CHAPTER V

DISCUSSION

This study indicated that 24 sessions of training on the workstation was associated with improvement in upper extremity function in 12 subjects with chronic hemiplegia. All subjects included in the study were more than 6 months post stroke, at which spontaneous recovery was unlikely to expect (60, 61). Moreover, all outcome measurements appeared unchanged between pretesting sessions. Thus, spontaneous recovery of upper extremity functions could not involve the improvement after treatment. Therefore, the quantitative parameters represented improvements in hemiplegic arm function were resulted from the circuit training.

Changes of strength and spasticity

Hemiparesis after stroke had a direct effect on decreasing force generation ability, people after stroke also took hard to reach the peak torque and decreased the upper limb dexterity (90, 91). After 6-week training, the strength gains were increased higher than initially measured and the muscle tone which measured using an isokinetic dynamometer remained unchanged during the circuit training of upper extremity. These results were similar with previous studies (43, 92) which showed that the muscle tone remained unchanged during training of the rapid and vigorous muscle contraction of the upper and lower extremity (43, 92).

Badics et al (43) studied the effects of strengthening exercises on muscle tone and strength in 56 patients with stroke. All patients received exercise program for restoring the strength of the legs and the arms by leg and arm pressing for 4 weeks. The program consisted of 3-5 sets of 20 repetitions at 30-50 % of maximum strength. The results showed that strength gain was positively correlated with the intensity and the number of exercising units. The muscle tone measuring with the Ashworth scale were not increase in any cases. Teixera-Salmela et al. (92) also discussed on the strength training program including 30 minutes of strength training and several lower extremity muscles exercise at 50-80 % of the 10 repetitions maximum for 3 sets. They found that the isometric, eccentric and concentric exercises did increase significantly in the group who participated in the 10 weeks program without change in the pendulum test which was used to measure spasticity.

The type of exercise intervention focused on the hemiparetic upper extremity was important. Patients who demonstrate upper extremity weakness after stroke but had the ability to actively move their limbs against gravity, were received resisted exercise using weights or an isokinetic machine (43, 92-94). For patients who lacked sufficient strength for a resisted exercise program, other types such as the self exercise training were needed. The non paretic arm was used to assist the affected side movement. Although the resisted exercise certainly increased the muscular strength, the active-assisted repetitive movements were reported to improve motor control and coordination (78, 95). Lum (78) compared the passive and progressive resistance with the robot therapy. Twenty stroke patients received 1 hours of reaching training using the robotic device 3 times each week for 6 weeks. Both groups had significant change in motor control as measured by the Fugl-Meyer, Status Scale and motor power scores. Fasolis' study (95) compared active-assisted or resisted reaching by robotic arm to the equal sessions of neurodevelopmental treatment. The results showed that patients who received the robotic training had greater gains in proximal upper extremity strength, Fugl-Meyer score, FIM score and reaching distance. Thus, the active-assistance exercise was the effective technique to increase strength gain in patients with stroke (76-78, 95).

The circuit training showed that various types of intervention, that is strengthening and repetitive passive-active movement training were found to be effectively improve strength in person with CVA. The intervention program can be progressed by altering time and form of rehabilitation therapy. The flexor and extensor muscle group of upper limb were specifically trained via circuit station and were measured directly. Other movement directions such as shoulder adduction/abduction were not shown in this research. The physiological mechanism underlying the increase in strength cannot be determined on the basis of the current data. However, practicing on the circuit exercise training may be similar to the standard exercises in the improvement of motor unit recruitment and development of the patterns of coordination between agonist and antagonist muscles (96, 97).

Based on this study, there was no significant decreased in the muscle tone after training. This study was designed to show whether circuit training increased motor performance without the increase of the spasticity. A few reasons may explain the result. First, the subject inclusion criteria were more than six months post stroke in which degree of spasticity might be steady. Because spasticity after stroke has been shown to reach peak within one to three months after onset (98). Second, Tsai et al (99) have studied the effect of prolonged muscle stretch (30 minutes) on the patients with spasticity. Tsai and coworker (99) suggested that prolonged muscle stretching may decrease motor neuron excitability and improve the function of the antagonist. In the present study, stretching duration was less than 30 minutes. This protocol might not affect excitability of motor neuron. The stretching exercise stations were mainly prepared muscle tone for the vigorous exercise and maintained range of motion and muscle length. However, it is possible that circuit training may have the long term effects on neurological and biomechanical aspects of the spastic muscles.

