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Original Article

Short-term effects of physiotherapy combining repetitive facilitation exercises and orthotic treatment in chronic post-stroke patients

Kazutoshi Tomioka, RPT[1)], Shuji Matsumoto, MD, PhD[2)*], Keiko Ikeda, PRT[3)], Tomohiro Uema, PRT[3)], Jun-ichi Sameshima, PRT[1)], Yuji Sakashita, PRT[1)], Tomokazu Kaji, PRT[1)], Megumi Shimodozono, MD, PhD[2)]

[1)] *Department of Rehabilitation, Tarumizu Municipal Medical Center Tarumizu Chuo Hospital, Japan*
[2)] *Department of Rehabilitation and Physical Medicine, Graduate School of Medical and Dental Sciences, Kagoshima University: 3930-7 Takachiho, Makizono-cho, Kirishima City, Kagoshima 899-6603, Japan*
[3)] *Department of Rehabilitation, Kirishima Rehabilitation Center of Kagoshima University Hospital, Japan*

Abstract. [Purpose] This study investigated the short-term effects of a combination therapy consisting of repetitive facilitative exercises and orthotic treatment. [Subjects and Methods] The subjects were chronic post-stroke patients (n=27; 24 males and 3 females; 59.3 ± 12.4 years old; duration after onset: 35.7 ± 28.9 months) with limited mobility and motor function. Each subject received combination therapy consisting of repetitive facilitative exercises for the hemiplegic lower limb and gait training with an ankle-foot orthosis for 4 weeks. The Fugl-Meyer assessment of the lower extremity, the Stroke Impairment Assessment Set as a measure of motor performance, the Timed Up & Go test, and the 10-m walk test as a measure of functional ambulation were evaluated before and after the combination therapy intervention. [Results] The findings of the Fugl-Meyer assessment, Stroke Impairment Assessment Set, Timed Up & Go test, and 10-m walk test significantly improved after the intervention. Moreover, the results of the 10-m walk test at a fast speed reached the minimal detectible change threshold (0.13 m/s). [Conclusion] Short-term physiotherapy combining repetitive facilitative exercises and orthotic treatment may be more effective than the conventional neurofacilitation therapy, to improve the lower-limb motor performance and functional ambulation of chronic post-stroke patients.

Key words: Stroke, Repetitive facilitation exercise, Ankle-foot orthosis

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INTRODUCTION

The mobility of many stroke survivors is limited, and most identify walking as a top priority for rehabilitation[1)]. One way to manage ambulatory difficulties is with an ankle-foot orthosis (AFO) or a foot-drop splint, which aims to stabilize the foot and ankle while weight-bearing and lift the toes while stepping[1)]. In stroke rehabilitation, various approaches, including robotic assistance, strength training, and task-related/virtual reality techniques, have been shown to improve motor function[2)]. The benefits of a high intensity stroke rehabilitation program are well established, and although no clear guidelines exist regarding the best levels of intensity in practice, the need for its incorporation into a therapy program is widely acknowledged[2)].

Repetitive facilitative exercises (RFE), which combine a high repetition rate and neurofacilitation, are a recently developed approach to rehabilitation of stroke-related limb impairment[2–5)]. In the RFE program, therapists use muscle spindle

*Corresponding author. Shuji Matsumoto (E-mail: shushu@m.kufm.kagoshima-u.ac.jp)

stretching and skin-generated reflexes to assist the patient's efforts to move an affected joint[5]. Previous studies have shown that an RFE program improved lower-limb motor performance (Brunnstrom Recovery Stage, foot tapping, and lower-limb strength) and the 10-m walk test in patients with brain damage[3].

An AFO is an assistive device to help stroke patients with hemiplegia walk and stand. A properly prescribed AFO can improve gait performance and control abnormal kinematics arising from coordination deficits[6]. Gait training with an AFO has been also reported to improve gait speed and balance in post-stroke patients[7, 8].

Therefore, we hypothesized that short-term physiotherapy combining RFE and orthotic treatment would improve both lower-extremity motor performance and functional ambulation. The present study aimed to confirm the efficacy of a combination therapy consisting of RFE for the hemiplegic lower limb and gait training with AFO.

SUBJECTS AND METHODS

The subjects consisted of 27 inpatients (24 males and 3 females) diagnosed with cerebral hemorrhage (15 patients) or cerebral infarction (12 patients). The patients' average age was 59.3 ± 12.4 years (33–73 years), the duration after onset was 35.7 ± 28.9 months (5–115 months), and Brunnstrom Stage medians and quartiles of the hemiplegic lower limb were Stage 4.0 and 4–4.5 (stage 3–6), respectively. Eleven patients had right hemiplegia, and 16 patients had left hemiplegia. Among the 27 study participants, one used a rigid AFO with a medial stainless steel upright[9], two used a posterior spring leaf[10], and 24 used a hinged AFO[10].

The inclusion criteria were as follows: age, 30–80 years; hemiplegia of the lower limb (Brunnstrom stage 3–6); ability to walk without assistance using a T-cane and/or AFO; diagnosis of hemiplegia due to stroke; morbidity period, 5 months or more; ability to understand the purpose of the study and follow instructions, and agreement to participate in this study. The exclusion criteria were as follows: onset of stroke, <4 weeks previously; abnormal gait prior to the onset of stroke (such as joint disability or peripheral neuropathy); any medical condition that limited the study design (such as severe cardiopulmonary disease or severe sensory disturbance); severe aphasia and dementia that made it impossible to follow verbal instructions; and lesions on both sides of the cerebral hemisphere.

