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OCCUPATIONAL THERAPY TREATMENTS AND UPPER EXTREMITY MOTOR AND SELF-CARE OUTCOMES OF PATIENTS POST-CVA

by

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A Dissertation

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for the degree of

Doctor of Philosophy

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This dissertation, submitted by Jan E. Stube in partial fulfillment of the requirements for the Degree of Doctor of Philosophy from the University of North Dakota, has been read by the Faculty Advisory Committee under whom the work has been done and is hereby approved.

Richard D. Landry
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This dissertation meets the standards for appearance, conforms to the style and format requirements of the Graduate School of the University of North Dakota, and is hereby approved.

Harvey Knull
Dean of the Graduate School

7-27-00
Date

PERMISSION

Title	Occupational Therapy Treatments and Upper Extremity Motor and Self-Care Outcomes of Patients Post-CVA
Department	Teaching and Learning
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Signature Jan E. Stube

Date 7-18-00

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ABSTRACT

Cerebrovascular accident (or stroke) afflicts approximately 550,000 Americans per year. It is estimated that three million U.S. citizens live with the disabling effects of strokes, which can limit function in one or more of the following areas: mobility, basic activities of daily living, bowel or bladder control, cognition, emotional functioning, among other disabling conditions (Gresham et al., 1995). Occupational therapists, as rehabilitation professionals, provide sensorimotor and basic activities of daily living assessment and intervention to promote recovery of function post-stroke. Upper extremity neuromuscular electrical stimulation is one strategy that may be used to promote motor recovery.

This study's purpose was to investigate the type of post-stroke variables (i.e., demographic, selected medical, and rehabilitative treatments) which contributed to and predicted improved upper extremity motor and activity of daily living outcomes within the context of an acute rehabilitation inpatient hospital setting. One specific treatment, neuromuscular electrical stimulation, was studied for its impact upon overall upper extremity motor and daily living outcomes. Medical records (N=136) served as the primary data source for this study's retrospective document review. Electrical stimulation was provided as a treatment to 13.2% of the sample.

Overall, this study found that in the comparison of the subgroups receiving electrical stimulation or not, the only significant difference was in muscle tone or

spasticity. When the two subgroups were compared by type of CVA or admit to discharge change scores, additional significant differences were observed on some daily living and motor variables. Specifically, the left brain etiology yielded more findings of significant difference than the right brain etiology.

Other study findings included significant differences in admit to discharge ratings of motor, self-care, and functional ratings for the entire sample and significant positive relationships between right or left hand strength and self-care ability. Higher self-care was predictive of higher cognitive ratings; and two OT function tests were predictive of higher self-care skill in a regression analysis.

CHAPTER I

INTRODUCTION

Cerebrovascular accident (CVA), also known as stroke or brain attack to the general population, afflicts approximately 550,000 Americans per year. It is estimated about three million United States citizens live with the disabling effects of strokes, which can limit function in one or more of the following areas: mobility, basic activities of daily living (ADLs), bowel or bladder control, cognition, emotional functioning, pain management, swallowing, or communication (Gresham et al., 1995). According to Woodson (1995), mild weakness or complete motor paralysis on one side of the body is "the most typical manifestation of CVA" (p. 677); this condition is known as hemiparesis or hemiplegia.

Epidemiology of Stroke

Wolf and D'Agostino (1998) present valuable information on the epidemiology of stroke. After heart disease and cancer, stroke accounts for the third leading cause of death in the United States, in fact, every 1 of 15 deaths to be exact. Mortality from stroke varies widely from country to country globally and is also variable in the United States. For example, the lowest death rates from stroke are in the Southwestern United States while the highest rates are in the Southeast, with the states of Georgia, North Carolina, and South Carolina comprising the "stroke belt" where there is a 40% increased risk of stroke comparatively. Overall, in the United States there has been a steady decline of

death rates due to stroke, particularly since 1972, purportedly due to improved medical management of hypertension. The severity rate of stroke has also been on the decline, possibly due to more accurate and early diagnosis through increased public awareness and the medical use of Computed Tomography (CT) scans in diagnosis. Since the incidence of stroke rises with age (doubling each decade of life for both men and women), and as the population of the United States (and other countries) ages, the number of persons affected by stroke is expected to rise (Wolf & D'Agostino, 1998).

Occupational Therapy (OT) as a Rehabilitation Service

Occupational therapists (OTs) are among a cadre o. rehabilitation service professionals who provide treatment to persons post-CVA. In fact, this is the most common diagnosis treated by OTs in clinics or home care (Trombly, 1989). OTs' assessment and treatment of persons post-CVA may occur in a variety of settings including acute care hospitals, rehabilitation centers, skilled nursing facilities, outpatient departments, and home health. Evaluation and treatment of persons post-CV y occupational therapists include three entities: (a) performance areas involvi..g ADLs referred to as self-care, work/productive, and leisure activities; (b) performance components that support sensorimotor, cognitive, and psychosocial/psychological abilities; and (c) performance contexts involving environmental factors that influence skill and performance. Sensorimotor performance components affected by CVA not only include motor control influencing posture and strength (typically on one side of the body), but also sensation, muscle tone, body scheme, and spatial relations deficits that impact the motor system function. In many persons post-CVA, cognitive, psychosocial,

and psychological abilities are also impaired, compounding the sensorimotor system mal-effects (Aquaviva, 1996).

