CHAPTER II

LITERATURE REVIEWS

Definition of stroke

Stroke is defined by the World Health Organization (WHO) as “a clinical syndrome characterized by rapidly developing clinical symptoms and/or signs of focal and at times global loss of cerebral function, with symptoms lasting more than 24 hours or leading to death, with no other apparent cause other than that of vascular orgin” (30). There are two major categories of brain damage in stroke patients.

1) Ischemias refer to a lack of blood flow depriving brain tissue of needed fuel and oxygen. Ischemic strokes are divided by pathophysiologic mechanism into thrombotic and embolic types (31).

- Thrombosis refers to an obstruction of blood flow due to a localized occlusive process within one or more blood vessels.
- Embolic refers to strokes which caused by migration of material to central nervous system blood vessels from some distant source causing vascular occlusion and ischemia of brain tissue.

2) Hemorrhage refers to the release of blood into the brain and into extravascular spaces within the cranium. Bleeding damages the brain by cutting off connecting pathways and by causing localized or generalized pressure injury to brain tissue.

Hemorrhage can be further subdivided into two subtypes; intracerebral and subarachnoid hemorrhage (31).

- Intracerebral hemorrhage describes bleeding directly into the brain substance. The cause is most often hypertension, with leakage of blood from small intracerebral arterioles damaged by the elevated blood pressure.
- Subarachnoid hemorrhage describes blood leaks out of the vascular bed on to the brain's surface and is disseminated quickly via the spinal fluid pathways into the spaces around the brain. Bleeding most often originates from aneurysms or arteriovenous malformations, but bleeding diatheses or trauma can also cause subarachnoid hemorrhage.

Impaired upper extremity function is one of the most common problems of a cerebrovascular accident. The Copenhagen stroke study included 515 stroke patients, 69% of whom had mild to severe upper extremity dysfunction on admission (5). The impairments in the upper extremity of stroke survivors reviewed in this study including spasticity, weakness, contractures and inefficient movement pattern.

Impairments and disability in the UE of strokes survivors

Spasticity

Spasticity, which is a positive symptom according to Jackson's classification system (32). It is defined as a motor disorder characterized by a velocity-dependent increase in tonic stretch reflexes with exaggerated tendon jerks. Spasiticity results from hyperexcitability of the stretch reflex. In a normal recovery after a flaccid stroke, an initial period occurs with little resistance to passive motion of the muscles and joints (32, 33). Four specific phenomena may be variably observed in the constellation of spasticity: hypertonia (frequently velocity dependent and demonstrating the clasp-knife phenomenon), hyperactive (phasic) deep tendon reflexes, clonus, and spread of reflex responses beyond the muscle stimulated (33). The upper extremity is usually in a flexor pattern and occurs throughout the hemiplegic side. Generally patients with spasticity having difficulty initiating rapid alternating movements and have abnormally timed electromyographic activation of the agonist and antagonist (34).

Sahrmann and Norton (35) studied normal subjects and subjects with upper motor neuron symptoms. The movement pattern studied was alternating flexion and extension of the elbow. The analysis of their electromyographic findings showed that the primary cause of impaired movement was not antagonist stretch reflexes. They found that limited and prolonged agonist contraction recruitment and delayed cessation of agonist contractions after movement had stopped were the main causes of the poor motor control. Therefore rather than focusing treatment on inhibiting spasticity, therapists should train patients to perform alternating movement patterns.

Fellows, Kaus, and Thilmann (36) studied the importance of hyperreflexia and paresis on voluntary arm movements in normal subjects and subjects with spasticity resulting from a unilateral ischemic cerebral lesion. The subjects with spasticity showed a lower maximum movement velocity; the more marked the paresis, the greater the reduction in maximum velocity. No relationship was found between the degree of voluntary movement impairment and level of passive muscle hypertonia in the antagonist. The conclusion was that agonist muscle paresis, rather than antagonist muscle hypertonia, had the most significant effect on impaired voluntary movement.

