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Task-Oriented Approach for Improving Motor Function of the Affected Arm in Chronic Hemiparetic Stroke Patients

Chiang-soon Song, Ph.D., O.T.
Dept. of Occupational Therapy, Chunnam Techno-College
Su-jin Hwang, Ph.D., P.T.
Institute of Health Sciences, Yonsei University

Abstract

The purpose of this study was to assess the feasibility of task-oriented arm training for chronic hemiparetic stroke patients. The experimental design in this study was the pre-test and post-test with control group for 4-week intervention. Thirty patients with chronic hemiparetic stroke were recruited from 2 rehabilitation units. The subjects were divided randomly into experimental and control groups. The experimental group conducted task-oriented approach, involving 3 subparts of upper extremity activities, and the control group involved in the general upper extremity exercises. Functional movements of the upper extremities were assessed using clinical measures, including the Fugl-Meyer Assessment-Upper Extremity Section, Box and Block Test, and Action Research Arm Test. The score of Fugl-Meyer Assessment showed greater increases in the experimental group than in the control group after training. The improvement in Box and Block Test between pre-test and post-test measurements was significantly greater after task-oriented arm training compared to general upper extremity exercises. Action Research Arm Test scores also improved after task-oriented arm training compared to exercises in the control group. The task-oriented arm training improves the gross and fine motor activities and encouraging the use of the paretic arm through activity dependent intervention expedites the recovery of functional activities in the upper extremities for chronic hemiparetic stroke.

Key Words: Hemiparesis; Stroke; Task-oriented approach; Upper extremity.

Introduction

Stroke is the leading cause of permanent and complex disabilities in adults, and most stroke survivors have a particular weakness in one side of their body, known as hemiparesis (O'Sullivan and Schmitz, 2007). Hemiparesis in the upper extremity is widely reported as one of the primary impairments in stroke patients (Page et al, 2001; van der Lee et al, 2001a). Previous studies show that 30% to 66% of stroke survivors present with upper extremity dysfunction at 6 months after the event, with only 5% to 20% of individuals achieving complete functional recovery following a stroke (Heller et al, 1987; Sunderland et al, 1989; Wade et al, 1983).

Upper extremity function is important for gross motor skills, such as crawling, postural control, and body transfer, as well as fine motor skills for daily activities, such as feeding, dressing, and grooming (Broeks, 1999). To enable the patients to resume normal and independent daily activities, community-dwelling, social activities, and work, recovery of voluntary arm movements is the most important goals in rehabilitation (Barreca et al, 2003; van der Lee et al, 2001b). There is plenty of evidence to demonstrate the success of these rehabilitation interventions in the recovery of proper up-

Corresponding author: Su-jin Hwang *ptsue@daum.net*

per extremity function for chronic stroke patients; however, this functional recovery appears to plateau approximately 6 months after a stroke (Olsen, 1991).

A task-oriented approach provides intensive, meaningful, and progressive training regime and it allows stroke patients to directly improve their motor disabilities with dynamic functional activities (Jonsdottir et al, 2010). Task-oriented approach has showed the effectiveness and efficiency to improve gait and postural performances for individuals with neurological disorders (Salbach and Mayo, 2005; Salem and Godwin, 2009; Yang et al, 2006). However, stroke patients currently experience little task-oriented training for their upper extremity during rehabilitation (Lang et al, 2007; Lang et al, 2009). Our everyday activities require the use of both arms and hands. Therefore, upper extremity training for hemiparetic stroke should involve both unilateral and bilateral training to improve the complete chances of patient recovery. Although constraint-induced movement therapy CIMT is involved in task-oriented upper extremity training, CIMT only incorporates unilateral arm training. The CIMT is also used for stroke patients with a mild impairment because of the strict inclusion criteria, and it only involves unilateral arm training (Hakkennes and Keating, 2005; Page et al, 2001).

