



Ability of electrical stimulation therapy to improve the effectiveness of robotic training for paretic upper limbs in patients with stroke



Hiroyuki Miyasaka^{a,b}, Abbas Orand^a, Hitoshi Ohnishi^b, Genichi Tanino^{a,b}, Kotaro Takeda^{a,*}, Shigeru Sonoda^{a,b,c}

^a Fujita Memorial Nanakuri Institute, Fujita Health University, 423, Oodori-cho, Tsu, Mie 514-1296, Japan

^b Fujita Health University Nanakuri Memorial Hospital, 424-1, Oodori-cho, Tsu, Mie 514-1295, Japan

^c Department of Rehabilitation Medicine II, School of Medicine, Fujita Health University, 424-1, Oodori-cho, Tsu, Mie 514-1296, Japan

ARTICLE INFO

Article history:

Received 31 December 2015

Revised 23 June 2016

Accepted 30 July 2016

Keywords:

Functional electrical stimulation
Therapeutic electrical stimulation
Hemiplegia
Robot rehabilitation
Reaching movement

ABSTRACT

We investigated whether untriggered neuromuscular electrical stimulation (NMES) can increase the effectiveness of shoulder and elbow robotic training in patients with hemiparesis. Thirty subacute stroke patients were randomly allocated to robot only (RO) and robot and electrical stimulation (RE) groups. During training, shoulder and elbow movements were trained by operating the robotic arm with the paretic arm, and the robotic device helped to move the arm. In the RE group, the anterior deltoid and triceps brachii muscles were electrically stimulated at sub-motor threshold intensity. Training was performed (approximately 1 h/day, 5 days/week for 2 weeks) in addition to regular rehabilitation. Active range of motion (ROM) values of shoulder flexion and abduction, and Fugl-Meyer assessment (FMA) scores were measured before and after training. Active shoulder ROM was significantly better after than before training in the RE group; however, no such improvement was noted in the RO group. FMA scores were significantly better in both groups, and there was no significant difference between the groups. Untriggered NMES might increase the effectiveness of shoulder and elbow robotic training in patients with hemiparesis. Additionally, NMES at a sub-motor threshold during robotic training might facilitate activation of paretic muscles, resulting in paralysis improvement.

© 2016 The Author(s). Published by Elsevier Ltd on behalf of IPPEM.

This is an open access article under the CC BY-NC-ND license.

(<http://creativecommons.org/licenses/by-nc-nd/4.0/>)

1. Introduction

Robotic training has been reported to be an effective treatment for hemiparesis after stroke [1]. The InMotion ARM™ Robot (Interactive Motion Technologies, Inc., Cambridge, MA, USA) is a therapeutic robotic training tool for upper limb rehabilitation [2], and many studies have reported that robotic training improves paralysis in patients with stroke [3–5]. In robotic training using the InMotion ARM Robot, shoulder and elbow movements are trained by operating the robotic arm with the paretic arm during reaching tasks in a horizontal plane. During the reaching tasks, the robotic device helps to move the arm when the patient is unable to move the arm. Previous studies have applied the InMotion ARM Robot to hemiplegic patients with acute and subacute

stroke and have shown improvements in the Fugl-Meyer assessment (FMA) scale, which indicates motor functional performance, and muscle strength of the hemiparetic upper limb [6,7]. Volpe et al. [4] and Finley et al. [8] have also reported that the robotic device improved the FMA score by 1–3 points in chronic stroke patients.

In recent years, it has been reported that further improvement in paralysis can be achieved in patients with stroke by combining electrical stimulation with upper limb rehabilitation programs, such as repetitive facilitative exercise [9], mirror therapy [10], and bilateral arm training [11]. Additionally, in stroke patients, a reduction in the synergy of shoulder abduction and elbow flexion has been reported with a combination of transcutaneous functional electrical stimulation to the triceps brachii muscle and shoulder movement training [12]. Although studies have reported on the effectiveness of electrical stimulation alone in patients with paralysis [13,14], electrical stimulation can be combined with robotic upper-limb training, as these approaches are compatible. Hu et al. reported that the improvement in upper-limb function with wrist movement training was greater when the combination of

* Corresponding author. Fax: +81 59 252 2744.

E-mail addresses: hmiyasak@fujita-hu.ac.jp (H. Miyasaka), orand@fujita-hu.ac.jp (A. Orand), kuro_beni_14@yahoo.co.jp (H. Ohnishi), gtanino@fujita-hu.ac.jp (G. Tanino), ktakeda@fujita-hu.ac.jp (K. Takeda), doctor.sonoda@nifty.ne.jp (S. Sonoda).

Table 1
Patient characteristics before training.

	RO group	RE group	<i>p</i> -value
Number of patients	15	15	
Age (years)	64.9 ± 9.4	56.9 ± 12.3	0.08
Sex (male/female)	12/3	9/6	0.22
Affected side (right/left)	5/10	6/9	0.70
Lesion type (hemorrhagic/ischemic)	9/6	7/8	0.46
Days after stroke onset	66.3 ± 11.2	65.7 ± 17.6	0.43

Data are presented as mean ± standard deviation or number.
RO, robot only; RE, robot and electrical stimulation.

electrical stimulation and robotic training was used than when only robotic training was used [15]. This previous study included patients with voluntary muscle contraction on the paretic side, and used triggered neuromuscular electrical stimulation (NMES). With triggered NMES, it is possible to contract muscles consistently with movement planning by the patient, and the improvement in paralysis is likely to be better with triggered NMES than with untriggered NMES that does not provide stimulation based on movement planning [16]. However, triggered NMES can be used only in patients with voluntary muscle contraction, while untriggered NMES can be used in patients without voluntary muscle contraction.