The traditional training for managed spasticity is stretching and develops motor control. Hummelsheim et al. (37) studied the results of sustained stretch in spastic patients. They found that sustained muscle stretch of approximately 10 minutes led to a significant reduction in the spastic hypertonus in the elbow, the hand, and the finger flexors. They hypothesized that this benefit is a result of stretch receptor fatigue or adaptation to the new extended position. Perry (38) emphasized early mobilization and assistance with developing evolving motor control into effective function. These two interventions resulted in minimal contractures and prevent improper use of patients' available control mechanisms. He summarized the effective rehabilitation of a patient with spasticity by using five methods: contracture minimization, realistic planning, muscle strength preservation and restoration, enhancement of returning control, and substitution for permanent functional loss.

Weakness

Weakness of the upper extremity musculature plays a major role in upper extremity dysfunction. Muscle weakness is reflected by the inability of patients to generate normal levels of muscle force.

Bourbonnias and Noven (39) reviewed the physiologic changes in the nervous system that contribute to muscle weakness in patients with hemiparesis. They summarized specific changes at the motor neuron and muscle levels.

- Motor neuron changes: loss of agonist motor units, changes in recruitment order of motor units, and changes in the firing rates of motor units
- Nerve changes: changes in peripheral nerve conduction
- Muscle changes: changes in the morphologic and contractile properties of motor units and in the mechanical properties of muscles

Many of the traditional perspectives on neurorehabilitation held that, of these motor sequelae, spasticity presented the most significant limitation to recovery of normal motor function. Moreover, because physical exertion was clinically observed to exacerbate spasticity, therapeutic activities using forceful contractions became strictly prescribed for persons with nervous system injury. Bohannon et al. (40) found that static strength deficits of the shoulder medial rotator and elbow flexor muscles did not correlate with antagonist muscle spasticity. They concluded that therapists might determine that capacity for force production for an agonist muscle based on its own tone rather than that of its antagonist. Gowland et al. (41) studied agonist and antagonist activity during upper limb movements in stroke patients and concluded that treatment should be aimed at improving motor neuron recruitment rather than reducing antagonist activity.

Early approaches to neurorehabilitation emphasized treatment from the techniques to normalize tone, facilitate normal patterns of movement, and decrease cocontraction of paired antagonist muscles (22-24). Recently positive effects of resistance exercise have been demonstrated in persons with poststroke hemiplegia. Winstein et al (42) evaluate the immediate and long-term effects of functional task practice (FT), and strength training (ST) approaches for stroke compared with standard care in participants stratified by stroke severity. The FT and ST groups received 20 additional hours of upper-extremity therapy beyond standard care distributed over a 4- to 6-week period. The results showed that significant increase in composite isometric torque and Fugl-Meyer motor scores when comparing FT and ST versus standard care post treatment. Badics et al. (43) trained resistive exercise of UE and LE of 56 CVA patients. The results showed that mean strength gain increased for the LE was 31% and for the UE was 36.8% and muscle tone, which was abnormally high at baseline, did not further increase in any one case. These studies suggest that strength training can significantly increased muscle power in CVA patients without any negative effects on spasticity.

Contractures and deformities

Contractures are periarticular motion impairments that result from loss of elasticity in the periarticular tissues, which include muscles, tendons, and ligaments (39). Contracture in stroke patients results from immobilization and may be attributed to spasticity, flaccidity, improper positioning, postural malalignment, a lack of variation in limb postures or a combination of various factors. In fact, only 10% of stroke patients recover limb strength and mobility rapidly enough to avoid developing contractures (39).

Contractures usually occur in a pattern of flexion, adduction, and internal rotation; muscles that span two joints are more susceptible to contracture formation (32, 44).

