

The effects of vibration stimulation applied to the left forearm on unilateral neglect in patients with stroke: A pilot randomized controlled trial

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Abstract

Objective : The purpose of this study was to investigate the effects of vibratory stimulation applied to the left forearm on unilateral neglect in patients with stroke.

Methods : The subjects were 11 unilateral neglect patients with stroke. They were divided into 2 groups; 6 experimental subjects and 5 control subjects. Both groups received standardized rehabilitation program and occupational therapy for the intervention of unilateral neglect in a day. In random order, line bisection test (LBT), Albert test, and star cancellation test (SCT) were conducted at baseline, the next day. During the process of all assessments of the next day, vibration stimulation was provided for the 6 subjects in the experimental group (EG), while the 5 subjects in CG carried out all assessments without vibration stimulation.

Result : No significant differences were found between groups on any demographic variable or baseline assessments scores. In the next day, there was significant improvement in the EG for the LBT($p<0.05$), Albert's test($p<0.05$), and SCT($p<0.05$). However, there was no significant improvement in the CG for the LBT($p<0.05$), Albert's test($p<0.05$), and SCT($p<0.05$).

Conclusion : These result indicate that vibratory stimulation has a positive effect on the unilateral neglect, and may be considered as alternative choice in clinical occupational therapy for reducing unilateral neglect.

Key words : Stroke, Unilateral neglect, Vibration stimulation

I. Introduction

Vibration stimulation is one of the methods of proprioceptive training to promote the transmission of information about the position, vibration, exercise and pressure of the joints from the muscles, joints, tendons and the surrounding tissues to the central nervous system(Oak, 2006). Especially, the vibration stimulation of tendons or muscles affects afferent nerve pathways(Pollock, Provan, Martin, & Newham, 2011) and stimulates muscle spindles to contract the muscles effectively, so it is used for the improvement of motor skills in the field of therapy in various ways(Kerschman Schindl et al., 2001).

In recent years, there have been studies reporting the effects of the application of vibration stimulation on the reduction of unilateral neglect as well as the improvement of motor skills(Johannsen, Ackermann, & Karnath, 2003; Kamada, Shimodozono, Hamada, & Kawahira, 2011; Pitteri, Arcara, Passarini, Meneghello, & Priftis, 2013). Unlike traditional interventions for unilateral neglect such as mental practice(Smania, Bazoli, Piva, & Guidetti, 1997), constraint induced movement therapy(van der Lee et al., 1999), visual search(Robertson & Murre, 1999), and limb activation(Robertson, Hogg, & McMillan, 1998), which have demerits that the patient should actively move the affected upper limb, most of them require special skills and it is difficult to apply to daily life, vibration stimulation has merits that it costs less, the method of use is simple and it can be easily applied(Schindler, Kerkhoff, Karnath, Keller, & Goldenberg, 2002).

While most studies applying vibration stimulation for the reduction of unilateral neglect

stimulate vibration on the patient's neck extensor muscles (Johannsen et al., 2003; Kamada et al., 2011; Schindler et al., 2002), there are also studies reporting the reduction of unilateral neglect by stimulating the vibration of the patient's left forearm(Pitteri et al., 2013; Vallar et al., 1995). Studies on the effects of vibration stimulation of the patient's affected upper limb on the reduction of unilateral neglect have long been conducted overseas; however, most of them applied it along with other interventions, and there has been a dispute over its curative value(Karnath, 1995; Karnath, Christ, & Hartje, 1993; Pitteri et al., 2013).

Vibration stimulation of the affected upper limb has the clinical advantage of being applicable with a variety of upper extremity activities at the same time. Therefore, we carried out this pilot study to determine whether vibration stimulation applied to the left forearm could lead to an improvement in unilateral neglect in patients with stroke.

II. Methods

1. Subjects

Subjects were recruited in a local rehabilitation hospital in Republic of Korea. The subjects of this study included 20 patients with stroke. All subjects provided written informed consent prior to study.