On this study, we used only the isokinetic dynamometer to measure response to passive movement of the elbow joint. No EMG data were recorded during the mearurement. Therefore we need to believe that participants were actually relaxed before measuring the spastic torque. From this limitation, the EMG may be used to indicate details of the spasticity (base line during relaxation and the amplitude of EMG during testing) in the future study.

Changes of active range of motion

There was a significant increase in the AROM of the shoulder, the elbow and the wrist joints. These results might be due to exercise (through the active stretching, various types of exercise and task practice) which were major factors in improvement of motor performance.

The static stretching and strengthening exercises were found to effectively improve ROM in patients with CVA (100-101). Hutchinson (100) demonstrated that 10-week manual therapy program followed by stretching, strengthening, and home exercise program resulted in substantial gains in both passive and active movements, as well as functions of the UE. Similarly, Kluding (101) described joint mobilization exercise to improve ankle ROM, ankle kinematic during sit to stand and time to complete the task. The results showed that all subjects significantly increased passive ankle ROM after 13 sessions of exercise. These evidences (100-101) showed the improvement of ROM in patients with CVA after receiving interventions for short period of time (ranging from 5 to 10 weeks). However, no consistency is apparent with regard to how long stretch will be benefit for patients. Borms et al. (102) speculated that ten seconds of static stretching was sufficient to elicit a Golgi tendon organ response and therefore provided an effective flexibility training stimulus. However, Roberts et al. (103) found that holding long stretch may result in greater improvements in active ROM. In this study, each position was stretched 30 seconds/action with four repetitions. This protocol may be sufficient to elicit a Golgi tendon organ response.

There was evidence that repetitive exercise could increase range of motion and decrease resistance to passive movement (61, 64). Repetitive and the feedback of movement (visual cueing from a mirror and auditory cueing from a therapist) were based on motor learning principle and might also contribute to motor relearning in hemiparetic patients. Classen (104) demonstrated that the short period of practicing in the simple motor movement could change the cortical motor map. He used transcranial magnetic stimulation (TMS) to produce 15 to 30 minutes of repetitive thumb movement. After training, the cortical area responsible for controlling thumb movement demonstrated cortical rearrangements. Moreover, Butefisch et al. (14) showed that the repetitive movement was benefit for the motor rehabilitation of a paretic arm. The training consisted of repetitive hand and finger flexion and extension. It was carried out twice daily during 15 to 20 minutes period. Grip strength, peak force and peak acceleration of isometric hand extension significantly improved after training period.

A number of circuit training stations naturally required the coordination of both hands. Whitall et al. (16) suggested that both arms were strongly linked as a coordinate unit in the central nervous system. Because the circuit training did not constrain a non paretic arm, bilateral action of the two limbs during exercise might facilitate or promote the performance.

The protocol of circuit training focused on arm functional activities was consisted of scapular control, proximal strengthening, and the shoulder and the elbow coupling for the transport phase of reaching. The transport phase of reaching defined as the beginning of the movement until an object is grasped. After training, patients demonstrated significant improvements in speed or force of movement and the movement ability, depending on the task on the mWMFT. The test quantifies upper extremity movement ability through timed single- or multiple-joint motions and functional tasks. The mWMFT also arranged in order of complexity, progress from proximal to distal joint involvement. Tasks 1st to 6th of the mWMFT involved timed joint-segment movements, and tasks 7th to 15th was consisted of timed integrative functional movements. On the clinical observation, patients progressed in speed and smoothness of movement or fluidity especially in the tasks 1st to 6th. Patients also showed the progression of proximal arm movement and isolated joint movement. However, some patients were still unable to complete complex (multijoint) activities. This failure was probably due the inability to grasp in the functional task. Thus, the amount of improvements resulted from the circuit training program depends on the initial control of grasping, and the desired motor tasks.