Botte, Nickel, and Akeson (45) have reviewed the literature correlating spasticity and contracture. As a stroke patient progresses to a state of spasticity, the increased activity of the spastic muscles may result in characteristic posturing of the limb, resulting in increased stiffness of the soft tissue surrounding the joint and the eventual formation of fixed contracture. Contracture is associated with loss of elasticity and fixed shortening of involved tissues. Contracture may occur in a variety of soft tissues including the following: skin, subcutaneous tissue, muscle, tendon, ligament, joint capsule, vessels, and nerves.

To prevent shortening of the connective tissue in muscles and joints, passive range of motion (PROM) and active range of motion (AROM) program must be used in traditional rehabilitation (38, 46). Other treatments include positioning with sling or splint, deep-heating modalities, and possible surgical release for long-standing, tight contractures.

Inefficient and ineffective motor control

The abnormal movement patterns caused CVA patients unable to move effectively and therefore unable to interact with the environment. Movement patterns have been described as reflex based, a release of abnormal synergies, the result of reversed inhibition or the release of lower patterns of activity from higher inhibitory control, and as learned patterns of movement. Upper-extremity flexor synergy consists of scapular retraction and/or elevation, shoulder adduction and internal rotation, elbow flexion, forearm pronation, and writs and finger flexion (47).

Ada et al (48) hypothesized that muscle weakness or paralysis effectively immobilized the upper limb, which resulted in soft tissue contracture. The immobility causes length associated changes in muscles, and persistent positioning results in contracture. These changes in the upper limb result in compensatory movements that generate strong neural connections after frequent repetitions, ensuring that the compensatory or adaptive movement patterns become learned rather than more effective and efficient motion. Many of the inefficient movement patterns in CVA patients may result from attempting tasks beyond their level of motor control.

Bernstein (49) introduced the concept of degrees of freedom. He hypothesized that the principal problem faced by the central nervous system was the large number of joints and muscles in the human body and the infinite combinations of muscle action. For example, the upper extremity has multiple degrees of freedom if the number of planes through which each joint moves are combined. When contemplating the combinations of degrees of freedom in the trunk, the scapula, and the shoulder to the hand, it becomes evident that task of controlling is phenomenal. Bernstein states that "The coordination of a movement is the process of mastering redundant degrees of freedom of the moving organ, that is, its conversion to a controllable system (49). With this concept many of the ineffective movement patterns observed in patients can be attributed to attempts to control the degrees of freedom. Therapists need to consider this during treatment planning when choosing activities. The degrees of freedom must be controlled carefully by stabilizing or eliminating use of some of the joints and therefore decreasing the number of joints involved (49).

<u>Disability</u>

Investigator in the Copenhagen Stroke Study showed that functional recovery in more than half of patients with stroke having severe UE paresis can be achieved only by compensation using unaffected UE (50). However, using unaffected UE or compensatory skills may affect the potential recovery in the hemiplegic arm. The phenomenon of learned nonuse was articulated by several authors (18, 20). Studies of laboratory human stroke survivors support the theory that potential motor recovery is limited by a learned nonuse on the affected limbs. Immediately after brain injury, contralateral flaccidity limits functional use of the affected arm and leg (32). Because motor function remains unaffected on the opposite side, most stroke patients compensate by dependence on the intact limbs to perform function. This theory of learned nonuse may explain why upper limb recovery lags behind lower limb recovery. Whereas each attempt to stand or walk requires bilateral activity in the legs, many upper limb activities may be accomplished by using the unaffected side exclusively.

Disability has been assessed in different ways: motor ability, dependency on others, and capacity for work (27). Most methods of disability measurement deal only with activities of daily living (ADL) (51) or instrumental activities of daily living (IADL) (52). However ADL measurement is difficult to test functions of the hemiplegic arm. The WMFT and MAL have been used to document the outcomes related to function of the hemiplegic arm (28, 29). The WMFT includes a variety of tasks such as reaching and manipulative tasks. The therapist times task performance and qualitatively grades movement. The MAL is a self-report questionnaire (report by patient or family) related to actual use of the involved upper extremity outside of structured therapy time. Quality and amount of use are graded on a scale.