1) Inclusion criteria

(1) stroke was confirmed by means of a computer tomography scan or magnetic resonance imaging

(2) presence of unilateral neglect diagnosed



Figure 1. Vibrator



Figure 2. Vibration stimulation

by pathological performance on the following test motor-free visual perception test (MVPT)

(3) no hemianopsia or apraxia

(4) Korean version of Mini Mental State Examination score ≥ 24 .

2. Materials

1) The Vibrator

The vibrator(Minqing Top Art & Craft Co., China) is 80×120×35mm units weighting 0.5kg, which has a frequency range of 40 to 85 Hz(Figure 1). The surface of vibrator is wrapped with a soft cotton and the strap connected to the vibrator' body serves to fix the vibrator to the left forearm of each patients.

2) Unilateral neglect assessments

(1) Line bisection test

The line bisection test (LBT), the overall number of omissions of the 18 lines and the average deviation score from objective midline were determined. The LBT consisted 20 cm long, horizontal line segments place on a white A4 sheet of paper (210 mm × 297 mm). Patients pointed to the estimated center position using

either a pencil or a stick(Schenkenberg, Bradford, & Ajax, 1980). The LBT has good test-retest reliability and interrater reliability(Halligan, Cockburn, & Wilson, 1991).

(2) Albert's test

In Albert's test, 40 short lines randomly laid out A4 size paper. The test sheet is presented to the patients, including those to extreme right and extreme left. The examiner then asks the patients to cross out all the lines, and demonstrates what is required by crossing out the central line. The Albert's test has been found to be reliable and valid(Fullerton, McSherry, & Stout, 1986).

(3) Star cancellation test

In star cancellation test (SCT), target detection task is presented to patients on an A4 sheet of paper. The test comprises 52 darkened large stars, 10 short words, and 13 randomly laid out letters, which are all spread around 56 filled small stars. Patients were instructed to cross out all targets, which are subdivided into 6 sections with 27 on each side(Bodak, Malhotra, Bernardi, Cocchini, & Stewart, 2014).