This study sought to assess the feasibility of task-oriented arm training for chronic hemiparetic stroke patients. This training involved 3 subparts, bilateral mobility, a combination of stability (less affected arm) and mobility (affected arm), and unilateral mobility, for improving arms and hands performance. The improvement in gross and fine motor skills was determined by comparing the results of task-oriented arm training versus those achieved with general upper extremity exercises.

Methods

Subjects

Thirty patients with chronic hemiparetic stroke were recruited from 2 rehabilitation units using a leaflet explaining the study information. The subjects were divided randomly into experimental and control groups by an independent person who selected sealed envelopes containing patient names. Informed consent was obtained from all subjects before participation in this study. Inclusion criteria for participation in the study were as follows: 1) more than 6 months should have passed after clinical diagnosis of ischemic or hemorrhagic hemiparetic stroke, 2) sufficient cognitive ability to participate, as indicated by Mini-mental state examination score of 19 or higher, and 3) Brunnstrom stage Ⅲ or above in the proximal and distal part of the arm (Folstein et al, 1975). Exclusion criteria included severe hemineglect, inability to follow 2 step commands, history or current diagnoses of an other neurological diseases or musculoskeletal conditions, concurrent participation in other upper extremity training, and treatment for spasticity for up to 3 months (for botulinum toxin or baclofen injections). Two participants were excluded from the study, and two participants dropped out before the post-test in the control group because of another treatment. Table 1 lists the demographic and clinical characteristics of the participants in the 2 groups.

Instruments

Functional movements of the upper extremities were assessed using clinical measures, including the Fugl-Meyer Assessment of Upper Extremity (FMA-UE) section, the Box and Block Test (BBT), and the Action Research Arm Test (ARAT).

The Fugl-Meyer assessment is a disease-specific performance-based measure and is one of the most widely used clinical assessment of upper extremity motor impairment. It measures 3 independent impairment sections, including voluntary movement of the upper and lower extremities, balance, and sensation. All items are scored on a 3-point ordinal scale, ranging from 0 (minimum) to 2 (maximum). This study used the FMA-UE section, which allows a maximum possible score of 66 (Fugl-Meyer et al,

Table 1. General characteristic of the subjects (N=26)

Characteristics	Experimental group (n_1=14)	Control group (n_2=12)	t	p
Sex (males/females)	3/11	7/5		
Age (yr)	54.9±13.2	54.9±8.30	-.272	.788
Months since stroke	28.1±7.80	31.8±11.2	-.963	.345
Brunnstrom stage (stage 3/4/5)	2/10/2	1/8/3		
Stroke type (ischemic/hemorrhagic)	9/5	8/4		
Hemiparetic side (right/left)	8/6	8/4		
Mini-Mental State Examination	22.9±2.3	23.9±2.4	-1.146	.263

Table 2. The protocol of task-oriented arm training

Subparts of protocol	Contents
Bilateral manipulation	1. skating board with rhythmic auditory cueing by metronome 2. reaching, lifting, and placing cans on shelves 3. bicycling for upper extremity 4. folding towels and handkerchief 5. managing and manipulating coins 6. moving a set of rings
Less affected arm stability with affected arm mobility	1. holding a jar 2. unscrewing the lid 3. stirring the coffee 4. stacking plastic cups
Unilateral activities	1. press a doorbell 2. turning over the page of book 3. drawing a line, circle, diagrams 4. spooning sugar and french beans into a coffee mug picking up and moving wooden blocks (2.54 ㎤), wooden balls (3 ㎝ and 2 ㎝)

1975). Inter-rater reliability of the upper limb section from .96 to .97, and test-retest reliability of the upper limb section was .97 in chronic stroke survivors (Platz et al, 2005; Sanford et al, 1993).

The BBT is a short performance-based test recommended to measure physical impairments in the upper extremity. It consisted of moving, one by one, as many wooden blocks as possible from one compartment of a box to another compartment within 60 seconds (Mathiowetz et al, 1985). Inter-rater reliability is r=1 for both hands with occupational therapy students without impairments, and test-retest reliability is ICC=.97 for the right hand and ICC=.96 for the left in persons with impairments (Platz et al, 2005).

