

# Effects of constraint-induced movement therapy (CIMT) on hemiparetic upper extremity And neuroplastic changes in post-stroke individuals: A preliminary functional connectivity study

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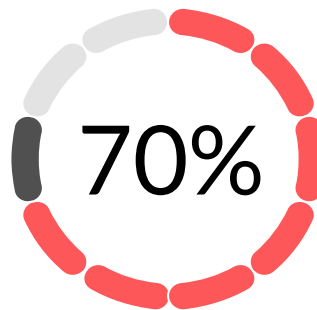
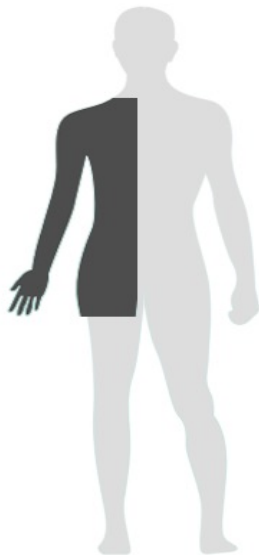
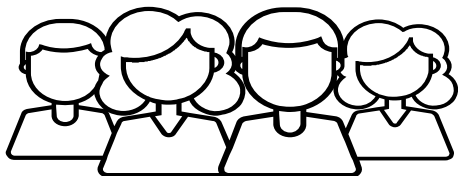
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**PolyU IRB Approval:** HSEARS20250108005

## Prevalence of motor paresis after stroke

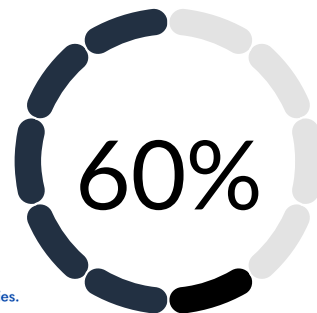
World Stroke Organization (2022). Global Stroke Fact Sheet 2022. Accessed February 3, 2023  
from <https://www.world-stroke.org/world-stroke-day-campaign/why-stroke-matters/learn-aboutstroke>

Today, one in four adults will have a stroke in their lifetime, and this number has increased 50% over the last 17 years (World Stroke Organization, 2022).



of the stroke survivors end up with residual physical disabilities as a major contributor to their loss of independence

Jørgense et al. (2000). Top Stroke Rehabil, 6, 1-19.



had little or no function in their hemiplegic arm in the chronic phase

Kwakkel, G., & Kollen, B. (2013). International Journal of stroke, 8(1), 25-32

(a) Standard Movement Tasks

	Less affected	Affected	Paired t-test (P value)	Ratio of nonuse (affected : less affected)	Nonuse %
Shoulder flexion	292.33	226.89	t= -3.758, p<0.001	0.78	22
Shoulder abduction	269.77	209.82	t= -3.914, p<0.001	0.78	22
Shoulder external rotation	71.91	45.14	t= -3.006, p=0.004	0.63	37
Elbow flexion	295.42	234.03	t= -3.008, p=0.004	0.79	21
Supination & pronation	346.65	188.06	t= -5.927, p<0.001	0.54	46
Reaching	247.32	186.95	t= -3.753, p<0.001	0.76	24
Finger to nose	346.80	239.32	t= -4.698, p<0.001	0.69	31
Hand to back head	358.17	243.70	t= -4.753, p<0.001	0.68	32
Opposite knee	182.94	127.38	t= -3.165, p=0.002	0.7	30
Total activity count of 9 standard movement tasks	2414.35	1701.29	t= -6.348, p<0.001	0.7	30

(b) Simulated Functional Tasks

	Less affected	Affected	Paired t-test (P value)	Ratio of nonuse (affected : less affected)	Nonuse %
Dressing	4599.52	1504.75	t= -7.792, p<0.001	0.33	67
Sit to stand	182.73	91.64	t= -3.525, p<0.001	0.5	50
Walking	208.89	71.78	t= -2.805, p=0.007	0.34	66
Washing & drying hand	1746.90	747.82	t= -7.980, p<0.001	0.43	57
Total activity count of 4 functional tasks	6559.26	2344.18	t= -8.958, p<0.001	0.36	64

## Measurement of functional use of the hemiparetic upper extremity using wearables in persons with unilateral stroke (Fong, et al., under preparation)



A cross-sectional experimental study of 66 adults with unilateral stroke

Accelerometer worn on both wrists in 9 standardized movement tasks and 4 simulated functional tasks

Overall nonuse rate in movement = 30%, in functional tasks = 64%

Levels of hemiparetic arm impairment can be clustered to 3 functioning groups – Lower, Moderate, Higher levels.