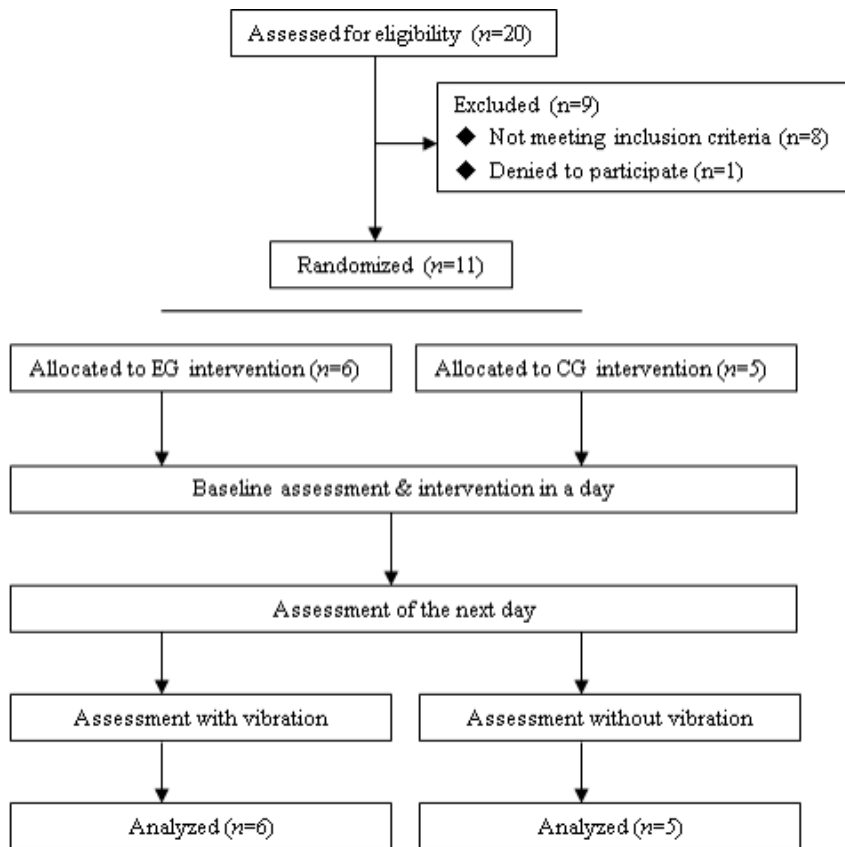


Figure 3. Flow diagram of the study

3. Procedures

This study was designed as a pilot randomized controlled trial. This study was conducted from November 3, 2014 to November 4, 2014. 20 patients were screened; 11 patients fulfilled the inclusion. The 11 subjects were randomly assigned to the experimental group (EG) or the control group (CG) in accordance with a random number table. Random allocation was performed by a research assistant under the blinded condition. All subjects were unaware of group assignments.

As for the baseline assessments, the extent of unilateral neglect was examined through a line bisection test, Albert test and star cancellation test. After the baseline assessments, both groups received occupational therapy for the intervention of unilateral neglect, such as visual scanning training and limb activation in a day. On the next day, all assessments were carried out in a random order to measure the subjects' unilateral neglect. During the process of all the assessments, vibration stimulation at a frequency of 85Hz was applied to the left forearm of the subjects in the EG (Figure 2), while the

Table 1. General Characteristics of subjects

Characteristics		EG (n=6)	CG (n=5)	p
Gender	Male	2	3	.376
	Female	4	2	
Etiology	Hemorrhagic	3	3	.740
	Ischemic	3	2	
Age (years)		62.67 \pm 5.68	67.00 \pm 8.57	.367
Onset (months)		4.83 \pm 1.17	5.00 \pm 1.00	.805
Clinical measures	LBT	10.81 \pm 2.04	10.99 \pm 1.98	.855
	Albert's test	10.67 \pm 1.37	11.00 \pm 1.58	.709
	SCT	47.00 \pm 3.58	47.00 \pm 4.06	.926

subjects in CG were carried out the assessments without vibration stimulation. The overall research procedures of this experiment are summarized as follows(Figure 3).

4. Statistical analysis

Due to our small number, the distributional that underlie the t test could not be satisfied. Thus, non-parametric statistical tests were used. The chi-squared was used to compare the difference the groups in sex, etiology, age, and onset time. The Mann-Whitney U test was used to test difference in baseline line bisection test, Albert test, and star cancellation test scores. The Wilcoxon signed-rank test was used to test difference in continuous variables within groups. For a statistical analysis, SPSS 20.0 was used, and the level of statistical significance was defined as $p < 0.05$.

III. Results

The distribution of the subjects by sex, etiology, age, and onset time, and main clinical characteristics did not show significant difference between the EG and CG($p > 0.05$)(Table 1). Table 2 summarizes the observed mean \pm standard deviation(SD) and other statistical results for all tests as they were measured on the compliant subjects at baseline assessment, post assessment. Using the Wilcoxon signed-rank test, a statistically significant improvement in the EG for the LBT($p < .05$), Albert's test($p < .05$), SCT($p < .05$) was found. However, the Wilcoxon signed-rank test did not show statistically significant improvement in the CG for the LBT($p > .05$), Albert's test($p > .05$), SCT($p > .05$).

IV. Discussion

This study investigated the effects of vibration stimulation applied to the left forearm on unilateral neglect in patients with stroke.

Interventions for unilateral neglect can be divided into three categories of functional approach, environmental adaptation approach, and impairment approach. From among these approaches, impairment approach is a method to control and identify the cause of unilateral neglect (Robertson, & North, 1992). The therapy focused on spatial representation attention is typical of impairment approach and it has been found that a positive effect on the reduction of unilateral neglect by promoting the spatial representation of the right cerebral hemisphere (Kim, 2011; Pitteri et al, 2013; Vallar et al, 1995). One of methods that focus on the spatial representation is the vibration stimulation (Kim & Chang, 2009).

As a result of this study, there was significant improvement in the experimental group only. These results from the promotion of spatial representation on the right hemisphere through vibration stimulation of the left forearm (Pitteri et al., 2013) and the improvement of attention

on the left side under stimulation (Vallar et al., 1995). It can be said that such a report in the preceding studies supports the results of this study. In contrast, control group did not show significant improvement, which means that the intervention of unilateral neglect in a day do not significantly effect unilateral neglect.