Recovery of the brain lesion

Recovery of the brain lesion can occur as a result of changes in neural organization which take place in response to injury. The possibility of plasticity, adaptation or reorganization of undamaged systems in the brain has been reported. Carr et al. (12) have reviewed some of the theories and mechanisms which have been proposed to account for recovery following brain damage as follows:

1. von Monakow's diaschisis theory (53). This is a theory of a temporary traumatic disruption of neural organization and integration, which is a type of 'functional shock'. This theory suggests that the widespread effects of such processes as edema and extracellular blood flow cause a suppression of activity in areas far from the site of the lesion. Similarly, reversible changes may occur in undamaged synapses resulting in a

temporary impairment of neural transmission. This theory could account for any recovery of function in the early period following a lesion.

2. Another theory which may provide part of the explanation for early recovery is that of denervation supersensitivity (54). The axons and terminals degenerate following a lesion and the denervated part of the target cells may develop an increased post-synaptic responsiveness to neurotransmitter substances, becoming increasingly sensitive to the remaining afferent input.

3. Redundancy theory (55). Several parts of the central nervous system may mediate the same motor function. That is, a part of a neural system may adequately mediate the function normally subserved by the system as a whole. Lashley (56) had a similar concept which he called equipotentiality. He suggested that a particular function was mediated by all the tissues in a given region. If part of that region was damaged, the remaining intact tissue would continue to mediate that function. The effect of the lesion would therefore depends more on the amount of tissue spared than on the location of the lesion.

4. Vicarious function (54). The intact system may have had a latent capacity to control the functions which are lost. After a lesion these latent functions would become uncovered.

5. Functional reorganization (54). It is possible that a neural system can change its functions qualitatively, in which case a neural pathway could take over the control of some motor behavior not ordinarily part of its function.

6. Two forms of neural sprouting within the central nervous system have been suggested (56). (a) Regeneration, which refers to new growth in damaged neurons (56). The newly generated axons may re-innervate the denervated areas. (b) Collateral sprouting, in which there is new growth in undamaged neurons adjacent to destroyed neural tissue (56). Sprouting would increase synaptic effectiveness and allow the new system to substitute for the destroyed synapses. The emergence of new synaptic connections may be inductive of a dynamic synaptogenesis which is continually occurring under normal circumstances, enabling the organism to adjust in the face of continually changing environmental needs. These widespread synaptic changes may be the underlying physiological mechanism for a relearning or compensatory process which is actually responsible for recovery (57). This process occurs fundamentally in a learning situation (57). Laurence and Stein (58) suggested that it was possible that in the normal brain, cells might die leaving a number of vacated sites which could be filled by intact cells. Therefore, the mature brain may differ from the immature one by three aspects, that is, the greater number and complexity of its interneural connections and the fine control from the large amount of absolute cell numbers.

7. Behavioral strategy change. This is a form of substitution, in which the strategy utilized in order to achieve a motor goal. Other forms of substitution may involve the use of a different sensory cue for guiding movement (59), or a functional substitution in which the recovered movements are produced differently from the lost movements, although they are essentially similar. However, one of the problems in research in this

area is the difficulty in identifying whether recovery is due to anatomical and physiological changes or to the use of alternative or compensatory strategies by the subject.

The pattern of recovery after stroke is very variable, depending on the patients considered, the criteria used to define independence, and the time at which observations are made. Information on recovery patterns were stratified by initial stroke severity (60). Recovery in neurological impairments was most rapid and preceded recovery in abilities by about 2 weeks (60). Recovery in both impairments and disabilities was most rapid in the least badly affected patients.

The rate of recovery has also been measured in small series of patients seen regularly (60, 61). These studies confirmed that the bulk of spontaneous recovery occurred in the first 3 months after the stroke, with some continued improvement up to 6 months and little change after this.

