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Clinical and brain imaging changes after upper-limb rehabilitation with a virtual reality tabletop system: a case study

OBJECTIVES

This case study describes the clinical improvements, measured with standard tests and supported by neuroimaging studies, observed after an upper limb rehabilitation protocol using a Virtual Reality (VR) system that provides enriched sensorimotor feedback to conventional physical therapy exercises.

METHODS

The hardware components of the tabletop system consist of a table, a standard computer, a projector, and a depth sensor (Kinect™). The projector and the sensor are fixed in an upper plane of the table oriented to its surface. This way, the projector displays the virtual environment on the table and the patients interact within it through movements of their own extremities. A set of exercises taking into account the brain plasticity and motor learning principles were designed to promote locomotor recovery of the upper extremities of individuals with ABI. The exercises covered movements that were likely to belong to the motor repertory of the patients previously to the injury and aim to maximize the correlation of the virtual tasks with the real tasks of the ADL (to dial a telephone number, to cook, to knock a door, etc.)

This case study presents the data from a chronic 62-year-old gentleman with left hemiparesis secondary to an intracerebral hemorrhage stroke (38 months post stroke) who took part in 30 1-hour sessions with the system. Clinical assessment was performed 1 month before the treatment (T1), 1 day before the treatment (T2), the day after the treatment (T3), and 1 month after the treatment (T4). Clinical measures included the Wolf Motor Function Test (WMFT), the Nine-hole Pegboard (9HP) and the Box & Block Test (BBT). Activity-induced neural reorganization was examined using functional magnetic resonance imaging (fMRI) and diffusion tensor tractography, before (T2) and after the treatment (T3). Usability and motivation were assessed at the end of the treatment with System Usability Scale (SUS) and the 'interest and enjoyment' and the 'value and usefulness' subscales of the Intrinsic Motivation Inventory (IMI).

RESULTS

Improvement was observed in all clinical scales (WMFT=3; 9HPT=19.24; BBT=7) after the treatment (T3-T2 scores). One-month after therapy (T4-T2 scores), clinical improvements were still evident (WMFT=1.5; 9HT=12.8; BBT=7). The participant considered that the system was easy to use, easy to learn, robust and consistent (SUS=95). He found the system enjoyable (IMI=4.1) and defined it as a 'useful system to improve their deficits' (IMI=5.4). fMRI during a sequential elbow movement revealed distinct therapy-related changes with a tendency to a reduction of the contralesional motor lateralization during movement.

CONCLUSIONS

The results suggest that VR therapy can induce functional recovery in chronic hemiparetic stroke patients. Results were supported by cortical reorganization, which evidenced an increase in the ipsilateral and a decrease in contralateral activity in the sensorimotor cortex.