

## New Modalities and Approaches in Stroke Rehabilitation

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### Abstract

During recent years, our understanding of recovery after stroke has changed dramatically. As a result, some new approaches and technologies have emerged to help stroke survivors improve even years after the accident. I am trying to introduce some of the most recent and scientifically investigated approaches and technologies used in stroke rehabilitation. Technologies and approaches such as intensive task-specific approach, repetitive Transcranial magnetic stimulation, transcranial direct current stimulation, virtual reality rehabilitation, robotic rehabilitation. [GMJ.2016;5(Supp.1):66-70]

**Keywords:** Stroke; Transcranial Direct Current Stimulation; Virtual Reality Rehabilitation; Robotic Rehabilitation.

### Introduction

Stroke is the leading cause of disability in the world and known as one of the most important causes of death. Most stroke survivors suffer from disabilities which interfere with their activities of daily living for the rest of their lives. The most important therapeutic approach to decrease disabilities and improve the quality of life after stroke is rehabilitation. Until recently, stroke rehabilitation has mostly focused on compensatory techniques to overcome physical deficits. Also, in most physical therapy and occupational therapy clinics, the therapists rely only on a few rehabilitation approaches such as; neurodevelopmental techniques, proprioceptive neuromuscular facilitation and electrical stimulation. There is still a false belief that recovery takes place

only during the first 6 to 9 months after stroke. However, the latest neurorehabilitation studies show that the concept of neural plasticity or the ability of the brain to repair works effectively long after the impact of stroke. During recent years, our understanding of recovery after stroke has changed dramatically. As a result, some new approaches and technologies have emerged to help stroke survivors improve even years after the accident. In this monograph, we are trying to introduce some of the most recent and scientifically investigated approaches and technologies used in stroke rehabilitation.


### Technologies and Approaches

1. Intensive Task-specific Approach:  
In a series of elegant experiments on primates, Nudo showed that neural plasticity and re-

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pair depend on the performance of functional tasks and not simply on the use of an extremity [1-4]. In his experiments, monkeys that only performed range-of-motion exercises showed minimal improvement, whereas those performing multiple repetitions of functional tasks made greater functional gains. Nudo also found that adjacent brain areas adopted the function of the damaged brain area in monkeys that received a full rehabilitation program. Schmidt noted that task specific practice is required for motor learning to occur [5]. More specifically, Karni et al. used functional MRI [6] and Classen et al. used transcranial magnetic stimulation [7]. Both of them reported a slowly evolving, long term, experience-dependent reorganization of the adult primary motor cortex following daily practice of task-specific motor activities.

Three key factors can be attributed to a successful rehabilitation plan:

- The task must be functional. The learning of a specific skill is required to bring about significant changes in neural connectivity. Neural plasticity and repair, therefore, depend on the performance of specific tasks rather than just using motor activities.
- The task must be exercised repeatedly. The number of repetitions appears to be crucial in driving plasticity and learning/relearning tasks. There is a critical level of rehabilitation and repetition needed for a patient to see continued improvement and to maintain their functional gains outside a therapy setting.
- Delays in therapy could result in the development of behaviours that interfere with recovery.

### **Conclusion for intensive task specific approach**

There is strong evidence (level 1a) that intensive task specific training can improve upper limb function and gait in patients with stroke.

### **2. Non-Invasive Brain Stimulation:**

Non-invasive brain stimulation is a term to describe methods by which we can stimulate some areas of brain cortex non-invasively. Using different methods of stimulation, the activity of a certain cortical area could be in-

creased or decreased. These methods mostly include repetitive Transcranial Magnetic Stimulation (rTMS) and transcranial Direct Current Stimulation (tDCS).

### **2.1. Repetitive Transcranial Magnetic Stimulation:**

rTMS is a novel approach that has been used recently in the fields of neurology, psychiatry, physical medicine and rehabilitation. It uses repetitive pulses of focal magnetic field applied over the skull of the patient and produces alterations in brain function lasting beyond the stimulation time. If the pulses are given with low frequency (i.e. 1 Hz or lower), the function of the stimulated brain cortex will be reduced and if the pulses are given with high frequency (i.e. 5 Hz or higher) the stimulated area will be more active. We can use these features to selectively increase or decrease the function of brain cortex locally.

One of the mostly recognized applications of rTMS in the field of neurology and rehabilitation medicine is for stroke patients. It is known that immediately after stroke, an imbalance between the inhibitory effects of brain hemispheres over each other will appear and the sound hemisphere predominates in inhibiting the function of the lesion side. By understanding this fact, we will have two options to use rTMS in patients with stroke. The first option is using high frequency rTMS over M1 area of the affected side which increases its function and the second option is using low frequency rTMS over M1 area of the contralateral hemisphere. Using this technique, the function of the non-affected M1 region will be decreased, so its inhibitory effect over the lesion side will be decreased too. Decreasing the inhibition over the affected site will increase its function [8]. This effect has been shown interestingly using functional Magnetic Resonance Imaging (fMRI) before and after an rTMS session. A recent meta-analysis by including the results of 18 RCTs and retrieving the data from 392 patients reported a clinically significant treatment effect of 0.55 for rTMS (9). Low frequency rTMS over the unaffected hemisphere appeared to be more effective than high frequency protocol (0.69 versus 0.41). Moreover, the treatment effects for acute, sub-

acute and chronic stages of stroke were 0.79, 0.63 and 0.66, respectively.