Without intervention, stroke survivors often use an uninvolved limb to accomplish functional goal, which results in learned nonuse phenomenon (11). In addition, prolong failure to use the paretic limb could produce secondary change such as immobile muscles, connective tissue shortening and deformity. The circuit training can prevent these changes and promote recovery via active participation.

Changes of functional outcome measures

The results indicated that participants showed significant improvement in performance on both the mWMFT and MAL. Two important aspects of the circuit training may promote the UE function. First, practicing circuit training can improve strength and voluntary control of UE. Muscular strength might be a major contribution to functional improvement because it was a prerequisite to performing tasks. A few studies have shown the effect of exercise on function in stroke subjects who were moderately weak. Exercise could not only improve strength, but also accompanied by improvement in function (43, 92-94). The voluntary movement and dexterity to do function were improved as reflected by the ability score and time score of mWMFT. The second aspect address may be the unmasking of patients ability. The patients had the ability to perform activity using the affected arm but this potential was masked from compensatory movements and the difficulty in using the affected arm. Taub et al. (105) have stated that changes that occur quickly after practice are more likely to represent the unmasking of the dormant neuromuscular pathways rather than neural organization or plasticity. Circuit training encouraged the use of the hemiplegic arm through the training session. Kwakkel et al. (106) investigated the effects of different intensity of arm and leg rehabilitations training on functional recovery. They concluded that the greater intensity of both leg and arm rehabilitations could improve higher treatment effect than the less training. The circuit training required more frequent attempts to use the impaired UE. This repetition may encourage the improvement in functional task.

The effective factors in this treatment appear to be the massing or concentration of practice in the use of the affected extremity for several sessions during a period of consecutive weeks. This therapy has been found to produce an improvement in the function and amount of use of an affected upper extremity as measured using mWMFT and MAL. Experience and learning induced from practice can transfers into the real world environment. Pascural et al. (107) demonstrated that gaining explicit knowledge of a task also changes motor cortex excitability. The process might have occurred as the patients required less movement time and increased amount of use of the affected extremity.

Generally, the brain has the potential to reorganize its function connectivity and therefore must also alter its structure in response to experience and cortical reorganization emerges in response to massed practice of behavioral relevant tasks (108). It is possible that circuit training might produce its therapeutic effect through the induction of cortical reorganization. This process enhances recovery-associated plastic changes that occur in the human brain after stroke (108-109). The mechanism of cortical reorganization probably reflects either an enhancement of the synaptic efficacy of existing connection and/or structural changes of brain mapping (110). Constraint-induced therapy (10-11) involved repetitive practice of tasks for three to six hours per day for six to twelve weeks. It has been found to produce cortical reorganization. Although circuit training requires less amount of training, the cortical plasticity results from the increased use of arm in the program is expected.

