

# Hemiparetic upper extremity recovery through telerehabilitation via smart reminder: From proof-of-concept and technology development to clinical applications

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## Introduction

Remind-to-move' (RTM) treatment through the use of smart reminders has been developed through various forms and technological versions, and proven to be useful in our published behavioral and imaging studies for improving hemiparetic upper extremity awareness and functional performance.

Originating from PolyU, RTM was the first treatment of its kind in the world to promote the use of a hemiparetic arm following the arm's non-use as a result of hemiplegia in adult stroke patients or children with cerebral palsy. Underpinned by attention theory, the first RTM protocol, which used a wearable sensory cueing device, was developed to promote a stroke patient's awareness of the affected side of the body after hemiplegia in order to reduce unilateral neglect and trace the actions associated with that awareness. The effects of treatment have already been published in more than 14 SCI-indexed journals in the areas of rehabilitation for people with stroke

In our previous paper on children with cerebral palsy, we found that RTM demonstrated therapeutic effects equivalent with those of another level of evidence A treatment – constraint-induced movement therapy (CIMT) in manual dexterity and functional hand use. In our randomized controlled trial, we found that RTM could promote more arm recovery than the sham or control could.

An examination of the neural mechanism of 'Remind-to-move' using functional near-infrared spectroscopic topography (fNIRS), we found that RTM enhances the recruitment of the contralateral primary motor cortex, and that effect appears to be associated with increased attention allocation toward moving the hands upon sensory cueing in stroke patients.



**Figure 1 - The smart reminder exercise program in RTM for telerehabilitation**

## Objective

To investigate the effects of RTM through telerehabilitation by comparing the outcomes of a 4-week program of closed-loop and open-loop RTM on the functional use of the hemiparetic upper extremity in people with chronic stroke in the community.

## Methods:

This is an on-going randomized trial on participants with chronic unilateral stroke resided in the community randomized to 3 groups: 1) Closed-loop group; 2) Open-loop group; 3) Sham-group.

In the open-loop group, the newly developed RTM device provides smart cueing to participants at a fixed time interval while engaging in a 4-weeks upper limb task-specific training, whereas the frequency of reminding signals is coupled with the usage of the hemiparetic arm with synchronization with that of the less affected arm in the closed-loop RTM.

Patients in all groups will be required to wear the devices on their affected arm for at least eight consecutive hours daily during the daytime, for a total of four weeks. In (1) the closed-loop RTM condition, vibration cues will be emitted dependent on a kinematic threshold-based algorithm, where the set vibration cue will be postponed to the next 10-minute interval if the user's affected arm has been deemed active for their level of impairment within the timeframe. In the open-loop RTM, vibrations will be activated at a set 10-minute interval. Once the patients feel the vibration sensory cue, they need to press the acknowledgement button, and they will not need to perform one of the assigned exercises after the cue. No vibrations will be emitted in the sham condition. All groups will be assigned a smart reminder treatment consisting of a daily 30-minute therapist-assigned exercise program to follow through in the App for the 4-week duration.

## Outcome measures:

Evaluations using MAL, FMA-UE, and ARAT, were conducted at pre/post intervention and 8-week follow-up using upper extremity functional outcomes and the kinematic data captured from the device.



Figure 2 - RTM Version 5.0

## Results:

Preliminary results show that both open-loop and closed-loop of training had achieved significant gains in the outcomes particular MAL during posttest and at follow-up. The closed-loop group has shown significant improvements in movement frequency and hand functions than that of the open-loop.

## Conclusion:

RTM treatment in telerehabilitation through the use of closed-loop smart reminders can reduce supervised care and should be considered by occupational therapists in home-based and community rehabilitation for boosting up upper limb recovery in the stroke population.

Figure 3 - Conceptual framework between closed-loop and open loop RTM

