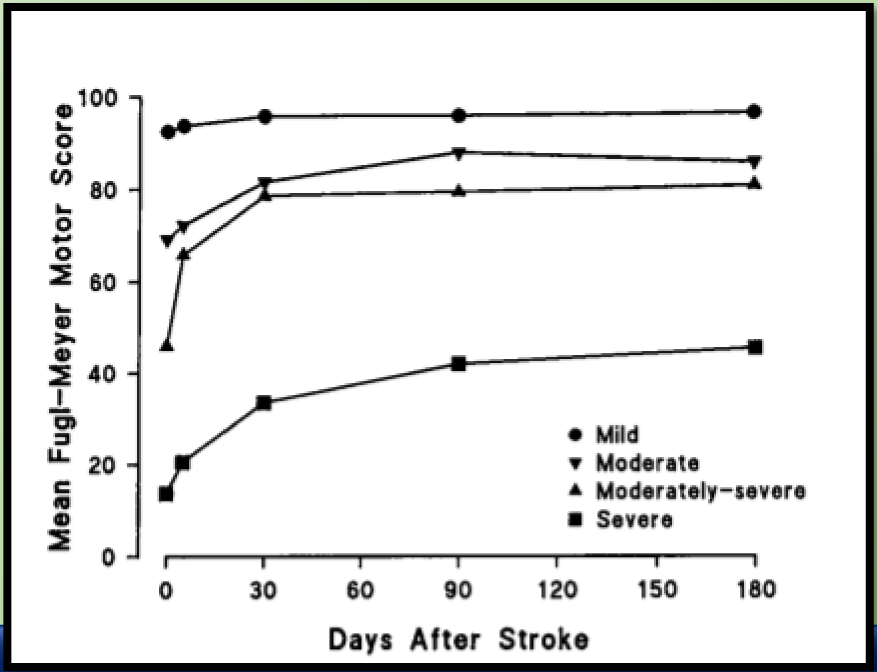


Natural history of recovery of upper limb impairment

The initial severity is the best predictor of functional outcome

Almost all recovery occurs in the first three months (Duncan et al., 1992)

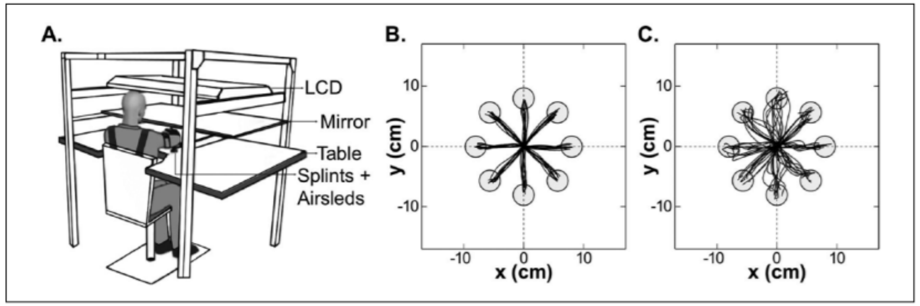
104 patients
5.30,90,180 days after onset

