Task-oriented bilateral upper extremity rehabilitation using functional electrical stimulation in a patient with hemiplegia: a case study

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Task-oriented Bilateral Upper Extremity Rehabilitation Using Functional Electrical Stimulation in a Patient with Hemiplegia: A Case Study

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Note: This document describes a Capstone Dissemination project reflecting an individually planned experience conducted under faculty and site mentorship. The goal of the Capstone Experience is to provide the occupational therapy doctoral student with a unique experience whereby he/she can demonstrate leadership and autonomous decision making in preparation for enhanced future practice as occupational therapists. As such, the Capstone Dissemination is not formal research.
Abstract

Functional recovery of the hemiplegic upper extremity after stroke is a great challenge faced by medical and rehabilitation professionals. In this case study, three approaches including task-oriented model of practice, bilateral training, and functional electrical stimulation were utilized with patient care. These three approaches have been preliminarily confirmed to be effective in stroke rehabilitation. The patient in this case study is a 57 year-old male. He sustained right middle cerebral artery stroke on January 1, 2012. This study included this patient’s intensive inpatient rehabilitation and outpatient therapy. At the beginning of his therapy, the patient did not have any movement in his left hand due to lack of motor control and hypotonicity; his active range of motion (AROM) of his left upper extremity (UE) was 0 - 70° for shoulder flexion and 0 - 70° for shoulder abduction; and he had decreased independence with his occupations of daily living secondary to left UE hemiparesis. Based on the patient’s goals and occupational therapy evaluation, a series of therapy goals were established to improve AROM and strength in his left UE with the ultimate goals to be independent with his occupations of daily living (ODLs), get back to driving, return to work, and be able to play guitar. A various interventions were used during his rehabilitation based on these three effective approaches. After more than 3 months of therapy, the patient had made excellent recovery and his occupational performance has substantially improved. He is using his left hand independently with majority of ODLs. His AROM in his left UE has returned to within functional limit. The grip strength for his left hand has improved from 0 to 14 pounds; the pinch strength for the left hand has improved from 0 – 10 pounds (tip pinch), 0 – 6 pounds (palmar pinch), and 0 – 11 pounds respectively. He is still participating occupational therapy and speech therapy at present time. The implication for practice and research was discussed in this case study.
Introduction

Heart disease and stroke statistics--2010 update: a report from the American Heart Association (Writing group members, Lloyd-Jones, Adams, Brown, Carnethon, Dai, et al., 2010) reported that stroke was the leading cause of disability and the third leading cause of death in the United States. Each year approximately 795,000 individuals experience stroke with 610,000 sustaining an initial event and the remaining 185,000 a reoccurrence of stroke. The indirect and direct costs of stroke for 2010 was $73.7 billion. The projected cost from 2005 through 2050 is expected to surpass 2.2 trillion dollars.

Stroke is the leading cause of long-term disability in western countries and one third of patients with stroke need help in at least one occupation of daily living (ODL) (Bonita, Solomon, & Broad, 1997). Upper extremity impairment occurs in 85% of patients at the beginning of their stroke, and at 3 months, 55–75% of patients still have upper extremity paresis (Thorngren & Westling, 1990). According to the Framingham study, older patients have been observed to have the following disabilities at 6 months after stroke: 50% had some hemiparesis, 30% were unable to walk without some assistance, 26% were dependent in the ODL, 19% had aphasia, 35% had depressive symptoms, 26% were institutionalized in a nursing home (Kelley-Hayes, Beiser, Kase, Scaramucci, D’Agostino, & Wolf, 2003). These disabilities severely affect patients’ quality of life.

Functional recovery of the hemiplegic upper extremity after stroke is a great challenge faced by medical and rehabilitation professionals. Over 60% of chronic stroke patients have motor dysfunction in their affected upper extremity, while only 5% recover their upper extremity dysfunction completely (Dobkin, 2005). Stroke rehabilitation represents a considerable workload for occupational therapists. It is one of the most important goals for occupational therapists to
help patients to recover their upper extremity function during stroke rehabilitation and regain their independence as much as possible.

During the history of stroke rehabilitation, rehabilitation professionals have used various techniques to manipulate elements of the central and peripheral nervous system, which include neurodevelopmental techniques, proprioceptive neuromuscular facilitation, biofeedback, repetitive task training, robot-assisted therapy, mirror therapy, bilateral training, task-oriented approach, constraint intensive movement therapy, and electrical stimulation, etc. The superiority or effectiveness of majority of these techniques or approaches has not been confirmed or established. As it is known, rehabilitation professionals are in the middle of a paradigm shift from empirical to evidence-based practice. It is important to choose the best and effective intervention techniques during clinical practice. It is the profession’s ethical responsibility for these patients. In this case study, three approaches including task-oriented model of practice, bilateral training, and functional electrical stimulation will be utilized with patient care. These three approaches have been preliminarily confirmed to be effective in stroke rehabilitation.

**Literature review**

**Task-oriented model of practice:** This model of practice is based on motor control, motor learning, and motor development (Mathiowetz & Bass-Haugen, 1994; Flinn, 1995). It assumes that “The nervous system itself is organized heterarchically such that higher centers interact with the lower centers but do not control them. Closed-loop and open-loop system work cooperatively and both feedback and feed-forward control are used to achieve task goals.” (Bass-Haugen, Mathiowetz, & Flinn, 2008, p599). The central nervous system needs to interact with personal and environmental factors as a person pursues a functional goal. When using this model of practice, therapists should simulate natural environment as much as possible and use
functional tasks or daily occupations that patients identify as important or meaningful to them. The therapists should help and encourage patients to try their own ways to perform these functional tasks effectively and efficiently. Varied practice should be used to help clients discover optimal strategies for achieving functional performance (Higgins, 1991).

Flinn (1995) studied the task-oriented approach using a case study in post-stroke rehabilitation. The patient was a 34-year old female with hemiplegia. The patient received a one-hour occupational therapy and 3 sessions per week over a period of six months. The focus of treatment was meeting the participant’s functional goals including childcare, homemaking occupations, and work-related occupations. Throughout the treatment, the therapists tried to revise the treatment plan by identifying the critical control parameters and working on them under the purpose of evoking functional performance improvements. The treatment was directed toward the client’s affected UE strength, ROM, and incorporation into daily use under controlled degrees of freedom (simplifying the tasks’ requirements by reducing the variables needed to be controlled). As the participants’ motor abilities were improved, she was getting more challenging functional tasks that required more degrees of freedom. The therapists tried to give as many repetitions of functional tasks with contextual variability to simulate real world contextual variability. At discharge, the patient’s affected UE was improved substantially; she was independent in all self-care tasks, was able to perform her housekeeping and childcare tasks, and was able to ambulate independently. The author concluded that the use of task-oriented approach have potential benefits in post-stroke rehabilitation.

In a randomized clinical trial by Dean and Shepherd (1997), twenty subjects at least 1 year after stroke were randomized into an experimental or control group. The experimental group participated in a standardized training program involving practice of reaching beyond arm's
length. These participants performed the reaching tasks in different conditions, for examples, distance and direction were varied by changing the location of the object; seat height, movement speed, object weight, and extent of thigh support on the seat were also varied. The control group received sham training involving completion of cognitive-manipulative tasks within arm's length. Performance of reaching in sitting was measured before and after training using electromyography, videotaping, and two force plates. Movement time, distance reached, vertical ground reaction forces through the feet, and muscle activity were measured. The training was done in a 2-week period. After training, experimental subjects were able to reach faster and further, increase load through the affected foot, and increase activation of affected leg muscles compared with the control group ($P<.01$). In comparison, the control group did not improve in reaching. This study suggests that task-oriented motor training can improve the ability of balance during seating reaching occupations after stroke.

**Bilateral training:** Bilateral arm training has emerged as an approach that leads to preliminary positive outcomes in upper extremity rehabilitation after stroke. Bilateral training is based on three principles: 1. What we do every day involves the use of both arms, for examples, both arms and hands are used for occupations of daily living and instrumental occupations of daily living such as dressing, feeding, bathing, toileting, driving, and cooking, etc. Therefore, bilateral re-training is necessary. 2. Bilateral training is based on bimanual coordination (Cardoso de Oliveira, 2002, Turvey, 1990). Both arms were centrally linked as a coordinative structure unit, hands and fingers function in a homologous coupling of muscle groups on both sides of the body. Bilateral training emphasizes the inherent characteristics of muscles as important for muscle control. 3. Bilateral training has neurophysiological justification. According to McCombe Waller & Whitall (2008), bilateral training led to reduced intracortical inhibition and increased
intracortical facilitation in both hemispheres, while unilateral training, no matter it is dominant or nondominant, produced increased ICF and reduced ICI only the contralateral hemispheres. This neurophysiological basis may encourage recruitment of undamaged neurons to construct new task-related neural network or lead to neuroplasticity.

Stewart, Cauraugh, & Summers (2006) did a meta-analysis on the effectiveness of bilateral movement in rehabilitation. They searched PubMed and Cochrane databases to find research on bilateral motor recovery and included 11 stroke rehabilitation studies for their systematic review. Their inclusion criteria included 1) Bilateral training protocols involved either functional tasks or repetitive arm movements; 2) Each study had one of three common arm and hand functional outcome measures: Fugl-Meyer, Box and Block, and kinematic performance. These meta-analysis findings suggest that bilateral movements alone or in combination with auxiliary sensory feedback are effective in stroke rehabilitation during the sub-acute and chronic phases of recovery.

**Functional Electrical Stimulation:** Electrical stimulation (Popovic, Sinkjaer, & Popovic, 2009) is the latest technology in stroke rehabilitation and it is a method to activate sensory-motor systems by delivering electrical charge in the form of bursts of electrical pulses to induce specific muscle contraction. Functional electrical stimulation involves the use of multiple channel electrical stimulation systems and it is a kind of designed neural prostheses for therapy. FES will help patients with stroke recover their voluntary movement and function and return them to independent life.

In this case study, BIONESS H200 (http://www.bioness.com/H200_for_Hand_Paralysis) was used for functional electrical stimulation. It is an electrical stimulation hand unit that has five surface electrodes integrated into the system to stimulate and activate muscle flexion or
extension in the hand and facilitate neuromuscular re-education. Therapy programs and function modes are pre-programmed, providing the clinician and the patient control over hand activation. In the past 10 years, there have been many research, case studies, and clinical trials done on BIONESS H200 system. It has been confirmed that it has many benefits for patients with stroke, spinal cord injury, and traumatic brain injury, such as improving hand active range of motion and function such as grasping, releasing, and opening and closing the hand, reducing muscle spasticity, re-educating muscles, preventing contractures, and increasing local blood circulation.

Functional electrical stimulation usually is not the only approach used during rehabilitation. It is commonly utilized with bilateral training or with task-oriented approach or with both. This combination will further improve the efficacy of stroke rehabilitation. The following evidence will demonstrate their effectiveness.

Chan, Tong, & Chung (2009) studied the effectiveness of functional electrical stimulation and bilateral occupations training on the recovery of upper extremity function in patients with stroke. They used a double-blinded randomized controlled trial design and recruited twenty patients who were 6 months after the onset of stroke. Patients were randomly assigned to the functional electrical stimulation group or to the control group. For the functional electrical stimulation group, each session consisted of stretching occupations (10 minutes), functional electrical stimulation with bilateral tasks (20 minutes), and occupational therapy treatment (60 minutes). The functional electrical stimulation was synchronized with the bilateral upper limb occupations during the training; while patients in the control group received the same duration of stretching and occupational therapy training except that they just received placebo stimulation (sensation only) with the bilateral tasks. All patients underwent 15 session treatments. Functional Test for the Hemiplegic Upper Extremity (FTHUE), Fugl–Meyer Assessment (FMA), grip
power, forward reaching distance, active range of motion of wrist extension, Functional Independence Measure, and Modified Ashworth Scale were measured for all these patients. Their results showed that, at baseline comparison, there was no significant difference in both groups for these measurements. After completing these treatment sessions, the functional electrical stimulation and bilateral training group had significant improvement in FMA ($P = .039$), FTHUE ($P = .001$), and active range of motion of wrist extension ($P = .020$) when compared with the control group. Their results suggest that the functional electrical stimulation and bilateral training could be an effective method for upper limb rehabilitation for patients with stroke.

In a study by Ring & Rosenthal’s group (2005), they investigated the effects of daily neuroprosthetic (BIONESS H200) functional electrical stimulation in sub-acute stroke. There were total of 22 patients with moderate to severe upper limb paralysis 3–6 months post-stroke participating this clinical study. Their experimental design is controlled randomized study. Patients were first clinically stratified to two groups: no active finger movement (10 patients, type I patients), and partial active finger movements (12 patients, type II patients), and then were randomized into control and neuroprosthesis groups. At baseline and completion of the 6-week study, the evaluator was blinded about patient group. All patients attended day hospital rehabilitation, receiving physical and occupational therapy 3 times per week. The neuroprosthesis group used the device at home, type II patients in neuroprosthesis group engaged functional occupations while using BIONESS H200. Their results showed as follows. For type I patients, there was greater improvement in active motion in the proximal upper extremity in the neuroprosthesis group, however, the difference did not reach a level of statistical significance. For type II patients in the neuroprosthesis group, there had significantly greater improvements in
spasticity, active range of motion and hand function. They concluded that supplementing standard outpatient rehabilitation with daily home neuroprosthetic stimulation and functional occupations improves upper extremity outcomes in voluntary movement and functional use of the hand.

A pilot study by Alon, Levitt, & McCarthy (2007) tried to test whether functional electrical stimulation can improve the recovery of upper extremity function during early stroke rehabilitation. It included 15 patients who had stroke more than 2 weeks and less than 4 weeks. These patients were stratified into blocks of 10 points (11-20, 21-30, 31-40) based on the modified Fugl-Meyer score for the upper extremity, and then randomized into a functional electrical stimulation group combined (n= 7 patients) or a control group (n= 8 patients). The patients begun their therapy at inpatient rehabilitation and continued at the patients’ home. Patients in functional electrical stimulation group received electrical stimulation combined with task-specific upper extremity occupations while the control group received task-specific therapy alone over 12 weeks. Hand function was measured by Box & Blocks and Jebsen-Taylor light object lift test and motor control was measured by modified Fugl-Meyer test, These measurements were video-recorded for both upper extremities at baseline, 4, 8, and 12 weeks. Their results showed that the patients in both groups improved their hand function; however, functional electrical stimulation combined with task-oriented occupations resulted in significant improvement over task-specific therapy alone. They concluded that upper extremity task-oriented training incorporating with functional electrical stimulation could help recover upper extremity function in patients with mild/moderate paralysis during early rehabilitation more than task-oriented training only.
Some effective evidences are presented in aforementioned studies or meta-analysis; however, the latest authoritative meta-analyses (Coupar, Pollock, van Wijck, Morris, & Langhorne, 2010; Pomeroy, King, Pollock, Baily-Hallam, Langhorne, 2009) had not confirmed that bilateral training and electrical stimulation were more (or less) effective than usual care or other upper limb interventions for functional movement of the upper extremity. Looking at all these studies, there were many limitations in these studies, for examples, all studies had small sample size; different studies used different protocol (treatment time, treatment length, or occupations, etc.); and there were differences among the patients (time after stroke, level of functional deficit, severity of stroke, etc.). It is very possible there is selection and detection bias in these studies. For the meta-analysis on bilateral training (Stewart, Cauraugh, & Summers, 2006), it reported a significant overall effect in favor of bilateral movement training alone or in combination with auxiliary sensory feedback for improving motor recovery post-stroke. However, its search strategy was limited and it included studies that were not randomized controlled trials. At present, there are insufficient robust data or good quality evidence to confirm their claims. More well-designed, large sample size, and multiple-site randomized controlled trials are needed to determine their effectiveness.