In the present study, we investigated whether untriggered NMES can increase the effectiveness of shoulder and elbow robotic training in patients with hemiparesis.

2. Materials and methods

The study enrolled 30 patients with stroke, who were hospitalized at Fujita Health University Nanakuri Sanatorium. The inclusion criteria were as follows: (1) first stroke in the cerebral hemisphere and (2) absence of sensory disorders (score of ≥ 2 for fine touch and joint position sense in the stroke impairment assessment set [SIAS] sensory evaluation) [17]. The exclusion criteria were as follows: (1) severe aphasia; (2) inability to maintain a sitting position; and (3) failure to provide consent.

The patients were randomly allocated to a robot only (RO) group and a robot and electrical stimulation (RE) group, with 15 patients in each group (Table 1). In both groups, robotic training using the MIT-MANUS/InMotion2 system (Interactive Motion Technologies, Inc.) was performed (approximately 1 h/day, 5 days/week for 2 weeks) in addition to a regular rehabilitation program. During robotic training, patients repeated reaching movements in a horizontal plane at least 1000 times in approximately 1 h. In the RE group, NMES was delivered to the anterior deltoid and triceps muscles using the Trio300 system (Ito Co., Ltd., Tokyo, Japan) during robotic training. The parameters of NMES were a pulse width of 250 μ s and a frequency of 20 Hz at sub-motor threshold intensity. NMES was continuously delivered during training.

We compared patient characteristics between the RO and RE groups, and used the Mann-Whitney *U* test for age and time since stroke and the χ^2 test for sex, side of stroke, and the hemorrhage/infarction ratio. Active range of motion (ROM) values of shoulder flexion and abduction, and FMA shoulder/elbow (FMA-SE) and FMA total (FMA-total) scores were measured before and after robotic training. The Wilcoxon signed-rank test was used to compare these parameters before and after training in each group, and the Mann-Whitney *U* test was used to compare the improvements in these parameters between the groups. All statistical analyses were performed using JMP[®] 9 software (SAS Institute Inc., Cary, NC, USA). A *p*-value < 0.05 was considered to indicate statistical significance.

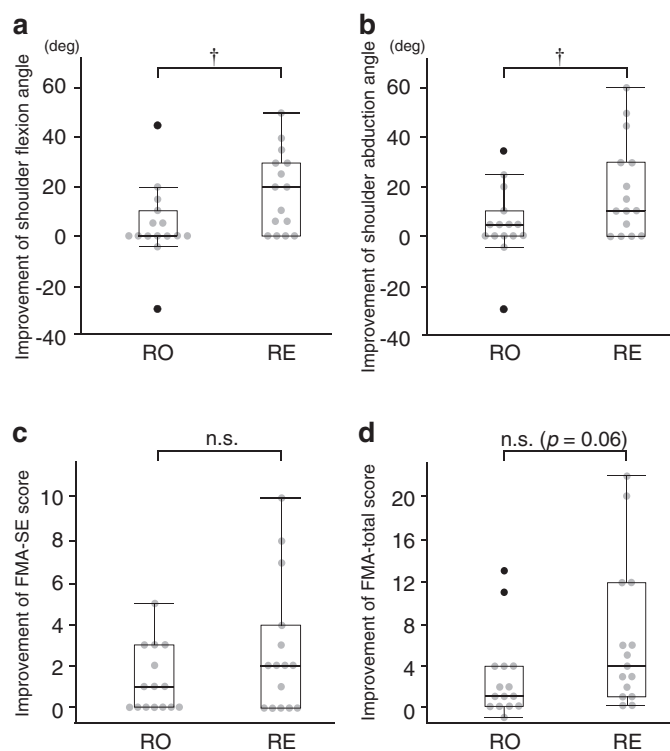


Fig. 1. Scatter plot (circle for each patient) and box-and-whisker plot (minimum, quartiles, and maximum) of the improvements in the robot and electrical stimulation (RE) group and the robot only (RO) group. The improvements in active range of motion values of shoulder flexion (A) and abduction (B) were significantly better in the RE group than in the RO group. There were no significant differences in the improvements in the FMA scores of the shoulder and elbow (C) and the FMA total score (D). †*p* < 0.05, n.s.: not significant; black circle: outliers over 1.5 × interquartile range.

3. Results

There were no significant differences in patient characteristics between the RO and RE groups prior to robotic training (Table 1). The clinical results before and after training are summarized in Table 2 and Fig. 1. Active shoulder ROM was significantly better after than before training in the RE group; however, no such improvement was noted in the RO group. Improvements in active ROM values of shoulder flexion and abduction were significantly higher in the RE group than in the RO group (20° and 10° vs. 0° and 5°, respectively). The FMA-SE and FMA-total scores were significantly better after than before training in both groups, and there were no significant differences between the groups, although the improvement in the FMA-total score tended to be greater in the RE group than in the RO group (*p* = 0.06).

4. Discussion

The combination of NMES and other therapeutic interventions, such as repetitive facilitative exercise and mirror therapy, has been reported to improve paralysis [9,10]. The present study showed that active ROM values of shoulder flexion and abduction were better with untriggered NMES combined with robotic training than with robotic training alone. Hsu et al. [13] reported better improvement in upper limb function with untriggered NMES (performed for a minimum of 10 h; 30 min/day, 5 days/week for 4 weeks) combined with a regular rehabilitation program than with a regular rehabilitation program alone. In the present study, robot training combined with continuously delivered untriggered NMES was performed for a total of 10 h over a period of 2 weeks, with improve-

Download English Version:

<https://daneshyari.com/en/article/5032833>

Download Persian Version:

<https://daneshyari.com/article/5032833>

[Daneshyari.com](https://daneshyari.com)