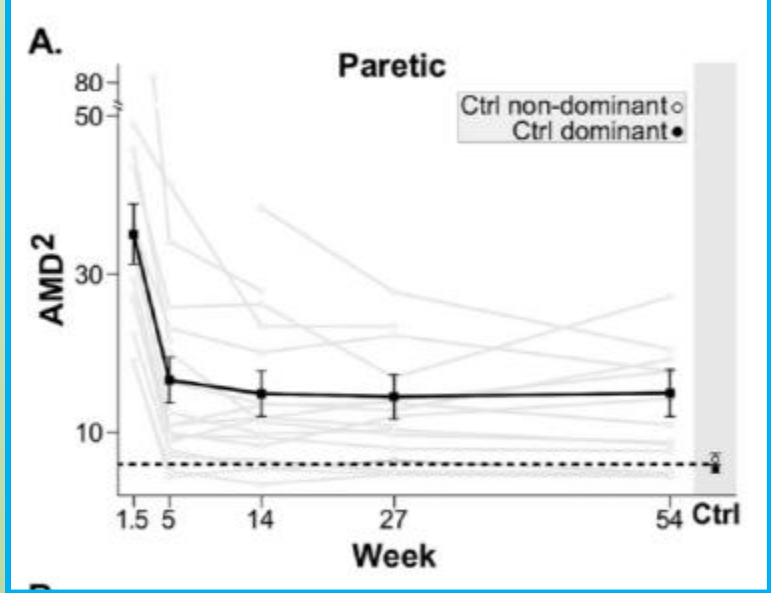


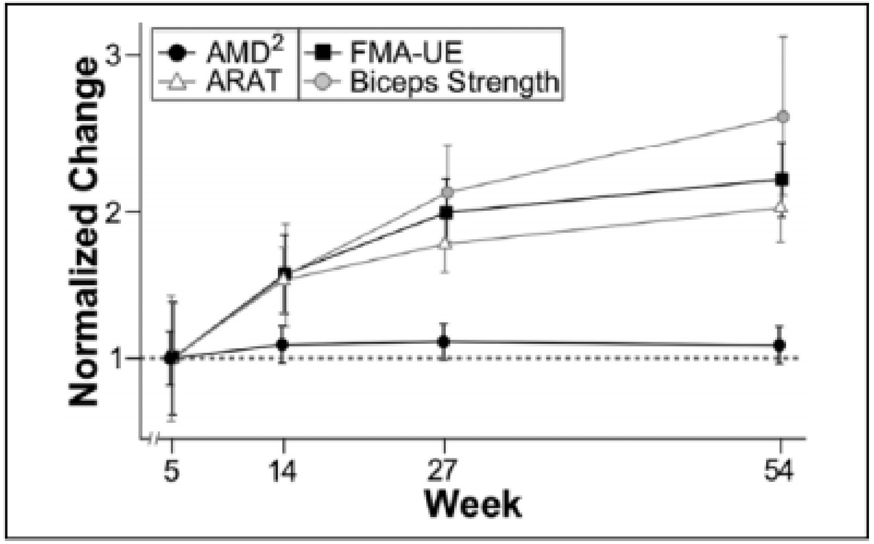
- ❑ FMA at 30 days explained 86% of the variance at 6 months regardless of initial severity
- ❑ The moderate and most severe patients continued to experience some recovery for 30-60 days

A short and distinct time window for recovery of arm motor control
(Cortes et al 2017)

1.5,5,14,27,54 weeks after onset

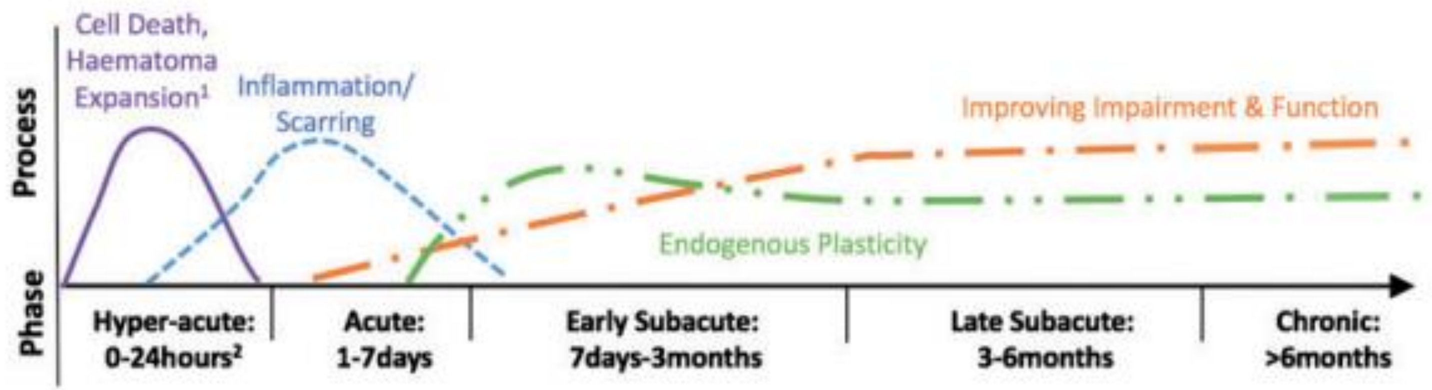






Time points following stroke

Figure 1. Framework that encapsulates definitions of critical timepoints post stroke that link to the currently known biology of recovery.



[1] Haemorrhagic stroke specific. [2] Treatments extend to 24 hours to accommodate options for anterior and posterior circulation, as well as basilar occlusion.