In the discipline of OT for purposes of rehabilitation of adults with physical and/or cognitive disabilities such as post-stroke, it is important to assess and treat the client for functional performance in self-care. "Although assessments of self-care have often defined this concept differently, it is well accepted that self-care includes such activities as hygiene and grooming, feeding, dressing, functional mobility, and functional communication" (Law, 1997, p. 421). These basic ADLs are those tasks that persons perform to maintain their own personal independence. Self-care or basic ADLs are important to assess in persons with disabilities who are hospitalized in rehabilitation units for several reasons cited by Law (1997). These include to describe the person's current functional status, to plan treatment and predict rehabilitation potential and outcome, and to evaluate the outcome of rehabilitation programs in terms of improving persons' functional abilities and skills. Law (1997) further states that "self-care assessments generally reflect a North American value of independence and respect for individual rights" (p. 422). It is common practice in the rehabilitation sciences to assume that clients wish to regain their personal independence in the areas of basic self-care because it allows further ability to partake in community and family activities such as productive work and leisure/social realms.

OT researchers have identified many pertinent self-care assessment issues: (a) that context or environment affects an individual's performance; (b) that individualizing an assessment is important to performance, both for diagnosis of individual differences such as cognition and for motivational purposes; and (c) that endurance and persistence have a

role in overall functional ability on a daily basis (Law, 1997). Therefore, the issue of self-care assessment is complex in nature. Clinicians cautiously use assessments and are aware that context is important in the evaluative process.

The typical OT assessment followed by treatment provided to persons post-CVA includes not only the performance of self-care, but also sensorimotor techniques to help patients relearn ADLs and mobility (Aquaviva, 1996). Common sensorimotor component areas assessed in stroke rehabilitation by occupational therapists include sensory awareness and processing; joint range of motion, muscle tone, muscle strength, postural control, and alignment; and coordination and dexterity. In addition, visual-perceptual, cognitive, and psychosocial skills are assessed and incorporated into the treatment regime to address the holistic perspective necessary for the complex challenges of successful independent living.

While it would seem that the assessment and treatment of individuals post-stroke are well established by the OT profession, questions remain to influence effective practice within the profession. What are the contributing factors to improved upper extremity motor outcome post-stroke? What, if any, sensorimotor or other performance components have a specific effect upon self-care performance at the close of the acute rehabilitation hospitalization period? Furthermore, which of the sensorimotor or additional performance components may serve as predictors of performance at discharge from the acute rehabilitation stay? These questions are addressed by the research study described in this dissertation.

Background of the Study

Since 1995, the American Occupational Therapy Association (AOTA) has challenged its members to pursue research that provides criteria to enable prognostication for patient services, to determine cost-effectiveness, and to measure outcomes of rehabilitation services provided (Foto, 1995). The OT of the 21st century is challenged to select the best CVA treatment approach for the individual from among a myriad of new technologies, treatment options, current neuroscience research that either supports or refutes trends, and various rehabilitation theories of practice.

Many instances can be found in the rehabilitation literature describing specific treatment techniques and/or their effects upon outcome. Historically, numerous rehabilitation approaches are described in the literature for the treatment of upper extremity sensorimotor deficits in CVA survivors (Bobath, 1990; Carr & Shepherd, 1990; Sawner & LaVigne, 1992; Voss, Ionta, & Myers, 1985). Further, contemporary motor learning approaches also are described as potentially helpful to the successful treatment of sensorimotor deficits after stroke (Haugen & Mathiowetz, 1995; Sabari, 1991). However, few studies describe the relationship between improved upper extremity motor ability and function within self-care or other ADL performance contexts. Two studies found no statistically significant relationship between sensorimotor treatment approaches and self-care and other ADL abilities (Woodson, 1995). Grimby, Andren, Daving, and Wright (1998) actually found a decrease in independence in self-care (and social-cognitive items) among stroke survivors two years post-CVA.

Neurologic and functional recovery are generally observed to be most rapid during the first one to three months post-CVA, but may occur up to six months or longer

(Horgan & Finn, 1997; Jorgensen et al., 1995). During that time, stroke rehabilitation takes place beginning in the acute to subacute phases of recovery (i.e., when a diagnosis has been determined and life-threatening problems are no longer of the greatest priority). Stroke rehabilitation involves a restorative learning process and interventions provided by a team of professionals. As defined by the Agency for Health Care Policy and Research (Gresham et al., 1995), the focus of rehabilitation includes "prevention of secondary complications; remediation or treatment to reduce neurological deficits; compensation to offset and adapt to residual disabilities; and maintenance of function over the long term" (p. 10).

With a remedial approach to treatment of persons post-CVA, rehabilitation therapists such as occupational, physical, and speech-language pathologists utilize existing neuroscience research to guide and develop best practice. Several current research studies hold potential for substantiating clinical practice parameters based on sound neuroscience principles for use by OTs in particular.

A study conducted by Jorgensen et al. (1995) determined that time for functional recovery is dependent upon the initial stroke severity. For example, the best self-care functional recovery was made in 8.5 weeks for persons with mild strokes and up to 20 weeks for persons with very severe strokes. They also stated that neurological recovery tended to precede the observable functional recovery by two weeks. This information is helpful in planning the length of rehabilitation based on severity of stroke initially.

Other research helps rehabilitation professionals understand the neural mechanisms for motor recovery and treatment post-stroke. Cramer et al. (1997) studied 20 stroke survivors using functional magnetic resonance imaging (MRI) during a finger

fine-motor task. They found that the cortical blood flow in the unaffected sensorimotor cortical areas of the brain was increased in two-thirds of the patients compared to the control group. In another experimental research study of stroke patients engaged in a fine-motor task, functional MRI revealed bilateral activation of the primary sensorimotor cortex in 50% of the patients and ipsilateral in the other 50%. The authors Cao, D'Olhaberriague, Vikingstad, Levine, and Welch (1998) concluded that preexisting uncrossed motor pathways were accessed post-stroke to compensate for the ischemic effects within the involved hemisphere. Nudo, Wise, SiFuentes, and Milliken (1996) studied the primary motor cortex of adult squirrel monkeys using intracortical microstimulation techniques to map the cortical hand representation areas of the brain before and after ischemic infarcts were induced. They found that after three to four weeks of intensive hand/limb therapy, the cortical representations changed significantly in the treatment monkey group. The treatment group had sparing of the adjacent intact cortex and the wrist-forearm cortical area increased significantly. These studies suggest that motor rehabilitation may access spared or previously unassigned regions of the brain in a variety of ways and, in some studies, that cortical remapping may occur via the stimulation of rehabilitation tasks post-stroke.