The ARAT is a criterion-referred assessment to evaluate specific changes in upper limb function after cortical damage. It consists of 19 items divided into 4 subscales measuring functional movements, such as grasp, grip, pinch, and gross movement. The performance of each item is rated on a 4-point scale, ranging from 0 (no movement possible) to 3 (movement performed normally), with a maximum obtainable score of 57 (Lyle, 1981). Inter- and intra-rater reliabilities have been reported as .99 and .99, respectively, for patients after hemiparetic stroke (van der Lee et al, 2001a).

Procedures

The experimental design in this study was the pre-test and post-test with control group design for 4

week intervention. Pre-tests and post-tests measurements were obtained 1 day before and after the training, respectively, using clinical measures. The experimental group was involved in task-oriented arm training, while the control group played table activities, such as puzzles and drawing pictures during the treatment period. Subjects in the experimental group participated in 4 weeks of task-oriented sessions, 5 times per week for 1 hour, while subjects in the control group participated in upper limb exercises involving a range of motion and stretching exercises.

The task-oriented arm training involved 3 subparts of upper extremity activities: bilateral mobility, stability (less affected arm) and mobility (affected arm), and unilateral mobility (Table 2). Each subject sat on a height-controlled back chair with a stool. The first week of training focused on skating board with rhythmic auditory cues (approximately 1.2 ㎐) and familiarizing subjects with the protocol of task-oriented arm training involving the entire arm, including the distal extremity. The subject was then asked to perform the task-oriented arm training according to the protocol for the next 3 weeks. These tasks were graded by 1) changing the size, weight, or shape of the cans, coin, ball, or wooden block, 2) changing the height and position of the shelf and box, 3) changing the location of the shelves and boxes with respect to the subject, or 4) changing the depth of the cans on the shelves. All subjects also received conventional physical and occupational therapy for 1 hour per day.

Statistical Analysis

The independent variables were task-oriented approach and general upper extremity exercises, and the dependent variables were scores on the FMA-UE assessment, the BBT, and the ARAT. An independent t-test was used to analyze differences in the general characteristics, including age, post-disease duration, and score of Mini-Mental State Examination between the 2 groups. An independent t-tests were used to determine whether the changes from the pre-test to the post-test of the clinical parameters differed significantly between the 2 groups. Results were considered statistically significant at $p < .05$. All statistical analyses were performed using the SPSS ver. 18.0 software.

Results

FMA-UE measurements showed greater increases in the experimental group than in the control group after training. The total score of FMA-UE increased significantly, from 31.0 to 43.3, after task-oriented approach, while a small yet significantly increased in the total score was observed after general upper extremity exercise, from 34.4 to 36.9. For each subpart, there were significant increases across all categories after

Table 3. Scores of the Fugl-Meyer assessment-upper extremity section in the two groups (N=26)

Subscale	Experimental group (n_1=14)		Control group (n_2=12)		t	p
	Pre-test	Post-test	Pre-test	Post-test		
FMA-UE	31.0±5.2	43.3±4.1	34.4±3.8	36.9±3.0	4.408	<.001
Shoulder/elbow/forearm	20.1±3.9	25.2±2.9	20.8±2.2	23.2±2.3	1.979	<.590
Wrist	3.9±.7	6.6±.5	4.9±1.0	5.0±1.0	5.628	<.001
Hand	4.5±.9	7.8±1.0	5.7±1.4	5.8±1.1	4.915	<.001
Coordination	2.4±.5	3.4±.5	3.1±.7	2.9±.3	3.058	<.005

Table 4. Scores of the box and block test in the two groups (N=26)

Clinical measure	Experimental group (n_1=14)		Control group (n_2=12)		t	p
	Pre-test	Post-test	Pre-test	Post-test		
Box and Block Test	22.3±3.9	34.5±4.3	23.3±3.4	24.9±3.7	6.071	<.001

Table 5. Scores of action research arm test in the two groups (N=26)

