

The effects of task-oriented versus repetitive bilateral arm training on upper limb function and activities of daily living in stroke patients

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Abstract. [Purpose] The purpose of this study was to investigate the effects of task-oriented bilateral arm training and repetitive bilateral arm training on upper limb function and activities of daily living in stroke patients. [Subjects] Forty patients with hemiplegia resulting from stroke were divided into a task oriented bilateral arm training group (n=20) and a repetitive bilateral arm training group (n=20). [Methods] The task-oriented group underwent bilateral arm training with 5 functional tasks, and the repetitive group underwent bilateral arm training with rhythmic auditory cueing for 30 minutes/day, 5 times/week, for 12 weeks. [Results] The upper limb function and the ability to perform activities of daily living improved significantly in both groups. Although there were significant differences between the groups, the task-oriented group showed greater improvement in upper limb function and activities of daily living. [Conclusion] We recommend bilateral arm training as well as adding functional task training as a clinical intervention to improve upper limb function activities of daily living in patients with hemiplegia.

Key words: Hemiplegia, Upper limb, Bilateral training

(This article was submitted Dec. 1, 2014, and was accepted Jan. 11, 2015)

INTRODUCTION

Stroke commonly causes loss of motor function due to weakening of upper/lower extremity muscles¹⁾. According to Ryerson²⁾, use of the affected upper extremity decreases because of the patient's dependency on the unaffected upper extremity for normal functions, which results in problems such as learned disuse, asymmetric postural patterns, contractures, and aggravated functional restrictions involving the affected upper extremity. Therefore, to improve functions of the affected upper extremity in stroke patients, measures that maximize opportunities to use the affected upper extremity are necessary. Bilateral activities have been discussed as measures to improve the body symmetry and to reduce abnormal muscle tone³⁾, thereby promoting voluntary movement of the affected upper extremity⁴⁾. Thus far, bilateral upper extremity coordination movements have been applied in the form of bilateral single exercises utilizing tasks such as figure imitation⁵⁾, robot arm upper extremity mechanisms⁶⁾ and functional stretching⁷⁾, and bilateral complex exercises combined with the principle of motor learning, such as rhythmic acoustic⁸⁾, unaffected extremity weight addition⁹⁾, and active neuromuscular electrical stimulation in stroke

patients¹⁰⁾. Most previous studies have reported the positive effects of these exercises on motor function recovery in stroke patients. Whitall et al.⁸⁾ reported that when chronic hemiplegia patients underwent bilateral training to push and pull upper extremity apparatuses, including acoustic signals, their upper extremity functions were improved. In a study conducted by Summer et al.⁷⁾ with 12 chronic stroke patients, the movement time of the patients' affected side upper extremity decreased and upper extremity functions showed more improvement when they performed tasks to hold objects by stretching both hands simultaneously than when they performed tasks to hold objects by stretching only one hand. However, Lee Su-Jin¹¹⁾ advised that the tasks in those studies involved mostly gross motor exercises of the upper extremity and simple repetitive training tasks, and that they were not sufficient to improve patients' grasping ability to hold objects with various sizes, shapes, and weights using the shoulder, elbow, wrist, and fingers.

Although studies that applied diverse functional training tasks including activities of daily living to symmetric bilateral upper extremity exercises have been conducted recently^{12, 13)}, these studies are still quite insufficient, and the effects of these new functional tasks on the recovery of upper extremity functions should be compared with those of existing bilateral upper extremity exercises.

Therefore, the purpose of this study was to compare the effects of symmetric bilateral upper extremity exercises using diverse functional training tasks with the effects of repetitive bilateral upper extremity exercises including acoustic signals on the recovery of upper extremity function and daily living activities in stroke patients.

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SUBJECTS AND METHODS

Forty patients diagnosed with hemiplegia resulting from stroke by a rehabilitation doctor in the N Hospital located in Daegu, South Korea participated in the study. They were randomly and equally assigned to a task-oriented bilateral arm training group (TBG: 11 males, 9 females) and a repetitive bilateral arm training group (RBG: 13 males, 7 females). The mean±SD age, height, and weight of the patients in the TBG were 51.15±14.81 years, 163.45±8.53 cm, and 62.07±9.79 kg, respectively. Eleven of the 20 patients in the TBG group had right hemiplegia, and 9 had left hemiplegia. The onset period was 14.10±11.40 months. The mean±SD age, height, and weight of the patients in the RBG were 48.65±12.81 years, 164.10±8.11 cm, and 63.80±9.26 kg, respectively. Eight of the 20 patients had right hemiplegia, and 12 had left hemiplegia. The onset period was 12.75±9.60 months.

The inclusion criteria were as follows: no visual field defect, no abnormality in the vestibular organs, no orthopedic disease, an unrestricted range of motion, ability to understand and perform the exercises as instructed by the researcher, a score of 24 or higher on the Mini-Mental State Examination-Korean version, and upper extremity paresis with ability to extend the affected wrist and fingers to at least 15 degrees. This study was approved by the University Institutional Review Board and all the subjects understood the purpose of this study and provided their written informed consent prior to their participation in the study, in accordance with the ethical standards of the Declaration of Helsinki.

The TBG bilateral training with 5 functional tasks such as towel sweep on the table, staking cups, positioning the cup upright, carrying a wooded block, and drinking water. The RBG underwent bilateral training with rhythmic auditory cueing (BATRAC). Both groups trained for 5 minutes and had a rest break of 1 minute. Both groups performed their exercises for 30 minutes each day, 5 times per week. Measurements were collected twice, before and after the intervention, which lasted for 12 weeks. The main outcome measurements were Box and Block test (BBT), Jebsen-Taylor test (JBT), and Modified Barthel Index (MBI) to determine upper limb function and ADL ability.

