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Technical Note

# The potential effect of a vibrotactile glove rehabilitation system on motor recovery in chronic post-stroke hemiparesis

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**Abstract.**
**BACKGROUND:** Poor fine motor skills are common among chronic stroke patients. Conventional rehabilitation programs only emphasize intensive and repeated exercises that do not motivate patients to continue rehabilitation. Using a vibrotactile glove rehabilitation system with a human-computer interaction interface can therefore resolve this issue.
**OBJECTIVE:** The objective of this study was to examine the potential benefits of this vibrotactile glove rehabilitation system for chronic stroke patients who have already reached the recovery plateau.
**METHODS:** Two interesting computer games were designed to coordinate with the vibrotactile gloves in patient training. The training sessions lasted for about 30 minutes twice a week for five consecutive weeks. We compared finger ROM, grip strength, pinch strength, NHPT, and MHQ results before and after the intervention and surveyed subject satisfaction afterwards.
**RESULTS:** The subjects showed slight improvements in muscle strength and hand after five weeks. The patients reported progress, but the differences did not reach statistical significance. In the satisfaction questionnaire, the subjects gave positive ratings.
**CONCLUSIONS:** This vibrotactile glove rehabilitation system has the potential to help chronic stroke patients who have reached their recovery plateau to make progress and is clinically quite effective in increasing their motivation.

Keywords: Motor recovery, hemiparesis, vibrotactivel glove

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## 1. Introduction

Neuro-Developmental Treatment/Bobath's Approach [1] is a conventional rehabilitation method in clinical practice to improve the upper limb functions of stroke patients. However, it is generally ineffective. New rehabilitation methods in recent years include constraint-induced movement therapy (CIMT) and auxiliary treatments combining virtual reality with robotics and computer gaming [2]. CIMT is an intensive rehabilitation method that prompts stroke patients to use their affected upper limb. Literature shows that CIMT produces significant clinical improvements in upper limb functionality and level of activity [3]. However, the training content of CIMT is very stringent, so some patients are resistant to it. Chronic patients reach a recovery plateau after more than six months post-stroke, and limited progress can cause patients to become less motivated to continue rehabilitation. Robot-assisted rehabilitation is a means of giving stroke patients intensive training for their affected fingers while enhancing their willingness to receive rehabilitation [4,5]. Recent studies have found that using force feedback rehabilitation systems has a positive impact on patients with neural damage [6,7]. For instance, authors in [8] have also proposed a vibrotactile glove rehabilitation system that uses vibration stimuli in coordination with human-computer interaction game interfaces to motivate users in rehabilitation and repeatedly trains the accuracy and speed of individual finger movements to improve hand dexterity. The objective of this study was to examine the potential benefits of this vibrotactile glove rehabilitation system for chronic stroke patients who have already reached the recovery plateau.

## 2. Materials and methods

### *2.1. System setup*

The vibrotactile glove system is a finger training system in which users interact with the computer. The glove is designed with light fabric for greater wearability. Vibration motors are installed at the proximal interphalangeal (PIP) joint and metacarpophalangeal (MCP) joint of each finger on the dorsal side. Patients interact with the computer via a magnetic plate on which the places where patients should lay their fingers can be adjusted according to the size of their hand. The magnetic plate is equipped with a force sensor that gauges how hard the fingers press [8].

### *2.2. Intervention*

#### *2.2.1. Subjects*

The subjects of this study were chronic stroke patients that had been receiving rehabilitation therapy at the Taipei Mackay Memorial Hospital for several months. The inclusion criteria included (1) age: 20–80 years, (2) chronic stroke ($\geqslant$ 6 months post-stroke), and (3) Brunnstorm recovery stage $\geqslant$ 4 for upper extremity.

The exclusion criteria included (1) cognition deficits, (2) biomechanical limitations (e.g., contracture of the muscles in their wrist and hand), (3) individuals whose visual or hearing impairment does not allow possibility of interaction with the system, (4) severe hemispatial neglect, (5) severe cardiopulmonary disease, and (6) impaired vibration sensation of affected hand. A total of nine subjects fitting the criteria above participated in this study (Table 1).

Ethical approval for this clinical study was granted by the Institutional Review Board of the Mackay Memorial Hospital. All eligible candidates who agreed to take part in the study were required to provide informed consent.

Table 1
Subject characteristics and clinical data

| Subject $n = 9$ | | |
|---|---|---|
| Gender (n) | Male | 7 |
| | Female | 2 |
| Age (yr) | Mean $\pm$ SD | $62.9 \pm 6$ |
| Stroke type (n) | Infarction | 7 |
| | Hemorrhage | 2 |
| Time poststroke (months) | Mean $\pm$ SD | $35.5 \pm 10$ |
| Dominant hand affected (n) | | 6 |
| Modified ashworth scale (wrist flexor) (n) | 0 | 3 |
| | 1 | 2 |
| | 1+ | 2 |
| | 2 | 2 |
| Brunnstrom stage U/E (P/D) | IV/IV | 2 |
| | V/V | 7 |
| Sensation: light touch (hand) (n) | Intact | 9 |
| Sensation: proprioception (wrist, finger) (n) | Intact | 9 |

*2.2.2. Protocol*

All of the subjects in this study were chronic stroke patients that had been receiving physical therapy and occupational therapy for several months at the hospital. The contents of the therapy included task-oriented training and upper limb strengthening sessions about half an hour long twice a week. Aside from conventional rehabilitation exercises, they were also recruited to participate in training with the vibrotactile glove system (human-computer interaction games for about 30 minutes twice a week for five consecutive weeks). Each game session comprised six rounds of either a gopher hitting game or a note hitting game [8].

