New functional vibratory stimulation device for extremities in patients with stroke

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The utility of a new device that delivers functional vibratory stimulation to the extremities was studied in 13 patients with stroke. We hypothesized that vibratory stimulation of the hemiplegic lower limb would increase gait speed in these patients. The device consisted of one battery, two small vibrators and a connecting wire. The small vibrators were stabilized on the anterior tibial muscle and gluteus medius muscle by a bandage. An analysis of the effects of functional vibratory stimulation on hemiplegic lower limb on gait speed indicated that gait speed was greater during stimulation than without. These results suggest that the new device of functional vibratory stimulation is useful for treatment in patients with stroke. *International Journal of Rehabilitation Research* 27:335–337 © 2004 Lippincott Williams & Wilkins.

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Introduction

Various approaches to stroke rehabilitation, such as the facilitation technique (Kott and Voss, 1956; Brunnstrom, 1970; Bobath, 1978), functional electric stimulation (FES) (Merletti *et al.*, 1978) and EMG biofeedback (Basmajian *et al.*, 1987) have been studied to help functional recovery from hemiplegia due to brain damage. Vibratory stimulation is commonly used to improve ejaculation in patients with spinal cord injury and voluntary movement of the hemiplegic limbs. Vibratory stimulation is usually applied to the hemiplegic limbs at rest, due to the large size of the device being incompatible for use on the extremities in patients while walking. Recently, it has become easy to apply small vibrators made for mobile and cellular telephones. In the present study, we investigated whether functional vibratory stimulation of the hemiplegic lower limbs would improve gait speed.

Materials and methods

The subjects consisted of 13 in-patients with stroke (age 58.2 ± 9.7 years, hemiplegia; nine right side and four left side) who had been admitted to our rehabilitation center and could walk with walking aids (Table 1). All procedures complied with the 1975 Declaration of Helsinki, as revised in 1983. Informed consent was obtained from all of the subjects according to the ethics rules of the hospital.

Device for functional vibratory stimulation

The new functional vibratory stimulation (FVS) device consisted of one battery and two small vibrators (disk type, 18 mm diameter, 3 mm high, FM23, TPC CoLTD, Tokyo, Japan) and a connecting wire (Fig. 1). The vibrators were fixed on a plastic plate (26 × 38 mm) to enlarge the contact area with the skin. The vibrators were stabilized on the anterior tibial muscle and gluteus medius muscle by a bandage before measurements (Fig. 2). After two practice trials without FVS, and identical measurement procedure was repeated four times with FVS after a 5 min rest. Vibratory stimulation (83 Hz) was applied continuously during measurements of gait speed with vibratory stimulation.

Evaluation

The Brunnstrom stage of recovery from hemiplegia (Brunnstrom, 1970) in the affected leg was evaluated. The maximum gait speed was measured by timing subjects over 10 m in a 14 m hallway with a stopwatch (Salbach *et al.*, 2001). The subjects were able to use walking aids and walked as fast as possible, with an assistant prepared to help in case of a fall.

These functional parameters were evaluated by physical therapists assigned to the patients to provide therapy. Therapists were blind to the results of the measurement throughout the study.

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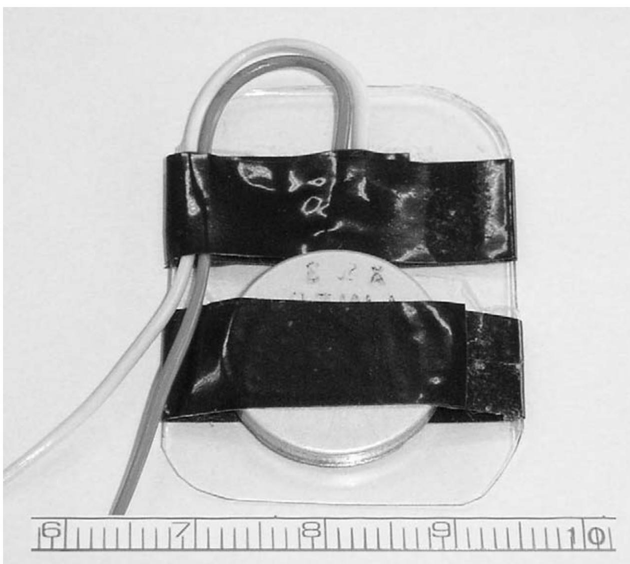
Table 1 Characteristics of the subjects

Characteristics	Patients with stroke ($n = 13$)
Age (years)	58.2 ± 9.7 (43–75)
Gender: man/woman	9/4
Diagnosis	
Hemorrhage	11
Infarction	2
Br. stage of hemiplegic leg (range) (stage)	5 4–6 (3–6)
Time since onset (weeks)	274.9 ± 473.3 (21–1724)