- Hyper acute- 24 hours following stroke cell death
- Acute-1-7 days post stroke (Apoptosis, inhibition in peri-infarct zone Brain tissue sensitive to further stress)
- Sub acute- up to 3 months (axonal sprouting, reduced inhibition)
- Chronic- beyond 3-6 months depending on stroke severity

Interaction between spontaneous recovery & training: repair vs learning- in the acute/subacute stage

Ogden & Franz 1917

M1+PMd

near complete recovery by 3 weeks only if it was trained and the unaffected arm restrained

A sensitive period of increased responsiveness to training

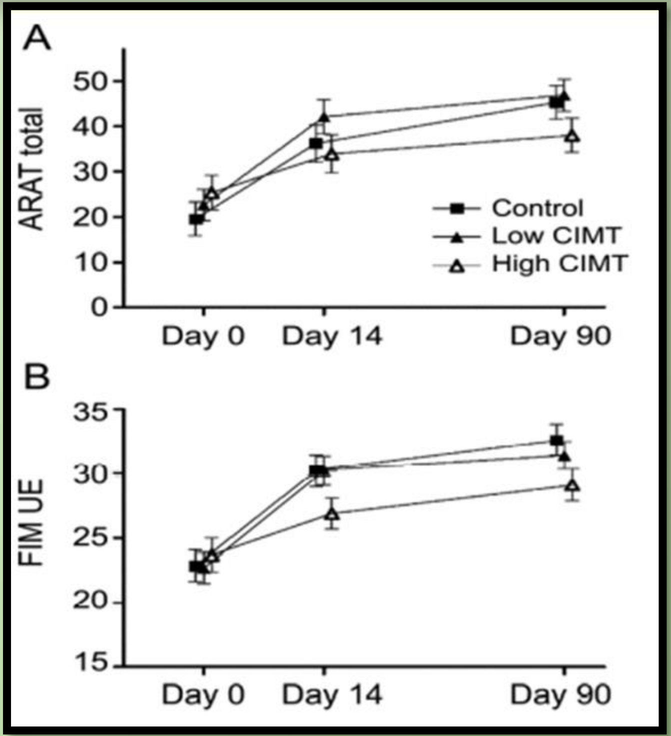
Time limited period of increased responsiveness to training due to heightened plasticity

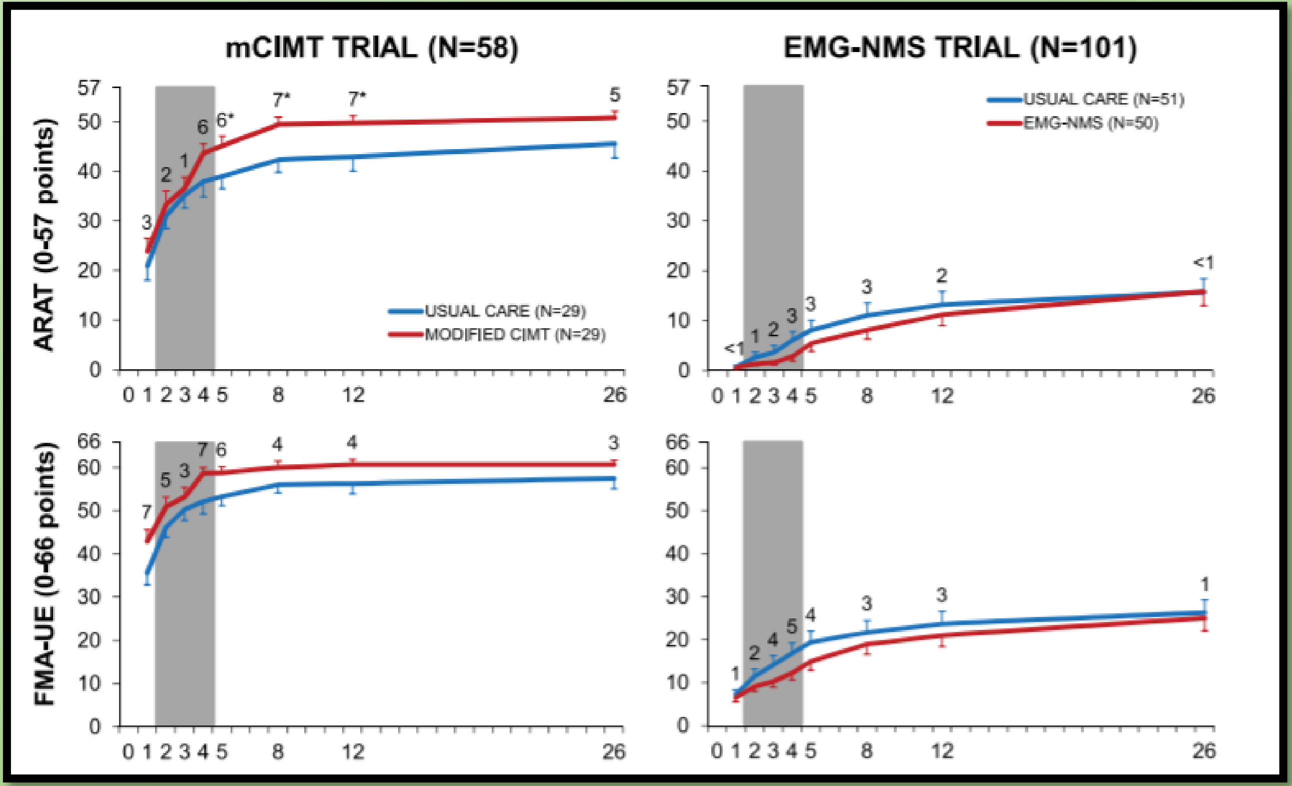
(Zeiler et al.,2016)