Clinical measure	Experimental group (n_1=14)		Control group (n_2=12)		t	p
	Pre-test	Post-test	Pre-test	Post-test		
Total score	33.2±2.0	44.5±3.7	33.8±1.9	35.5±1.4	7.915	<.001
Grasp	11.5±.9	14.5±1.3	12.4±1.2	12.4±1.2	4.081	<.001
Grip	7.1±.8	9.3±1.1	7.1±.8	7.3±.8	5.013	<.001
Pinch	10.9±.8	13.6±1.2	10.1±1.1	10.1±.9	8.671	<.001
Gross movement	3.7±.5	7.1±.8	4.2±.6	5.7±.5	5.137	<.001

task-oriented approach, including wrist, hand, and coordination, except shoulder/elbow/wrist (Table 3).

The improvement in gross manual dexterity between pre-test and post-test measurements was significantly greater after task-oriented arm training compared to general upper extremity exercise. After training, the BBT score increased from 22.3 to 34.5 in the experimental group, while the BBT score only increased from 23.3 to 24.9 in the control group (Table 4).

ARAT scores also greatly improved after task-oriented arm training, compared to exercises in the control group. The scores in all 4 categories-gross movement, grasp, grip, and pinch-increased significantly after task-oriented arm training, compared to the general upper extremity exercise after training (Table 5).

Discussion

The purpose of this study was to compare the effect of task-oriented arm training with that of regular upper extremity training on the gross and fine motor skills of the upper extremity in chronic stroke patients. Three distinct clinical measures revealed that significant functional improvement of the upper extremity was obtained with task-oriented approach over general upper extremity exercise, including improvements in 1) manual dexterity, 2) movement in the shoulder, elbow, forearm, wrist, and hand, 3) coordination of finger-to-nose touching, 4) grasp, grip, and pinch hand movements, and 5) gross movement in the upper extremity.

Previous studies reported that the task-oriented approach can help improved the performance of daily activities because the training consists of various components, from daily activities to social motor skills for individuals with neurological disorders (Barreca et al, 2003; Bravi and Stoykov, 2007; Ivey et al, 2008; Jonsdottir et al, 2010). Functional activities in upper extremity mainly involve unilateral manipulations and bilateral activities. The unilateral manipulations differ quite substantially from bilateral manipulations in the upper extremity; in bilateral activities, often one hand stabilizes while the another hand completes the task (Courpar et al, 2010; Wu et al, 2011).

In this study, task-oriented approach of the upper extremity consisted of 3 subparts: bilateral mobility, stability (affected arm) and mobility (less affected arm), and unilateral mobility. Bilateral mobility training focused on repetitive reaching practice and whole arm functional tasks via training using a skating board, bicycling, moving a set of rings, etc. The bilateral training for stability and mobility included activities such as unscrewing a lid, stirring a cup of coffee, and stacking plastic cups. Unilateral mobility training involved manipulative skills, such as holding and moving objects from the shoulder to the hand. That is, the task-oriented approach involved intensive and varied exercise training directed toward the range of motion in shoulder/elbow/forearm, muscle weakness, coordination, grip, holding, and speeds in repetitive movements. Therefore, the task-oriented approach also involved functional activities in the arm from the proximal joints and distal parts in contrast to the general upper extremity exercise.

This study showed greater improvement in 3 measured clinical outcomes after task-oriented arm training compared with that achieved with general

upper limb exercise. The scores in each of the FMA-UE category increased significantly with task-oriented approach, while subjects in the general upper extremity exercise group reported an increase in only the shoulder/elbow/forearm category. Above mentioned, the protocol of task-oriented approach involved gross and find motor skills in intensive movements while the general upper extremity exercise conducted simple table activities. Therefore, the result would be influenced of the differences in the two protocols. FMA-UE is an indirect quality measurement tool for spasticity. The test includes the measurement components associated with clinical phenomena in the context of spasticity, such as passive range of motion, synergy patterns, and reflex activity. This study did not measure spasticity, such as co-contraction ratio and maximum voluntary contraction using electromyography via the modified Ashworth scale. However, we believe that task-oriented arm training is effective in improving spasticity, based on large gains in the FMA-UE scores.

