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Final report summary

Can brain stimulation help with re-learning movement after stroke?

The effect of transcranial direct current stimulation on motor learning after stroke

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Why did we fund this research?

Stroke is the leading cause of complex, adult disability, and even after rehabilitation many survivors are left dependent on others for normal activities of daily living[1,2].

Rehabilitation of movement after stroke requires the re-learning of normal movement patterns that have been lost due to the brain injury[3], and this process is known as motor learning.

There is some evidence that the rate at which motor learning takes place can be improved in healthy adults and well recovered chronic stroke survivors using a safe and painless, non-invasive brain stimulation technique called Transcranial Direct Current Stimulation (tDCS)[4-6]. This is delivered through two plastic electrodes on the scalp for up to 20 minutes at a time. The positive electrode is called the anode and the negative one is called the cathode.

Given the current evidence, it is unclear which is the best position of the electrodes on the scalp in order to improve the rate of motor learning for stroke survivors[8-13]. One of the most important parts of the brain involved in motor learning is the motor cortex, which is present in the left and right sides (hemispheres) of the brain. It could be that placing the anode over the motor cortex affected by stroke works best. Alternatively, placing the cathode on the unaffected side may work best, or placing the electrodes over both the affected and unaffected sides of the motor cortex (bihemispheric stimulation) could produce the best results.

Aims of the current study were to determine whether and how tDCS using different electrode placements on the scalp can:

- change the rate of motor learning in stroke survivors with one-sided arm and hand weakness
- change the functional ability of the affected arm and hand
- change the way the two sides of the brain communicate with each other.

A final aim was to study whether the outcomes of the first three aims may be related.

It was hoped this study would inform the design of a larger clinical trial of how tDCS can be best used to improve the effects of rehabilitation after stroke.

What did the researchers do?

Twenty-four stroke survivors with an average age of 60 years completed the study. All had their stroke at least three months before taking part. Twelve had their right arm affected by stroke and the others their left.

All participants attended five sessions. In the first session they were familiarised with the tasks and tests used in the study. These were a computer-based movement learning task, the Jebsen Taylor Test of hand function, and a test of the activity of the connections between the two sides of the brain. In the following four sessions, participants received 20 minutes of tDCS during the computer-based motor learning task and also performed the Jebsen Taylor test before and after receiving tDCS. At the end of each session they underwent the test of activity of the two sides of the brain.

In the computer based movement learning task, participants used their affected hand to move a computer mouse to targets on a computer screen which lit up in a repeating order. They were instructed to move the cursor out of a central (red) square to the lit target as quickly as possible. The time it took to move the cursor out of the central square and the speed and accuracy of movements to each of the targets was recorded. This was to see whether learning was improved with repetition, and with tDCS.

The tDCS was delivered in different ways over the four sessions. Sham (dummy) tDCS was used as a 'control' condition to determine the participants' rate of learning and arm function without real brain stimulation. Anodal tDCS was delivered by placing the positive electrode over the stroke-affected hemisphere of the brain, in order to increase its activity. Cathodal tDCS was delivered by placing the negative electrode over the "unaffected" hemisphere, to decrease any over-activation.

Bihemispheric tDCS delivered both anodal and cathodal stimulation at the same time.

The Jebsen Taylor Test consists of a number of tasks of hand and arm function. Participants were timed both for how long it took them to complete the tasks before and after receiving tDCS in order to see whether function of the hand and arm improved. Activity of the connections between the two sides of the brain was measured with a different type of brain stimulation called transcranial magnetic stimulation (TMS).

Brain connectivity being measured with TMS (transcranial magnetic stimulation).

What did the researchers find?

Although performance on the computer based motor learning task improved over the course of a session, it was not affected by the use of tDCS, regardless of the electrode arrangement.

The time taken to perform the tasks of the Jebsen Test was reduced (improved) after participants received real tDCS in comparison with the sham version. This was dependent upon the electrode arrangement, with significant improvements after anodal tDCS on the side of the brain affected by stroke, or cathodal tDCS on the unaffected side. Stimulating both sides of the brain did not lead to improvement.

Overall it was found that there were no changes in the activity between the two hemispheres of the brain as a result of the tDCS. This suggests that the improvements in hand and arm function observed in the Jebsen Taylor Test were not due to this type of change in brain activity.

This is the first study to demonstrate a clear effect of electrode arrangement on tasks that reflect activities of daily living in chronic stroke survivors.

It has implications for the design of future clinical trials to test the effect of tDCS in combination with physiotherapy after stroke.

Findings from the study were published in the journal Disability & Rehabilitation in 2016[14].

What does this mean for stroke survivors?

This study suggests that electrode arrangement on the scalp is an important factor in the effectiveness of transcranial direct current stimulation (tDCS) to improve functional arm and hand ability after stroke. This finding may prove important in future study combining tDCS with physiotherapy for arm and hand rehabilitation.

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