Two specific outcome measurements were used in this case study. One was Action Research Arm Test (Carroll, 1965; Crow, Lincoln, Nouri, & De Weerdt, 1989; De Weerdt, & Harrison, 1985; Lyle, 1981). It is an observational test used to determine upper extremity function and assess functional recovery in upper extremity after brain insult. The test consists of 19 items grouped in subtests (grasp, grip, pinch, and gross arm movement) and performance of each item is rated on a 4-point scale ranging from 0 (no movement possible), 1 (performs test partially), 2 (completes test, but takes abnormally long or has great difficulty), and 3 (movement
performed normally). Another test is Motor Activity Log (Uswatte, Taub, Morris, Light, Thompson, 2006). This log is used to evaluate actual use of the impaired arm outside of the treatment setting and in patient’s real life. Each item evaluates on how much the client uses the affected arm and how well he/she uses the affected arm. Administration of the MAL before and after treatment provides valuable data for rehabilitation professionals to tracks a patient's progress during the therapy process.

This case study is innovative because 1) its intervention is evidence-based; 2) its intervention combines three effective approaches: task-oriented, bilateral training, and functional electrical stimulation; and 3) it provides effective evidence for stroke rehabilitation.

**Patient Information**

Mr. RH is a 57-year-old male and the patient had left-side weakness with worsening symptoms over several days. His wife took him to a local hospital where he was diagnosed having a right middle cerebral artery stroke. The patient had accompanying facial droop in addition to left-side weakness in his leg and arm. The weakness in left arm was the severest. He was transferred to a medical center rehabilitation center for intensive rehabilitation on January 7, 2012. His hospital stay was complicated by a fall as he walked to the bathroom unattended. However, a CT scan did not reveal any acute intracranial pathology other than the subacute right cerebrovascular accident (CVA). The patient had inpatient intensive therapy for three weeks and then was discharged to home. He started outpatient rehabilitation with occupational therapy, physical therapy, and speech therapy on January 30, 2012. This writer participated in this patient’s care from inpatient to outpatient rehabilitation.

**Patient Evaluation**
Before his stroke, the patient worked full-time as a registered nurse at burn unit of a local hospital for 23 years. Before his nursing career, he was a musician who played the guitar with a band for 10 years. His medical history included coronary artery disease for 15 years that was treated implanted stent, diabetes mellitus type II for 16 years, hypertension, tobacco abuse, daily alcohol abuse, hypercholesterolemia, and depression. He has married with his wife for 20 years and is currently living with her in a two-story home with 5-step to enter. Their bathroom and bedroom are on the second floor and they have a bathroom on the main floor. They have two children, a 30 years old daughter and a 21 years old son. Their son is presently living with them and can provide help for the patient.

The patient is right-hand dominant. The active range of motion (AROM) for right upper extremity (UE) was within functional limit. The AROM of left UE was shown as follows. Left shoulder elevation and depression were within functional limit (WFL). Left shoulder scapular protraction and retraction were WFL. Left shoulder flexion was 0 - 70° with slight upper body compensation. Left shoulder abduction was 0-70° with moderate upper body compensation. Left shoulder internal rotation was grossly WFL. Left shoulder external rotation was 0-60°. Left elbow flexion/extension was 15-140°. Left forearm pronation was WFL. Left forearm supination was 0-45°. The patient did not demonstrate any movement in his left wrist and hand; the patient did try to initiate wrist and hand movement but unsuccessfully. The passive ROM of left UE was WFL.

The patient’s strength for right UE was 5/5 throughout. The strength of left UE was 3-/5 for should flexion and abduction, 3/5 for elbow flexion and extension, 0/5 for wrist extension, 3/5 for wrist flexion. The patient was unable to achieve a gross grasp or digit extension. Coordination for right hand was intact while it was severely impaired for left hand. Muscle tone
was normal for right UE and hypotonic throughout left UE. Sensation was intact for bilateral UEs. For functional mobility, static standing balance was fair, dynamic standing was fair-, ambulation was fair with roller walker and contact guard assistance. Bed mobility needed minimal assistance. Transfers (from bed to roller walker, walker to toilet, walker to shower bench, walker to chair) needed minimal assistance. At sitting position, patient showed slight left shoulder elevation, slight left shoulder scapular retraction, and slight anterior pelvic tilt.

The patient wears glass all times. His near visual acuity for eyes, left eye, and right eye independently was 20/20. His distance visual acuity for both eyes was 20/30, left eye was 20/25, -2, right eye is 20/30. Peripheral vision is intact for superior, inferior, left, and right. The ROM, saccades, pursuits of the patient’s eyes were within functional limits (WFL). Eye alignment was centered on left, but displaced on right pupil. Convergence was WFL. Stereo Titmus test was used to assess the patient’s deep perception and he perceived 8/9 on this test, which was WFL. The MVPT test showed that the patient’s overall score was 30/36, which was below normal limits (norm for a gentleman of his age is 32-36). His visual perceptual processing speed was 3.8 seconds, which is WFL (norm for a gentleman of his age is 3.0 – 5.4).

The patient is pleasant and cooperative, but showed impulsive at times. Contextual memory test was used to test the patient’s visual memory. His immediate recall was 8 and delayed recall was 7. Norm for immediate recall is 12 and norm for delayed recall is 11. The results suggested the patient was mild impaired in visual memory. The Hopkins Verbal Learning test was used to assess the patient’s auditory memory skills. His total recall was 18 (norm is 27); his delayed recall was 6 (norm is 10). This indicates that the patient was below normal limit in auditory memory. The Digit Span test was used to test the patient’s auditory selective attention. His score fell within the average range; however, he had more difficulty with repeating digits
backwards, which indicates decreased mental flexibility. The Symbol digit modality test was used to assess the patient’s visual selective attention. He was able to complete 40 within 90 seconds period, which is within 0.5 standard deviation. The trail making part B was used to assess the patient’s divided attention/mental flexibility and he completed this test in 42 seconds, which falls within the borderline range.

**Occupations of daily living:** The patient was feeding and grooming himself with his dominant right hand and was unable to use left hand to do any occupations of daily living. The patient needed moderate assistance in bathing, upper body and lower body dressing.

**Instrumental occupations of daily living:** Prior to stroke, the patient was responsible for washing dishes, cleaning the kitchen, and doing some laundry and yard work. He was an active driver and was in charge of budgeting at home.

**Work:** Prior to stroke, the patient had worked full time as a registered nurse at the burn unit of local hospital for 23 years.

**Leisure:** The patient enjoys playing guitar. He has a studio at home where he practices and records music with friends. He likes to golf.

The Action Research Arm Test was used to assess the patient’s upper extremity function. The patient achieved score of 3 out of 57. During this test, the patient showed no grasp, grip, and pinch abilities in his left hand. His left UE demonstrated a limited AROM in shoulder flexion, abduction, and external rotation as shown by not being able to place left hand behind his head, not being able to place left hand on top of his head, and not being able to raise his left hand to his mouth. The motor activity log was used to assess the daily functional use of the affected arm in the patient’s daily life. Unfortunately, the patient did not use his affected left arm at all in all his
occupations of daily living. He chose to use his unaffected right arm to do everything entirely instead.

Through the patient’s evaluation, the following are problems identified:

1. Left UE hemiparesis, distal > proximal.
2. Hypotonicity throughout UE.
3. Edema in left hand.
4. Decreased independence with his occupations of daily living secondary to left UE hemiparesis.
5. Cannot engage in leisure occupations.
6. Dependent on driving.
7. Currently cannot work.
8. Decreased visual perceptual skills.
9. Mild impaired in visual memory, below normal limits for auditory memory, slight reduction in areas of attention/mental flexibility.

**Intervention Goals**

As it is aforementioned, the patient was a full-time registered nurse in a burn unit. He changed patients’ dressing every day. When the patient was young, he was also a guitarist in a band and he still loves to play guitar in his spare time with his friends. It is necessary that his arms and hands move freely and skillfully to fulfill his job and hobby. The patient’s short-term goals were to improve movement and strength in his left arm to use in his occupations of daily living; his long-term goals were to get back to driving, return to work, and be able to play guitar.

Based on evaluation, the occupational therapy long-term goals (LTG) and short-term goals (STG) set for the patient were as follows:
LTG 1: The patient will regain full active ROM of left UE with Bioness motor retraining by the end of 1 year to enable independence with ODLs.

STG 1-1: The patient will initiate finger extension in his left hand with Bioness motor retraining by the end of 1 week.

STG 1-2: The patient will be able to flex his left UE to 90° independently while supine on mat with Bioness motor retraining by the end of 3 week.

LTG 2: The patient will improve his left UE strength up to 4/5 throughout according to manual muscle test by the end of 6 months to improve functional performance with ODLs.

STG 2-1: The patient will be able to do graded control of elbow flexion/extension with dowel rod wrapped with 2 pounds cuff weight 20 times while supine on mat and with bilateral UE by the end of 5 weeks.

STG 2-2: The patient will be able to do shoulder flexion with dowel rod wrapped with 3 pounds wrist weight 20 times while sitting at edge of mat and with bilateral UE by the end of 8 weeks.

LTG 3: The patient will improve his left hand speed of dexterity to 40 seconds by the 9-hole peg test by the end of 1 year.

STG 3-1: The patient will be able to grasp/release blocks, marbles, pegs, and various size and shape objects with Bioness motor retraining by the end of 1 week.

STG 3-2: The patient will be able to grasp/release blocks, marbles, and pegs without Bioness device and with modified independence by the end of 5 weeks.

LTG 4: The patient will integrate left UE into his occupations of daily living independently by the end of 1 year.
STG 4-1: The patient will be able to start to use his left hand to facilitate his occupations of daily living by the end of 3 week.

STG 4-2: The patient will be able to feed himself with utensils with built-up handle by the end of 5 weeks.

LTG 5: The patient’s edema in left hand will return to normal through retrograde massage, proper position of left UE by the end of 6 months.

STG 5-1: The patient will be able to demonstrate correct retrograde massage technique independently by the end of 1 week.

STG 5-2: The patient will be able to position his left UE correctly during night by the end of 2 weeks.

LTG 6: The patient will return to driving independently by the end of 1 year.

LTG 7: The patient will start to play guitar to his own satisfaction by the end of 1 year.

LTG 8: The patient will return to work as a registered nurse with modified independence by the end of 1 year.

This case study utilized task-oriented model of practice combined with bilateral training and functional electrical stimulation approaches to rehabilitate a 57-year-old male with left hemiplegia. The task-oriented model of practice is based on a systems model of motor control and contemporary motor learning theories. According to systems models, functional performance emerges from the interaction and cooperation of many systems, which include personal factors (cognitive, psychosocial, and sensorimotor) and environmental factors (physical, cultural, and socioeconomic). The idea behind this approach is that, at different times, or at different environments, various systems can control the behavior that emerges from the interaction of systems. The goals for this patient were based on this model and these approaches. These goals
were started with the most basic requirements for occupational performance such as UE ROM and strength, progressed to the patient’s occupations of daily living, and then ended with returning the patient to his work and leisure role. All these goals were meaningful and purposeful to this patient because by fulfilling these goals, the patient would return to live his full life again.

As a care coordinator, the occupational therapist will update key members of the patient’s health care team on his occupational performance after the patient’s authorization. This could include the patient’s physician, his employer, or other health professionals. This could also include relevant family members (wife, daughter, and son) if the patient permits. The occupational therapist will also keep lines of communication open throughout the rehabilitation process ensuring the highest level of rehabilitation success for the patient. Vocational rehabilitation counselor was recommended to involve on his care team to assist with determining his feasibility whether the patient was possible to return to his previous job as a registered nurse.

**Patient Interventions**

Mr. R.H. sustained his stroke on January 1, 2012. He was transferred to intensive rehabilitation unit on January 7, 2012 and was discharged from hospital on January 27, 2012. During the three weeks intensive rehabilitation, the patient underwent 3 hours intensive therapy per day, 6 days per week. 1.5 hours was for occupational therapy and 1.5 hours for physical therapy. This writer treated this patient two times during this period with focus on ROM of hand and upper extremity with Bioness H200 hand rehabilitation system, weight-bearing to normalize postural tone and gain trunk control, reaching occupations while standing to assist trunk control, and left shoulder scapular mobilization to facilitate left UE ROM and reduce complication of shoulder pain and shoulder freeze.
The patient started outpatient therapy on January 30, 2012 and he was scheduled with occupational therapy 2 times per week, 1 hour each therapy session. The patient’s goals were to improve movement and strength in his left arm, get back to driving, and resume his social and professional roles. The occupational therapy goals were set up based on the patient’s goals, interest, and roles. The treatment was grounded on prioritizing therapy goals, which include ROM, strengthening, and hand gross motor and fine motor skills. After these goals made progress, other goals would add to therapy. The eventual goal was to return the patient to be independent with his life. For these reasons, treatment was initially directed toward left UE AROM, strengthening, and its use in daily tasks and later toward specific anticipated work tasks. His rehabilitation program was frequently revised, based on his progress and his environment in occupational performance.

**Left UE ROM**

At the beginning of therapy, the patient did not demonstrate any movement in his left wrist and hand. The ROM exercise was carried out with Bioness H200 hand rehabilitation system with active participation from the patient. The Bioness H200 Hand Rehabilitation System (H200, Bioness Inc., Valencia, CA) is a neuromuscular electrical stimulation (NMES) system incorporating a forearm-hand orthosis and NMES. The H200 is a microprocessor-based, U.S. Food and Drug Administration–approved, and American Occupational Therapy Association-endorsed device that was utilized as part of a structured activity program described as follows. It consists of a forearm–hand molded orthosis that contains an array of five surface electrodes with different sizes. The electrodes are positioned over the extensor digitorum, extensor pollicis brevis, flexor digitorum superficialis, flexor pollicis longus, and adductor pollicis muscles. The panels within the orthosis are custom fit for the patient to optimize the contraction of the digit
flexors and extensors. The optimized panels and electrode positions enhance the consistency of stimulation with each use. The electrodes are connected to a stimulation control unit that delivers alternating current for muscle stimulation. The stimulation intensity, duration, and speed were all optimized for this patient. For this particular patient, the stimulation intensity was set 8 for extensors, 6 for flexors; the stimulation duration and speed was set at 6. The patient’s therapy would always start to check his ROM in left UE, and then the H200 was put on his left forearm and hand. The stimulation started with open/relax and grasp/relax exercise with left hand, the patient was instructed to do the synchronized movement with right hand. At same time, the patient was instructed to use the stimulation as biofeedback to open or close his hands as far as he could go. To facilitate left UE ROM, the patient did active assistive ROM (AAROM) with left UE (flexion to 90° at the shoulder) while Bioness H200 was in open exercise mode (serving as biofeedback) and the patient was supine on mat or sat at the edge of mat; right UE did same movement. At the beginning, the patient needed minimal to moderate assistance to keep his left elbow straight. When the patient’s UE reached 90° at shoulder, the patient was instructed to reach up to protract shoulder scapula. The patient did reach/push target occupations using
DynaVision scanning board and moving up/down dowel rod ladder occupations to facilitate the return of left UE AROM. During some therapy sessions, the therapist used receiving/tossing ball activity to treat the patient and help him move his left affected arm. During the patient’s rehabilitation, the therapist did manual mobilization with left shoulder flexion, abstraction, internal rotation, and external rotation, left forearm supination, and left wrist extension.

