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Upper Extremity Rehabilitation Using Virtual Reality System with tDCS with Stroke Patients

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Background
Recently, novel tools based on emerging technologies such as non-invasive brain stimulation (NIBS), robotics and virtual reality (VR) have been developed to improve motor function after stroke. There are growing evidences that a combination of NIBS and motor skill training is a new treatment option in the field of neurorehabilitation. However, it lacks of studies about VR-based rehabilitation system combined with NIBS. Therefore, the aim of this study was to investigate the effect of combination of transcranial direct current stimulation (tDCS) and VR-based therapy on distal upper extremity in patients with stroke.

Methods
The present study was a randomized, double-blinded controlled trial (NCT03465631). The study included 20 stroke patients who were randomized to an experimental (VR-based training with tDCS; VR-tDCS) group or a control (VR-based training with sham-tDCS; VR-Sham) group. All participants received a 20 sessions of 20 minutes-intervention (VR program with tDCS or sham-tDCS) over 20days. The primary outcome was the change in the Box and Block Test (BBT) scores, and the secondary outcomes were the changes in the Jebsen–Taylor hand function test (JHFT), Fugl-Meyer assessment of the upper extremity (FMA), Grip strength, and Stroke Impact Scale (SIS) version 3.0 scores. The outcomes were assessed before the intervention, immediately after the intervention, and 1 month after the intervention. The change of those variables were compared between the two groups using the RMANOVA.

Results
Both groups demonstrated gains in all evaluated areas. There was no interaction of time and group, indicating no difference between two groups, although VR-tDCS produced greater improvements in all other outcome measures, except for the SIS-activities of daily living/instrumental activities of daily living (ADL/IADL) domain. There was no adverse events during the study.

Conclusions
These findings suggest that tDCS combined with VR-based rehabilitation could be with safety. However, robust evidence needs to be investigated and clarified with further studies.

Table 1. Baseline Characteristics of Subjects

	VR–dual (n = 10)	VR–sham (n = 10)	P -value
Age (year)	54.2 ± 12.2	53.8 ± 8.7	.631[a]
Gender, male	8 (80)	5 (50)	.160[b]
Dominant hand, right	10 (100)	10 (100)	NA
Time from stroke, months	22.2 ± 40.9	20.8 ± 37.1	.529[a]
Affected arm, right	5 (50)	5 (50)	1.000[b]
Stroke type, infarction	5 (50)	6 (60)	.653[b]
MAS wrist flexor	0.4 ± 0.5	0.3 ± 0.5	.739[a]
MAS wrist extensor	0.5 ± 0.5	0.4 ± 0.5	.739[a]
MRC wrist flexor	2.7 ± 0.5	2.5 ± 0.7	.631[a]
MRC wrist extensor	2.9 ± 0.6	2.7 ± 0.5	.529[a]
MRC finger flexor	3.0 ± 0.8	3.2 ± 0.6	.631[a]
MRC finger extensor	2.8 ± 0.4	2.8 ± 0.4	1.000[a]
BBT score	16.2 ± 14.5	23.5 ± 13.6	.247[a]
FMA-proximal score	26.6 ± 7.2	28.3 ± 7.1	.529[a]
FMA-distal score	14.4 ± 3.7	15.1 ± 4.6	.796[a]
JTHF score (sec)	503.1 ± 301.4	343.5 ± 313.8	.280[a]
Grip power (kg)	5.3 ± 7.5	3.2 ± 4.8	.971[a]

Abbreviations: VR, virtual reality;

MAS, modified ashworth scale; MRC, medical research council scale;

BBT, box and block test; FMA, fugl-meyer assessment; JTHF, jebsen-taylor hand function test;

NA, not applicable.

Values are mean ± standard deviation or number (%)

[a]Mann-Whitney U test, [b]χ^2 test

(*MAS: 0:0, 1:1, 2:1+, 3:2, 4:3, 5:4)

Table 2. VR–dual and VR-sham group comparison on the amount of performance change