The experimental results were statistically analyzed using SPSS 20.0 KO (SPSS Inc., Chicago, IL, USA). After the general characteristics of the subjects were determined, the paired t-test was used to compare the variations in BBT,

JTT, and MBI between pre- and post-intervention within each group. The significance of the difference between the two groups was investigated using the independent t-test. Statistical significance was set at $p < 0.05$.

RESULTS

Both groups demonstrated significant improvement on the BBT, JTT, and MBI after the intervention ($p < 0.05$) (Table 1). The differences in the BBT, JTT, MBI between the 2 groups were compared and were found to be significant ($p < 0.05$) (Table 1).

DISCUSSION

This study was conducted to examine the effects of symmetric bilateral upper extremity exercises applied with diverse functional training in comparison with repetitive bilateral upper extremity exercises including acoustic signals on the recovery of upper extremity functions and daily living activities in stroke patients. According to the results of this study, both the TBG and RBG showed significant effects on the recovery of upper extremity motor functions and daily living activities. After implementing the exercise programs, both groups showed significant improvement in the BBT, JTT, and MBI scores.

In a study conducted by Lin et al.¹²⁾ on chronic stroke patients who had had the disease for at least 6 months, the group that performed bilateral upper extremity exercises showed further improvement in spatial-temporal control of the affected upper extremity and Fugel-Meyer assessment scores than the control group. In a study conducted by Cauraugh et al.⁹⁾, 2 complex bilateral upper extremity exercise groups were able to move more blocks than the control group in the BBT. In a study conducted by Brunner et al.¹³⁾ with sub-acute stroke patients that compared the effects of modified constraint induced movement therapy (mCIMT) with those of bilateral upper extremity training, results indicated that bilateral upper extremity training was as effective as mCIMT in the improvement of upper extremity motor functions. According to researchers most sub-acute stroke patients were not required to wear a restraining band during training of the affected upper extremity.

Similar to the above-mentioned previous studies, the results of this study indicated that upper extremity functions and daily living activity functions were improved after per-

Table 1. Comparison of the BBT, JTT, and MBI between pre- and post- intervention of each group

	TBG		RBG	
	Pre-intervention	Post-intervention	Pre-intervention	Post-intervention
BBT	29.40 ± 11.3	47.7 ± 7.9 ^a	32.8 ± 11.4	44.1 ± 11.5*
JTT	45.3 ± 23.3	61.1 ± 23.1 ^a	55.8 ± 19.5	64.9 ± 19.9*
MBI	51.1 ± 17.3	71.1 ± 19.0 ^a	50.9 ± 20.7	62.2 ± 21.6*

Mean±SD. *significant difference from pre-test at $p < 0.05$. ^a significant difference gains between two groups at $p < 0.05$. TBG: Task oriented bilateral arm training group; RBG: Repetitive bilateral arm training group; BBT: Box and Block Test; JTT: Jebsen-Taylor Test; MBI: Modified Barthel Index

forming bilateral upper extremity exercises, which supports the opinion that when both hands move simultaneously, instead of acting as separate units, they act as a unit, which is perceived as a coordinated unit by the brain¹⁴). The study also found that when homologous muscle groups on the left and right sides are activated simultaneously by symmetrical bilateral exercises, the neural networks in the 2 cerebral hemispheres that are involved in upper extremity movement on both sides are similarly activated¹⁵).

In this study, in comparison with the group that performed repetitive bilateral upper extremity exercises, the group that underwent task-oriented bilateral upper extremity exercise showed significant improvement in the BBT, JTT, and MBI scores. Given this result, functional task training related to movement frequently used in daily life is considered to have more positive effects on the recovery of upper extremity motor functions in stroke patients than repetitive training using simple movement.

In a study conducted by Wu et al.¹⁶) on the performance of stretching motions in chronic stroke patients, kinematically better performance was shown when actual objects used in daily life were used when no such objects were available. In a study conducted by Thielman et al.¹⁷), in the case of subjects with low functional levels, coordination between the shoulder and elbow joints was improved when they underwent task-related training than when they performed gradual resistive exercises.

Senesac et al.¹⁸) conducted a study on whether bilateral arm training with rhythmic auditory cueing (BATRAC) helped the recovery of motor functions the affected upper extremity and whether the effects of the recovery of motor functions would be transmitted to the performance of new tasks. The subjects underwent BATRAC for a total of 8 times in 2 weeks, and the effects of the training were evaluated using similar tasks and new tasks. Although the maximum speed increased in both tasks, the training did not affect exercise time, speed up areas, or acceleration. With regard to such results, the researchers presented a stated opinion that if the repetitive bilateral training was composed of significant movement related to the patients' daily living activities, the training should have shown positive effects on the recovery of the patients' motor functions.

In this study, only the functional aspect of upper extremity exercises was evaluated, and the performance of the exercises was not evaluated kinematically. In future studies, the functional aspect of upper extremity exercises and the kinematic and qualitative aspects of the exercises as well as the recovery in terms of neurophysiology should be evaluated.

Based on the results of this study, it can be seen that bilateral upper extremity exercises applied with functional tasks are more effective in improving upper extremity func-

tions and daily living activities in stroke patients compared to simple, repetitive bilateral upper extremity exercises. Therefore, performing symmetrical bilateral upper extremity exercises which utilize treatment tools of different sizes and weights and movements involved in daily living activities, can be used as an effective therapeutic intervention method in the recovery of upper extremity functions and daily living in stroke patients.

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