Human studies

VECTORS- Very Early Constraint-Induced Movement during Stroke Rehabilitation
(Dromerick et al., 2009)

Effects of Unilateral Upper Limb Training in Two Distinct Prognostic Groups Early After Stroke: The EXPLICIT-Stroke Randomized Clinical Trial
(Kwakkel et al., 2016)





Conclusions from early rehabilitative intervention (within 3 months of stroke)

Non human primates

Intense training at the level of motor control deficit/impairment can augment what is expected from spontaneous recovery

Humans

- There is no good evidence that this is true early after stroke
- Lack of evidence doesn't mean that there can't be interaction between training and spontaneous recovery
- There is a lack of interest targeting impairment early after stroke
- Studies didn't measure or target impairment

Recovery in the chronic stage?

Intensive upper limb neurorehabilitation in chronic stroke: outcomes from the Queen Square programme
(Ward et al. 2019)

6h/d
5 weeks=90 hours

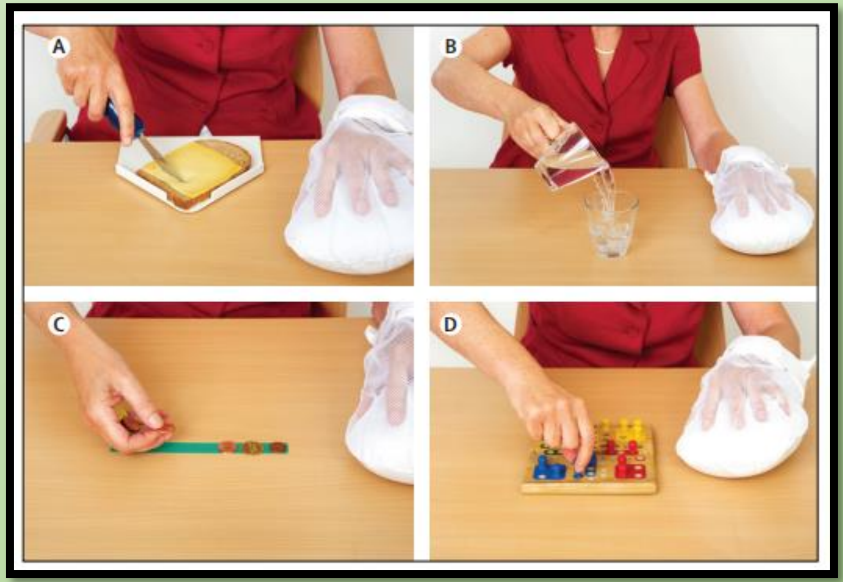
Table 2 Upper limb scores before and after admission

