

Simultaneous tDCS during Gait training in Chronic Stroke

: A randomized Double-blind Clinical Trial

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BACKGROUND

Transcranial direct current stimulation (tDCS) is a therapeutic tool for improving post-stroke gait disturbances, with ongoing research focusing on specific protocols for its application. We evaluated the feasibility of a rehabilitation protocol that combines **tDCS with conventional gait training** in chronic stroke patients.

METHODS

Participants

- 20 to 90 years old
- ischemic stroke, more than 3 months from onset
- unilateral hemiplegia
- functional ambulatory category grade 2~4

Grouping

- All participants were randomly assigned to two groups
- GtDCS group: gait training with simultaneous tDCS
- Gsham group: gait training with sham stimulation

Motor evoked potential (MEP) guided navigation

- For optimal electrical stimulation to the target motor cortex, MEP-guided navigation was performed before training program
- The scalp area with maximal MEP of hemiparetic tibialis anterior muscle was recorded (Table 1.)

tDCS protocol

- Device: HDCstim® (Newronika, Milan, Italy)
- Anode: above motor cortex of hemiparetic tibialis anterior muscle
 - Participants whose MEP is not induced: at C3 or C4
- Cathode: at contralateral supraorbital area
- Stimulation: intensity, 2.0 mA; duration, 20 minutes
- Sham stimulation: 15 seconds at the beginning and end of training

Training program

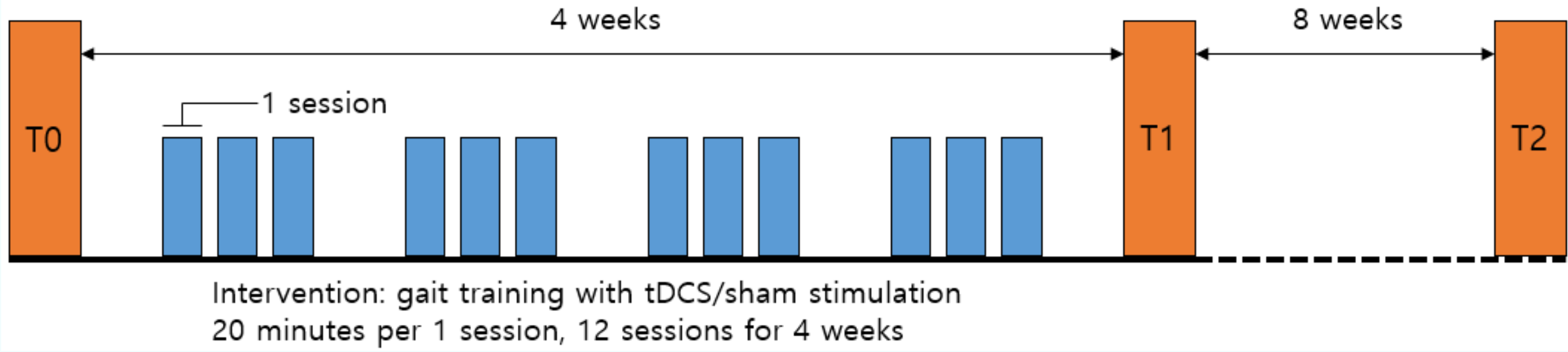
- 10 minutes of simple gait training on flat ground
- 10 minutes of complex gait training such as stair climbing, sideway walking, backway walking
- 3 times a week for 4 weeks, total 12 sessions (Fig. 1.)

Table 1. Estimated Location of the Motor Cortex of the Tibialis Anterior Muscle

	ID	Sex	Age	Horizontal (cm) ⁺	Vertical (cm) [†]
	Pt 1	F	81	+5	+2
	Pt 2	M	64	NR	NR
	Pt 3	M	62	-2	+3
	Pt 4	M	75	+3	-2
	Pt 5	M	70	+4	-5
	Pt 6	F	42	NR	NR
	Pt 7	F	74	-4	-2
	Pt 9	M	72	+9	-2
	Pt 10	M	72	NR	NR
	Pt 11	M	67	-4	-3
	Pt 12	M	59	NR	NR
	Pt 15	M	51	-2	+2
	Pt 16	F	47	+7	-3
	Pt 17	M	58	-4	+4
	Pt 18	F	61	+3	+1
	Pt 19	F	43	-3	+2
	Pt 20	F	51	+3	+1

*Horizontal distance from Cz; positive values indicate the right direction. †Vertical distance from Cz; positive values indicate the anterior direction. Abbreviations; Pt, patient; NR, non-response.

Fig. 1. Study design



All participants received 12 sessions of tDCS or sham stimulation during gait training. Outcome assessments were performed at 3 time points.