Despite positive effects shown in many RCTs, there are also other investigations that have shown no or minimal effects for this intervention; so overall, the final drawback needs more research.

#### **Conclusion regarding rTMS in stroke**

There is conflicting (level 4) evidence that rTMS improves mobility or upper extremity function following stroke.

#### **2.2. Transcranial Direct Current Stimulation:**

Electrical brain stimulation, a technique developed many decades ago and then largely forgotten, has re-emerged recently as a promising tool for experimental neuroscientists, physiatrists, clinical neurologists and psychiatrists in their quest to investigate cortical representations of sensorimotor and cognitive functions and to facilitate the treatment of various neuropsychiatric disorders.

tDCS is a newly emerged technique of non-invasive brain stimulation that has been found useful in examining cortical function in healthy subjects and in facilitating treatments of various neurologic disorders. A better understanding of adaptive and maladaptive neuroplasticity and its modulation through non-invasive brain stimulation have opened up experimental treatment options using tDCS for patients recovering from stroke.

The stimulation takes place through application of 2 saline-soaked surface electrodes over the scalp of the areas of interest. There are two major stimulation techniques. In anodal stimulation, the anode will be put over the cortical area which we want to increase its activity (M1 area of the affected side in stroke patients) and in cathodal stimulation, the cathode will be put over the cortical area which we want to decrease its activity (M1 area of the non-affected side in stroke patients). The other electrode will be applied on the contralateral M1 area or the contralateral supra-orbital region. The former montage seems to be superior to the latter [10].

In a meta-analysis conducted recently, the effect of anodal tDCS was investigated [11]. The results showed a mild to moderate effect size.

#### **Conclusion regarding tDCS in stroke**

There is strong (level 1a) evidence for the effect of tDCS in chronic stroke. There is moderate (level 1b) evidence that anodal tDCS is more effective than cathodal montage.

#### **3. Virtual Reality Rehabilitation**

Virtual reality (VR) or virtual environment is a technology that allows individuals to interact with objects which do not exist in reality. Using this technology, the person will be capable of performing actions which are not available or possible or are dangerous to perform in real life. For example, a patient with stroke can jump from a flying plane and navigate through the sky or work in a factory and move heavy objects. The most common forms of virtual environments are conventional computer monitors or projector screens. A computerized virtual environment has opened the doors to an exercise environment where the intensity of practice and positive feedback can be consistently and systematically manipulated and enhanced to create the most appropriate individualized motor learning approach [12]. The most important features of VR for stroke patients are increasing motivation, visual and auditory feedbacks, computerized tracking of the changes in patient's performance and unlimited types of exercises to be taken.

Some VRs are more immersive than others. For example, Head Mounted Displays (HMDs) uses a technology to show the virtual environment immediately in front of the person's eyes, increasing the perception of the being in the new environment. Although VR technologies can be used separately to improve the function in stroke survivors, they can be embedded in other technologies such as robotic devices to enhance their effectiveness.

In a systematic review of VR studies, the authors examined both RCTs and observational investigations. According to RCT results, using VR was associated with significant improvement of 13.7% to 20% in upper limb outcome measures. In an analysis of observational studies, there was a 14.7% improvement in terms of impairment-level measures and 20.1% in motor function [13].

A Cochrane review including 19 RCTs re-

ported a moderate treatment effect for VR technology [14].

#### **Conclusion regarding VR technology in stroke**

There is strong (level 1a) evidence that VR can improve motor function in the chronic stage of stroke.

#### **4. Robotic Rehabilitation**

During past few years, robots are being used more and more in the field of rehabilitation. Robots can aid in passive movement of the joints to maintain range of motion and flexibility and to help reduce hypertonia. Robots can also assist in movements when the patient has some voluntary movement but has not enough power to complete the task. In patients who have enough power to do a certain task, robots can resist the movement or induce perturbations in movement trajectory to increase strength or equilibrium. Even though unassisted movement may be the most effective technique in patients with mild to moderate impairments, actively-assisted movement with robotic devices may be beneficial in more severely impaired patients [15]. Major advantages of robotic therapy include the ability to conduct unlimited number of exercises without fatigue, embedding with virtual reality environments, the ability to have fully controlled passive, actively-assisted or resisted movements with feedback of the patient's progress over time and decreasing the need for special therapists in the clinic which decreases the costs over time.

There are also a number of robotic devices to help rehabilitation of lower limb. These devices can be used with or without a sling assembly device to support weight during gait training. These devices can be classified as either end-effector robots which have the patient's feet placed on foot plates and stimulate the stance and swing phases during gait training or an exoskeleton robot in which the patients are outfitted with programmable drives or passive elements moving their hips and knees during gait phases.

A systematic review of upper limb robot-aided therapy on stroke patients included the results of 8 RCTs. It concluded that robotic therapy can improve short and long term shoulder and elbow functions more than what can be achieved by traditional therapy [16].

A Cochrane review including the results of 23 trials (999 participants) concluded that robotic devices are associated with increased odds of being an independent ambulatory and an increase in walking capacity but not with an increase in walking speed [17].

#### **Conclusion regarding the use of robots in rehabilitation of stroke**

There is strong (level 1a) evidence that sensorimotor training with robot devices improves upper extremity functional outcomes and motor outcomes of the shoulder and elbow but not motor outcomes of the wrist and hand. There is conflicting (level 4) evidence that robotic devices are superior to conventional gait training in the improvement of functional walking performance.

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