*2.2.3. Outcome measurement*

The motor performance of the subjects were evaluated before and after the five-week intervention by an experienced physical therapist. Outcome measurement included range of finger motion, grip/pinch strength, the Nine-Hole Peg Test (NHPT) [9], and the Michigan Hand Outcomes Questionnaire (MHQ) [10]. At the end, the patients were also asked to fill out a satisfaction questionnaire. We designed a satisfaction survey containing the five satisfaction items: Interest, Comfort, Duration, Effectiveness, and Continuing participation. The possible responses for these items included not satisfied at all, not very satisfied, more or less satisfied, quite satisfied, and very satisfied. Paired-t tests were used to determine whether significant differences existed between pre-intervention and post-intervention conditions.

## 3. Results and discussion

No significant differences were found in all physical measurements among two time points ($P > 0.05$). Table 2 presents the details of the outcome measurement results, where finger ROM: $P = 0.817$; grip strength: $P = 0.6$; tip pinch: $P = 0.624$; lateral pinch: $P = 0.864$; NHPT: $P = 0.469$. The MHQ scores showed no significant differences, and the scores of each of the six domains were shown in Fig. 1. The P values of the statistics were $P = 0.86/0.074/0.81/0.2/0.903/0.966$. However, consistent reports of high satisfaction score were found in all patients.

According to the survey, the patients expressed a high level of satisfaction after using the system. Eight out of the nine patients felt that glove system was interesting as a rehabilitation; seven felt that using the

Table 2
Difference between finger ROM, grip strength, pinch strength, and NHPT (before and after intervention)

| | Before | After | P-value |
|---|---|---|---|
| Finger ROM (degree) | 393 | 395 | 0.817 |
| Grip strength (kg) | 16.78 ± 10.9 | 17.72 ± 10.89 | 0.6 |
| Tip pinch (kg) | 5.56 ± 2.03 | 5.31 ± 2.14 | 0.624 |
| Lateral pinch (kg) | 5.67 ± 2.08 | 5.76 ± 2.63 | 0.864 |
| NHPT (s) | 64.26 ± 40.65 | 60.22 ± 35.83 | 0.469 |

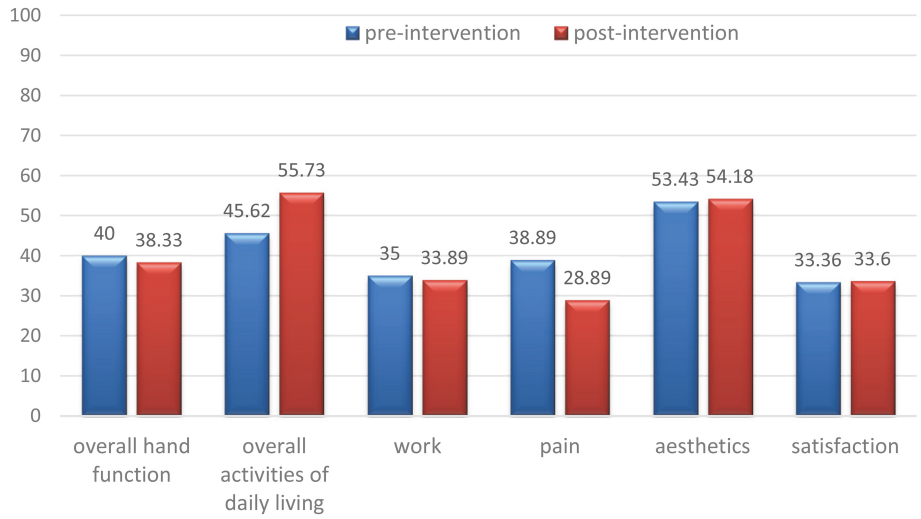


Fig. 1. MHQ score.

system was comfortable; seven indicated that the duration of training was appropriate; eight felt that the glove system was effective in improving hand function, and eight were willing to use the glove system as part of their rehabilitation program in the future.

The vibrotactile glove rehabilitation system in this study did not lead to significant differences, which is likely due to the small sample size and measurement errors. There was no control group, and the training period in this study was only five weeks, which is relatively short for chronic stroke patients who have already been receiving treatment for more than three years. Nevertheless, the subjects expressed high levels of satisfaction with various aspects of the system and were very willing to continue using it for rehabilitation. Future studies can lengthen the treatment period and add a control group to analyze the differences between pre-intervention and post-intervention conditions. Further investigation can also be conducted on the clinical effects of this training tool for home use.

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## Conflict of interest

None to report.

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