Upper limb rehabilitation and management

Plasticity  Motor learning  Therapy  Priming  Management

Ulrike Hammerbeck, PhD, MCSP
Upper Limb Management  
What do we know?

~40% of stroke survivors don’t recover upper limb function

Current evidence supports
Guidelines  
Intensity & repetition
Patient centred
Multidisciplinary
Early after stroke (Cortes et al, 2017)

However, in clinical practice:
Arm therapy dose very low (Hayward 2015)
• 4 min Physio, 17 min Occupational,
• repetitions 23-32
Patient compliance – mood, fatigue etc

Why are we striving for intensity & repetition?
What is neuroplasticity?
• Changes in the brain due to behaviour
• Brains ability to learn
• Recovery vs Compensation

Stroke recovery through neuroplasticity
• Form new connections - synaptogenesis

Johansson and Belichenko, 2002
What is neuroplasticity?
- Changes in the brain due to behaviour
- Brains ability to learn
- Recovery vs Compensation

Stroke recovery through neuroplasticity
- Form new connections - synaptogenesis
- More efficient connections
Upper Limb Management  Neuroplasticity

What is neuroplasticity?
• Changes in the brain due to behaviour
• Brains ability to learn
• Recovery vs Compensation

Stroke recovery through neuroplasticity
• Form new connections - synaptogenesis
• More efficient connections
• Expansion of representation – Use different connections/pathways

Nudo et al, 1997 (a)
**Upper Limb Management**  
**Motor learning**

**Motor learning**
- Learning
- Off-line learning
- Retention

Therapy can influence/improve one or all three
Upper Limb Management  Motor learning

Stroke survivors (n=36)

Hammerbeck et al, 2017
Neurorehabilitation Neural Repair
Upper Limb Evidence

- **National Clinical Guidelines for Stroke 2016**
- Stroke Unit
- Multidisciplinary
- Interventions:
  - CIMT
  - Repetitive task training
  - Robotic
- Priming techniques: Increase neuroplasticity to maximise effectiveness of therapy
- Self-management:
  - Gym
  - Exercise groups
  - GRASP
Constraint-induced movement therapy

6 hours per day shaping
95% of waking day in mitt
Inclusion criteria: 20° wrist extension
Measured with MAL (motor activity log)
Most evidence in chronic phase
Shorter intervention periods also effective

Constraint-induced movement therapy after stroke

Gert Kwakkel, Janne M Veerbeek, Erwin E H van Wegen, Steven L Wolf

Constraint-induced movement therapy (CIMT) was developed to overcome upper limb impairments after stroke and is the most investigated intervention for the rehabilitation of patients. Original CIMT includes constraining of the non-paretic arm and task-oriented training. Modified versions also apply constraining of the non-paretic arm, but not as intensive as original CIMT. Behavioural strategies are mostly absent for both modified and original CIMT. With forced use therapy, only constraining of the non-paretic arm is applied. The original and modified types of CIMT have beneficial effects on motor function, arm–hand activities, and self-reported arm–hand functioning in daily life, immediately after treatment and at long-term follow-up, whereas there is no evidence for the efficacy of constraint alone (as used in forced use therapy). The type of CIMT, timing, or intensity of practice do not seem to affect patient outcomes. Although the underlying mechanisms that drive modified and original CIMT are still poorly understood, findings from kinematic studies suggest that improvements are mainly based on adaptations through learning to optimise the use of intact end-effectors in patients with some voluntary motor control of wrist and finger extensors after stroke.
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Subtotal (95% CI) -415 401
Heterogeneity: Tau² = 0.11; Ch² = 43.02, df = 24 (P = 0.01); P = 45%
Test for overall effect: Z = 2.80 (P = 0.0052)

2 Constraint therapy versus no treatment

Kim 2008 9 1.24 0.12 8 0.37 0.62 2.2 0.25 0.70 1.21
Tasb 1993 4 0.8 0.18 5 0.08 0.6 3.95 1.18 6.72
Wittberg 2003 9 0.4 0.36 7 0.14 0.3 0.68 -0.34 1.71

Subtotal (95% CI) -22 20
Heterogeneity: Tau² = 0.05; Ch² = 6.12, df = 2 (P = 0.05), P = 67%
Test for overall effect: Z = 1.51 (P = 0.13)

Total (95% CI) -437 421
Heterogeneity: Tau² = 0.13; Ch² = 50.52, df = 27 (P = 0.04); P = 47%
Test for overall effect: Z = 3.08 (P = 0.0021)
Test for subgroup differences: Ch² = 11.11, df = 1 (P = 0.29), P = 10%
Upper Limb  Effectiveness: Repetitive task

Repetitive task training for improving functional ability after stroke
Active motor sequence performed repetitively, Multi-joint
Upper Limb Interventions

- Robotics  Higher intensity and dose, assistive or deweighting
- Functional electrical stimulation  experimental upper limb

Clinical Research Articles

Differential Effects of Power Training Versus Functional Task Practice on Compensation and Restoration of Arm Function After Stroke