**Left UE strengthening and endurance**

After the patient achieved some range of motion in his left UE, strengthening treatment started for the patient. The patient started with isometric strengthening at left shoulder first, then progressed to do shoulder press with dowel rod wrapped with different amount of weight (2 -5 pounds cuff weight) while supine on mat or sitting at the edge of mat while Bioness H200 in grasp mode. The repetition of these occupations varied according to the patient’s stage of recovery. The patient moved up and down a dowel rod ladder using a dowel rod with different weight. As the patient’s grasp ability, grip strength, and endurance increased, the patient started to work on different tools such as 122 and 162 with Baltimore Therapeutic Equipment (BTE, BTE Technologies, Inc., Hanover, MD) to strengthen left UE. The distance and torque were increased as the patient progressed in the rehabilitation.

**Left hand fine motor coordination**

Before the patient’s left hand had voluntary movement, he had started to engage grasp/release occupations with pegs, blocks, marbles, and beanbags with Bioness H200 in grasp exercise mode. As the patient progressed, he engaged in these grasp/release occupations without
Bioness H200 on his arm and carried out in-hand manipulation with pegs, bolts, washers, and nuts with his left hand or both hands working together. He was instructed to work with Digiflex to increase hand dexterity with each finger in his left hand. The patient engaged in functional occupations with left hand holding bottles of different styles or different sizes and opened their lids with his right hand.

**Self-care**

*Proper positioning:* During week 3 and 4 therapy session, the patient complained left shoulder pain. The patient reported that he liked to sleep on his right side; however, he dangled his left UE behind him so he felt left shoulder pain when he woke up. The therapist educated the patient the importance of proper positioning of his left UE to prevent left shoulder pain. The therapist instructed and demonstrated to use two or three pillows to support his left arm during sleep and the therapist suggested to the patient to ask his wife to help him properly position his left arm during nighttime. The patient was instructed to self-mobilize shoulder scapula by “rock-baby”, shoulder elevation and depression, and scapular protraction and retraction.

*Left hand edema:* Due to improper position of his hand, the patient had edema in his left hand. The patient was instructed on self retrograde massage and proper positioning by elevating left arm during daily occupations.

*Occupations of daily living:* The patient was encouraged to engage the affected arm in his daily life occupations starting from the first therapy session. Starting with limited use of the left hand in his daily life at the beginning of occupational therapy, the therapist asked the client to come to the clinic sharing new use(s) of the affected UE in daily life situations. The therapist suggested functional occupations to engage the left hand in the patient’s daily life. He could carry out many functional occupations even though he had limitation of movement and strength.
in his left hand. The following were some examples: using his left UE as a facilitator or stabilizer when he ate, eating with utensils with built-up handle, holding groceries bags, opening door knobs, opening the refrigerator and the freezer, opening drawers and taking clothes out of them, moving chairs around the table, washing and drying hands, wiping the kitchen table after meals, holding the laundry basket, holding the remote control, turning the light switches on and off, and opening food containers, etc. The patient gradually formed a habit to integrate his left arm into daily occupations.

**Simulated feeding:** In order to enable eating independently, the patient engaged simulated feeding during one therapy session when he could close his left hand but he could not form a firm fist. The therapist checked the movement of his left UE and found that the patient could slowly close his left hand with index and middle fingers touching DIP joint of his left thumb and extend his fingers; however, his fingers in his left hand were not fully extended especially at DIP and PIP joints. He could also bring his left hand to his mouth with him lowing his head down and forward a little bit. The student therapist decided to try utensils to see whether he could feed himself. The student therapist gave the patient a regular spoon and a spoon with built-up handle and put a container with rice inside in front of the patient. The patient grasped the regular spoon with a palmar grasp with great effort. The spoon was easily pulled out of the patient’s left hand by the student therapist. The patient was suggested to use the spoon with built-up handle because built-up handle is large for easy and comfortable gripping. The student therapist instructed the patient to hold the spoon with his thumb and index and middle fingers and pretend to take rice to his mouth. It was noticed that limitation of supination in his left forearm would make feeding himself difficult. The student therapist did mobilization to facilitate his left forearm supination. The patient showed improvement with his left forearm supination.
When the patient took rice up to his mouth, his movement was slow and he needed effort. The student therapist suggested the patient supported his left elbow on the table and tried again. The patient’s movement became better with his left elbow supported by table. The student therapist gave the patient a piece of foam tube so that he could put it on his utensils as built-up handle. Before this therapy session, the patient had not actively used his left hand to feed himself and he chose to use his non-affected hand instead. Before the stroke incidence, the patient was independent with occupations of daily living. After he sustained stroke, he had left UE hemiparesis and hypotonicity throughout his left UE. He had limited movement in his left arm and no movement at all in his left hand. It was very difficult for him to do any occupations of daily living. After a few weeks’ occupational therapy, he had made very good improvement. He could close his left hand now. One of his occupational therapy goals is to integrate his left UE into his occupations of daily living independently. It was time to train him to use his left hand to feed himself. This stimulated feeding occupation would start the use of his left hand in the right track. This occupation was meaningful and purposeful to him because eating is a very important occupation of daily living and the most basic need for a person to live. He is highly motivated, looking forward to gaining more functions, and enjoying his life. He understood the occupation, instruction given to him, and the reason he had to do this. He needed his left hand to eat independently. It was very reasonable to infer that he accepted the therapeutic goal.

**Patient Outcomes**

After more than 3 months of outpatient therapy, which includes inpatient intensive rehabilitation and outpatient rehabilitation, the patient had made excellent recovery and his occupational performance has substantially improved. He is still undergoing occupational therapy and speech therapy. The outcome described here is his progress so far (January 1, 2012...
to April 20, 2012). He is independent in all self-care and is able to help his wife at home. He is ambulating independently without any assistive devices. However, he has not started driving because of his cognitive issues. He has not returned to his former job as a registered nurse and leisure activity such as playing guitar because he still needs therapy to improve fine motor coordination.

The patient’s arm function had improved significantly. Before the therapy, there was no movement in his left hand at all. Now he can use his left hand independently with majority of ADLs, such as feeding, dressing, bathing, etc. Performance of some tasks had become automatic, with no conscious planning of arm or hand movement. His active range of motion in his left UE has returned to within functional limit. The strength of his left UE and grip strength and pinch strength in his left hand have improved considerably (Table 2).

Action Research Arm Test assesses the patient’s grasp, grip, pinch, and gross movement in affected UE. The patient scored 3/57 before his therapy. He achieved 51/57 on April 4, 2012. He finished grasp, grip, and gross movement with ease; however, his action was a little slow when he was tested on pinch items (picking up ball of 6 mm with middle finger and thumb and picking marble of 1.5 cm up with combination of thumb and index or middle or ring or little finger).

UE Motor Activity Log (MAL) is a tool used to assess spontaneous use of an affected arm outside the treatment setting. The patients are interviewed on how much (Amount of use scale) and how well (How well scale) they use their impaired arm to accomplish each of thirty occupations of daily living in the week before interview. Mr. RH’s amount of use scale and how well scale were both 0/5 because he did not use his affected left arm at all and used his dominant right arm instead. After therapy (April 4, 2012), his amount of use scale was 3.18/5 and how well
scale was 2.87/5, which suggested that the patient has started to integrate his left arm into his
daily occupations; however, he still felt that his left arm was not working as normal as he likes.

Mr. RH is very motivated to get better from his stroke. Through his therapy so far,
he has made significant progress toward his own short-term goals. His short-term goals were to
improve movement and strength in his left arm to use in his occupations of daily living. This
short goal has been met. The ROM of his affected left UE has returned to within functional limit;
he is trying to integrate his left hand into his daily occupations; and his strength in his left arm
has improved. His long-term goals were to get back to driving, return to work, and be able to
play guitar. The long-term goal has not met yet but the patient is working hard to achieve this
goal.

Based on the three months rehabilitation, the patient is progressing nicely toward his
occupational therapy goals.

LTG 1: The patient will regain full active ROM of left UE with Bioness motor retraining
by the end of 1 year to enable independence with ODLs.

STG 1-1: The patient will initiate finger extension and flexion in his left hand with
Bioness motor retraining by the end of 1 week.

STG 1-2: The patient will be able to flex his left shoulder UE to 90° independently
while supine on mat with Bioness motor retraining by the end of 3 week.

This LTG and its STGs had been met as mentioned in aforementioned paragraph.

LTG 2: The patient will improve his left UE strength up to 4/5 throughout according to
manual muscle test by the end of 6 months to improve functional performance with ODLs.
STG 2-1: The patient will be able to do graded control of elbow flexion/extension with dowel rod wrapped with 2 pounds cuff weight 20 times while supine on mat and with bilateral UE by the end of 5 weeks.

STG 2-2: The patient will be able to do shoulder flexion with dowel rod wrapped with 3 pounds cuff weight 20 times while sitting at edge of mat and with bilateral UE by the end of 8 weeks.

This LTG has generally met as showed in table 2 except left abduction and elbow flexion were 4-. The patient had achieved all STGs.

LTG 3: The patient will improve his left hand dexterity to 40 seconds by the 9-hole peg test by the end of 1 year.

STG 3-1: The patient will be able to grasp/release blocks, marbles, and pegs with Bioness motor retraining by the end of 1 week.

STG 3-2: The patient will be able to grasp/release blocks, marbles, and pegs without Bioness device and with modified independence by the end of 5 weeks.

This LTG has not met and is progressing nicely toward the goal. Currently, the patient’s left hand dexterity test was 90 seconds as assessed by 9-hole peg test. The patient could not take this test before therapy because there was no movement in his left hand. The patient is able to grasp/release blocks, pegs, and marbles with ease; however, it needs more therapies to improve his left hand dexterity to normal, especially in-hand manipulation.

LTG 4: The patient will integrate left UE into his occupations of daily living independently by the end of 1 year.

STG 4-1: The patient will be able to start to use his left hand to facilitate his occupations of daily living 30% times by the end of 3 week.
STG 4-2: The patient will be able to feed himself with utensils with built-up handle 50% times by the end of 5 weeks.

This LTG has not met but the patient has made very good progress toward it. The patient has started to integrate his left arm into his daily occupations; however, he needs diligently to remind himself. Its STGs had been met. Currently, the patient uses his left hand 50 – 60% times to do his occupations of daily occupations and he can feed himself with regular utensils.

LTG 5: The patient’s edema in left hand will return to normal through retrograde massage, proper position of left UE by the end of 6 months.

STG 5-1: The patient will be able to demonstrate correct retrograde massage technique independently by the end of 1 week.

STG 5-2: The patient will be able to position his left UE correctly during night 80% times by the end of 2 weeks.

This LTG has not met but is progressing toward the goal. Its STGs were met. At present time, with the instruction and hand-on teaching, the patient is able to do retrograde massage on his left hand and properly position himself during night. The edema in his left hand has decreased significantly; however, there is still slight edema in the patient’s left hand.

LTG 6: The patient will return to driving independently by the end of 1 year.

LTG 7: The patient will start to play guitar to his own satisfaction by the end of 1 year.

LTG 8: The patient will return to work as a registered nurse with modified independence by the end of 1 year.

LTGs 6 – 8 have not been addressed so far. The driving evaluation and training has not started due to the patient’s cognition. The fine motor coordination in the patient’s left hand and
strength in his left UE need to be improved before starting playing guitar and returning to work as a registered nurse.

**Conclusion**

**Discharge**

The patient is currently still in therapy and is not discharged yet. However, the recommendation for his future treatment is to focus on fine motor skill in his left hand and strength in his left UE. Mr. RH is very pleased with his functional recovery and indicated many times that the occupational therapy stroke rehabilitation helped him the most. He appreciates occupational therapy in helping him start to use his left hand again in daily occupations. It is strongly suggested that the patient continues using his left arm in daily occupations and home exercise program to maximize his recovery.

**Implications for practice**

This patient achieved significant progress toward OT goals through this rehabilitation. During this process, three approaches were used, which included bilateral training, task-oriented approach, and functional electrical stimulation. These approaches have been preliminarily confirmed to be effective in stroke rehabilitation. As we all know now, implementing evidence-based practice (EBP) has become a priority in the health care professions. EBP will improve patient care, reduce health care cost, and shorten hospital stay. It is time to take rehabilitation professionals accountable for their practice. In the past decade, occupational therapy has made great strides in research; however, occupational therapy still faces many challenges to implementing EBP across settings, populations, and individual therapist. Occupational therapists should take initiative to catch up with the latest literature and use evidence-based strategy in their practice.
Implications for research

As shown in this case study, task-oriented approach, bilateral training, and functional electrical stimulation combined were effective in this patient’s rehabilitation. However, it is a case study and its success cannot warrant its effectiveness in other patients. As it is said in introduction, there is no robust data to support their effectiveness of bilateral training and electrical stimulation; more randomized controlled trials are required to determine their effect during stroke rehabilitation. Stroke is a very complicated medical condition; each case may be different in some way with another. It is proposed that rehabilitation professionals should use more than one approach in practice to help patients as much as possible. The research can be done comparing combination of task-oriented approach, bilateral training and functional electrical stimulation with usual care. During this research, there should have large sample size; participants should be clearly defined (e.g. time since stroke, initial upper limb deficits); the intervention type, frequency, duration, and intensities of each approach should be uniform with each participant; and standard outcome measurements should be carried out.

In Summary

During the rehabilitation process of this patient, task-oriented model of practice, bilateral training, and functional electrical stimulation were used for treatment planning. The outcome for this particular patient was excellent. These treatments help recover this patient’s UE functions. This case report provides effective evidence in support of these three combined approaches in stroke rehabilitation.