Some impairment had a similar pattern of recovery as disability. Upper arm paresis showed most recovery between 3 and 6 weeks, depending on initial severity, and by 3 months no further recovery could be expected (5). In a study comparing both upper and lower limb recovery, patterns were similar, with rapid recovery in the first month and a clear plateau reached by 90 days, which rather contradicted to the clinical belief that upper limb recovery was less good than lower limb recovery (2). Also, a general belief among rehabilitation professionals is that the lower limb recovers faster and more completely than the upper limb (62). According to Kwakkel et al. (62), most stroke survivors regained the ability to walk, whereas only between 30 and 66 percent of stroke survivors were able to use their affected arm. Luria (64) suggested that an essential condition of such reorganization was activity dependent. The author also stated that the greater the need, the more automatically and easily would reorganization be carried out. Determination in the rehabilitation program which is appropriate to make a recovery of impairment and function are still in progress.

Neurorehabilitation program

The most widely used clinical rehabilitation were neurodevelopment treatment (NDT) (22) and proprioceptive neuromuscular facilitation (PNF) (23). The main principles of these two treatment techniques are different. The main principles of NDT are to inhibit abnormal movement pattern and facilitate autonomic reaction (22). The main principle of PNF is to strengthen functional movement patterns using sensory stimuli as the facilitation technique (23). From the previous study, both therapeutic interventions had positive treatment effect after training (14). However, many investigators concluded that NDT and PNF techniques were not different from a traditional physical therapy in treating the hemiplegic upper limb (15, 16).

At present, the number of evidences suggested that repetitive, bilateral, and task-specific training were the key characteristics of the effectiveness in the UE rehabilitation program (14-20). The repetitive movement training is benefit for the functional outcome of motor rehabilitation of the paretic arm and hand. This technique has been demonstrated by Butefisch (14). The training consisted of repetitive hand and finger flexion and extension against various loads twice daily during 15 minutes periods. The results of the study emphasized the importance of movement repetition for improvement of strength, and motor function during the training period. Feys et al. (15) compared effect of repetitive sensorimotor training versus control group in which short wave therapy was applied to the shoulder during movement. The treatment group had inflatable splint applied to the hemiplegic upper limb while performing a rocking movements in a rocking chair with hand in the training position. It was showed significant differences between the treatment group and the control group at 6 months and at 12 months on the Motor Status Test for the shoulder and the elbow whereas no difference was observed between the two groups on the Action Research Arm Test.

A number of investigations have examined the efficacy of bilateral training on the recovery of paretic limb movements post stroke (16, 17). Whitall et al. (16) used a custom-designed bilateral arms training machine which required repetitive rhythmical shoulder flexion with elbow extension and the shoulder extension with elbow flexion timed to an auditory cue. The results showed a significant improvement in the Fugl-Myer Upper Extremity Motor Performance Test and WMFT with post-test and retention test. Improvement was seen in the elbow flexion, the wrist flexion isometric strength and in active range of movement in the shoulder extension, the wrist flexion, and the thumb opposition, in addition to functional reaching, grasping and placing of various objects (17). This study found that the performance on all three activities (lifting a cube, simulated drinking, peg the board in the eye level) improved with bilateral isokinetic training (speed constancy movement performed bilaterally but the two limbs performed independence movements). This type of training was compared with unilateral training of paretic limb and bilateral training.

One recent approach was the constraint-induced movement therapy, which focused on physically constraining the nonparetic limb and intense practice of tasks with the involved UE. Vanderlee et al. (18) and Wolf et al. (19) indicated that force-use treatment exerted effect on the functional ability of the hemiplegic arm and hand in patient with chronic stroke. Similarly, Dromerick et al. (20) performed in the acute setting. They compared score change in Action Research Arm Test (ARAT) two weeks after the training and found that a constraint-induced movement therapy was more effective than a traditional therapy. The success following this intervention had been limited to subjects who have moderately good initial UE function and engage in intense supervised practice for long time (18-20). This protocol may not be plausible in outpatient service.