Still other studies' findings led to additional motor remediation and compensatory possibilities for stroke patients. For example, in research results reported by Nolte (1999) regarding the premotor cortex, it was concluded that movements are guided and reinforced by external stimuli, such as reaching for objects within one's visual space. When therapists provide visual-reinforcing reach tasks for patients, they may be accessing and/or assisting the inherent "remapping" of the neuronal connections to and

from this motor area. It has been suggested that patients may benefit from the use of visual imagery prior to upper extremity rehabilitation activity, in order to access the supplemental motor cortex. In a recent study conducted in the Netherlands, two types of visual imagery were used in an experimental study involving upper extremity weight lifting in healthy individuals. The visual imagery involving more affective, descriptive imagery was found to be more effective than mere descriptions of the context (Bakker, Boschker, & Chung, 1996).

Accessing the pre-supplemental motor area that also extends into the anterior cingulate gyrus in some individuals may also be possible via the use of contextual decision-making in the therapeutic process (Humberstone et al., 1997). It is speculated that expanding the person's motor repertoire (i.e., novel motor learning) will assist in remediation of the upper extremity musculature.

Accessing the cingulate motor cortex of the limbic lobe is a particularly new and promising option for CVA patients. This cortex is supplied by the anterior cerebral artery, and its function may compensate for stroke effects on other arteries (e.g., post-middle cerebral artery CVA). The research indicates that to engage this region for upper extremity retraining purposes, therapeutic activity selection should be goal-directed in nature (Humberstone et al., 1997; Morecraft & Van Hoesen, 1996; Weiller, Chollet, Friston, Wise, & Frackowiak, 1992). Although this would need to be researched further, therapists may begin by goal-setting with the patients and selecting activities that are meaningful and purposeful to each person to observe effects upon motor control and functional outcome. Additionally, it could mean that activities must have some inherent

goal-directed quality to them, such as a sport activity like golf where a motor act yields a visual and psychosocial goal attainment.

Researchers in the OT profession are working to develop the theory of occupational science, which carefully examines the meaning of engagement in purposeful activity. Trombly is conducting research with CVA patients, controlling object parameters and studying the effect upon upper extremity motions, such as reach. In a recent study, Wu, Trombly, Lin, and Tickle-Degnen (1998) reported that "providing natural objects for completing a task and providing functional information on the objects may enhance the functional performance of persons who have had a CVA" (p. 447). In another study, Ferguson and Trombly (1997) recommend that

> occupations that both are meaningful and have added purpose may be the most effective in enhancing motor learning, and this needs to be studied. Before such a study can be undertaken, occupational therapists must develop an operational definition of meaningfulness and a method of measuring it. (p. 514)

Sabari (1991) stated that "therapists must select motor tasks with goals that are clear, relevant, and worthwhile in the eyes of the patient" (p. 527). She proposed an "activity synthesis model" that incorporates motor learning concepts, such as awareness of postural set prior to participation in an activity, postural adjustments required for the activity, and anticipation of trajectories of body parts, as well as other inherent and contextual task requirements.

As therapists team with neuroscience researchers to conduct studies and access neuroscience research relative to the effects of remediation upon outcomes with stroke patients, the effects will continue to be enlightening, and patients will have the potential to achieve greater functional gains and satisfaction with their abilities.

One contemporary treatment technique with promise for motor remediation post-stroke is called neuromuscular electrical stimulation (NMES). Chae et al. (1998) documented significant upper extremity motor recovery post-CVA; unfortunately, no significant effect upon self-care/ADL ability could be established. In another study of NMES used with persons post-CVA, significant upper extremity motor and self-care improvements were found between the treatment and control groups (Francisco et al., 1998).

Occupational therapists recognize the complexities of human functioning and the performance components, areas, and contexts which support function after a cerebrovascular event (Aquaviva, 1996). The challenge for therapists is to ascertain and utilize the most effective therapy strategies that are soundly supported by neuroscience research to promote improved function in areas which are important to the individual and support life after the cerebrovascular event.

Purpose of the Study

General rehabilitation research studies have been conducted regarding rehabilitation overall outcomes for stroke survivors. However, few studies have involved the occupational therapy perspective or have described the broad range of treatment considerations or components and then make connections to outcomes of the post-CVA survivor. The purpose of this research was to investigate the type of post-stroke variables (i.e., demographic, medical, and rehabilitative) that contributed to improved acute rehabilitation of upper extremity motor and ADL outcomes. This study's perspective of post-CVA OT motor interventions may prove beneficial to treatment selection based on outcomes and to define further areas for causal-comparative or experimental research.

NMES as a specific sensorimotor treatment intervention is becoming more commonly used by occupational therapists to treat the affected upper extremity of stroke survivors. As referenced in the literature review of this study, relatively few studies have shown the efficacy of NMES for purposes of upper extremity muscle re-education post-CVA, nor has the relationship been demonstrated to self-care or other types of function. More research with pertinence to the objectives of OT assessment and intervention will be beneficial to future CVA patients treated by occupational therapists.

The purpose of this study was to investigate the type of post-stroke variables (i.e., demographic, selected medical, and rehabilitative treatments) which contributed to and predicted improved upper extremity and ADL outcomes within the context of an acute rehabilitation inpatient hospital setting. Further, one specific sensorimotor technique, upper extremity NMES, was studied for its impact upon overall motor and ADL outcomes.