The procedures complied with the 1975 Declaration of Helsinki, as revised in 2013. The study was conducted after obtaining approval from the ethics committee of the Tarumizu Chuo Hospital, and all participants provided written informed consent.

The subjects were enrolled in a before-after study. Intervention was combination therapy consisting of RFE for the hemiplegic lower limb and gait training with AFO. According to a previous study, all subjects underwent an RFE program consisting of 7 specific exercise patterns[3], which were used to elicit movement of the hip, knee, and ankle in a manner designed to minimize synergistic movements. This technique involved the use of rapid passive stretching of the muscles in conjunction with tapping and rubbing the skin to assist in generating contractions of the targeted muscles[5]. Exercises were performed as two sets of 50 repetitions with a 1–2 minute rest period in between sets[5]. In addition, all patients underwent gait training with a self-made AFO.

This intervention was performed 40 minutes/day, 6 days/week for 4 weeks. Outcomes were measured before intervention and after 4 weeks of intervention. The outcome measures used to assess motor performance were the Fugl-Meyer Assessment of the lower extremity (FMA-LE)[11] and the Stroke Impairment Assessment Set (SIAS)[12]. Functional ambulation was assessed with a Timed Up & Go Test (TUG)[13] and a 10-m walk test (10MWT).

To determine whether physiotherapy that combined RFE and orthotic treatment improved the lower-limb motor performance and functional ambulation, the Wilcoxon Signed-Rank Test was performed, because the Shapiro-Wilk's test showed that the data were not normally distributed. The analysis was performed with the statistical analysis program SPSS Statistics for Windows version 22.0 (IBM Corporation, Armonk, NY, USA) with a significance level of α=0.05.

RESULTS

Table 1 shows the changes in FMA-LE, SIAS, TUG, and 10MWT (comfortable gait speed and fast gait speed). In terms of lower-limb motor performance, FMA-LE increased significantly from 22.96 ± 4.07 to 25.85 ± 4.03 ($p<0.01$), and SIAS increased significantly from 46.59 ± 8.34 to 53.63 ± 7.63 ($p<0.01$). In terms of functional ambulation, TUG decreased significantly from 17.35 ± 5.57 seconds to 14.02 ± 4.46 seconds ($p<0.01$), comfortable gait speed increased significantly from 0.68 ± 0.22 (m/sec) to 0.81 ± 0.24 (m/sec) ($p<0.01$), and fast gait speed increased significantly from 0.80 ± 0.28 (m/sec) to 0.96 ± 0.31 (m/sec) ($p<0.01$).

DISCUSSION

In this study, short-term combination therapy consisting of RFE and orthotic treatment was conducted to improve the lower-limb motor performance and functional ambulation of chronic post-stroke patients. There were statistically significant improvements in FMA-LE, SIAS, TUG, and 10MWT after the intervention. Furthermore, the results of the 10MWT at a fast gait speed reached the minimal detectible change threshold (0.13 m/s)[14].

Table 1. Lower-limb motor performance and functional ambulation at the baseline and after the combining training

Outcome measurements		Baseline	After the training	Difference mean ± SD
FMA-LE		22.96 ± 4.07	25.85 ± 4.03	2.89 ± 2.99**
SIAS		46.59 ± 8.34	53.63 ± 7.63	7.04 ± 4.60**
TUG (sec)		17.35 ± 5.57	14.02 ± 4.46	−3.33 ± 3.52**
10MWT	CGS (m/sec)	0.68 ± 0.22	0.81 ± 0.24	0.12 ± 0.09**
	FGS (m/sec)	0.80 ± 0.28	0.96 ± 0.31	0.16 ± 0.16**

**Significant difference $p<0.01$.
SD: standard deviation; FMA-LE: the Fugl-Meyer Assessment of the lower extremity; SIAS: Stroke Impairment Assessment Set; TUG: Timed "Up & Go" test; 10MWT: 10-m walk test; CGS: comfortable gait speed; FGS: fast gait speed

Recently, some systemic reviews of AFO have reported that gait training with AFO can improve walking ability and balance in people with stroke[1, 15]. However, few studies have focused on the correlation between AFO and motor performance changes of the lower limb in post-stroke patients[16–18]. Changes seen in this study were more marked in the lower-limb motor performance, with a substantial clinically meaningful change in fast walking speed (0.13 m/s) being achieved by all participants who completed the study protocol. The results of this study show that short-term combination therapy consisting of RFE and gait training with AFO may enhance lower-limb motor function, thereby improving walking ability in patients with chronic stroke, which is beneficial for comprehensive stroke treatment.

Several studies suggested that RFE might promote functional recovery of hemiplegia and activities of daily living to a greater extent than conventional neurofacilitation therapy, using a randomized controlled design[2–5, 19, 20]. Especially, RFE with other interventions (i.e., neuromuscular electrical stimulation, direct application of vibratory stimulation repetitive transcranial magnetic stimulation, and pharmacological treatments) may be more effective than RFE only for the recovery of limb motor performance. In the present study, patients who received RFE with gait training with AFO showed significant functional and ambulatory improvements.

This study had some limitations because it involved a small number of subjects, and its intervention period of four weeks was short. In addition, this was not a randomized controlled trial, and the efficacy of RFE with orthotic treatment could not be compared; therefore, it is difficult to generalize its results. Further, this study could not exclude observer bias and subject bias because the same staff implemented assessment and training.

In conclusion, the differences in FMA-LE, SIAS, TUG, and 10MWT demonstrated that application of a short-term combination therapy consisting of RFE and orthotic treatment has beneficial therapeutic effects on improving functional ambulation and motor performance of the lower limb in chronic post-stroke patients.

Conflict of interest

The authors have no conflicts of interest to declare.

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