# Training Programme

## 3 Elements of CIMT (Morris, Taub, & Mark, 2006)

Components	Subcomponents
(1) Repetitive, task-oriented training	<ul style="list-style-type: none"> <li>– Shaping</li> <li>– task practice</li> </ul>
(2) Adherence-enhancing behavioral strategies	<ul style="list-style-type: none"> <li>– Daily administration of the motor activity log</li> <li>– Home diary</li> <li>– Problem solving to overcome apparent barriers to use the more affected upper extremity (UE) in the real world</li> <li>– Behavioral contract</li> <li>– Caregiver contract</li> <li>– Home skill assignment</li> <li>– Home practice</li> <li>– Daily schedule</li> </ul>
(3) Constraining use of the more-affected upper extremity	<ul style="list-style-type: none"> <li>– Mitt restraint for 9 hours</li> <li>– Any method to continually remind the participant to use the more-affected UE</li> </ul>

## Two-week Training Phase

### Daily Five-hour Restraint at Home

- wear mitt on less affected hand (> 5 hours)
- write daily exercise log

### 6 Two-hour Intensive Shaping Sessions

- 10 mins: warm-up exercise
- 45 mins: shaping & functional task
- 15 mins: break
- 45 mins: shaping & functional task
- 05 mins: discussion about homework



Successive approximation:  
Carrying out parts of  
a movement  
sequence



Folding clothes



Meal preparation (using chopsticks)

### Examples of shaping: Upper limb motor learning tasks for CIMT

Repetitive task  
practice  
continuously

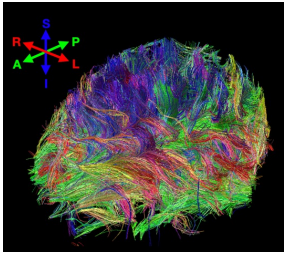
Selecting tasks  
tailored to address  
the motor needs



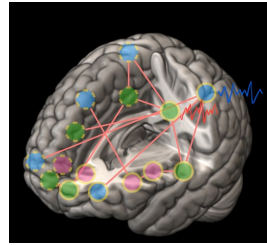
Explicit verbal  
feedbacks



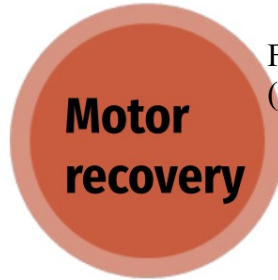
# The Neuroimaging Biomarkers



Structural connectivity  
(Diffusion MRI)



Functional connectivity  
(fMRI)

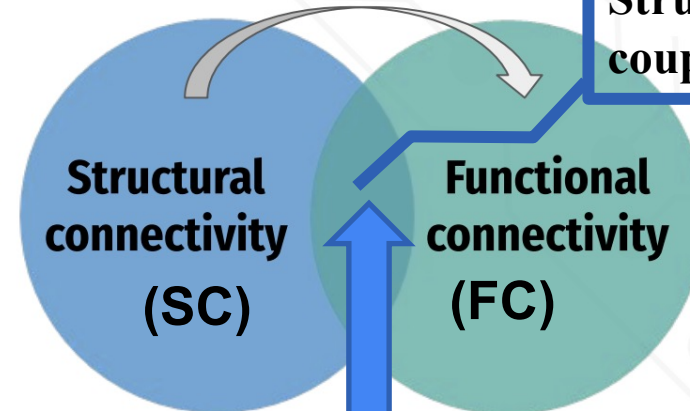


**1. Post-stroke motor recovery** has been demonstrated to be **associated with structural connectivity & functional connectivity**

(*Chan et al., 2006; Liu et al., 2004*)

**2. Anatomical brain connections influence functional brain connections**

**Structure-function coupling (SFC)**



**1a. Anatomical connections** between different brain regions

**1b. Functional connections** between different brain regions

- SFC is derived from the correlation between structural connectivity (SC) and functional connectivity (FC) - reflects the degree to which brain function is constrained by its anatomical wiring.
- Individual variations in SFC correlated with cognitive performance in both young and older adults
- Previous studies have shown that whole brain coupling strength altered due to stroke  
=> may be an alternative measure of the neuroplasticity underlying rehabilitation-induced recovery