Delimitations of the Study

Medical record documents from a Midwestern United States acute care hospital served as the primary data source for this retrospective document review. One hundred fifty-four CVA patient medical records from the dates of September 1, 1996, through June 1, 1999, were examined. Individual records of patients who met the following criteria were included in this research study: (a) post first-time acute cortical cerebrovascular accident, (b) ages 30-80 years, and (c) were treated by occupational therapists while participating in a comprehensive inpatient acute rehabilitation program.

Limitations of the Study

Due to the convenience sampling method of a retrospective document review, limitations of generalizability to the overall stroke population are probable with inherent bias of unknown proportions. Other limitations of this study include documentation accuracy; therapist inter-rater consistency of documentation (and interpretation of testing); therapist experience level in assessment and treatment (especially in use of NMES); validity (and reliability) not established for some patient tests used by the OTs; and finally, the effects of unknown confounding variables such as patient motivation, patient daily performance fluctuations, and patient emotional response during the rehabilitation period of time.

Statement of the Hypotheses

The literature points to several demographic and medical variables that may predict the best motor and ADL performance outcomes. These variables include admit Functional Independence Measure (FIM) scores, length of hospital stay, discharge to home or community status, and sustaining a left CVA especially of hemorrhagic origin. Although not formally included in a hypothesis statement, these variables were considered in the descriptive and other forms of analysis.

It was proposed that post-CVA inpatient rehabilitation patients who received NMES treatments experienced upper extremity motor and self-care outcomes at a higher rating than did those persons who received traditional OT motor treatment (H-01). An assumption related to this hypothesis was that bimanual upper extremity sensorimotor skill functioned as a supporting component of self-care and other performance abilities.

Additionally, with higher quality of upper extremity sensorimotor return post-CVA, a higher performance outcome resulted (H-02). Clinically, an assumption would be that more normalized muscle tone and sensory status in the affected limb would contribute to better quality upper extremity sensorimotor functioning. Additionally, the type of stroke (hemorrhagic or non-hemorrhagic) and location of stroke (i.e., right or left hemisphere) were expected to be associated with outcome.

Fundamental to the second hypothesis was that motor treatment techniques provided by occupational therapists promoted sensorimotor improvement of upper extremity (i.e., arm, forearm, and hand) function post-CVA from admit to discharge ratings (H-03). Relative to this hypothesis is an assumption that all CVA patients received sensorimotor and ADL assessments and treatments by OTs as a standard of inpatient rehabilitative care.

Another hypothesis was that with higher cognitive status the results were higher sensorimotor and ADL outcomes (H-04). Although this was not the primary intent of this research, it was considered in the analysis and discussed to some extent. An assumption in this regard was that patients with decreased cognition received different combinations of treatment services during their inpatient rehabilitation.

Finally, this study investigated which sensorimotor variable best predicted ADL (i.e., self-care) outcome post-CVA treatment (H-05). The prediction of the variables that best related to higher function in self-care activities addressed the primary treatment aim of OT interventions with post-stroke individuals.

Terminology

For purposes of this study, the following terminology and interpretation were used.

ADLs – As defined by AOTA, it refers to basic activities of daily living encompassing functions such as eating, grooming, bathing, dressing, and community mobility (Aquaviva, 1996).

FIM/UDS – Functional Independence Measure/Uniform Data System is a functional status measurement used nationally to collect data on acute rehabilitation patients. Subscales include self-care, mobility, locomotion, sphincter control, communication, and social expression (Dodds, Martin, Stolov, & Deyo, 1993).

NMES – Neuromuscular Electrical Stimulation is "the use of electrical current applied transcutaneously via the motor nerve for the purpose of inducing the physiological response of a muscle contraction" (Empi, Inc., 1999, p. 1).

Performance Areas – This term refers to a broader category of human ADL activity including work and productive activities (e.g., meal preparation, money management, care of others, job performance) and leisure activities (Aquaviva, 1996).

Sensorimotor – As defined by AOTA, this term includes sensory, neuromusculoskeletal, and motor sub-components necessary to maintain human function in ADL and other performance areas (Aquaviva, 1996).

Stroke (or Cerebrovascular Accident, CVA) – A current definition is

> an acute neurologic dysfunction of vascular origin with symptoms and signs corresponding to the involvement of focal areas of the brain; alternatively, the rapid onset of a neurological deficit that persists for at least 24 hours and is caused by intracerebral or subarachnoid hemorrhage or the blockage of a blood vessel supplying or draining the brain. (Gresham et al., 1995, p. 202)

Summary

In Chapter I, the introductory information on stroke epidemiology, rehabilitation of patients post-stroke, and background leading to this study's purpose are presented. Relevant delimitations, limitations, hypotheses, and terminology that frame this study are provided. Chapter II focuses on a salient review of stroke literature in general, then stroke rehabilitation outcomes, with particular attention given to the neuroanatomical and demographic variables that served as a basis for this study's design and methodology presented in Chapter III. Results and discussion are described in Chapter IV, followed by a summary of the conclusions and recommendations in Chapter V.

CHAPTER II

REVIEW OF LITERATURE

Parameters were established to summarize the literature regarding the broad topic of cerebrovascular accident (or stroke) and to organize the topic for this study's purpose. First, recency of research publication was considered primary to the purpose of this study. Chapter II begins with a compilation of descriptive research pertaining to stroke (i.e., definition and types of) followed by relevant neuroanatomical aspects and stroke symptomatology. The neurorehabilitation of persons post-stroke is based upon an understanding of neuroscience research; therefore, this research provides an underpinning for the subsequent sections of the review of literature.