	T2-T1				T3-T1			
	VR–dual (n = 10)	VR–sham (n = 10)	RM –ANOVA		VR–dual (n = 10)	VR–sham (n = 10)	RM –ANOVA	
			F	P-value			F	P-value
FMA–proximal score	3.9 ± 4.8	4.3 ± 2.6	0.053	.820	4.0 ± 4.5	4.1 ± 3.1	0.003	.955
FMA–distal score	4.7 ± 2.9	5.7 ± 2.4	0.691	.417	5.0 ± 2.2	6.0 ± 2.3	1.023	.325
FMA-total score	5.8 ± 6.4	7.2 ± 3.3	0.378	.547	6.2 ± 4.7	7.3 ± 4.1	0.304	.588
Grip power (kg)	1.9 ± 3.3	1.8 ± 1.6	0.007	.933	1.4 ± 4.5	1.1 ± 1.4	0.040	.844
BBT score	5.6 ± 4.4	5.4 ± 3.8	0.012	.915	4.5 ± 3.8	7.0 ± 3.2	2.506	.131
JTHF–gross (time)	-52.1 ± 82.7	-18.7 ± 36.3	1.367	.258	-51.6 ± 78.2	-9.6 ± 25.9	2.598	.124
JTHF–fine (time)	-25.4 ± 46.5	-20.3 ± 55.3	0.050	.826	-58.3 ± 69.4	-41.2 ± 72.7	0.289	.597
JTHF–total (time)	-77.8 ± 88.3	-39.2 ± 80.5	1.043	.321	-110.1 ± 107.8	-50.7 ± 98.0	1.662	.214
SIS–strength score	6.3 ± 15.8	5.8 ± 13.8	0.003	.954	ND	ND	ND	ND
SIS–hand score	4.0 ± 7.4	17.5 ± 21.4	3.564	.075	ND	ND	ND	ND
SIS–ADL/IADL score	-1.6 ± 6.5	3.5 ± 16.9	0.810	.380	ND	ND	ND	ND
SIS–recovery score	12.0 ± 16.9	11.0 ± 8.7	0.028	.870	ND	ND	ND	ND

Abbreviations: VR, virtual reality; FMA, Fugl-Meyer assessment; BBT, Box and block test; JTHF, Jebsen Taylor hand function test; SIS, Stroke impact scale; ND, no data.
Values are mean ± standard deviation.
P-value < .05

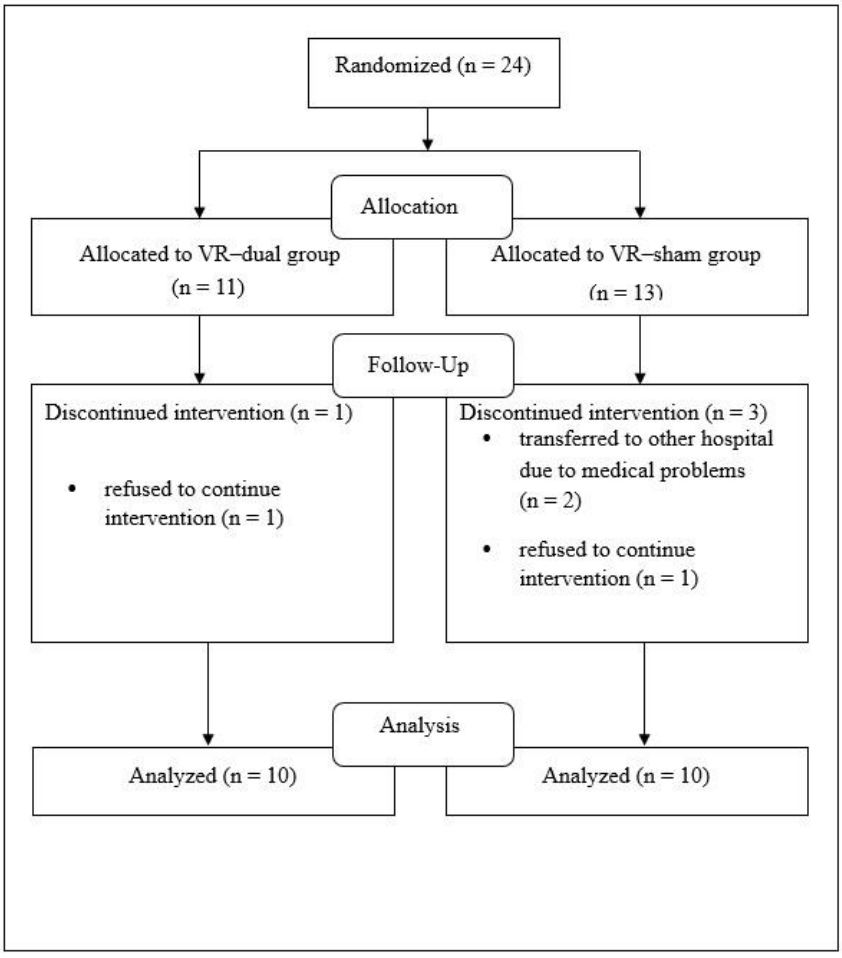

Fig 1. Study flow-chart