Acknowledgments
I would like to thank my capstone faculty mentor Lynne Chapman, MS, OTR/L, LICDC, for her advice and teaching throughout my capstone experience. I would always be grateful for her dedication to teaching next generation of occupational therapy professionals. I would like to thank my site mentor, Kelly Farley, OTR/L, and Christine A. Robinson, MOT, OTR/L, for their supervision and consideration during my capstone practicum. I would like to thank my patient, Mr. RH for his cooperation with me during my capstone experience.
References


**Table 1**

Occupations used during therapy for bilateral rehabilitation*

<table>
<thead>
<tr>
<th>Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opening and closing pill box</td>
</tr>
<tr>
<td>Washing hands, drying hands and face</td>
</tr>
<tr>
<td>Putting on socks</td>
</tr>
<tr>
<td>Pushing shopping cart</td>
</tr>
<tr>
<td>Wiping table</td>
</tr>
<tr>
<td>Twisting /untwisting bottles and jars</td>
</tr>
<tr>
<td>Pulling out chairs</td>
</tr>
<tr>
<td>Squeezing out toothpaste</td>
</tr>
<tr>
<td>Eating with a knife and fork</td>
</tr>
<tr>
<td>Opening/closing a two-handle drawer</td>
</tr>
<tr>
<td>Folding a towel</td>
</tr>
<tr>
<td>Catching thrown objects, e.g. ball</td>
</tr>
<tr>
<td>AROM or AAROM of bilateral UE with dowel rod</td>
</tr>
</tbody>
</table>

*Most occupations were instructed the patient to practice at home and report back how well he did with them and what he should work on during therapy.
### Table 2

**Summary of Mr. RH pre-treatment and post-treatment change**

<table>
<thead>
<tr>
<th>Test</th>
<th>Pre-treatment</th>
<th>Post-treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Left UE AROM</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shoulder flexion</td>
<td>0 - 70°</td>
<td>0 - 160°</td>
</tr>
<tr>
<td>Shoulder abduction</td>
<td>0 - 70°</td>
<td>0 - 160°</td>
</tr>
<tr>
<td>Shoulder IR</td>
<td>WFL</td>
<td>WFL</td>
</tr>
<tr>
<td>Shoulder ER</td>
<td>0 - 60°</td>
<td>0 - 90°</td>
</tr>
<tr>
<td>Elbow flexion/extension</td>
<td>15 - 140°</td>
<td>5 - 140°</td>
</tr>
<tr>
<td>Forearm pronation</td>
<td>WFL</td>
<td>WFL</td>
</tr>
<tr>
<td>Forearm supination</td>
<td>0 - 45°</td>
<td>0 - 90°</td>
</tr>
<tr>
<td>Wrist extension</td>
<td>0 - 0°</td>
<td>0 - 60°</td>
</tr>
<tr>
<td>Finger flexion/extension</td>
<td>0 - 0°</td>
<td>WFL</td>
</tr>
<tr>
<td><strong>Left UE strength</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shoulder flexion</td>
<td>3-</td>
<td>4</td>
</tr>
<tr>
<td>Shoulder abduction</td>
<td>3-</td>
<td>4-</td>
</tr>
<tr>
<td>Elbow flexion</td>
<td>3</td>
<td>4-</td>
</tr>
<tr>
<td>Elbow extension</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Wrist extension</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td><strong>Grip strength</strong></td>
<td>NT</td>
<td>14 lbs</td>
</tr>
<tr>
<td>Tip pinch</td>
<td>NT</td>
<td>10 lbs</td>
</tr>
<tr>
<td>Palmar pinch</td>
<td>NT</td>
<td>6 lbs</td>
</tr>
<tr>
<td>Lateral pinch</td>
<td>NT</td>
<td>11 lbs</td>
</tr>
<tr>
<td><strong>Left hand dexterity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9-hole test</td>
<td>NT</td>
<td>90 seconds</td>
</tr>
<tr>
<td><strong>Left UE ARAT</strong></td>
<td>3/57</td>
<td>51/57</td>
</tr>
<tr>
<td><strong>Left UE MAL</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount of use scale</td>
<td>0/5</td>
<td>3.18/5</td>
</tr>
<tr>
<td>How well scale</td>
<td>0/5</td>
<td>2.87/5</td>
</tr>
</tbody>
</table>

UE: Upper extremity; AROM: Active range of motion; WFL: Within functional limit; IR: Internal rotation; ER: External rotation; ARAT: Action Research Arm Test; MAL: Motor Activity Log; NT: Not tested due to no movement in the patient’s left hand.
Appendix A
Permission for Using Action Research Arm Test

Re: Action Research Arm Test
Julie Kirchem [Julie.Kirchem@UTSouthwestern.edu]
To: Yin, Jiyi
Tuesday, March 06, 2012 10:38 AM

Jiyi,
You may use the test for free. Please give attribution to the Internet Stroke Center when possible.

Thank you.

Julie Kirchem
Content Producer
Neurology Information Services
UT Southwestern Department of Neurology and Neurotherapeutics
Julie.kirchem@utsouthwestern.edu
214-648-4499

From: "Yin, Jiyi" <Jiyi.Yin@rockets.utoledo.edu>
Date: Tue, 6 Mar 2012 08:40:09 -0600
To: "info@strokecenter.org" <info@strokecenter.org>
Subject: Action Research Arm Test
Resent-From: <NeuroInfo@UTSouthwestern.edu>

Hi,
I plan to use Action Research Arm Test in my case study as a measurement for functional recovery of a stroke patient. I wonder whether I can use this test for free or it is copyrighted and I have to get permission? Thanks.

Jiyi Yin
Appendix B
Action Research Arm Test

Patient Name: __________________ Rater Name: __________________
Date: ____________________

Instructions
There are four subtests: Grasp, Grip, Pinch, Gross Movement. Items in each are ordered so that:
• If the subject passes the first, no more need to be administered and he scores top marks for that subtest;
• If the subject fails the first and fails the second, he scores zero, and again no more tests need to be performed in that subtest;
• Otherwise the subject needs to complete all tasks within the subtest.

Activity Score

Grasp
1. Block, wood, 10 cm cube (If score = 3, total = 18 and to Grip) _______
   Pick up a 10 cm block
2. Block, wood, 2.5 cm cube (If score = 0, total = 0 and go to Grip) _______
   Pick up 2.5 cm block
3. Block, wood, 5 cm cube_______
4. Block, wood, 7.5 cm cube_______
5. Ball (Cricket), 7.5 cm diameter_______
6. Stone 10 x 2.5 x 1 cm_______

Grip
1. Pour water from glass to glass (If score = 3, total = 12, and go to Pinch) _______
2. Tube 2.25 cm (If score = 0, total = 0 and go to Pinch) _______
3. Tube 1 x 16 cm _______
4. Washer (3.5 cm diameter) over bolt _______
**Pinch**
1. Ball bearing, 6 mm, 3rd finger and thumb (If score = 3, total = 18 and go to Grossmt) ________
2. Marble, 1.5 cm, index finger and thumb (If score = 0, total = 0 and go to Grossmt) ________
3. Ball bearing 2nd finger and thumb ________
4. Ball bearing 1st finger and thumb ________
5. Marble 3rd finger and thumb ________
6. Marble 2nd finger and thumb ________

**Grossmt (Gross Movement)**
1. Place hand behind head (If score = 3, total = 9 and finish) ________
   (If score = 0, total = 0 and finish)
2. Place hand on top of head ________
3. Hand to mouth ________

Performance on each item is rated on a 4-point ordinal scale ranging from:
- 3: Performs test normally
- 2: Completes test, but takes abnormally long or has great difficulty
- 1: Performs test partially
- 0: Can perform no part of test

Lyle’s decision rule: Patients who achieve a maximum score on the first (most difficult) item are credited with having scored 3 on all subsequent items on that scale. If the patient scores less than 3 on the first item, then the second item is assessed. This is the easiest item, and if patients score 0 then they are unlikely to achieve a score above 0 for the remainder of the items and are credited with a zero for the other items. The maximum score on the ARTS is 57 points (possible range 0 to 57).

**References**

Appendix C
Permission for Using the Motor Activity Log

RE: The Motor Activity Log
Edward Taub [etaub@uab.edu]
To: Yin, Jiyi
Tuesday, March 06, 2012 11:50 AM

Dear Dr. Yin (pending),
You are welcome to download the MAL from the website. There is no cost. If there is a problem, let me know; I can send you the MAL material.

Sincerely,
Edward Taub, Ph.D.
University Professor
Director, CI Therapy Research Group and
Taub Training Clinic
Department of Psychology
1530 3rd Avenue South, CPM 712
University of Alabama at Birmingham
Birmingham, AL 35294-0018
Phone: (205) 934-2471 Fax: (205) 975-6140

From: Yin, Jiyi [mailto:Jiyi.Yin@rockets.utoledo.edu]
Sent: Tuesday, March 06, 2012 8:48 AM
To: etaub@uab.edu
Subject: The motor activity log

Dr. Taub,
I am an occupational therapy doctoral student at University of Toledo and I am doing my project on stroke rehabilitation. I plan to use the motor activity log as one of my measurements. I wonder whether I can directly download it from your web site and use it or I need to get your permission and pay for it. Thank you very much.

Sincerely,
Jiyi Yin
### Motor Activity Log (UE MAL) Score Sheet

Name ___________________  Examiner _________  Date _________

<table>
<thead>
<tr>
<th>Amount Scale</th>
<th>How Well Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Turn on a light with a light switch</td>
<td>___</td>
</tr>
<tr>
<td>2. Open drawer</td>
<td>___</td>
</tr>
<tr>
<td>3. Remove an item of clothing from a drawer</td>
<td>___</td>
</tr>
<tr>
<td>4. Pick up phone</td>
<td>___</td>
</tr>
<tr>
<td>5. Wipe off a kitchen counter or other surface</td>
<td>___</td>
</tr>
<tr>
<td>6. Get out of a car (includes only the movement needed to get body from sitting to standing outside of the car, once the door is open)</td>
<td>___</td>
</tr>
<tr>
<td>7. Open refrigerator</td>
<td>___</td>
</tr>
<tr>
<td>8. Open a door by turning a door knob/handle</td>
<td>___</td>
</tr>
<tr>
<td>9. Use a TV remote control</td>
<td>___</td>
</tr>
<tr>
<td>10. Wash your hands (includes lathering and rinsing hands; does not include turning water on and off with a faucet handle)</td>
<td>___</td>
</tr>
<tr>
<td>11. Turning water on/off with knob/lever on faucet</td>
<td>___</td>
</tr>
<tr>
<td>12. Dry your hands</td>
<td>___</td>
</tr>
<tr>
<td>13. Put on your socks</td>
<td>___</td>
</tr>
<tr>
<td>14. Take off your socks</td>
<td>___</td>
</tr>
<tr>
<td>15. Put on your shoes (includes tying shoestrings and fastening straps)</td>
<td>___</td>
</tr>
</tbody>
</table>

if no, why? (use code) ________
16. Take off your shoes ___ ___ if no, why? (use code) _______
   (includes untying shoelaces and unfastening straps)

17. Get up from a chair ___ ___ if no, why? (use code) _______
   with armrests

18. Pull chair away from ___ ___ if no, why? (use code) _______
   table before sitting down

19. Pull chair toward table ___ ___ if no, why? (use code) _______
   after sitting down

20. Pick up a glass, bottle, ___ ___ if no, why? (use code) _______
    drinking cup, or can (does not need to include drinking)

21. Brush your teeth ___ ___ if no, why? (use code) _______
    (does not include preparation of toothbrush or brushing dentures unless the dentures
    are brushed while left in the mouth)

22. Put on makeup base, ___ ___ if no, why? (use code) _______
    lotion, or shaving cream on face

23. Use a key to ___ ___ if no, why? (use code) _______
    unlock a door

24. Write on paper ___ ___ if no, why? (use code) _______
    (If hand used to write pre-stroke is more affected, score item; if non-writing hand pre-
    stroke is more affected, drop item and assign N/A)

25. Carry an object in ___ ___ if no, why? (use code) _______
    your hand (dрапing an item over the arm is not acceptable)

26. Use a fork or ___ ___ if no, why? (use code) _______
    spoon for eating (refers to the action of bringing food to the mouth with fork or spoon)

27. Comb your hair ___ ___ if no, why? (use code) _______

28. Pick up a cup ___ ___ if no, why? (use code) _______
    by a handle

29. Button a shirt ___ ___ if no, why? (use code) _______

30. Eat half a sandwich ___ ___ if no, why? (use code) _______
    or finger foods
Amount Scale (AS)
0 - Did not use my weaker arm (not used).
.5
1 - Occasionally used my weaker arm, but only very rarely (very rarely).
1.5
2 - Sometimes used my weaker arm but did the activity most of the time with my stronger arm (rarely).
2.5
3 - Used my weaker arm about half as much as before the stroke (half pre-stroke).
3.5
4 - Used my weaker arm almost as much as before the stroke (3/4 pre-stroke).
4.5
5 - Used my weaker arm as often as before the stroke (same as pre-stroke).

How Well Scale (HW)
0 - The weaker arm was not used at all for that activity (never).
.5
1 - The weaker arm was moved during that activity but was not helpful (very poor).
1.5
2 - The weaker arm was of some use during that activity but needed some help from the stronger arm or moved very slowly or with difficulty (poor).
2.5
3 - The weaker arm was used for the purpose indicated but movements were slow or were made with only some effort (fair).
3.5
4 - The movements made by the weaker arm were almost normal, but were not quite as fast or accurate as normal (almost normal).
4.5
5 - The ability to use the weaker arm for that activity was as good as before the stroke (normal).

Possible Reasons for Not Using the Weaker Arm for the Activity:
Reason A. “I used the unaffected arm entirely.”
Reason B. “Someone else did it for me.”.
Reason C. “I never do that activity, with or without help from someone else because it is impossible.” For example, combing hair for people who are bald.
Reason D. “I sometimes do that activity, but did not have the opportunity since the last time I answered these questions.”
Reason E. "That is an activity that I normally did only with my dominant hand before the stroke, and continue to do with my dominant hand now."

Annotated Bibliography

Jiyi Yin

University of Toledo

January 2012
Annotated Bibliography

Outcome measurement


Abstract

**Objective:** To investigate the use of the Action Research Arm Test (ARAT), the Wolf Motor Function Test (WMFT), and the Motor Activity Log (MAL) in patients with stroke and different degrees of severity of hemiparetic upper extremity impairment in a community centre in Hong Kong.

**Methods:** Twelve participants with stroke, who resided in the community, were recruited by convenience sampling. Outcome measures included the ARAT, the WMFT, and the MAL, and were conducted on a single occasion.

**Results:** The ARAT, the WMFT, and the amount of use (AOU) and quality of movement (QOM) of the MAL were highly correlated with the hemiplegic upper limb functional levels. The ARAT and the WMFT were interrelated ($r = 0.96$). Both the AOU and the QOM subscales of the MAL were highly correlated with the ARAT ($r = 0.91$; $r = 0.97$) and the WMFT ($r = 0.86$; $r = 0.92$).

**Conclusion:** Occupational therapists should consider administering the WMFT first, and the ARAT can then be used to identify problems in certain areas of upper extremity function, such as grasping, gripping and pinching, in order to guide treatment. The MAL is highly recommended as an outcome measure across patients, and the results could guide treatment planning.
**Summary and Significance**

It has been a challenge to medical and rehabilitation professionals on recovering function of the hemiplegic upper extremity after stroke. In the past few years, stroke rehabilitation has achieved a lot of progress. A number of upper extremity interventions, such as task-oriented model of practice, bilateral training, functional electrical stimulation, constraint-induced movement therapy, and robotic arm therapy, have been used to improve motor dysfunction in patients with stroke. It has become an important issue how to evaluate the recovery of the upper extremity function after intervention. This study investigated the use of the ARAT, WMFT, and MAL in patients with stroke. Its conclusion has been clearly stated in its abstract. It gave us a clear correlation among the ARAT, WMFT, and MAL and some very good suggestions how to use them effectively during our treatment.


**Abstract**

Background: Data from monkeys with deafferented forelimbs and humans after stroke indicate that tests of the motor capacity of impaired extremities can overestimate their spontaneous use. Before the Motor Activity Log (MAL) was developed, no instruments assessed spontaneous use of a hemiparetic arm outside the treatment setting.

Objective: To study the MAL’s reliability and validity for assessing real-world quality of movement (QOM scale) and amount of use (AOU scale) of the hemiparetic arm in stroke survivors.
Methods: Participants in a multisite clinical trial completed a 30-item MAL before and after treatment (n = 106) or an equivalent no-treatment period (n = 116). Participants also completed the Stroke Impact Scale (SIS) and wore accelerometers that monitored arm movement for three consecutive days outside the laboratory. All were 3 to 12 months post-stroke and had mild to moderate paresis of an upper extremity.

Results: After an item analysis, two MAL tasks were eliminated. Revised participant MAL QOM scores were reliable (r = 0.82). Validity was also supported. During the first observation period, the correlation between QOM and SIS Hand Function scale scores was 0.72. The corresponding correlation for QOM and accelerometry values was 0.52. Participant QOM and AOU scores were highly correlated (r = 0.92). Conclusions: The participant Motor Activity Log is reliable and valid in individuals with subacute stroke. It might be employed to assess the real-world effects of upper extremity neurorehabilitation and detect deficits in spontaneous use of the hemiparetic arm in daily life.