Next, the literature review chapter continues with general outcome studies conducted of post-stroke samples, illuminating the prevalent variables and presenting the interrelationships among them. Included within the summary is a compilation of demographic independent variables, such as specific diagnosis or origin of stroke, CVA type or hemispheric location, length of hospital stay, age, gender, and disposition (or discharge site) status. Dependent variables within the research are presented and include cognitive and visual-perceptual effects of stroke, self-care status (with an emphasis on studies which utilized the FIM as a measure), and motor system recovery with corresponding current neuroscience explanations.

The following outline guides the organization of Chapter II:

- Description and Definition of Stroke
- Types of Stroke and Frequency
- A Physiological Description of Stroke Types
- Stroke Symptomatology
  - Neuroanatomy of the Brain
  - Stroke Symptomatology Related to CNS Functional Heterogeneity
- Implications for Neurorehabilitation
  - Post-CVA Outcome Studies
  - Cognitive and Perceptual Effects of Stroke
  - Activities of Daily Living Recovery Issues
- Motor System Literature
  - Motor System Functioning and Recovery Issues
  - Neuromuscular Electrical Stimulation for Limb Motor Retraining
- Summary

Description and Definition of Stroke

Stroke, as it is known to the mainstream population, is also called cerebrovascular accident (or CVA) to health care professionals. A formal definition is given by Sharp, Swanson, Honkaniemi, Kogure, and Massa (1998):

> The term stroke and its synonym cerebrovascular accident refer to irreversible brain injury resulting from cerebral ischemia. Cerebral ischemia occurs when blood flow decreases to the point that metabolic substrate delivery fails to meet the metabolic demand of the tissue. The actual flow rate at which this occurs is variable, since brain metabolic demand is variable from region to region and varies during different conditions. (p. 51)

Essentially, stroke results from lack of oxygenated blood supply to brain tissue which causes cell death. More specifics related to human central nervous system (CNS) vascular supply is offered by Nolte (1999):

> Normally, about 50 ml of blood flows through each 100 g of CNS per minute. This is a little more than the CNS needs to survive, but significant reduction of this perfusion rate rapidly causes malfunction or even death of neurons. Reduction of the flow rate to about 20 ml/100 g/min causes neurons to stop generating electrical signals. Neurons can survive in this condition for a while, and timely restoration of normal flow can restore their function. Reduction to about 10 ml/100 g/min for more than a few minutes sets in motion multiple destructive cascades of events that result in necrosis (death) of the involved brain tissue. A necrotic region of tissue is called an infarct. An abrupt incident of vascular insufficiency or of bleeding into or immediately adjacent to the brain is called a stroke. (p. 132)

Types of Stroke and Frequency

As cited by many sources (Bartels, 1998; Kelley, 1998; Saladin, 1996), there are two broad categories of stroke: hemorrhagic and ischemic (or non-hemorrhagic). Ischemia, which is tissue anoxic death due to loss of cerebral blood flow, accounts for 80-85% of all CVAs. Embolism is the most prevalent reason for cerebral ischemia (often precipitated by a cardiac origin); thrombosis is another origin for ischemia. Hemorrhage is the second broad category, accounting for roughly 15-20% of the remainder of strokes. Hemorrhage may be caused by hypertensive bleeding, aneurysms, or arteriovenous malformations, among other less common etiologies.

A Physiological Description of Stroke Types

Embolism

Embolism is the most common form of non-hemorrhagic ischemia in stroke etiology. Embolic strokes are caused by substances which travel from a site of origin within the vascular system to the cerebral arteries where they lodge and obstruct blood

flow. The most common embolic material originates in the heart (i.e., approximately 75% of cardiac emboli migrate to the brain), but occasionally the embolism may be fat, fragments of atherosclerotic plaque, tumor cells, or even air. Emboli tend to lodge in the areas of bifurcation within the circulatory system; however, the middle cerebral artery is most frequently involved with this process (Saladin, 1996).

Thrombosis

Thrombosis is another common cause of non-hemorrhagic ischemic stroke. Thrombosis refers to the development or existence of a blood clot (or thrombus) within a cerebral blood vessel. In most stroke patients, this event is precipitated by atherosclerotic vascular disease. Saladin (1996) provides a clear discussion of this vascular disease:

> Atherosclerosis is the most common form of vascular disease and is associated with the accumulation of lipids, complex carbohydrates, fibrous tissue, and calcium deposits on the arterial walls. These substances form plaques that begin to obstruct the lumen of arteries causing stenosis (narrowing). The plaques develop preferentially at bifurcations and curvatures in the arterial system and are most common in the internal carotid and vertebral arteries, followed by the basilar and middle cerebral arteries. Platelets aggregate around the plaques and produce clots, especially following degeneration or hemorrhage in a sclerotic vessel. The acute formation of a thrombus may occlude the lumen of the artery and produce focal ischemia and infarction. (p. 488)

The prior paragraph points out an important piece of information in the etiology of thrombotic strokes: that they may combine and convert into a hemorrhage within the area of ischemia. According to Saladin (1996),

> Thrombi can migrate, lyse, and reperfuse into an ischemic area, leading to small hemorrhages (petechial hemorrhages) because the damaged capillaries and small blood vessels no longer maintain their integrity. . . . These conversions are more common in large infarcts, such as an occluded MCA (middle cerebral artery), or in a large infarction in the distribution of a lenticulostriate artery. (p. 8)

This information has implications for the diagnosis and medical treatment of stroke. Patients who have the large infarcts with a possibility of this hemorrhagic conversion will not be treated with anticoagulants because of the possibility of exacerbating the hemorrhaging.