Also, therapy providing vibration stimulation to the left forearm of patients with stroke for the unilateral neglect intervention is based on the proprioceptive stimulation therapy. This therapy aims to change the damaged right brain as well as reducing unilateral neglect in patients with stroke (Tardy-Gervet, Guieu, Ribot-Ciscar, & Roll, 1993). Regarding preceding research related to this study, Pitteri et al (2013) reported on the reduction of unilateral neglect when vibration stimulation on the left forearm of patients with stroke was provided for two weeks (Pitteri et al., 2013). Like this, it is known that vibration stimulation affects the activation of the sensori-motor region of the right hemisphere, which means a change in the damaged central nervous system (Vallar et al., 1995).

Most preceding studies reported the effects of vibration stimulation applied to the left neck extensor muscles in patients with stroke on the reduction of unilateral neglect (Johannsen et al.,

Table 2. Subjects score on the LBT, Albert's test, and SCT pre- and post day

	LBT			Albert's test			SCT		
				M (SD)					
	Pre	Post	p	Pre	Post	p	Pre	Post	p
EG (n=6)	10.81 (2.04)	9.38 (2.56)	.028	10.67 (1.37)	9.50 (1.87)	.038	47.00 (3.58)	48.67 (3.27)	.023
CG (n=5)	10.99 (1.98)	10.70 (1.85)	.138	11.00 (1.58)	10.60 (1.52)	.317	47.00 (4.06)	47.80 (3.63)	.102

2003; Kamada et al., 2011; Schindler et al., 2002) but there have been a few studies of the effects of vibration stimulation applied to other parts of the body instead of the neck on the reduction of unilateral neglect, as well (Karnath, 1995; Karnath et al., 1993; Pitteri et al., 2013; Vallar et al., 1995). As a result of a study about vibration stimulation applied to the left hand in patients with stroke, there was no impact on unilateral neglect, so it reported that unconditional vibration stimulation of the body opposite to the damaged hemisphere did not have any effects on the reduction of unilateral neglect (Karnath et al., 1993).

Limitations of this study include: First, it was carried out with a small number of subjects. The reason was that since the effects of vibration stimulation applied to the upper limbs of patients with stroke on unilateral neglect were yet unclear, it was difficult to provide a large number of subjects with that as therapy. Second, since the intervention of occupational therapy was focused on unilateral neglect, it could not be seen as the pure effects of vibration stimulation. Lastly, this study used a written examination only for the assessment of unilateral neglect. Since there are many cases of unilateral neglect clinically in the patient's daily life in spite of normal performance in the written examination (Halligan & Marshall, 1992), Azouvi et al. (2002) reported that behavioral assessment with higher sensitivity could be achieved when a behavioral assessment was used together, rather than a written examination was used alone (Azouvi et al., 2002).

In the future, a study of the effects of vibration stimulation with various activity on unilateral neglect in patients with stroke should

be carried out more because vibration can be easily applied to various upper limbs activity. Regarding the effects of vibration stimulation used for the intervention of unilateral neglect, most studies prove its immediate effects, but there are not sufficient studies that understand its long-term effects (Luaut, Halligan, Rode, Rossetti, & Boisson, 2006). Therefore, studies in the future should verify whether vibration stimulation has long-term effects on unilateral neglect; discuss the methods of using it as occupational therapy in clinical settings; and prepare methods of its application.

V. Conclusion

The purpose of this study was to investigate the effects of vibration stimulation on unilateral neglect in patients with stroke. The subjects were a total 11 of patients with stroke, and vibration stimulation was provided to the left forearm of six persons in an EG to carry out the assessments of unilateral neglect. As a result of the study, there was significant improvement in all the assessments of unilateral neglect in EG only. Future studies should carry out behavioral assessments as well as written examinations when vibration stimulation is provided for the intervention of unilateral neglect and consider the long-term effects of the vibration stimulation.

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