



Introduction

- Many chronic stroke patients suffer from upper limb paresis, but treatment is limited as they cannot get upper limb rehabilitation training from occupational therapist after acute and subacute periods. Therefore, in this study we tried to apply robotic training for chronic stroke patients.
- This study will explore the clinical effectiveness of upper limb training using **Rebless®**, a commercially available rehabilitation device for patients with stroke, via **functional near-infrared spectroscopy (fNIRS)** assessments of cortical activity and functional outcomes.

Methods

Design

- Unblinded, prospective, randomized controlled trial
- From March 2022 to August 2022

Inclusion criteria

- Ischemic or hemorrhagic stroke
- Stroke onset (>24 months)
- Age(≥19)
- Stroke-affected arm paresis
- Spasticity on their elbow or wrist which is equal to or lower than Modified Ashworth Scale (MAS) grade 3

Equipment

- Rebless® is a motorized type of orthopedic exercise device manufactured by H. Robotics Co., Ltd.
- Offers range of motion (ROM) and resistance exercise of the elbow and wrist joint
- Different operating modes for patients while collecting data, such as ROM, the level of assistance and resistance, and number of repetitions.

Procedure and interventions

- Patients were randomly assigned to receive robotic training (experimental group; n= 15) with Rebless® or conventional therapy (control group; n= 15) with Motomed®(Figure. 1)
- Upper limb training lasting for 30 minutes per session with a total of 10 training sessions, within 4 weeks.



Figure 1. (A) Rebless® for the experimental group and (B) Motomed® for the control group

Clinical data

- Age, gender, height, weight, BMI, time post-stroke, stroke etiology (ischemia, hemorrhage), and affected side

Functional evaluation

- Fugl-Meyer Assessment of the Upper Extremity(FMA-UE)
- Modified Barthel Index(MBI)
- The spasticity of the elbow flexor, the elbow extensor, the wrist flexor, and the wrist extensor of the affected upper extremity was measured by MAS
- The ROM of the elbow flexion, the elbow extension, the wrist flexion and the wrist extension of the affected arm
- Motricity Index for the upper extremities

fNIRS data acquisition

- A continuous-wave fNIRS system (NIRScout, NIRx Medical Technologies LLC, Germany)

Results

- A total of 30 chronic-stage stroke patients were enrolled in the study.
- The experimental group demonstrated a significant improvement in Fugl-Meyer Assessment-Upper Extremity score and Modified Ashworth Scale grade in elbow flexor. (Table. 1)
- The cortical activity of the unaffected hemisphere was significantly decreased after 10 sessions of training in the experimental group compared to the control group. (Figure 2)

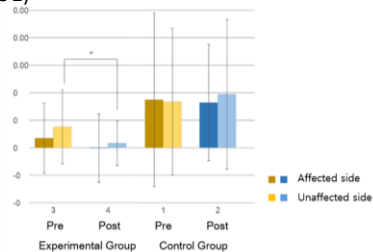


Figure 2. Changes in cortical activation measured by fNIRS of the affected and the unaffected hemisphere.

Conclusion

- The experimental group showed significant improvement in FMA-UE score and the spasticity of the elbow flexor.
- The cortical activity of the unaffected hemisphere was significantly decreased in the experimental group.
- Training with Rebless® may help chronic stroke patients in restoring upper limb function and recovering the contralateral predominance of activation in motor function.

Table 1. Outcome measures at baseline and post-training.

	Experimental group (N=15)			Control group (N=15)			p-value**
	Baseline	Post	p-value*	Baseline	Post	p-value*	
FMA-UE	27.7±8.4	32.0±9.2	0.19	22.1±10.1	23.7±9.5	0.658	0.003
MBI	88.7±6.1	90.3±4.4	0.415	90.6±4.6	90.9±4.7	0.877	0.117
MI_Upper	62.4±12.1	68.1±11.4	0.197	61.0±11.6	64.3±10.9	0.423	0.196
MAS (elbow flexor)	0.6±0.6	0.3±0.5	0.12	0.6±0.6	0.8±0.5	0.31	0.004
MAS (elbow extensor)	1.1±0.7	0.6±0.6	0.039	1.4±0.4	1.2±0.5	0.271	0.055
MAS (wrist flexor)	0.63±0.6	0.5±0.5	0.399	0.9±0.9	0.8±0.7	0.733	0.577
MAS (wrist extensor)	1.2±0.6	0.8±0.6	0.045	1.4±0.9	1.2±0.7	0.563	0.088
ROM (elbow flexor)	128.3±12.6	134.0±9.5	0.176	123.3±14.7	126.0±14.3	0.619	0.208
ROM (elbow extensor)	0.7±1.8	1.0±2.1	0.638	0.0±0.0	0.0±0.0	1	0.326
ROM (wrist flexor)	54.3±19.7	58.0±20.2	0.618	47.3±20.5	49.7±19.9	0.754	0.505
ROM (wrist extensor)	37.3±22.6	45.7±16.4	0.257	31.0±17.7	33.7±16.4	0.672	0.051

Values are presented as mean±standard deviation. FMA-UE, Fugl-Meyer Assessment Upper Extremity; MBI, Modified Barthel Index; MI_Upper, Motricity Index for the upper extremities; MAS, Modified Ashworth Scale; ROM, Range of Motion.

*P < 0.05, by the Wilcoxon signed-rank test, for baseline versus post-training.

**P < 0.05, by the Mann-Whitney U test (Wilcoxon signed-rank test), for the difference (post-training) of the experimental group versus control group.