Hemorrhage

Hemorrhage as a source of stroke consists of two major types based on location within the brain: intracerebral or subarachnoid. Intracerebral hemorrhage is a bleeding into the parenchyma of the brain, most likely due to hypertension (Saladin, 1996). This type of hemorrhage occurs in typically a smaller penetrating artery: in the basal ganglia and thalamus (70%), brainstem (13%), the cerebral white matter (10%), or cerebellum (9%). Conversely, the subarachnoid hemorrhage typically involves a larger cerebral artery, and the bleeding occurs into the subarachnoid space. This type of hemorrhage accounts for approximately 6-8% of all strokes. Its etiology is much different from the intracerebral hemorrhage, often from a developmental abnormality of the muscular and elastic layers of the cerebral vessels. Other origins of hemorrhage may be arteriovenous malformation, bleeding disorders, vasculitis, drug abuse, or infections (Saladin, 1996).

Hypoperfusion

Hypoperfusion (or hypoxia) is a cause of stroke, most commonly due to cardiac pump failure (e.g., myocardial infarction or arrhythmia) resulting in low systemic perfusion pressures, or systemic hypotension resulting from significant blood loss such as in cases of trauma. The low systemic blood pressure below a critical threshold causes cerebral tissue ischemia, which is often global and bilateral in nature, and occurs at the "watershed" regions within the brain (Saladin, 1996).

Lacunar Stroke

A lacunar stroke is a specific small, deep vessel stroke, often found in the penetrating branches of large cerebral vessels, such as those supplying the basal ganglia. It is different from earlier types of strokes in that major vessels and their cortical distribution areas (e.g., MCA) are not affected; only the small, deep vessels and corresponding neuroanatomical structures are involved in a lacunar stroke. Found mostly in the basal ganglia, other commonly affected structures are the thalamus, the white matter of the internal capsule, and the pons. The pathology is most often found to be microatheroma, resulting from advanced hypertension often accompanied by type I diabetes (Mohr & Marti-Vilalta, 1998).

As referred to in Chapter I, the sample of stroke included in this study includes cortical, large-vessel pathology due to ischemia (i.e., non-hemorrhagic stroke) or hemorrhage, not global stroke effects from hypoperfusion or sub-cortical structures affected by lacunar strokes. In the following section, stroke symptomatology and accompanying neuroanatomy are presented. This knowledge further guides the medical and rehabilitation assessment and management of persons with stroke.

Stroke Symptomatology

Neuroanatomy of the Brain

In order to describe the symptomatology of stroke, a general or global perspective of the functional neuroanatomy will follow. An understanding of the site of the stroke and the functions of the respective regions of the brain is fundamental to the assessment and rehabilitation of persons post-stroke.

There are five major lobes within each of the cerebral hemispheres of the brain: frontal, parietal, temporal, occipital, and limbic lobe. Interconnecting pathways exist between each lobe (via myelinated commissural, projection, and association fibers) to allow for appropriate "communication" and integration of physiologic information within the CNS.

Although there is a gestalt or "whole" of the CNS with its global coordination and processing functions, there also exists a specialization within each lobe and area of the CNS. In the early 20th century, a German neuroanatomist named Korbinian Brodmann constructed a "cytoarchitectural map" to depict various zones of the neocortex (Bear, Connors, & Paradiso, 1996). Although he did not know at that time, but predicted, each zone had a different function. Since then, his assumptions related to functional specialization have been verified by "ablation and stimulation, electrically and with various chemicals" (Waxman, 1996, p. 147). His map and functional classification system continue to be used very widely to describe function and are found in newer research of function and specialization.

The circulation of blood within the neocortex is important to the medical assessment and management of stroke and to the understanding of stroke pathology by rehabilitation professionals. The arterial supply of the brain is comprised of two pairs of vessels, the internal carotid and vertebral arteries, which branch and connect via the Circle of Willis. The internal carotid arteries branch into two major branches, the middle and anterior cerebral arteries (MCA & ACA), and smaller branches which are the anterior choroidal, opthalmic, and posterior communicating arteries. The two anterior cerebral arteries are joined by the anterior communicating artery, thus forming the anterior portion

of the Circle of Willis. The vertebral arteries join to form the basilar artery along the anterior surface of the brainstem at the level of the pons. Branches of the vertebral artery supply the spinal cord, medulla, and cerebellum. The basilar artery gives rise to branches that also supply the pons, midbrain, and cerebellum, but continues on to bifurcate into two posterior cerebral arteries (PCA), forming the posterior part of the Circle of Willis (Waxman, 1996).

The major arterial blood supply to the neocortex is provided by the anterior, middle, and posterior cerebral arteries. The middle and anterior cerebral arteries supply the frontal and parietal lobes; the middle and posterior cerebral arteries supply the occipital and temporal lobes; and the anterior and posterior cerebral arteries provide blood to the limbic lobe. It is notable that the middle cerebral artery supplies most of the lateral cortex in each hemisphere while the anterior cerebral artery supplies the medial areas such as the limbic lobe. As reported by Saladin (1996), the MCA is the most common artery to be occluded with cerebral vascular accident (CVA) or stroke; because of its vast blood supply to the neocortex, the effects can be disastrous functionally for survivors.

Stroke Symptomatology Related to CNS Functional Heterogeneity

The general neocortical specialization and related functions are presented next followed by a brief description of the predicted dysfunction due to stroke within the five lobes of the human brain.

The frontal lobe. The frontal lobe can be distinguished for its specialization relative to motor function or behavior. Within this lobe can be found these five general

areas: the primary motor cortex, premotor cortex, frontal eye fields, Broca's area, and the prefrontal cortex.

The primary motor cortex (Brodmann's area 4) is found within the precentral gyrus; it is organized in a somatotopic orientation, from the toes (medially) to the muscles of mastication (laterally). This somatotopic organization is sometimes presented visually as a "homunculus," as per Kingsley (1996, p. 212).

The primary motor cortex is responsible for the initiation of voluntary movements. It is now known that cortical neurons in this area actually encode for direction of movement but also for force of muscle contraction. This means that as the load requirements on a muscle increase, neurons in this primary motor area increase their firing rate. Velocity encoding also occurs here, but the majority of this parameter of muscle control is encoded via the extrapyramidal rubrospinal neurons (Kingsley, 1996).