Muscular strengthening and repetition are not only two factors which explain the increase in functional performance. Practicing in a desired activity is another essential factor, Langhammer and Stranghelle (111) suggested that a task specific program was more effective with respect to motor recovery and to the level of independence in the daily living than the Bobath approach which focusing on normalizing tone and movement patterns. The Bobath approach states that inhibition spasticity should result in an improved motor function (112). On the task specific station, time on task and shaping tasks were used to reinforce patient ability. Shaping is applicable to patients at various levels of limb recovery, the shaping procedure involved; First, selecting tasks that were tailored to address the motor deficits of the individual patient. Subject was graded to three groups for selected task. Mild hemiparesis was defined as motor dysfunction that permitted closely full range of movement but with reduced strength, and the patient was able to perform all ordinary motor activities without aids. The tasks involved fine motor activities and specific activities of daily living which used a variety of real objects and environment. Moderate hemiparesis was defined when the arm could be elevated against gravity to the target and have some skill movement of the hand. The functional activities almost included: (a) grasp, (b) release, (c) reach and grasp. Severe hemiparesis was described when the arm could not be elevated against gravity to the target and the hand could not be used functionally. The functional activity involved transport phase of reaching with the use of an assisted device or use an unaffected hand. Second, helping the patient to carry out parts of a movement sequence if they were incapable of completing the movement on their own. Finally, providing explicit verbal feedback and verbal reward for small improvements in task performance. Modeling and prompting of task performance were also used. Tasks involved everyday activities, such as pressing a light switch, moving an object. A therapist was the key person to providing a task which affected progression of training. This station was based on the task orientated approach which could promote transfer of learning from the training to activity of daily living. However, we did not control the effort involved in performing a motor task and performance levels across all subjects. Any differences in efforts across patients could result in the different degrees of recovery. However, the intensity of the circuit training was not as hard as the constraint-induced movement therapy. The standard constraint-induced movement therapy for the upper extremity required 6 hours of daily training for 2 or 3 weeks and wearing a padded mitt for 90% of waking hours (18, 19). The circuit training did not need to restrict the use of the unaffected limb and permitted the less-affected upper extremity free movement. Assistance was given when necessary, while patients used their affected hands. The present study demonstrated that functional gains in a chronic paretic arm could be achieved after 90 minutes/day of the circuit training technique. This protocol is possible to adapt the dose, intensity and timing of training periods or add other variations of circuit activities which may result in the grater motor and functional gain.

CONCLUSION

This study suggested that the clinical trial of circuit training during outpatient rehabilitation was feasible. Six weeks of the training program leaded to a significant improvement in the functional UE performances of chronic hemiparetic patients. This program also improved the upper limb’s strength and the active range of motion. Moreover, some stations of training were simple and hence may be feasible for the home use.

CLINICAL APPLICATION

The circuit training program can be applied to the outpatient service for treatment of the upper limb function in patients with stroke. The results of this study showed that the circuit training could improve not only the physical impairment (such as strength and AROM) but also the functional ability of the affected arm. The various types of therapeutic techniques from the evidence-based research were combined together to maximize or restore motor function in the limited time of training (around 90 minutes). There was adequate resting which helped to reduce the muscle fatigue. The circuit training program also included various types of movements between individual stations which could increase the efficiency of training. Moreover, the participants could participate and run the program by themselves while a therapist had a role as an instructor. The circuit training program can reduce the ratio of the patient to a therapist. In this study, we used one therapist to train the individual patient in the early week of training. When the participants understood the therapeutic program the number of participants was increased during session. The present study could train five stroke patients and used two therapists within two hours. Because the stroke patients usually have complication and long term disability. The patients have large demand for continued rehabilitation program. The advantage of this training program in the domain of time and number of therapist made the circuit training appropriate for the chronic stroke patients who need the effective program in the outpatient service. However, the circuit stations on this study were designed to use in the patients who had some ability to actively move their limb against gravity. For patients who are in the flaccid stage or lack sufficient movement ability, the circuit training program is needed to adapt and more information are required.

FUTURE STUDY

Because of the absence of a control group, we cannot completely compare the circuit training protocol with the other forms of the standard therapy of similar duration. However, the goal of our study was to make an initial evaluation of the efficacy of the circuit training in delivering goal-directed training with quantified outcomes to a defined group of chronic stroke patients who were stable motor function and were able to partially move their upper limb. In this regard, the circuit training proved to be practicable and useful for the selected criteria of stroke patients. Further research may compare the circuit training with standard outpatient service to confirm the result. Furthermore, it needs to understand the dose, intensity and timing of training. In the present study, we applied a 90 minutes of therapy specific to the upper extremity for 24 sessions and distributed it over a 6-7 weeks period. Kwakkel et al (106) shown dose-dependent effect of rehabilitation, with more time spent in training leading to greater recovery. Therefore increased timing of training and collected data on the long term follow up are likely to increase confidence in the clinical findings. A further examination in other conditions of stroke such as in the flaccid upper limb function and in determining the optimal dose, intensity and the timing of training in the circuit training of stroke are needed.