Dexterity is the ability to quickly and efficiently manipulative various objects using different prehension patterns. This is very important skill for independent day-to-day and work activities. This study did not measure dexterity using various sizes of objects but measured gross manual dexterity via BBT. The average BBT scores for the right and left arms in males were 79.0 and 77.0, respectively, for subjects aged 50~54 years and 71.3 and 70, respectively, for subjects aged 60~64 years; for females, the scores were 77.7 and 73.6, respectively, for subjects, aged 50~54 years and 76.1 and 73.6, respectively, for subjects aged to 60~64 years (Desrosiers et al, 1994). These results indicate that BBT scores for gross manual dexterity revealed grossly unqualified scores after task-oriented arm training in stroke patients compared to those in age-matched normal adults. However, the BBT scores showed improvements after task-oriented arm training; therefore, this protocol may have positive effects on gross manual dexterity.

Fine motor skills require greater control of the smaller muscles, especially those involved in hand-eye coordination, and a higher degree of precision in hand and finger movement. These skills do not incorporate the arm and shoulder muscles, although many fine motor skills may also involve the primary musculature (Magill, 2011). The results of this study showed significant improvement in grasp, grip, and pinch after task-oriented arm training compared to the control group. Gross movement in ARAT also increased after training in the 2 groups; however, general upper extremity exercises did not positively influence grasp, grip, and pinch after training.

The results of these assessments demonstrate that individuals with chronic hemiparetic stroke derive benefits from task-oriented approach with respect not only to gross movement but also to fine motor skill performance in the upper extremity. Findings from previous studies that have examined the effects of the task-oriented approach or functional task practice in upper extremity have been controversial for hemiparetic stroke (Desrosiers et al, 2005; Higgins et al, 2006; Winstein et al, 2004). According to Desrosiers et al. (2005), repetition of unilateral and symmetrical bilateral practice did not reduce impairment and disabilities nor functional outcomes in the subacute phase after stroke more than the usual therapy. Higgins et al. (2006) also evaluated the efficacy of a task-oriented intervention in enhancing arm function in people with stroke. The authors reported that a task-oriented intervention did not improve voluntary movement or manual dexterity of the affected arm.

Winstein et al. (2004) reported significant relationship between functional training and upper extremity function for stroke patients. They reported that functional task practice had significantly greater increases in FMA and isometric torque after 20 hours of upper extremity therapy. Other researchers have reported that the task-oriented approach to motor recovery of poststroke hemiparesis emphasizes integration of the impaired limb into all functional tasks (Bravi and Stoykov, 2007; Shumway-Cook and Woollacott, 2011).

Our results are consistent with Winstein and coworkers studies showing the effectiveness of repetitive task training for improving functional abilities after stroke. Sterr et al. (2002) suggested that the beneficial effect of intensive training associated with CIMT is related to the training volume. This study compared only one hour task-oriented approach with the same time general upper extremity exercise.

Overall, there are 2 major findings in this study: 1) task-oriented approach improves the gross and fine motor activities, and 2) encouraging the use of the paretic arm through activity dependent interventions expedites the recovery of functional activities in the upper extremity. The protocol in the study involved bilateral arm training for improving stability and mobility. While this study measured only manipulative skills of the paretic limb, there is an evidence to suggest that training improves the supportive or assistive activities of the paretic limb. Further studies should evaluate the performance of the paretic limb in a more supportive or assistive role, such as those involved in bimanual tasks. This study only included chronic stroke patients, so this study cannot generalize the effectiveness of task-oriented approach for stroke patients of all stages. In addition, further studies may want to incorporate neurophysiologic measures, as this may be more informative for clinicians with respect to brain recovery.

Conclusion

Compared with general upper extremity exercises, task-oriented approach is more effective for individuals with chronic hemiparetic stroke, with greater improvement in functional activities, including active movement, coordination, dexterity, manipulation, and grasp/grip/pinch of the upper extremity.

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