From the evidence-based practice, the functional training, neurofacilitation techniques, and strength training were the approaches which have been used to improve upper extremity function following stroke (18-20, 22-24, 43). However, selection only one approach may not get a successful outcome. For example, the strength training has been reported to mainly increase strength, there was no indication of functional improvement use on the affected upper extremity (42-43). The approach such as forced used therapy (18-20) , repetitive bilateral arm training with rhythmic auditory cueing (16), and repetitive exercise training (14) have been developed to improve function but they were usually involved the one patient to one therapist ratio. After discharged from the acute treatment, a lot of patients could not proceed on the exercise or therapeutic program. The cessation of treatment may increase complication and disability. The concept of circuit training programs is also applicable with the health care policy to prevent secondary disabilities for chronic stroke patients.

Circuit training

Circuit training generally was a form of exercise training in which several different exercises were performed (a combination of aerobic exercise, muscular strength, or endurance training) (65-66). Wilmore et al. (67) used the circuit resistance training (CRT) in persons without disability. The benefit of CRT was well established. There were greater muscular strength and aerobic capacity achieved than performing resistance training and/or aerobic training alone. These results were similarly with Bhambhani et al. (68), who examined the effect of twelve weeks circuit training program to enhanced muscular strength, endurance, and aerobic fitness in patients with traumatic brain injury.

The circuits training in the present study was the therapeutic approach which mixed the evidence-based therapeutic techniques together and aimed to maximize motor function of the hemiparesis upper extremity. Carr and Shepherd (69) suggested that the rehabilitation involved motor learning training could be organized into a circuit with a series of workstations designed to increased muscles strength and provided the performance for task practice. To date, a limited number of studies have evaluated the effect of the stationary exercise in the chronic stroke patient on impaired upper extremity function. Pang et al. (70) used the community-based group program to be an alternative approach to upper extremity rehabilitation after a stroke. A randomized controlled trial (RCT) was conducted to examine the efficacy of two different self directed exercise groups, arm exercise group and leg exercise group (control group) for 19 weeks. In the arm exercise group, the participants were required to rotate through 3 exercise stations. Three stations consisted of 1) theraband exercises movements 2) range of motion, weight bearing activities and the elbow and the wrist exercise 3) hand activities and functional training (hand muscle strength training, functional activity and electrical stimulation to wrist extensors). The results indicated that overall, the arm group had significantly more improvement than the leg group on the WMFT, Fugl-Meyer Assessment (FMA), hand-held dynamometry (grip strength), and the Motor Activity Log score. Dean et al. (71), was designed the circuit program work station. Ten functional task stations focused on strengthening the affected lower limb and practicing functional tasks involving the lower limbs, while the control group practiced upper-limb tasks. The control group designed to improve upper limb function of the affected upper limb. The organization was similar in every respect to the experimental group training (used the circuit workstation, progressed according to performance and given feedback). The results showed that the experimental group demonstrated significant immediate and retained (2-month follow-up) improvement compared with the control group in walking speed and endurance, force production through the affected leg during sit-to-stand, and the number of repetitions of the step test but there were no significant differences between the groups in grip strength and hand dexterity measured over the immediate or retention periods. The failure to demonstrate improvement in upper limb function in the control group were described by many factors including subject inclusion criteria, measurement tools, and the program was trained in subjects with chronic stroke.

The chronic stroke patients had a number of positive and negative signs (27) combinations of which often impaired performance of many of the motor skills, activities of daily living, and independence. The individual impairment-focused programs such as neuromuscular stimulation, stretching exercise, strengthening exercise were difficult to generalize to functional improvements. As the effect of weakness, spasticity and the impairment of voluntary movement caused the limited of functional training. For improved upper extremity motor recovery, the combinations of rehabilitation treatment protocol should emphasis both impairment and functional factors. The seven workstations incorporated into the circuit were:

1) Stretching exercise

The static stretching is the most widely used because of the simplicity motion. The active stretching exercises are used before each training session. The reason were following, first the stretching exercise prepared muscles for training because it activated the muscle nervous system and prevented injuries form other session such as muscle strain (72). Second, the active stretching exercises might reduce muscle tension and increase range of motion (73). Finally, the stretching exercises prevented contracture from muscle shortening, stiffness and spasticity (73).