Outcome assessment

- Before intervention (T0), after intervention (T1), after 8 weeks (T2)
- Primary outcome: 10MWT (comfortable & maximal speed)
- Secondary outcome: TUG, BBS, FAC, MBI, EQ-5D-3L
- Subgroup analyses for participants with elicited MEPs

RESULTS

Table 2. Outcomes throughout the intervention

	Group	T0	T1	T2	Time effect*	Time-Group effect*
Primary outcome						
10MWT, m·s ⁻¹						
Comfortable speed	GtDCS	0.619 ± 0.243	0.653 ± 0.237	0.726 ± 0.286	0.054	0.381
	Gsham	0.762 ± 0.194	0.706 ± 0.165	0.925 ± 0.107	0.118	
Maximal speed	GtDCS	0.755 ± 0.291	0.819 ± 0.306	0.872 ± 0.318	0.278	0.444
	Gsham	0.904 ± 0.223	0.886 ± 0.251	1.006 ± 0.076	0.269	
Secondary outcomes						
TUG, s	GtDCS	12.2 ± 3.8	11.8 ± 4.3	11.5 ± 5.7	0.841	0.480
	Gsham	10.7 ± 4.0	10.5 ± 3.9	8.1 ± 0.6	0.658	
BBS	GtDCS	32.11 ± 4.78	33.56 ± 4.88	34.17 ± 4.70	0.001*	0.034*
	Gsham	40.50 ± 8.72	41.00 ± 8.00	39.00 ± 11.31	0.546	
FAC	GtDCS	3.33 ± 0.71	3.56 ± 0.73	3.67 ± 0.52	0.051	0.434
	Gsham	3.75 ± 0.89	3.75 ± 0.71	4.00 ± 0.00	0.410	
MBI	GtDCS	73.56 ± 10.05	76.78 ± 7.61	78.17 ± 8.70	0.054	0.417
	Gsham	79.62 ± 10.47	80.50 ± 11.10	72.50 ± 16.26	0.147	
EQ-5D-3L	GtDCS	8.33 ± 2.18	7.33 ± 2.24	8.50 ± 2.07	0.346	0.310
	Gsham	8.75 ± 1.83	8.88 ± 1.80	9.00 ± 2.82	0.915	

Repeated-measures analysis of variance was conducted to examine within-group and between-group over-time differences. Values are presented as mean ± standard deviation. Time effect and time-group effect are shown as p-values. p-value <0.05 was considered to be of statistical significance. Abbreviations; 10MWT, 10-meter walk test; TUG, Timed up and go test; FAC, Functional ambulation category.

CONCLUSION

Simultaneous tDCS during gait training is a feasible rehabilitation protocol for chronic stroke patients with gait disturbances. Furthermore, this study suggests the potential of a **targeted tDCS protocol** to be employed as a novel rehabilitative technique for gait dysfunction caused by stroke.

Table 3. Outcomes of subgroup analyses for participants with elicited MEPs

	Group	T0	T1.	T2	Time effect*	Time-Group effect*
Primary outcome						
10MWT, m·s ⁻¹						
Comfortable speed	GtDCS	0.689 ± 0.247	0.742 ± 0.214	0.837 ± 0.241	0.031*	0.929
	Gsham	0.746 ± 0.225	0.706 ± 0.195	-	0.552	
Maximal speed	GtDCS	0.857 ± 0.289	0.952 ± 0.255	1.003 ± 0.236	0.306	0.840
	Gsham	0.884 ± 0.258	0.893 ± 0.295	-	0.820	
Secondary outcomes						
TUG, s	GtDCS	11.0 ± 3.5	10.1 ± 3.2	9.3 ± 2.8	0.093	0.689
	Gsham	11.5 ± 4.5	11.0 ± 4.4	-	0.463	
BBS	GtDCS	32.50 ± 4.76	33.83 ± 4.26	35.75 ± 4.57	0.005*	0.051
	Gsham	41.67 ± 7.74	42.17 ± 8.42	-	0.581	
FAC	GtDCS	3.50 ± 0.55	3.83 ± 0.41	3.75 ± 0.50	0.212	0.711
	Gsham	3.83 ± 0.98	3.83 ± 0.75	-	1.000	
MBI	GtDCS	77.17 ± 8.89	79.50 ± 6.66	81.50 ± 5.80	0.128	0.434
	Gsham	82.50 ± 8.60	83.17 ± 9.24	-	0.175	
EQ-5D-3L	GtDCS	8.33 ± 2.07	6.83 ± 1.94	8.00 ± 2.45	0.339	0.312
	Gsham	8.83 ± 1.47	8.50 ± 1.87	-	0.363	

Repeated-measures analysis of variance was conducted to examine within-group and between-group over-time differences. Values are presented as mean ± standard deviation. Time effect and time-group effect are shown as p-values. p-value <0.05 was considered to be of statistical significance. Abbreviations; 10MWT, 10-meter walk test; TUG, Timed up and go test; FAC, Functional ambulation category.