The premotor area occupies the remainder of the precentral gyrus and is known as Brodmann's area 6. Together with neurons of the primary motor cortex, neurons of area 6 give rise to axons of the corticospinal and corticobulbar tracts that provide input to lower motor neurons to influence the activity of the entire musculature of the body. In humans, the premotor area is about six times the size of the primary motor area, M1; yet despite its size, it contributes less to the corticobulbospinal tract than does the primary motor area. The function of the premotor area is to initiate voluntary movements, but it also is believed to play a role in planning and preparation for the motor act to follow (Kingsley, 1996). Nolte (1999) states that the "premotor cortex may have a special role in movements guided by external stimuli, such as reaching for a seen object" (p. 442).

In the region of the premotor cortex, another area known as the supplemental motor area exists. Its location is the medial surface of the precentral gyrus, just anterior to the "foot" somatotopic region of the primary motor cortex. The supplemental motor area is thought necessary for coordination of complex, bimanual motor tasks (Kingsley, 1996). Although we do not know everything about this region, "blood flow increases in this area even if a movement is mentally rehearsed but not actually performed" (Nolte, 1999, p. 444). Lesions in this area result in motor apraxia, or the inability to perform patterned, complex motion.

In a recent MRI study by Humberstone et al. (1997), a human pre-supplemental (or anterior) motor area was identified which appears to involve more complex "movement decision-making" within a stimulus-response, go/no-go motor decision-making research task. An interesting resultant observation is that the pre-supplemental motor area had a connection to the anterior cingulate gyrus in two of the six participants in the study, thereby involving the additional Brodmann's areas 32 and 24.

The frontal eye fields (Brodmann's area 8) are located in the middle frontal gyrus, just anterior to the facial representation within the precentral gyrus. This area is responsible for the initiation of saccadic eye movements, which are rapid, horizontal eye movements allowing us to respond to fast, lateral stimuli within our environment (as in driving skills) and also used in reading. This area works in collaboration with the supplementary eye field (located yet more anteriorly) and parietal eye field for the initiation of saccadic eye movement. A lesion in the frontal eye field would cause a lateral or conjugate gaze paralysis to the contralateral side.

Broca's area (Brodmann's areas 45 and 46) of the dominant hemisphere is responsible for motor speech initiation. If a lesion occurred in this area, a person would be able to understand speech but would have difficulty in motor speech expression of thoughts. This condition is also known as expressive or non-fluent aphasia, a disorder of language, often seen in persons post-CVA of the dominant hemisphere.

The prefrontal cortex comprises the remainder of the frontal cortex, anterior to the prefrontal gyrus (Brodmann's areas 9, 10, and 11). This area is involved with many "executive" functions such as personality, planning and organization abilities, insight, and appropriate social behaviors. A lesion here would result in a loss of initiation of action, decreased self-monitoring of social behavior and actions in general, and an inability for strategic thinking tasks.

The parietal lobe. The parietal lobe is located posterior to the central sulcus and is associated with three broad functions: sensation, language comprehension, and perception. The functions are described further in relation to Brodmann's areas.

The postcentral gyrus (Brodmann's areas 3, 1, and 2) contains the primary sensory area where the sensory information from the body's periphery converges. This sensory information is carried via the lateral spinothalamic tract (for pain and temperature); the dorsal column-medial lemniscus system (for deep touch, proprioception, vibration, and two-point discrimination); the anterior spinothalamic tract (for light touch); and facial sensation from the trigeminal nerve of the pons. If there is a lesion to the primary sensory area of the brain, sensory information from the contralateral side of the body will not be interpreted.

Immediately posterior to the areas 3, 1, and 2, can be found the sensory association areas (Brodmann's areas 5 and 7), also known as the posterior parietal cortex. This region is important to interpretation of discriminative sensation, because the dorsal column-medial lemniscus system and main sensory nucleus of the trigeminal nerve "terminate" here from the periphery. This area is also believed to integrate sensation from a number of senses of the body: taste, vision, pain, and the other tactile sensations. If a lesion is found in the sensory association area of the brain, discriminative information from the contralateral side of the body will not be interpreted. A special condition known as astereognosis may result, which is the inability to recognize a familiar object via the tactile senses, such as identifying a coin in one's pocket without the benefit of vision.

Language comprehension is a functional part of the parietal lobe, mostly involving the angular gyrus (Brodmann's area 39) necessary for reading and writing ability. Area 39 lies within the arcuate fasciculus which has interconnections between the temporal lobe's receptive speech area and Broca's motor speech area; therefore, the connection is established among the auditory, visual, and sensory components of speech production and language comprehension. If there exists a lesion only to area 39, the resulting impairments would be an inability to read (alexia) and an inability to write (agraphia).

Perception and spatial orientation are important functions of the remainder of the parietal lobe. For example, Brodmann's area 40 located within the supramarginal gyrus is important to recognition of sensory information. A lesion in this area or other areas of the parietal lobe can result in a condition known as agnosia, referring to an inability to recognize information. There are various types including auditory agnosia (inability to

recognize sounds, noises), visual agnosia (inability to recognize visual stimuli), anosognosia (inability to recognize one's own body parts), prosopagnosia (inability to recognize faces of known people), and other forms of agnosia. In addition to recognition problems, persons with lesions affecting the non-dominant parietal lobe will have other perceptual difficulties such as inattention to visual space (usually on the contralateral side of the body). A phenomenon known as neglect syndrome may also occur, which is the inability to perform ADLs on the affected side of the body or limb, copy visual images by drawing, and other manifestations, despite the person's somatic sensations being intact (Kandel, Schwartz, & Jessell, 1995).