Manuela Corti, PT\textsuperscript{1,3}, Theresa E. McGuirk, MS\textsuperscript{1,4}, Samuel S. Wu, PhD\textsuperscript{5}, and Carolynn Patten, PhD, PT\textsuperscript{1,2,3,4}
Upper Limb  Priming to increase therapy benefit

Priming techniques (some)
- Enriched environment

Table I. Types of enrichment activities available in the “Activity Arcade”

- Computers with internet connection, Skype facility
- Several workstations with computer/television based sensor and game technology for upper and lower limb exercises, such as Able-X, Able-M, Mii, Nintendo Wii, and cognitive exercises (with assistance from a member of the rehabilitation team)
- Library with reading materials (books, audio-books, magazines, newspapers etc.)
- Music station
- Life-size mirrors for visual-perceptive deficits
- Simulated shopping corner with groceries
- Electronic funds transfer at point of sale (EFTPOS) machine for making payments
- Automatic bank teller machine
- Board games, puzzles, chess
- Painting, wood workshop and other activities
Upper Limb  Priming to increase therapy benefit

Priming techniques (some)
  • Enriched environment
  • Brain stimulation

rTMS: repetitive Transcranial Magnetic Stimulation
tDCS: transcranial Direct Current Stimulation
Cochrane, 2016: very low - moderate evidence

![Image of rTMS application](image1)

![Image of tDCS application](image2)

![Graph showing MEP changes over time](image3)
Upper Limb  Priming to increase therapy benefit

Priming techniques (some)
- Enriched environment
- Brain stimulation
- Multisensory integration: Mental imagery, Action observation, Mirror Box, Virtual reality
Upper Limb  Priming to increase therapy benefit

**Priming techniques (some)**
- Enriched environment
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- Multisensory integration: Mental imagery, Action observation, Mirror Box, Virtual reality
- Sensory stimulation

Carrico et al, 2016 Stroke
Upper Limb  Priming to increase therapy benefit

Priming techniques (some)
- Enriched environment
- Brain stimulation
- Multisensory integration: Mental imagery, Action observation, Mirror Box, Virtual reality
- Sensory stimulation
- Aerobic exercise

Ploughmann and Kelly, 2016
Upper Limb  Priming to increase therapy benefit

Priming techniques (some)
- Enriched environment
- Brain stimulation
- Multisensory integration: Mental imagery, Action observation, Mirror Box, Virtual reality
- Sensory stimulation
- Aerobic exercise
- Medication and transmitter manipulations

Increasing neurotransmitters in synapses
**Serotonergic** - re-uptake inhibitor
Fluoxetine (Prozac) - improve functional outcome

FLAME Chollet, et al, 2011 (n=118)
FOCUS ongoing trial n=3000
**Upper Limb Techniques: effectiveness**

Interventions for improving upper limb function after stroke.
Pollock et al, Cochrane Database Syst Rev. 2014

1840 records, included 40 completed reviews, 18 interventions, 503 studies (n=18,078)

**Quality of evidence**
High: 1/127 comparisons tDCS no benefit on ADLs
Moderate: 49/127 comparisons (7 interventions)
- high dose of repetitive task practice
- unilateral training more effective than bilateral
- constraint-induced movement therapy (CIMT),
- virtual reality
- mirror therapy
- mental practice
- interventions for sensory impairment,

Low or very low: 77/127 comparisons

![Graph showing effectiveness of different interventions](image)
Upper Limb  Self-management

- Group
- Increase intensity
- Resource management
- Social aspect
- Peer-support

- Home exercise programme
- Activity monitoring
- Computer games
- GRASP

Graded Repetitive Arm Supplementary Program
Upper Limb Management

**Spasticity**
- Positioning
- Splinting Guidelines
- Medication, Botulinum toxin
- Contracture prevention
- No contra-indication for strengthening (Schmit et al, 2009)

**Self-management, self efficacy**
- Psychology
- Time
- Patient centred
<table>
<thead>
<tr>
<th><strong>Shoulder pain</strong></th>
<th>Tone, strength, mm shortening, alignment</th>
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<tbody>
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<td>Subluxation not painful</td>
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**Reduce risk:**
- Education to prevent trauma
- no movement >90°
- Positioning and support (wheelchair tray)

**Management**
- Gentle stretches – increase external rotation and abduction
- Strengthening - realignment
- Medication
- Limited evidence for taping and slings
PREP algorithm

• Stinear et al, 2012

• SAFE = sum of the shoulder abduction and finger extension Medical Research Council muscle grades 72 h after stroke

• PNR = point of no return, where asymmetry index values greater than this predict no potential for meaningful recovery of upper limb function

Upper Limb Future: Predicting Recovery
Upper Limb Future: Predicting Recovery

PREP algorithm n= 40

Stinear et al, 2012

![Graph showing ARAT score over time since stroke for different levels of recovery](image)
Upper Limb  Future: Predicting Recovery

- Stinear et al, 2017 Stroke
  Increasing rehab efficiency n=192
  Shorten hospital admission by 1 week (from 17 to 11 days)

- 70% recovery rule

Prabhahkaran et al 2008
Upper limb rehabilitation and management

Need

Targets

Mechanism

Techniques

Future

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