Summary and Significance

The Motor Activity Log-28 is a self-scored scale for assessing daily use of the hemiparetic arm after stroke. It measures actual use of the impaired arm outside of the treatment setting. This study is to validate the MAL’s reliability and validity for assessing real-world quality of movement and amount of use of the hemiparetic arm in stroke survivors. The common used MAL scale has 28 items (MAL-28). It covers a comprehensive range of occupations. The MAL-28 items include both basic and instrumental ADL from multiple spheres (e.g., eating, dressing, and housework). Furthermore, approximately two-thirds of items require finger movement, whereas one-third do not and, according to how able-bodied individuals use their upper extremities, approximately half of the items are unimanual, one-fourth bimanual, and one-
fourth can be unimanual or bimanual. The wide array of ADL increases confidence that differences in MAL-28 test scores reflect differences in upper extremity use generally rather than on a narrow set of items. This study confirmed its validity. For myself, I will use this scale with my capstone project. However, I do have questions on its reliability because patients will score by themselves and patients with paraplegic arm often do not use their impaired arm unless someone reminds them. I do believe it is a useful tool because patients will see progress during the rehabilitation progress before, in between, and after their long time rehabilitation.

**Functional Electrical Stimulation**


**Abstract**

**Objectives:** This nonblinded, block-randomized clinical trial tested the hypothesis that task-oriented functional electrical stimulation (FES) can enhance the recovery of upper-extremity volitional motor control and functional ability in patients with poor prognosis.

**Design:** Ischemic stroke survivors (FES + exercise group, n =13, 17.4±7.6 days after stroke, and exercise-only group n=13, 23.8±10.9 days after stroke) trained with task-specific exercises, 30 min, twice each day. The FES group practiced the exercises combined with FES that enabled opening and closing of the paretic hand and continued with FES without exercises for up to 90mins of additional time twice a day. Both groups trained for 12 wks. Volitional motor control (modified Fugl–Meyer [mF-M]), hand function (Box & Blocks [B&B], and Jebsen–Taylor light
object lift (J-T)] were video recorded for both upper extremities at baseline and at 4, 8, and 12 wks.

**Results:** Mean mF-M score of the FES group (24±13.7) was significantly better (P = 0.05) at 12 wks compared with the control group that scored 14.2±10.6 points. The B&B mean score did not reach statistical significance (P = 0.058) in favor of the FES group (10.5 ±2.4 blocks) over the control group (2.5±4.9 blocks). The J-T task time did not differ between groups. Eight (FES) compared with three (control) patients regained the ability to transfer five or more blocks (P = 0.051), and six (FES) compared with two (control) completed the J-T task in 30 secs or less after 12 wks of training (P = 0.09).

**Conclusions:** FES + exercise as used in this preliminary study is likely to minimize motor loss, but it may not significantly enhance the ability to use the upper extremity after ischemic stroke. Anecdotally, more patients may regain some functional ability after training with FES compared with training without FES. Patients with severe motor loss may require prolonged task-specific FES training.

**Summary and Significance**

This was another preliminary study by Alon’s group with Bioness H200. It used non-blinded, block-randomized clinical trial design. It included total 26 patients, 13 for control group and 13 for functional electrical stimulation group. For control group, the patients were treated with task-specific occupations, while functional electrical stimulation group used electrical stimulation plus task-specific occupations. The study period lasted for 12 weeks. The results showed that functional electrical stimulation and task-specific occupations improved these patients’ upper extremity function. However, there were some flaws in this study, 1. It had very small size; 2. Treatment time were different, the treatment time for functional electrical
stimulation group were more than doubled. I do like their combined approaches (functional electrical stimulation and task-specific activities) during stroke rehabilitation.


**Abstract**

*Objective.* To test if functional electrical stimulation (FES) can enhance the recovery of upper extremity function during early stroke rehabilitation. *Methods.* Open-label block-randomized trial, begun during inpatient rehabilitation and continued at the patients’ home. Patients were assigned to either FES combined with task-specific upper extremity rehabilitation (n = 7) or a control group that received task-specific therapy alone (n = 8) over 12 weeks. *Outcome measures.* Hand function (Box & Blocks, B&B; Jebsen-Taylor light object lift, J-T) and motor control (modified Fugl-Meyer, mF-M) were video-recorded for both upper extremities at baseline, 4, 8, and 12 weeks. *Results.* B&B mean score at 12 weeks favored (*P* = .049) the FES group (42.3 ± 16.6 blocks) over the control group (26.3 ± 11.0 blocks). The FES group J-T task was 6.7 ± 2.9 seconds and faster (*P* = .049) than the 11.8 ± 5.4 seconds of the control group. Mean mF-M score of the FES group at 12 weeks was 49.3 ± 5.1 points out of 54, compared to the control group that scored 40.6 ± 8.2 points (*P* = .042). All patients regained hand function. *Conclusion.* Upper extremity task-oriented training that begins soon after stroke that incorporates FES may improve upper extremity functional use in patients with mild/moderate paresis more than task-oriented training without FES.

**Summary and Significance**
This is one of a few earlier studies using Bioness H200 in the U.S. It had a very strict inclusion criteria, for examples, patients with single unilateral ischemic stroke that occurred between 2-4 weeks prior to this study and patients had to have 60% of full finger flexion and extension in response to Bioness H200 stimulation (in FES group), etc. Their treatment lasted 12 weeks. It is a typical treatment frame. Exercise training was tailored to each patient. Each patient received 2 30-minute sessions each day, 5 days per week during hospitalization. Their results showed that their task-specific FES protocol improved patients’ hand function ranging from almost complete recovery to varying levels of partial recovery. As always, every study has some shortcomings. For this study, it includes 1) small sample size and 2) no follow-up. Overall, this is a very good study. It provided detailed inclusion and exclusion criteria, protocols, and bank of exercises.

This study provides evidence on the effectiveness of task-oriented rehabilitation and functional electrical stimulation. I could adapt their inclusion criteria, protocols, and exercises and use them during my capstone experience.


Abstract

BACKGROUND AND PURPOSE: Loss of upper extremity function following stroke remains a major rehabilitation challenge. The purpose of this investigation was to determine whether the Handmaster system (NESS Ltd., Ra'anana, Israel) could improve selected hand functions in persons with chronic upper extremity paresis following stroke.
METHODS: Twenty-nine poststroke subjects consented to participate in a home-based, 3-week, nonrandomized case series trial. Main outcome measures included 3 occupations of daily living (ADL) tasks: (1) lifting a 2-handled pot, (2) holding a bag while standing with a cane, and (3) a subject-selected-ADL. Secondary outcomes included lifting a 600-g weight, grip strength, electrically induced finger motion, Fugl-Meyer spherical grasp, and perceived pain scale.

RESULTS: Comparing baseline to study end point with the neuroprosthesis, the percent of successful trials with lifting the pot, weight, and bag (0% v 93%, 14% v 100%, and 17% v 93%, respectively) increased significantly. All subjects performed successfully their selected ADL and improved their Fugl-Meyer scores using the neuroprosthesis. Grip strength (6.4 +/- 7.3N v 17.7 +/- 6.2N) and active finger motion (0.5 +/- 1.2 cm v 8.4 +/- 2.6 cm) also improved with the neuroprosthesis. Pain scores significantly decreased in subjects reporting pain at baseline. Responses to questionnaire were favorable regarding the utility and therapeutic benefits of the device.

CONCLUSIONS: We conclude that the Handmaster is a safe and effective noninvasive neuroprosthesis for improving the studied hand functions and impairments in selected persons with chronic hemiplegia secondary to stroke.

Summary and Significance

This study is a proof-of-concept study. Its purpose was to conform whether use of Bioness H200 with stroke patients was safe and effective. They recruited 29 stroke patients and did a 3-week, home-based, nonrandomized case series study. During their home treatment programs, these patients practiced activities of daily living with the help from Bioness H200. Their result showed that Bioness H200 was safe, effective, and efficient in recovering upper
extremity function of stroke patients. The patients’ response with using Bioness H200 was highly favorable. This study provides basis for my case study.


Abstract

OBJECTIVES: To test if a combined stimulation-training program can improve selected hand functions and impairments of chronic stroke survivors.

DESIGN: Pretest-Posttest, multi-site 5-week training program. Stroke survivors (N = 77) with chronic upper limb paresis completed a home-based stimulation program combining activation of the wrist-fingers flexors and extensors with functional grasp, hold and release training. Subjects trained 2-3 times each day, 7 days a week. Outcome measures included: the Jebsen-Taylor simulated feeding (S-feed); light object lift (J-T light); heavy object lift (J-T heavy); Box and Blocks test (B+B); Nine-Hole Peg (9-HP); Ashworth scale (Spasticity); Visual analog scale-VAS (Pain). Paired t-tests (alpha < 0.01) were performed on each study outcome.

RESULTS: Simulated feeding time decreased from 39.1 +/- 30.9 sec to 25.5 +/- 23.3 sec (34.8% improvement). The task time of the J-T light decreased by 13.3 sec and the J-T heavy by 11.5 sec (44.9% and 40.9% improvement respectively). The number of blocks moved increased from 19.4 +/- 11.6 to 24.5 +/- 12.5 (26.3% improvement) and the time to complete the 9-HP decreased from 178.8 +/- 170.8 to 105.0 +/- 117.1 sec (58.7% improvement). Mean reduction of spasticity was 0.87 and 0.78 points at the elbow and wrist respectively. Patients with persistent pain (N = 33) reported mean reduction from 3.5 +/- 2.5 to 1.9 +/- 1.8.
CONCLUSIONS: Five weeks of daily home training with a task-specific stimulation program improved selected hand functions and upper limb impairments associated with chronic post-stroke paresis.

Summary and Significance

This study used a pre- and post-test design and was multiple site clinical trials. It selected 77 patients with chronic stroke and trained these patients to use Bioness H200 with their affected arms, and then set up a home-based 5-week program. During this 5-week period, the patients practiced functional activities such as holding a glass, carrying a bag, grasping a mop or a broom, and opening a bottle, etc. with help from functional electrical stimulation. Their results showed improvement with their hand functions. However, this was not a very strictly designed study because it used pretest and posttest design and it had inclusion criteria (75% full ROM of finger flexion). I wonder what result they would get if they had control group without functional electrical stimulation. This was a multiple sites study but they had only 77 patients. The results need to be confirmed by randomized clinical trials. I learn from this study that research needs to be done in a appropriate way, otherwise, it will waste time and waste money.


Abstract

The majority of stroke survivors continue to suffer residual functional deficits due to weakness and inadequate motor control of their paretic muscles. Non-invasive functional electrical stimulation has been limited to stimulation of only 1-2 muscle groups. The purpose of this study
was to test if the use of a multi-segment hybrid orthosis-stimulation system combined with electrically augmented functional training would promote improvement in gait and hand functions of patients with chronic hemiparesis. A control group (n = 9) received individual instructions for specific functional training and self-exercised up to 60 minutes twice daily. The stimulated group (n = 10) received self-administered electrical stimulation training using the NESS system. Training time increased to 60 minutes twice daily and comprised of specific functional exercise. Each group trained for 3 months. Upper limb outcome measures included the Box & Block (B & B) and 3 sub-tests of the Jebsen-Taylor (J & T) battery. Gait outcomes included 10-meter walk time, speed, cadence, and number of steps. Post-test-pretest data were analyzed by unpaired t-tests (P = 0.05). The stimulated group improved significantly compared to the control group in B & B (7.9 +/- 4.5 vs 0.2 +/- 2.2 more blocks); J & T simulated feeding (12.6 +/- 14.8 vs 1.2 +/- 2.09 sec); J & T light object lift (8.2 +/- 9.7 vs. -0.3 +/- 2.8 sec); J & T heavy object lift (7.6 +/- 11.0 vs -0.8 +/- 1.6 sec); walk time (3.3 +/- 1.1 sec vs -0.3 +/- 1.8 sec); walking speed (0.33 +/- 0.12 vs. -0.01 +/- 0.1 m/sec); cadence (0.30 +/- 0.18 vs. -0.02 +/- 0.14 steps/sec). The number of steps over 10 m decreased 2.7 +/- 1.4 vs -0.2 +/- 1.98 steps. We concluded that electrically-dependent functional training with multi-segment hybrid orthosis-stimulation system can improve the studied functional outcomes of chronic stroke survivors.

Summary and Significance

Considering research studies in rehabilitation, this was a very nice study with good control. The patients in the stimulation group used both Bioness hand and leg devices combined with functional training, while the patients of control group received specific functional training and self-exercises. Their therapy was for 3 months. Their results suggested that, comparing with
control group, functional electrical stimulation group improve their hand functions based on Box & Block test, J-T tests, and gait. However, this study had very small sample sizes (control group 9 and stimulation group 10), which compromised their results and conclusion.


**Abstract**

Objective: To compare the effect of cyclic and electromyography (EMG)-triggered electrical stimulation on motor impairment and function of the affected upper extremity in chronic stroke. 

Design: Randomized controlled trial. 

Setting: Outpatient clinic of a rehabilitation centre. 

Subjects and intervention: Twenty-two subjects in the chronic stage after stroke were randomly assigned to receive either cyclic (n = 11) or EMG-triggered electrical stimulation (n = 11) of the wrist and finger extensor muscles for a six-week period. 

Outcome measures: The primary outcome measure was the Action Research Arm test (0–57 points) to assess arm function. Grip strength, Fugl-Meyer Motor Assessment and Motricity Index were secondary outcome measures. Assessments were made at the start of the treatment and after 4, 6 and 12 weeks. 

Results: Both groups improved on the Action Research Arm test. The group receiving cyclic stimulation improved by 2.3 points, and the group receiving EMG-triggered stimulation improved by 4.2 points. The difference in functional gain was not statistically significant. Differences in gain on the secondary outcome measures were not significant either.
Conclusion: The present study did not detect a significant difference between EMG-triggered and cyclic electrical stimulation with respect to improvement of motor function of the affected arm in chronic stroke.

**Summary and Significance**

Electrical stimulation has confirmed to improve function with patients of stroke. However, there are multiple ways to carry out electrical stimulation in patients. This study used cyclic or EMG-triggered electrical stimulation to stimulate wrist and finger extensors for six weeks and their study did not facilitate improvement of motor function of the hemiplegic arms with patients of chronic stroke. Reading their study, it does not surprise me they did not improve patients’ function. There are some flaws in their research design. They just used electrical stimulation to extend wrist and finger and no functional training; they did not have control group, even if they saw some positive results, it was not sure it was placebo effect or electrical stimulation; and it had a very small sample size (11 patients in each group). This study reminds me the importance of functional training during stroke rehabilitation.


**Abstract**

*Purpose:* EMG-triggered electrostimulation (EMG-ES) may improve the motor performance of affected limbs of hemiparetic stroke patients even in the chronic stage. This study was designed
to characterize cortical activation changes following intensified EMG-ES in chronic stroke patients and to identify predictors for successful rehabilitation depending on disease severity.

Methods: We studied 9 patients with severe residual hemiparesis, who underwent 8 weeks of daily task-orientated multi-channel EMG-ES of the paretic arm. Before and after treatment, arm function was evaluated clinically and cortical activation patterns were assessed with functional MRI (fMRI) and/or transcranial magnetic stimulation (TMS).