# Research Approach

## Single-group Longitudinal Investigation

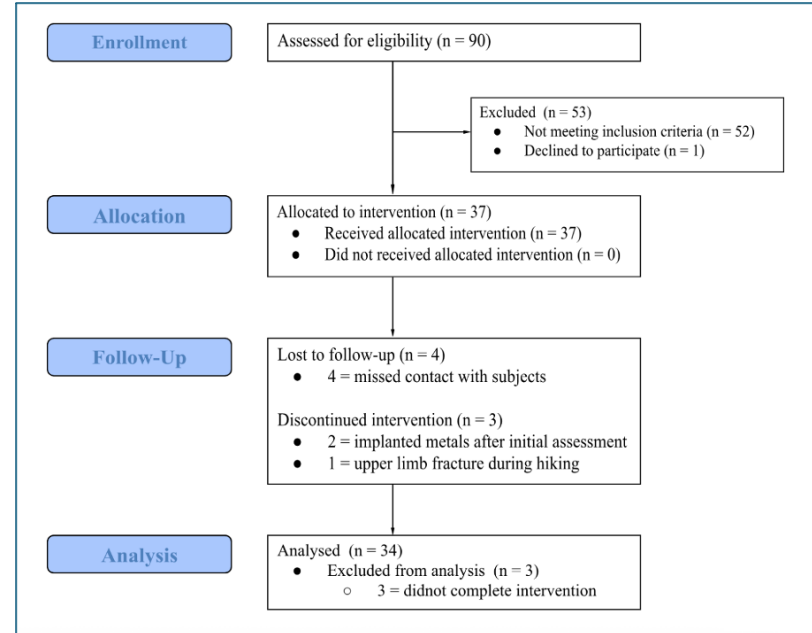
- compare same group over 4 timepoints

### Purpose

examine neuroplastic **change** induced by CIMT on behavioral and functional regain of individuals with chronic stroke

### Ethical Review (Ref. no: HSEARS20250108005)

- PolyU Institutional Review Board
- Informed written consent



CONSORT Flow Diagram

# Outcome Measurements

(Harms et al., 2018)

## Four Time-point

T0: Baseline

### 1) MRI Scans

- by 3-T MRI Scanner (Prisma, Siemens, Erlangen)

T1: Mid-treatment

### 2) Behavioral Measures

T2: post-treatment

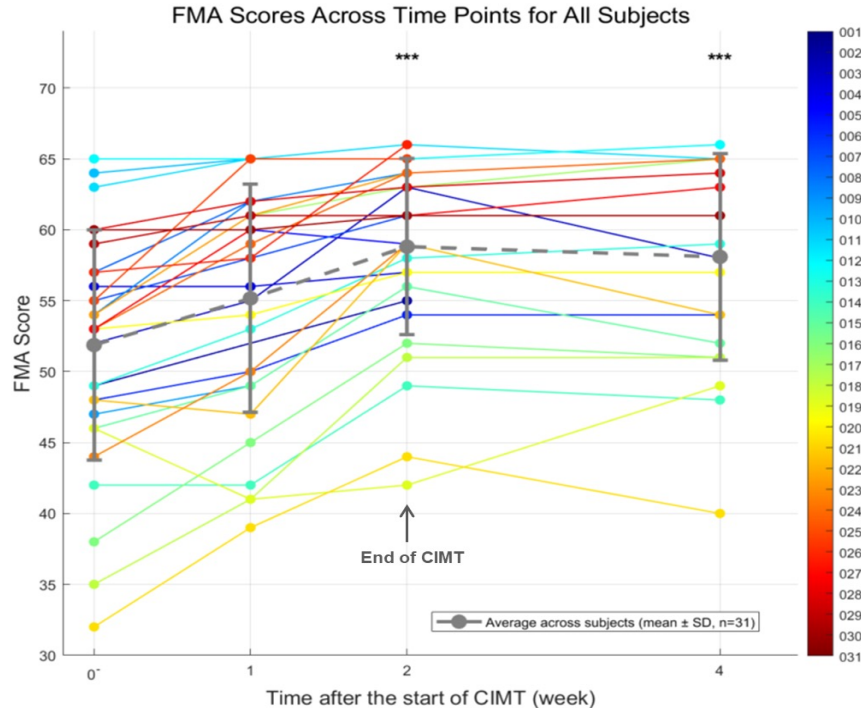
- **Primary outcome:**
- Motor Activity Log (MAL) – Amount of Use + Quality of Movement
- **Secondary outcomes:**
- Fugl-Meyer Assessment for Upper Extremity (FMA-UE)
- Modified Barthel Index (MBI)

T3: Two weeks post-treatment

- Lawton IADL

# Results

Longitudinal motor recovery during CIMT. FMA-UE scores for each patient are plotted over the course of CIMT. The thick black line represents the group mean  $\pm$  standard error of the mean (SEM). A significant main effect of time on FMA-UE score was observed ( $p < 0.001$ ; see Results). 0-: the time immediately after the start of CIMT.