2) Self active exercise

The active repetitive practice of movements can have a profound effect on recovery from stroke (74). The active training can also positively shape the cortical reorganization associated with motor recovery (75). In this station we used self directed exercise to improve arm movement. However, some patients need the unaffected arm to assist the movement of the affected arm. The effectiveness of the repetitive practice was shown on the robot assisted movement training which used in stroke patients (76-77). The robot assisted movement reported that treatment in the form of repetitive practice of movements and functional activities with a trained assistant was effective (77-78). However, the program used the specific equipment which caused increased cost intensive.

3) Bilateral arm training

Cohen (79) reported that concurrent bilateral movement involved central regulatory mechanism controlling both limbs. Bilateral neural networks may govern upper extremity motor control as a central mechanism (80). This mechanism supports that the two arms had strong coordination. The training movement on both limbs directly stimulated both hemispheres. The program of bilateral training used a sled device at which patients could move their UE in straight line forward and backward through a certain distance. This station was designed to facilitate the isolated motor training. The purpose of this station was to enhance the capability to use bilateral arm concomitant with facilitate the affected arm control.

4) Repetitive sensory training

Poolle (81) found that spasticity of the paretic limb decrease after applying an inflatable pressure splint. An inflatable splint was modified to use in the reflex inhibiting position and could reduce muscle tone and prevent muscle stiffness (82). Robichaud et al. (83) showed that circumferential pressure applied by an air splint around the lower leg reduced soleus muscle motoneuron reflex excitability in subjects with stroke. Long duration stretch techniques (30 minutes) of the involved muscles have been demonstrated to be efficacious in spasticity reduction than over short duration (10 minutes) or ballistic stretching (45). The efficacy of the propioceptive neurofacilitated technique could be attributed mainly to the repetitive stimulation of muscle activity in the arm (15). The muscle activity will increase with the speed of the stretch with a fairly good linear relationship. When the stretch is performed slowly, tone may feel relatively normal, but if it is done more quickly, the resistance will increase. Moreover the rhythmic and repetitive sensory input may improved motor control (84). The repetitive sensory training station was selected to reduce muscle tone by an air splint and slow rocking motion. This combination of relaxation techniques and maintain sensory input (maintain pressure) will help to decrease muscles tone in the affected arm.

5) Repetitive task specific training

There were increasing in evidence that patients were benefit from exercise programs in which functional tasks were directly and intensively trained (18-20). The task-oriented training could induce cortical reorganization in chronic stroke patients (18-20). The main goal of this station was to train the specific task which used both unimanual and bilateral tasks. The functional programs were shaped and considered the opportunity to transfer to the real life.

6) Bilateral isokinetic training

It was known that the reduced magnitude, speed-dependent properties of torque development were following stroke (85). Functional activities often demand performance under concentric and eccentric conditions (86). On isokinetic station, the force was carried over and moved through a maintain speed. The force was produced by the upper extremity muscles making an extension/flexion movement of the arm in the short time. This training required simultaneously motion of the shoulder, the elbow and the wrist in a closed kinematic chain. The training allowed practicing all major muscles of the upper extremity. The isolated overloading from training or provocation of the muscular imbalance could be counteracted (85-87). Then, the use of setting velocities at training might increased the arm strength and dexterity which transferred to the improvement of function.

7) Strength training exercise

The resistance training station aims to improve muscular strength and functional performance. The evidence suggested that persons with poststroke weakness could improve strength through resisted exercise in the absence of negative side effects such as spasticity (43, 88). Accordingly, to improve strength in patients with hemiplegia, studies used the intensity of 60 - 80 percents of 1- RM and a maximum of 10 - 12 repetitions per set for minimum period of 6 to 12 weeks (88 - 89).