Results: As response to therapy, arm function improved in a subset of patients with more capacity in less affected subjects, but there was no significant gain for those with Box & Block test values below 4 at inception. The clinical improvement, if any, was accompanied by an ipsilesional increase in the sensorimotor cortex (SMC) activation area in fMRI and enhanced intracortical facilitation (ICF) as revealed by paired TMS. The SMC activation change in fMRI was predicted by the presence or absence of motor-evoked potentials (MEPs) on the affected side.

Conclusions: The present findings support the notion that intensified EMG-ES may improve the arm function in individual chronic hemiparetic stroke patients but not in more severely impaired individuals. Functional improvements are paralleled by increased ipsilesional SMC activation and enhanced ICF supporting neuroplasticity as contributor to rehabilitation. The clinical score at inception and the presence of MEPs have the best predictive potential.

Summary and Significance

This study was carried out by a group of German scientists. It used EMG-triggered electrical stimulation and daily task-oriented training to treat chronic hemiparetic patient of stroke. It used pre- and post-test design to monitor patients’ arm function using box and block test and cortical activation patterns with functional MRI (fMRI) and/or transcranial magnetic
stimulation (TMS). Its results implied that these treatments were effective with mild-moderate motor impaired patients. This study has some merits (functional training, functional test, and high-tech to assess cortical pattern change); there are some limitations also. There is no control group and it was comparison before and after treatment design; the sample size was small (nine patients); they had very limited functional training (put plastic cup into each other and move away from the body); and their treatment time was short (40 minutes daily for 8 weeks). I should learn these lessons for my capstone experience.


**Abstract**

*Objective:* Assess the effects of daily neuroprosthetic (NESS Handmaster) functional electrical stimulation in sub-acute stroke.

*Design:* Controlled study, patients clinically stratified to 2 groups; no active finger movement (10), and partial active finger movements (12), and then randomized to control and neuroprosthesis groups. Observer blinded evaluations at baseline and completion of the 6-week study.

*Subjects:* 22 patients with moderate to severe upper limb paresis 3–6 months post-onset.

*Methods:* Patients in day hospital rehabilitation, receiving physical and occupational therapy 3 times weekly. The neuroprosthesis group used the device at home.

*Results:* The neuroprosthesis group had significantly greater improvements in spasticity, active range of motion and scores on the functional hand tests (those with partial active motion). Of the
few patients with pain and oedema, there was improvement only among those in the neuroprosthesis group. There were no adverse reactions.

**Conclusion:** Supplementing standard outpatient rehabilitation with daily home neuroprosthetic activation improves upper limb outcomes.

**Summary and Significance**

In this study, they investigate the effects of daily neuroprosthetic (BIONESS H200) functional electrical stimulation in sub-acute stroke. There were total of 22 patients with moderate to severe upper limb paralysis 3–6 months post-stroke participating this clinical study. Their experimental design is controlled randomized study. Patients were first clinically stratified to two groups: no active finger movement (10 patients, type I patients), and partial active finger movements (12 patients, type II patients), and then were randomized into control and neuroprosthesis groups. At baseline and completion of the 6-week study, the evaluator was blinded about patient group. All patients attended day hospital rehabilitation, receiving physical and occupational therapy 3 times per week. The neuroprosthesis group used the device at home, type II patients in neuroprosthesis group engaged functional activities while using BIONESS H200. Their results showed as follows. For type I patients, there was greater improvement in active motion in the proximal upper extremity in the neuroprosthesis group, however, the difference did not reach a level of statistical significance. For type II patients in the neuroprosthesis group, there had significantly greater improvements in spasticity, active range of motion and hand function. They concluded that supplementing standard outpatient rehabilitation with daily home neuroprosthetic stimulation and functional activities improves upper extremity outcomes in voluntary movement and functional use of the hand. Here is a trivia for rehabilitation research. From this study, it showed different results: The patients with no active
finger movement did not improve with Bioness H200, and the patients with partial active finger movements after using Bioness H200 improved significantly. While the results perhaps did not surprise anyone, the study design and inclusion criteria played a very important role in their results. It is a lesson I have to learn.


**Abstract**

*Background.* Functional electrical stimulation (FES) allows active exercises in stroke patients with upper extremity paralysis. *Objective.* To investigate the effect of motor training with FES on motor recovery in acute and subacute stroke patients with severe to complete arm and/or hand paralysis. *Methods.* For this pilot study, 23 acute and subacute stroke patients were randomly assigned to the intervention (n = 12) and control group (n = 11). Distributed over 4 weeks, FES training replaced 12 conventional training sessions in the intervention group. An Extended Barthel Index (EBI) subscore assessed the performance of activities of daily living (ADL). The Chedoke McMaster Stroke Assessment (CMSA) measured hand and arm function and shoulder pain. The Modified Ashworth Scale (MAS) assessed resistance to passive movement. Unblinded assessments were performed prior to and following the end of the training period. *Results.* The EBI subscore and CMSA arm score improved significantly in both groups. The CMSA hand function improved significantly in the FES group. Resistance to passive movement of finger and wrist flexors increased significantly in the FES group. Shoulder pain did not change significantly. None of the outcome measures, however, demonstrated significant gain differences
between the groups. Conclusion: We did not find clear evidence for superiority or inferiority of FES. Our findings, and those of similar trials, suggest that the number of sessions should be at least doubled to test for superiority of FES in these highly impaired patients and approximately 50 participants would have to be assigned to each therapeutic intervention to find significant differences.

Summary and Significance

Functional electrical stimulation has been proved to be effective in upper limb rehabilitation in patients with stroke. This study was done in Switzerland. They recruited 23 acute and subacute patients with stroke and randomized them into two groups, one intervention group, another was control group. In intervention group, functional electrical stimulation training replaced conventional training 3 times per week for 4 weeks. The result showed that hand function in the functional electrical stimulation group improved significantly according to The Chedoke McMaster Stroke Assessment. However, there was no statistical significance between the overall effects of these two groups. There are a few problems in this study: 1) small sample size; 2) treatment was too short; 3) imbalanced samples between intervention and control group in gender, dominant hand affected, neglect, and EBI baseline, 3 patients in functional electrical stimulation did not finish these treatment sessions. For my Capstone, I can learn lessons from their intervention.

Abstract
None available.

Summary and Significance

I am very excited to read this article because it is written by bioengineering scientists and it gives me new ideas how I can help my patients in clinic. I do think biomedical engineering contributes tremendously to medical advance and it is also true in physical rehabilitation. According to this article, Bioness H200 belongs to the first generation of wearable electrical stimulation devices. From my experience working with Bioness H200, I like it because it does help patients with stroke or spinal cord injury to recover their hand function; however, I think it can improve in many ways. Current Bioness H200 stimulates hand extensors or flexors all together, it does not facilitate finger opposition function, and it is still bulk and it impacts patients’ supination function. I like the electrode array technology they mentioned in this article. In this technology the authors developed, they embedded a series of electrodes (conductive rubber patches) on flexible straps and it will be wearable in daily life. It will produce better muscle stimulation and improved muscle activation patterns, compared to Bioness H200 predetermined electrode positions. The authors mentioned in the article, their main issue is to develop a method to select the optimal electrode location; I think these biomedical engineers should collaborate with rehab personnel to perfect their system. If there is any opportunity, I perhaps can help them to advance treatment techniques because I have knowledge in medicine, rehab, and computer.

Abstract

Objectives: To review current and explore future applications of neuromuscular electrical stimulation (NMES) to restore or retrain upper limb (UL) recovery after stroke.

Methods: Short summaries of NMES applications that have been investigated and a discussion of future research directions are presented.

Results: Neuromuscular electrical stimulation applications that have been developed and investigated to restore or retrain UL recovery after stroke include: cyclic NMES; triggered NMES which includes electromyogram-triggered NMES (EMG-NMES), positional feedback NMES, contralateral-triggered NMES, outcome-triggered NMES and accelerometer-triggered NMES; iterative learning control mediated NMES; and neuroprostheses such as the Bioness H200. Overall, published studies of these applications indicate that NMES can improve UL function after stroke, with improvements at the impairment level more common than improvements at the activity level. While EMG-NMES has been researched most widely and has the highest level of evidence to support its use, newer applications (e.g. outcome-triggered NMES, accelerometer-triggered NMES) appear promising, on the basis that key requirements for motor learning are employed.

Discussion: There are several areas for further research of NMES to achieve greater functional gains at the activity level than are currently achieved post-stroke. These include the use of NMES to retrain multijoint movements; and exploration of single- versus multichannel stimulation, cortical changes that occur after NMES, and NMES with other technologies. Use of
NMES to restore or retrain UL function after stroke has come a long way and presents exciting challenges for research and clinicians in the future.

**Summary and Significance**

This review is written by a group of physical therapists, Not like the article “Wearable neural prostheses” which is on bioengineering side, this article’s focus is advances in application of neuromuscular electrical stimulation for upper extremity post-stroke. It reviewed multiple neuromuscular electrical stimulation applications in which some are old generation I never heard before and provides evidences for their effectiveness.

I like contralateral-triggered NMES the most. This system was developed at Cleveland FES Center. I attended a lecture given by an occupational therapist from this center before so I knew a little of this system. However, this system is like Bioness H200, it has pre-defined electrode positions and stimulated pre-set muscles. I would wish this system would integrate with the electrode array technology and the integrated technology would certainly revolution rehabilitation with patients of stroke.

When the authors talked about future directions for NMES, they pointed out that future NMES investigation should consider use of goal-directed training protocols. I could not agree more. From my limited rehabilitation experience n rehabilitation field, function- or task-oriented training will work much better for patients.

This paper will serve background for my capstone.

Abstract

Objective: To examine and compare efficacy of 30-, 60-, and 120-minute repetitive task-specific practice (RTP) sessions incorporating use of an electrical stimulation neuroprosthesis (ESN) on affected upper-extremity (UE) movement.

Design: Prospective, single-blinded, randomized controlled trial.

Setting: Outpatient rehabilitation hospital.

Participants: Chronic stroke subjects (N=32) exhibiting moderate, stable affected UE motor deficits.

Interventions: Subjects participated in 30-, 60-, or 120-minute therapy sessions involving RTP incorporating the ESN, occurring every weekday for 8 weeks. During sessions, they wore the ESNs to enable performance of valued activities that they had identified. A fourth group participated in a 30-minute per weekday home exercise program.

Main Outcome Measures: Outcomes were evaluated using the UE section of the Fugl-Meyer Assessment of Sensorimotor Impairment (FM), the Arm Motor Ability Test (AMAT), the Action Research Arm Test (ARAT), and Box and Block (B&B) 1 week before and 1 week after intervention.

Results: After intervention, subjects in the 120-minute condition were the only ones to exhibit significant score increases on the FM ($P=.0007$), AMAT functional ability scale ($P=.002$), AMAT quality of movement scale ($P=.0002$), and ARAT ($P=.02$). They also exhibited the largest changes in time to perform AMAT tasks and in B&B score, but these changes were nonsignificant, ($P=.15$ and $P=.10$, respectively).

Conclusions: One hundred and twenty minutes a day of RTP augmented by ESN use elicits the largest and most consistent UE motor changes in moderately impaired stroke subjects.
Summary and Significance

This study was carried out by Stephen Page’s group at OSU. Their results suggested patients in the 120-minute condition were the only ones to exhibit significant functional recovery. It is not surprising to me at all. As it is known, stroke is a devastating disease. In this study, they chose patients in chronic condition and with moderate impairment; it will take long and laborious rehabilitation to recover their function.

I think his design in this research had many flaws: 1. Small sample size, 32 patients completed this research, which means 7 - 9 people in one group; 2. Control group they used was HEP group. These patients received 1.5 hour education session and provided a customized list of exercise. The right control should be patients who receive same treatment except electrical stimulation.

This study provides evidence for my capstone case study, which is to use electrical stimulation combining with task-oriented training to improve functional recovery.

Bilateral Rehabilitation


Abstract

*Background.* The recovery rate of upper limb function after stroke is poor when compared with independent walking. Therefore, effective methods are warranted for upper limb rehabilitation. *Objective.* The aim of this study was to investigate the effectiveness of functional electric stimulation (FES) with bilateral activities training on upper limb function. *Methods.* This study
was a double-blinded randomized controlled trial. Twenty patients were recruited 6 months after the onset of stroke and completed 15 training sessions. Participants were randomly assigned to the FES group or to the control group. Each session consisted of stretching activities (10 minutes), FES with bilateral tasks (20 minutes), and occupational therapy treatment (60 minutes). The participants used a self-trigger mechanism, with an accelerometer as a motion detector, for generating an electric stimulation pattern that was synchronized with the bilateral upper limb activities during the training. The participants in the control group received the same duration of stretching and occupational therapy training except that they just received placebo stimulation with the bilateral tasks. The outcome measures included Functional Test for the Hemiplegic Upper Extremity (FTHUE), Fugl–Meyer Assessment (FMA), grip power, forward reaching distance, active range of motion of wrist extension, Functional Independence Measure, and Modified Ashworth Scale. Results. At baseline comparison, there was no significant difference in both groups. After 15 training sessions, the FES group had significant improvement in FMA ($P = .039$), FTHUE ($P = .001$), and active range of motion of wrist extension ($P = .020$) when compared with the control group. Conclusions. Bilateral upper limb training with FES could be an effective method for upper limb rehabilitation of stroke patients after 15 training sessions.

Summary and Significance

Only 50% of stroke survivors are likely to regain some functional use of their affected upper extremity. Functional electrical stimulation is an emerging treatment for the rehabilitation of the upper limb function in patient with stroke. In a normal person, many daily tasks naturally require the coordinated participation of both hands. Maybe bilateral movement training between good and affected hands will activate motor synergies between hands. This paper enrolled 20
patients after 6 months of their stroke. Patients were randomized into 2 groups, one with functional electrical stimulation and bilateral training, control group received placebo stimulation and bilateral training. Their results showed that upper limb functions in functional electrical stimulation plus bilateral training group were significantly improved.

However, this study had an experimental design defect. Besides their functional electrical stimulation plus bilateral training group, placebo plus bilateral training group, they should have functional electric stimulation only group, placebo only group and bilateral training only group. Only in this way can we draw a clear conclusion whether functional electric stimulation plus bilateral training is superior among all groups. It also had a small sample size. For my Capstone experience, I will do a case study. Its shortcoming does not matter to me. This study provides an evidence for my Capstone Practicum.


**Abstract**

**Background and Purpose**—Overcoming chronic hemiparesis from a cerebrovascular accident (CVA) can be challenging for many patients, especially after the first 12 months after the CVA. With the use of established motor control theories, the present study investigated electromyogram (EMG)-triggered neuromuscular stimulation and bilateral coordination training.

**Methods**—Twenty-five CVA subjects volunteered to participate in this motor recovery protocol study. Subjects were randomly assigned to 1 of 3 groups: (1) coupled protocol of EMG-triggered stimulation and bilateral movement (n = 10); (2) EMG-triggered stimulation and unilateral
movement (n = 10); or (3) control (n = 5). All participants completed 6 hours of rehabilitation during a 2-week period according to group assignments. Motor capabilities of the wrist and fingers were evaluated on the basis of 3 categories of motor tasks in a pretest-posttest control group design.

**Results**— Significant findings for the (1) number of blocks moved in a functional task, (2) chronometric reaction times to initiate movements, and (3) sustained muscle contraction capability all favored the coupled bilateral movement training and EMG-triggered neuromuscular stimulation protocol group. In addition, the unilateral movement/stimulation group exceeded the control group in the number of blocks moved and rapid onset of muscle contractions.