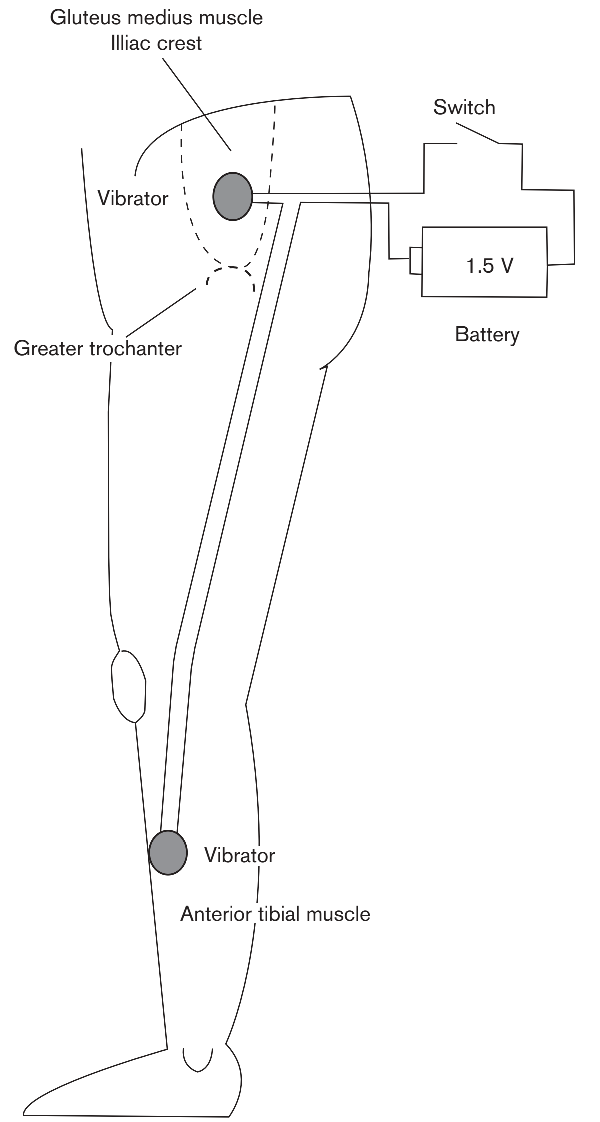
Values reported as mean ± s.d., (range) except Brunnstrom, stage of hemiplegic leg. Value in Brunnstrom stage of hemiplegic leg reported median and quartile, (range).

Fig. 1



A small vibrator used as a device to elicit functional vibratory stimulation: disk type small vibrators 18 mm diameter and 3 mm high.

Fig. 2



Functional vibratory stimulation and the stimulated site of the hemiplegic lower limb. The device consisted of one battery, two small vibrators and a connecting wire. Two small vibrators were stabilized on the anterior tibial muscle and gluteus medius muscle by a bandage.

Gait speed data were statistically analyzed using Wilcoxon's non-parametric test.

Results

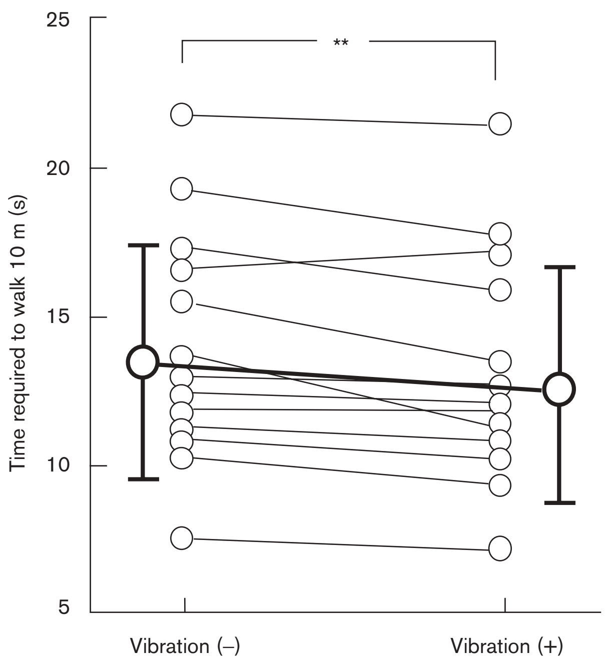
The time required to walk 10 m decreased from 13.7 ± 4.0 s without FVS to 12.8 ± 3.9 s during FVS (Fig. 3). This increase in gait speed during FVS was statistically significant ($P < 0.01$).

Discussion

In this preliminary report, we describe the utility of an FVS device which makes it possible to elicit vibratory stimulation whenever necessary regardless of the posture and motion of patients. Targeted FVS of the hemiplegic lower limb during walking significantly improved gait speed in patients with stroke.

The physiological effects of vibratory stimulation have been previously studied on muscle strength, standing balance and sensory motor system; however, there are few reports regarding the effects of vibratory stimulation during walking in healthy subjects (Ivanenko *et al.*, 2000). Conventional vibrators have been used as a therapeutic tool, but their size has made it difficult to deliver vibratory stimulation to active patients. In this study, FVS delivered to the anterior tibial muscle and hip abductor muscle theoretically would enable the patient to swing the hemiplegic leg due to the decrease in spasticity of the extensor muscle, in addition to improving the ability to

Fig. 3



Effects of functional vibratory stimulation of the hemiplegic lower limb on gait speed. **$P < 0.01$.

stand on the hemiplegic leg due to increased hip abductor contraction.

There is some physiological evidence that vibratory stimulation could disturb postural stability (Polonyova and Hlavacka, 2001) and skilled movement in healthy subjects (Roll and Gilhodes, 1995). Further research is needed to better define the influence of the site of vibratory stimulation, severity of hemiplegia and spasticity, and sensory disturbance of the affected extremities.

FES may be effective at inducing muscle contraction in patients without voluntary muscle contraction in the extremities, however FVS cannot elicit muscle contraction without the voluntary action of patients synchronized to the vibratory stimulation. Combined vibratory stimulation during voluntary movement seem to be more beneficial for improving motor function recovery in less severe hemiplegic extremities than using FES independent of voluntary muscle contraction. We anticipate that FVS technology will develop using a computer system to control multiple vibratory sitimulation during active movement, and may be a useful technique for stroke rehabilitation.

Further research is needed to better define the effect of FVS during voluntary movement on functional motor recovery in hemiplegic patients.

Conclusion

A new device, designed to elicit FVS and consisting of one battery, two small vibrators and a connecting wire, improved gait speed. Therefore, FVS may be useful as a treatment during therapeutic exercise for hemiplegic extremities.

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