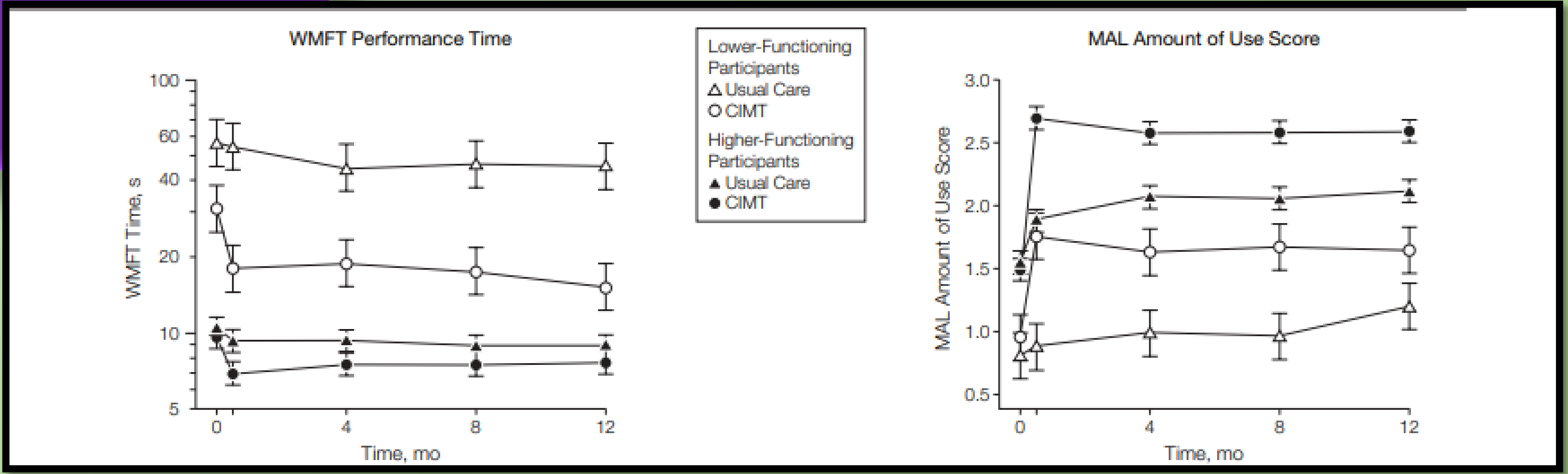
	Admission	Discharge	6 weeks	6 months
FM-UL	26 (16–37)	34 (23–44)	35 (23–46)	37 (24–48)
ARAT	18 (7–33)	25 (10–42)	26 (11–44)	27 (11–45)
CAHAI	40 (28–55)	49 (36–70)	50 (35–73)	52 (35–77)
ArmA-A	8 (4.5–12)	5 (2–8)	4 (2–7)	3 (1–6.5)
ArmA-B	38 (24–46)	26 (13–37)	21 (11–35)	19 (8.5–32)

All scores given as median (IQR).
ARAT, Action Research Arm Test; ArmA-A, Arm Activity Measure A; ArmA-B, Arm Activity Measure B; CAHAI, Chedoke Arm and Hand Activity Inventory; FM-UL, Fugl-Meyer (upper limb).

The EXCITE Trial: Retention of Improved Upper Extremity Function Among Stroke Survivors Receiving CI Movement
(Wolf et al., 2008)

- CIMT was delivered up to 6h/d, 5d/for 2 weeks
- Measurements every four months: Wolf Motor Function Test – WMFT, Motor Activity Log - MAL)
- CIMT d produced meaningful improvements in the WMFT +MAL





Stroke 2021

TOPICAL REVIEW

Section Editors: Julie Bernhardt, PhD, and Pam Duncan, PhD

Timing and Dose of Upper Limb Motor Intervention After Stroke

A Systematic Review

Kathryn S. Hayward, PhD; Sharon F. Kramer, PhD; Emily J. Dalton, MOccTherPrac (Hons); Gemma R. Hughes, MPT; Amy Brodtmann, PhD; Leonid Churilov, PhD; Geoffrey Cloud, MBBS; Dale Corbett, PhD; Laura Jolliffe, PhD; Tina Kaffenberger, MD; Venesha Rethnam, PhD; Vincent Thijs, PhD; Nick Ward, MD; Natasha Lannin, PhD; Julie Bernhardt, PhD

- ❑ 261 studies, n=9704
- ❑ 1 hyperacute (<24 h), 13 acute (1-7 d), 176 early subacute (8–90 days), 34 late subacute (91–180 days), 4 were unable to be classified

- Dose selection to date has been pragmatic
- All were broadly consistent with standard care descriptions from recent observational reports, that is, 45 to 60 min/d
- Such a dose is insufficient to optimize upper limb recovery in systematic reviews with meta-analysis (Loshe et al. 2014, Schneider et al. 2016)
- Most recent suggestion is that 2 or more h/d represents a dose threshold that leads to clinically meaningful improvements (Schneider et al. 2016)
- Lack of consistent data elements, there was insufficient evidence to conclude the optimal time to commence upper limb intervention poststroke, nor the effect of timing and dose on efficacy
- Improve understanding of recovery in order to build a clear biological rationale for the selection of timing, dose, and intervention type poststroke

How to encourage true recovery

Understanding the Mechanism → time points → effective tools → Better upper limb rehab post stroke

- ✓ Training strategies that promote movement outside of abnormal synergies
- ✓ Training aimed to reduce compensatory behavior
- ✓ Appropriate sensory-motor mappings need a high number of repetitions
- ✓ Intensity with different treatment tools
- ✓ Consider inter-individual variance (lesion parameters’ CTS integrety…)
- ✓ Limited Time window +Mechanism for reopening the window in the chronic stage
- ✓ Enriched environment

- The hemiparetic upper limb is often poorly functional even when the paresis is mild
- Fugl Meyer score of>50 (Maximum score 66)
- Impaired motor control preventing smooth and coordinated movements (Lang et al., 2005)

Upper limb must be treated


Thank You