**Conclusions**— This new evidence is convincing in that subjects in the coupled protocol group were able to demonstrate enhanced voluntary motor control across 3 categories of tasks. Chronic hemiparesis decreased considerably in the wrist and fingers as CVA patients expanded their motor repertoire.

**Summary and Significance**

This is a well-designed study. It had a nice review on dynamic systems theory (bimanual coordination). It referred back to Bernstein who suggested that both arms were centrally linked as a coordinative structure unit: hands and fingers function in a homologous coupling of muscle groups on both sides of the body. Bilateral training emphasizes the inherent characteristics of muscles as important for muscle control. Other studies postulated that bilateral actions trigger interhemispheric disinhibition that may allow alternative recruitment pathways to be activated. This study utilized electromyogram (prototype functional electric stimulation Bioness H200) and bilateral training to help recover motor function in patients’ hemiplegic upper limb. Their
patients had some movements in their hands (selection criteria: 10 degree extension from 90 degree flexed position), their treatment lasted 90 minutes per session for 4 times within a 2 weeks period. Their results showed that coupled electromyogram with bilateral training were more effective than electromyogram plus unilateral training and control according their three measurements: Box and Block test, reaction time, and sustained muscle contraction.

I think this is a very good proof-of-concept study. In current practice, we will treat patients longer than the time frame they used. Therefore, for me, if I combine functional electric stimulation with bilateral training plus task-oriented MOP (It is what I plan to do), the rehabilitation outcomes will be even better. I will refer this paper in my capstone practicum.


Abstract

Stroke interferes with voluntary control of motor actions. Although spontaneous recovery of function can occur, restoration of normal motor function in the hemiplegic upper limb is noted in fewer than 15% of individuals. However, there is increasing evidence to suggest that in addition to injury-related reorganization, motor cortex functions can be altered by individual motor experiences. Such neural plasticity has major implications for the type of rehabilitative training administered post-stroke. This review proposes that noteworthy upper extremity gains toward motor recovery evolve from activity-dependent intervention based on theoretical motor control constructs and interlimb coordination principles. Founded on behavioral and neurophysiological mechanisms, bilateral movement training/practice has shown great promise in expediting progress toward chronic stroke recovery in the upper extremity. Planning and executing bilateral
movements post-stroke may facilitate cortical neural plasticity by three mechanisms: (a) motor cortex disinhibition that allows increased use of the spared pathways of the damaged hemisphere, (b) increased recruitment of the ipsilateral pathways from the contralesional or contralateral hemisphere to supplement the damaged crossed corticospinal pathways, and (c) upregulation of descending premotorneuron commands onto propriospinal neurons.

**Summary and Significance**

This is a review report on bilateral training and its potential mechanism. When the upper extremity is used unilaterally, there is inhibition of the ipsilateral hemisphere and the interhemispheric inhibition is specifically directed to prevent mirror movements by the opposite upper limb; On the contrary, when using both hands symmetrically, both hemispheres are activated and intracortical inhibition is reduced. Research suggested that the supplementary motor area (SMA) in each hemisphere projects to the ipsilateral primary cortex and intact SMA might act alone in executing bilateral movements so when two arms work together, the arms are coordinated as a unit. In addition to SMA and sensorimotor cortex, the cingulate motor cortex, lateral premotor cortex, superior parietal cortex, and cerebellum have been shown to be involved in bimanual coordination.

This paper provides a summary on neuroscience evidences on bilateral training for my Capstone project. I will include this paper in my introduction


**Abstract**
Objective and design: Bilateral movement training is being increasingly used as a post-stroke motor rehabilitation protocol. The contemporary emphasis on evidence-based medicine warrants a prospective meta-analysis to determine the overall effectiveness of rehabilitating with bilateral movements.

Methods: After searching reference lists of bilateral motor recovery articles as well as PubMed and Cochrane databases, 11 stroke rehabilitation studies qualified for this systematic review. An essential requirement for inclusion was that the bilateral training protocols involved either functional tasks or repetitive arm movements. Each study had one of three common arm and hand functional outcome measures: Fugl-Meyer, Box and Block, and kinematic performance.

Results: The fixed effects model primary meta-analysis revealed an overall effect size (ES=0.732, S.D.=0.13). These findings indicate that bilateral movement training was beneficial for improving motor recovery post-stroke. Moreover, a fail-safe analysis indicated that 48 null effects would be necessary to lower the mean effect size to an insignificant level.

Conclusion: These meta-analysis findings indicate that bilateral movements alone or in combination with auxiliary sensory feedback are effective stroke rehabilitation protocols during the sub-acute and chronic phases of recovery.

**Summary and Significance**

Bilateral training is a prominent rehabilitation technique in post-stroke rehabilitation. It applies neurological interlimb coordination theory in activating motor synergies between limbs. According to my knowledge, this systematic review is the only one meta-analysis on bilateral training. For their first meta-analysis, they included 11 studies. Their across studies heterogeneity test showed that there was heterogeneity (Q = 30.65, p < 0.02). However, they still used fixed effect model. Usually if there is heterogeneity across studies, random effect model has
to be used during the meta-analysis because random effect model represents true effect size. With their fixed effect model, their effect size was 0.732. It did suggest that bilateral training were effective in stroke rehabilitation. During their second meta-analysis, they reduced some data and did not find heterogeneity across studies. The effect size was 0.582 that was moderate. It still suggests that bilateral training is effective.

Currently, we should use evidence-based practice. As majority of occupational therapy research use small sample sizes, their results often suggest ambiguous and confusing conclusions. This meta-analysis provides combined convincing treatment effect on stroke rehabilitation using bilateral training. It definitely gives me the confidence to use this technique during my Capstone Practicum. However, I need to check some original studies which included in this meta-analysis to see how they did their bilateral training.


**Abstract**

**Context**—Reorganization in central motor networks occurs during early recovery from hemiparetic stroke. In chronic stroke survivors, specific rehabilitation therapy can improve upper extremity function.

**Objective**—To test the hypothesis that in patients who have chronic motor impairment following stroke, specific rehabilitation therapy that improves arm function is associated with reorganization of cortical networks.
Design, Setting, and Patients—A randomized controlled clinical trial conducted in a US ambulatory rehabilitation program with 21 patients (median [IQR], 50.3 [34.8-77.3] months after unilateral stroke). Data were collected between 2001 and 2004.

Interventions—Patients were randomly assigned to bilateral arm training with rhythmic auditory cueing (BATRAC) (n = 9) or standardized dose-matched therapeutic exercises (DMTE) (n = 12). Both were conducted for 1 hour, 3 times a week, for 6 weeks.

Main Outcome Measures—Within 2 weeks before and after the intervention, brain activation during elbow movement assessed by functional magnetic resonance imaging (fMRI) and functional outcome assessed using arm function scores.

Results—Patients in the BATRAC group but not in the DMTE group increased hemispheric activation during paretic arm movement ($P = .03$). Changes in activation were observed in the contralesional cerebrum and ipsilesional cerebellum ($P = .009$). BATRAC was associated with significant increases in activation in precentral ($P < .001$) and postcentral gyri ($P = .03$) and the cerebellum ($P < .001$), although 3 BATRAC patients showed no fMRI changes. Considering all patients, there were no differences in functional outcome between groups. When only BATRAC patients with fMRI response were included (n = 6), BATRAC improved arm function more than DMTE did ($P = .02$).

Conclusions—These preliminary findings suggest that BATRAC induces reorganization in contralesional motor networks and provide biological plausibility for repetitive bilateral training as a potential therapy for upper extremity rehabilitation in hemiparetic stroke.

Summary and Significance

This is a pilot study on the effect of bilateral training to improve upper limb function with chronic stroke and its neurophysiological mechanisms. Its results showed that, comparing with
unilateral training, 6 weeks of bilateral arm training increase motor function in 6 out of 9 patients. In these 6 patients showing improvement, their brains showed an increase of activation in the contralesional hemisphere (precentral gyri and post central gyri and ipsilesional cerebellum).

As we do every day, we involve both of our hands for ADLs and IADLs. Bilateral training makes sense. This study provides theoretical background for my case study.


Abstract

**Background:** Simultaneous bilateral training, the completion of identical activities with both arms simultaneously, is one intervention to improve arm function and reduce impairment.

**Objectives:** To determine the effects of simultaneous bilateral training for improving arm function after stroke.

**Search strategy:** We searched the Cochrane Stroke Trials Register (last searched August 2009) and 10 electronic bibliographic databases including the Cochrane Central Register of Controlled Trials (CENTRAL) (The Cochrane Library Issue 3, 2009), MEDLINE, EMBASE, CINAHL and AMED (August 2009). We also searched reference lists and trials registers.

**Selection criteria:** Randomised trials in adults after stroke, where the intervention was simultaneous bilateral training compared to placebo or no intervention, usual care or other upper limb (arm) interventions. Primary outcomes were performance in activities of daily living (ADL)
and functional movement of the upper limb. Secondary outcomes were performance in extended activities of daily living and motor impairment of the arm.

**Data collection and analysis:** Two authors independently screened abstracts, extracted data and appraised trials. Assessment of methodological quality was undertaken for allocation concealment, blinding of outcome assessor, intention-to-treat, baseline similarity and loss to follow up.

**Main results:** We included 18 studies involving 549 relevant participants, of which 14 (421 participants) were included in the analysis (one within both comparisons). Four of the 14 studies compared the effects of bilateral training with usual care. Primary outcomes: results were not statistically significant for performance in ADL (standardised mean difference (SMD) 0.25, 95% confidence interval (CI) -0.14 to 0.63); functional movement of the arm (SMD -0.07, 95% CI -0.42 to 0.28) or hand (SMD -0.04, 95% CI -0.50 to 0.42). Secondary outcomes: no statistically significant results. Eleven of the 14 studies compared the effects of bilateral training with other specific upper limb (arm) interventions. Primary outcomes: no statistically significant results for performance of ADL (SMD -0.25, 95% CI -0.57 to 0.08); functional movement of the arm (SMD -0.20, 95% CI -0.49 to 0.09) or hand (SMD -0.21, 95% CI -0.51 to 0.09). Secondary outcomes: one study reported a statistically significant result in favour of another upper limb intervention for performance in extended ADL. No statistically significant differences were found for motor impairment outcomes.

**Authors’ conclusions:** There is insufficient good quality evidence to make recommendations about the relative effect of simultaneous bilateral training compared to placebo, no intervention or usual care. We identified evidence that suggests that bilateral training may be no more (or
less) effective than usual care or other upper limb interventions for performance in ADL, functional movement of the upper limb or motor impairment outcomes.

**Summary and Significance**

As what we do every day involves the use of both of our arms, so it makes sense to use bilateral training. However, this meta-analysis (18 studies, 549 relevant participants) did not achieve significance. Looking at all these studies, there were many limitations in these studies, for examples, all studies had small sample size; different studies used different protocol (treatment time, treatment length, or activities, etc.); and there were differences among the patients (time after stroke, level of functional deficit, severity of stroke, etc.). It is very possible there is selection and detection bias in these studies. More well-designed, large sample size, and multiple-site randomized controlled trials are needed to determine the effectiveness of bilateral training. Overall, there are positive clinical outcomes there. It is encouraging enough to use it as an approach in my case study.

**Task-oriented Approach**


**Abstract**

Functional tasks using real-life objects in an enriched environment provide a multidimensional approach to treatment. Functional tasks are therapeutic for stroke survivors, because they require the simultaneous use of motor control, cognition, visual perception, sensation, and motor planning. Therapists utilizing functional tasks as treatment modalities must also be
multidimensional in their implementation. This article provides a systematic approach to guide therapists in developing a functional upper extremity training program for stroke survivors.

**Summary and Significance**

This is an excellent review on task-oriented model of practice. It provides a superb guideline for stroke rehabilitation. For occupational therapist, we should 1) start the therapy session with the patient in a good starting position that facilitates optimal upper extremity movement; 2) incorporate the involved upper extremity into all functional tasks; 3) position the task to facilitate the desired movement; 4) position ourselves for safety; 5) observe the patient’s response during treatment; and 6) modify the number of steps required for task and give the patient just right challenge. For task selection, we should 1) select tasks based upon impairments identified during the initial assessment; 2) select a task that is meaningful to the patient; 3) select a task that use simple, common objects; 4) consider the shape, size, texture, surface, and rigidity of task objects used; 5) select a task that requires repetition of movement; 6) select a task that requires repetition of the entire task; 7) select a task that requires the same movement we are trying to facilitate; select a task that requires light, easy movement; 8) select a task that requires problem solving; 9) select tasks that do not require precision; and 10) select a task that has a definite beginning and end point. When selecting tasks, we also need to consider the environment. We should 1) avoid environment with excessive sensory stimulation; 2) provide stable surfaces for patients who are fearful; 3) provide contact support to help patients fell safe; and 4) consider the height of the work surface.

This review provides a comprehensive guideline on task-oriented rehabilitation approach. I will use it to guide me to design occupation-based therapy. I think all suggestions are so good that I need to read this paper again and again.

**Abstract**

OBJECTIVE. We examined the efficacy of a remotely based arm rehabilitation regimen. A 62-year-old man participated in occupation-based, task-specific practice of activities of daily living (ADLs) >3 years after stroke. The entire regimen was administered over the Internet using personal computer–based cameras and free network meeting software.

METHOD. Fugl-Meyer Assessment (FM), Action Research Arm Test (ARA), and Canadian Occupational Performance Measure (COPM) were administered before intervention. One week after treatment, FM, ARA, and COPM were readministered.

RESULTS. The participant exhibited reduced impairment and reduced functional limitation. He also expressed enhanced satisfaction with his ability to perform ADLs and rated his ADL performance better after intervention. The participant could now drive using both hands, use eating utensils, and catch and throw a ball.

CONCLUSION. Data suggest feasibility and efficacy of a remotely based, inexpensive approach using functional electrical stimulation for affected arm rehabilitation after stroke.

**Summary and Significance**

This report was a case study. It will be the format for me to fellow in my Capstone Dissemination. There are some unique characteristics about this study: 1) the patient used functional electrical stimulation device Bioness H200 by himself at home, 2) Intervention sessions were instructed on the internet, 3) Intervention occupations were meaningful and
purposeful occupations of daily living, 4) OT used Canadian Occupational Performance Measure (COPM) to measure the patient’s satisfaction.

This is a proof-of-concept study on feasibility of telerehabilitation and electrical stimulation. In my case, I may use telerehabilitation to observe and instruct my patients’ home exercise program.


**Abstract**

**Background.** Existing task-specific practice interventions do not increase movement in stroke patients exhibiting minimal distal movement in the paretic upper extremity. Although often used, an important limitation of conventional electrical stimulation is that it does not involve task-specific practice. **Objective.** To determine the impact of an activity-specific electrical stimulation program on paretic limb impairment, functional limitation, and ability to perform valued activities in a subacute stroke patient exhibiting minimal paretic wrist and hand movement. **Method.** A female subject exhibiting trace paretic hand and finger movement was administered, 9 months after stroke, the upper extremity section of the Fugl-Meyer Impairment Scale (FM), the Action Research Arm Test (ARAT), and the Arm Motor Ability Test (AMAT). She then engaged in paretic upper extremity, task-specific training incorporating an electrical stimulation neuroprosthesis. Training occurred 3 hours per day, 5 days per week for 3 weeks. The FM, ARAT, and AMAT were again administered. **Results.** After intervention, she exhibited reduced impairment (evidenced by an FM score change of 22 to 29), decreased functional limitation
(evidenced by an ARAT score change of 4 to 10), and increased ability and speed in performing valued AMAT activities. She also reported using the paretic hand and fingers more and new abilities to perform valued activities such as playing piano. **Conclusion.** Although conventional paretic upper extremity training strategies are ineffective in patients at this level, electrical stimulation training incorporating a neuroprosthesis appears promising.