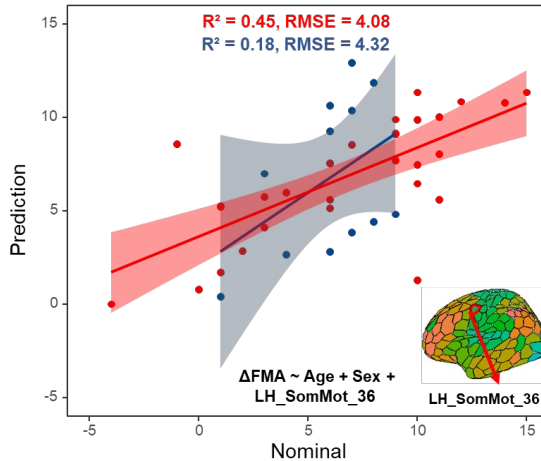
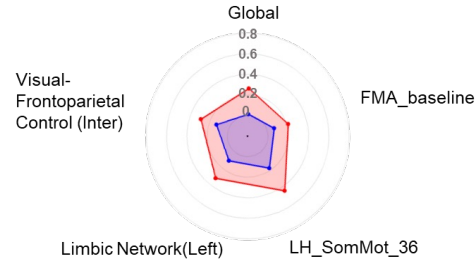
- **Total participants: 34**
- **Mean age: 62**
- **M: 52.9%, F: 47.1%**
- **Average months since stroke: 52**
- **Dominant: 38.2%, Non-dominant: 61.8%**
- **Weakness: R -44.1%, L -55.9%**
- **HK-MoCA: 27/30**
- **MAL-AOU: 3.04/5**
- **MAL-QOM: 2.75/5**
- **FMA-UE**
  - Total: 51.24/66
  - Upper Limb: 30/36
  - Hand: 21/30
- **MBI: 98/100**
- **Lawton IADL: 24/27**

# Results

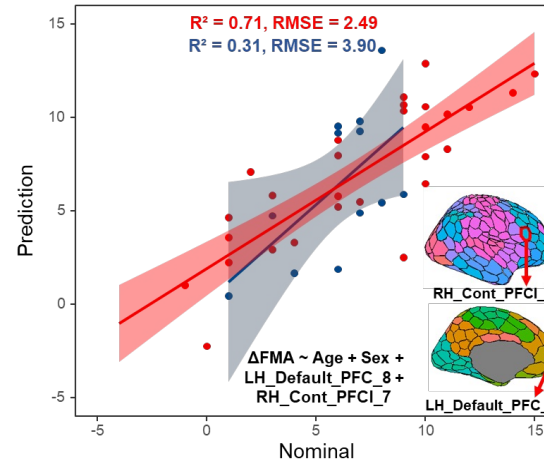
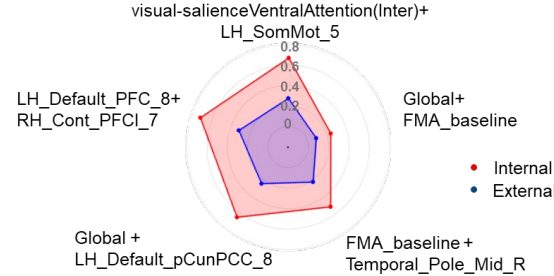
- MAL:
- **Significant improvement** from pre- to post-treatment ( $p < 0.001$ )
- Mean improvement **exceeding the MCID**
  - MAL-AOU: 1.05 (MCID: 0.89)
  - MAL-QOM: 0.81 (MCID: 0.77)
- Gains **sustained at the 2-week follow-up**
- FMA-UE
- **Significant improvement** ( $p < 0.001$ ) in
  - Total score for Upper Extremity
  - Upper Limb
  - Hand
- Mean improvement: 7.06 -> **exceeding MCID 4.25**

- Lawton IADL: Significant improvement ( $p < 0.001$ )
- MBI: did not change significantly
- Neuroarchitectural Change:
- Insignificant increase in SFC values ( $p = 0.128$ ) overall
- Significant increase in SFC value ( $p = 0.006$ ,  $\eta^2 = 0.545$ ) for level 6
- changes in SFC was significantly correlated with post-treatment motor outcomes (FMA-Hand ( $r = 0.727$ ,  $p = 0.017$ ,  $R^2$  (adj) = 0.470) & FMA-UE ( $r = 0.649$ ,  $p = 0.042$ ,  $R^2$  (adj) = 0.349))

### Model 1 (17.8% of the variance)



### Model 2 (31.2% of the variance)



Predictors included baseline age, sex, and a distinct pairwise combination of two SFC/FMA metrics

## Multivariate regression models predicting motor rehabilitation outcome

Predictors included baseline age, sex, and one of the following: baseline FMA) score or an SFC metric (whole-brain, network-level, or regional).



Q & A

The End

Thank you for your attention