**Summary and Significance**

This was a case study done by Dr. Stephen Page from University of Cincinnati. According to him, it was one of the first repetitive, task-specific practices with functional electrical stimulation in a patient with only trace activity in finger and wrist movements. He described in detail his setup for Bioness H200 and functional activities they used during their therapy. I am sure I need to refer to this paper when I do my capstone. Their patient was a 54 years old woman. She experienced stroke 9 months ago. She underwent 3 hours therapy every weekday for 3 weeks. At the end of her treatment, functions of her paretic upper limb were dramatically improved. This was a very good study. However, I have not read any studies except this one that treated patients for three hours using functional electrical stimulation every weekday (even according to Bioness H200 protocol). It seems a little unrealistic.

I did learn that these activities used in intervention were chosen by the patient. They were meaningful and purposeful to her and she was motivated to do more and more. It suggests to me that I should do the same during my Capstone and avoid rote exercise if possible.


**Abstract**

**Objective:** To evaluate the immediate and long-term effects of 2 upper-extremity rehabilitation approaches for stroke compared with standard care in participants stratified by stroke severity.

**Design:** Nonblinded, randomized controlled trial (baseline, postintervention, 9mo) design.

**Setting:** Inpatient rehabilitation hospital and outpatient clinic.

**Participants:** Sixty-four patients with recent stroke admitted for inpatient rehabilitation were randomized within severity strata (Orpington Prognostic Scale) into 1 of 3 intervention groups. Forty-four patients completed the 9-month follow-up.

**Interventions:** Standard care (SC), functional task practice (FT), and strength training (ST). The FT and ST groups received 20 additional hours of upper-extremity therapy beyond standard care distributed over a 4- to 6-week period.

**Main Outcome Measures:** Performance measures of impairment (Fugl-Meyer Assessment), strength (isometric torque), and function (Functional Test of the Hemiparetic Upper Extremity [FTHUE]).

**Results:** Compared with SC participants, those in the FT and ST groups had significantly greater increases in Fugl-Meyer motor scores (*P* = .04) and isometric torque (*P* = .02) posttreatment. Treatment benefit was primarily in the less severe participants, where improvement in FT and ST group Fugl-Meyer motor scores more than doubled that of the SC group. Similar results were found for the FTHEU and isometric torque. During the long term, at 9 months, the less severe FT group continued to make gains in isometric muscle torque, significantly exceeding those of the ST group (*P* < .05).
Conclusions: Task specificity and stroke severity are important factors for rehabilitation of arm use in acute stroke. Twenty hours of upper extremity–specific therapy over 4 to 6 weeks significantly affected functional outcomes. The immediate benefits of a functional task approach were similar to those of a resistance-strength approach, however, the former was more beneficial in the long-term.

Summary and Significance

This study was done at Rancho Los Amigos National Rehabilitation Center, Downey, CA. It was designed as a feasibility trial in preparation for a larger-scale, single-blind, and multisite phase III randomized clinical trial so it had a small sample size. Their results were clearly showed in their abstract. I did learn something from this study. 1) They used Orpington Prognostic Scale to stratify subjects by severity into different intervention. I think it is a wise choice because occupational therapy emphasizes just right challenge. 2) Their task-specific functional training focused on the systematic and repetitive practice of tasks that could be performed within the level of available voluntary motion. Their tasks were progressively arranged and customized to account for any unique proximal-to-distal recovery patterns of reaching and grasping actions. All their tasks were designed to be standard, repeatable and to have some functional goal (eg, pointing, grasping, and stirring). The principles of motor learning were applied during the treatment and patients were given progressed tasks to keep the participants challenged, motivated, and engaged. 3) It had an appendix on functional test for the hemiparetic upper extremity I can adapt to use in my Capstone Practicum.

Constraint-induced Movement Therapy

Abstract

Background

In stroke patients, upper limb paresis affects many activities of daily life. Reducing disability is therefore a major aim of rehabilitation programmes for hemiparetic patients. Constraint-induced movement therapy (CIMT) is a current approach to stroke rehabilitation that implies the forced use and the massed practice of the affected arm by restraining the unaffected arm.

Objectives

To assess the efficacy of CIMT, modified CIMT (mCIMT), or forced use (FU) for arm management in hemiparetic patients.

Search methods

We searched the Cochrane Stroke Group trials register (last searched June 2008), the Cochrane Central Register of Controlled Trials (CENTRAL) (The Cochrane Library Issue 1, 2008), MEDLINE (1966 to June 2008), EMBASE (1980 to June 2008), CINAHL (1982 to June 2008), and the Physiotherapy Evidence Database (PEDro) (June 2008).

Selection criteria

Randomised control trials (RCTs) and quasi-RCTs (qRCTs) comparing CIMT, mCIMT or FU with other rehabilitative techniques, or none.

Data collection and analysis
Two review authors independently classified the identified trials according to the inclusion and exclusion criteria, assessed methodological quality and extracted data. The primary outcome was disability.

**Main results**

We included 19 studies involving 619 participants. The trials included participants who had some residual motor power of the paretic arm, the potential for further motor recovery and with limited pain or spasticity, but tended to use the limb little if at all. Only five studies had adequate allocation concealment. The majority of studies were underpowered (median number of included patients was 15) and we cannot rule out small-trial bias. Six trials (184 patients) assessed disability immediately after the intervention, indicating a significant standard mean difference (SMD) of 0.36, 95% confidence interval (CI) 0.06 to 0.65. For the most frequently reported outcome, arm motor function (11 studies involving 373 patients), the SMD was 0.72 (95% CI 0.32 to 1.12). There were only two studies that explored disability improvement after a few months of follow up and found no significant difference, SMD -0.07 (95% CI -0.53 to 0.40).

**Authors’ conclusions**

CIMT is a multifaceted intervention: the restriction to the normal limb is accompanied by a certain amount of exercise of the appropriate quality. It is associated with a moderate reduction in disability assessed at the end of the treatment period. However, for disability measured some months after the end of treatment, there was no evidence of persisting benefit. Further randomized trials, with larger sample sizes and longer follow up, are justified.

**Summary and Significance**

This is an authoritative meta-analysis article on constraint-induced movement therapy. It included randomized clinical trials up to 2008 and based on 19 studies involving 619 participants.
To measure disability, they concluded that there was no evidence of persisting benefit. According to their analysis, the majority of studies included had a small sample size (median number of included patients was 15) and there might be small-trial bias. I had to agree with them.


Abstract

AIM:

Upper extremity paresis is a leading cause of disability after stroke. A Cochrane review found an impact on disability of Constraint-Induced Movement Therapy (CIMT), its modified forms (mCIMT) and Forced Use (FU), with a moderate significant effect and a large significant effect on arm motor function. This article aims to present an update of the Cochrane review and assess the effects of CIMT, mCIMT and FU on disability and arm motor function.

METHODS:

Electronic databases were searched for Randomised Controlled Trials (RCT) and quasi-RCTs comparing CIMT, mCIMT or FU with other rehabilitative techniques, or none, in adult stroke patients. The primary and secondary outcomes were disability and arm motor function. Two reviewers independently screened search results, documented the methodological quality and extracted data.

RESULTS:

Four new studies were added to the previous review, for a total of 18 studies. The updated meta-analyses no longer indicate a benefit of CIMT mCIMT and FU on disability (eight studies, 276
participants, Standardised Mean Difference (SMD) 0.21, 95% CI -0.08 to 0.50), and a moderate benefit on arm motor function (14 studies, 479 participants, SMD 0.44, 95% CI 0.03 to 0.93).

**CONCLUSION:**

New evidence pushes the overall estimate of benefit toward the null effect. The majority of studies were underpowered and imprecise, exposing these analyses to small-study bias. This may explain why accumulation of evidence makes overall estimates inconsistent. Larger randomised trials to resolve these uncertainties are needed.

**Summary and Significance**

This was a updated version of meta-analysis on constraint-induced movement therapy from *Cochrane Database of Systematic Reviews* 2009, Issue 4. Art. No.: CD004433 by same group of authors. In this systematic analysis, it added 4 new studies and got same conclusion. I wish all researchers should have strict training on how to conduct their design and their trials.

**General Review**


**Abstract**

**Background**

Occupational therapy aims to help people reach their maximum level of function and independence in all aspects of daily life.

**Objectives**
To determine whether occupational therapy focused specifically on personal activities of daily living improves recovery for patients following stroke.

**Search methods**

We searched the Cochrane Stroke Group Trials Register (last searched January 2006). In addition, we searched the Cochrane Central Register of Controlled Trials (CENTRAL) *(The Cochrane Library Issue 1, 2006)*, MEDLINE (1966 to March 2006), EMBASE (1980 to March 2006), CINAHL (1983 to March 2006), PsycLIT (1974 to March 2006), AMED (1985 to March 2006), Wilson Social Sciences Abstracts (1984 to March 2006) and the following Web of Science databases: Science Citation Index (1945 to March 2006), Social Science Citation Index (1956 to March 2006) and Arts and Humanities Citation Index (1975 to March 2006). In an effort to identify further published, unpublished and ongoing trials we searched The Occupational Therapy Research Index and Dissertation Abstracts register, scanned reference lists of relevant articles, contacted authors and researchers and handsearched relevant journals.

**Selection criteria**

We identified randomised controlled trials of an occupational therapy intervention (compared to usual care or no care) where stroke patients practiced personal activities of daily living, or performance in activities of daily living was the focus of the occupational therapy intervention.

**Data collection and analysis**

Two review authors independently selected trials and extracted data for pre-specified outcomes. The primary outcomes were the proportion of patients who had deteriorated or were dependent in personal activities of daily living and performance in personal activities of daily living at the end of follow up. We identified 64 potentially eligible trials and included nine studies (1258
participants). Occupational therapy interventions reduced the odds of a poor outcome (Peto odds ratio 0.67 (95% confidence interval (CI) 0.51 to 0.87; P = 0.003), and increased personal activity of daily living scores (standardised mean difference 0.18 (95% CI 0.04 to 0.32; P = 0.01). For every 11 (95% CI 7 to 30) patients receiving an occupational therapy intervention to facilitate personal activities of daily living, one patient was spared a poor outcome.

**Authors’ conclusions**

Patients who receive occupational therapy interventions are less likely to deteriorate and are more likely to be independent in their ability to perform personal activities of daily living. However, the exact nature of the occupational therapy intervention to achieve maximum benefit needs to be defined.

**Summary and Significance**

The most important goal for occupational therapy is to return their patients to their independence with their daily life while activities of daily living are the essential part of people’s daily life. In this authoritative systematic analysis, they identified 64 potential eligible studies and 9 studies were included in this analysis (total 1258 participants). Their conclusion showed that occupational therapy prevents the patients’ functional deterioration and these patients received occupational therapy are more likely to be independent in their daily life. This article should be like music to the ear of occupational therapy professionals and it confirms the value of occupational therapy.

**Writing group members, Lloyd-Jones, D., Adams, R.J., Brown, T.M., Carnethon, M., Dai, S., …**

**American Heart Association Statistics Committee and Stroke Statistics Subcommittee.**

**Summary**

Each year, the American Heart Association, in conjunction with the Centers for Disease Control and Prevention, the National Institutes of Health, and other government agencies, brings together the most up-to-date statistics on heart disease, stroke, other vascular diseases, and their risk factors and presents them in its Heart Disease and Stroke Statistical Update. The Statistical Update is a valuable resource for researchers, clinicians, healthcare policy makers, media professionals, the lay public, and many others who seek the best national data available on disease morbidity and mortality and the risks, quality of care, medical procedures and operations, and costs associated with the management of these diseases in a single document. Indeed, since 2000, the Statistical Update has been cited more than 6500 times in the literature (including citations of all annual versions). In 2008 alone, the various Statistical Updates were cited approximately 1300 times (data from ISI Web of Science). In recent years, the Statistical Update has undergone some major changes with the addition of new chapters and major updates across multiple areas. For this year’s edition, the Statistics Committee, which produces the document for the American Heart Association, updated all of the current chapters with the most recent nationally representative data and inclusion of relevant papers from the literature over the past year. In future years, the Committee plans for the Statistical Update to be a major source for monitoring both cardiovascular health and disease in the population, with a focus on progress toward achievement of the American Heart Association’s 2020 Impact Goals. In addition, future Statistical Updates will begin to incorporate the vast amounts of data
becoming available from large population-based efforts to study the genetics of cardiovascular disease (CVD).

**Summary and Significance (focus on stroke)**

This paper is an authoritative paper from the American Heart Association on heart disease and stroke statistics. It is updated annually. This one is the latest update. The statistical update on heart disease and stroke provides a valuable resource for researchers, clinicians, healthcare policy makers, media professionals, the lay public, and many others. It covers disease prevalence and incidence, demographic information, the risk factors, public awareness of warning signs and risk factors, quality of care, medical procedures and operations, and costs associated with the management of these diseases in a single document. Stroke is the leading cause of disability and the third leading cause of death in the United States. Each year approximately 795,000 individuals experience stroke with 610,000 sustaining an initial event and the remaining 185,000 a reoccurrence of stroke. The indirect and directs costs of stroke for 2010 is $73.7 billion. Considering the seriousness of stroke and its effect on patients’ quality of life, effective rehabilitation is highly needed.

This paper will provide background and statistics data for my capstone case study.


**Abstract**

Stroke often leads to impairment of hand function. Over the following months a variable amount of recovery can be seen. The evidence from animal and human studies suggests that reorganization rather than repair is the key. Surviving neural networks are important for
recovery of function and non-invasive techniques such as functional magnetic resonance imaging allow us to study them in humans. For example, initial attempts to move a paretic limb following stroke are associated with widespread activity within the distributed motor system in both cerebral hemispheres, more so in patients with greater impairment. Disruption of activity in premotor areas using transcranial magnetic stimulation prior to movement can impair motor performance in stroke patients but not in controls suggesting that these new patterns of brain activity can support recovered function. In other words, this reorganisation is functionally relevant. More recently, research has been directed at understanding how surviving brain regions influence one another during movement. This opens the way for functional brain imaging to become a clinically useful tool in rehabilitation. Understanding the dynamic process of systems level reorganization will allow greater understanding of the mechanisms of recovery and potentially improve our ability to deliver effective restorative therapy.

Summary and Significance

This is a review article, which analyzes and evaluates recent articles on cortical reorganization after stroke during hand function recovery. As we all know, after stroke, there is an area of brain damage and this area will not be able to generate motor signal to spinal cord neurons. However, some patients do recover their hand function innervated by this region. Researchers have long suspected that the recovery was caused by adaptive reorganization (cerebral reorganization).

It has been confirmed by multiple studies, which showed that greater task-related activity in secondary motor areas such as dorsal and ventral premotor cortices (PMd and PMv), supplementary and cingulate motor areas in both affected and unaffected hemispheres and contralesional M1 in more impaired patients. M1 refers to the primary motor cortex, a brain
region that in humans is located in the posterior portion of the frontal lobe. It works in
association with pre-motor areas to plan and execute movements.

This review provides a very nice summary of available evidences supporting brain
neuroplasticity after stroke.