The temporal lobe. This lobe specializes in audition and receptive language abilities but also has roles in visual information processing, learning, and memory. Contained within the temporal lobe is the primary auditory cortex (Brodmann's areas 41 and 42). Area 41 receives most of the auditory information, then sends the information on to area 42, per Nolte (1999). Because auditory information is bilaterally represented, a lesion to areas 41 and 42 will not result in a complete hearing loss; but rather, a subtle hearing loss or localization difficulty may ensue on the contralateral side.

An adjacent area, Wernicke's Area (Brodmann's 22), is known as the auditory association cortex. Should a lesion occur in this area within the dominant hemisphere, a major deficit in language comprehension results, known as receptive aphasia. In this case, the aphasia is fluent because it is normal in rate and melody; however, comprehension of both auditory and visual language is impaired. Paraphasias may result (i.e., difficulty in word-finding or using the wrong word/words). Another manifestation

may be neologisms, which refers to "making up" words, especially nouns (Kandel et al., 1995).

The most medial portion of the temporal lobe is associated with "complex aspects of learning and memory," according to Nolte (1999, p. 58). The most inferior and medial portion of the temporal lobe contains the parahippocampal gyrus and uncus, two structures which are part of the limbic system and therefore are associated with the limbic lobe. Because of the close approximation with the limbic lobe, the temporal lobe has functional connections with learning and memory. Further functions of the limbic lobe are described in a later paragraph.

The occipital lobe. The primary function of the occipital lobe is visual system processing. The primary visual cortex is Brodmann's area 17, but is also called the striate cortex or V1. As with the other lobes of the brain there exist visual association areas, Brodmann's areas 18 and 19, required for visual processing and interpretation, such as movement of objects, color, depth, form, and other visual properties. These areas are retinotopically organized for the various visual properties and apparently contain information-specific pathways (Kandel et al., 1995). The visual system is a complex mechanism involving receptors found in the retina. Sensory information is carried via the optic nerve and tract to the lateral geniculate body of the thalamus. From the thalamus, information is carried to the primary visual cortex, the visual association areas, and beyond.

As mentioned earlier, the temporal lobe has a shared area of visual processing, V4, in the occipitotemporal gyrus believed to have importance for shape and color perception, as well as other types of visual perception and visual memory (Bear et al.,

1996). If a lesion occurs in the visual cortical areas, blindness or various forms of agnosia (i.e., the inability to recognize and interpret) may occur, depending upon the area affected.

The limbic lobe. The structures comprising the limbic lobe include the cingulate gyrus (on the deep, medial surfaces of the hemispheres) and the parahippocampal gyrus (on the inferio-medial surface of the temporal lobe). Also part of the limbic system are the uncus, amygdala, hippocampus, and various other sub-cortical and brainstem structures, the functions of which have been the subject of much debate among neuroscientists.

The limbic system has wide-reaching connections with the rest of the neocortex and with the hypothalamus (which is important for autonomic, somatic, endocrine function, and emotional behavior). The limbic system as a whole is one of the least understood areas within the CNS. It is believed that the major functions of this system are basic drives; emotions (especially fear, anxiety, self and reality connection, and "fight or flight" types of affect); memory (particularly for encoding new information); and olfactory sensory function (Nolte, 1999).

Regarding the cingulate gyrus, the "Papez Circuit" comprises the interconnection between the thalamus and the cingulate and parahippocampal gyri. By way of the thalamus, the cingulate gyrus is connected to the cerebral cortex and hypothalamus for "the convergence of cognitive (cortical) activities, emotional experience, and expression" (Waxman, 1996, p. 251).

Further, Morecraft and Van Hoesen (1996) discuss the cingulate motor cortex (M3), which is located in the cingulate gyrus. This motor cortex is somatotopically

organized and projects to subcortical motor centers (e.g., the red nucleus, motor thalamus, and reticular formation). They describe the unique nature of this motor cortex which has widespread connections to the primary and premotor cortices; the frontal eye fields; supplemental sensory cortex; association cortices of the prefrontal, parietal, and temporal lobes; and others. From electrophysiologic studies, it has been found that the anterior cingulate region is involved in the mediation of face and upper extremity, especially goal-directed movements. Neurons in this region are found to be active prior to and during movement, even prior to the supplemental motor cortex involvement. Since this region is supplied by the anterior cerebral artery, it has recently been suggested as a possible key to motor retraining of the upper extremity post-MCA stroke.

Implications for Neurorehabilitation

With a remediation approach to treatment of persons post-CVA, rehabilitation therapists such as occupational, physical, and speech-language pathologists utilize existing neuroscience research to guide and develop their practice. The current research allows increasing understanding of the neural mechanisms behind stroke and the recovery options post-stroke, including preferable timelines.

Accessing previously unknown regions of the brain such as the pre-supplemental motor area and cingulate motor cortex of the limbic lobe through enriched therapeutic contexts and cognitive engagement of the patient in challenging, goal-directed ways are believed to enhance outcomes. Occupational therapy researchers (Ferguson & Trombly, 1997; Sabari, 1991; Wu et al., 1998) are contributing to the theory of occupational science, which encompasses the aspects of context and active engagement of patients in their rehabilitation.

Study of the current neuroscience research literature shapes current rehabilitation assessment and treatment interventions, but also provides guidance for future experimental research to guide best practice. In the following section, overall post-stroke and rehabilitation outcome studies are summarized to provide a basis for this study's information collection and analysis phases.

Post-CVA Outcome Studies

Common variables included in outcome studies conducted of the post-CVA population include classifications of stroke by their major type of etiology (i.e., non-hemorrhagic/ischemic or hemorrhagic), level of stroke according to neurologic pathology (e.g., right or left hemispheric involvement and/or by cortical or sub-cortical classification), age, gender, onset to admission interval, and occasionally comorbidities. The comorbidities, if described, include hypertension, diabetes, and cardiovascular disease, with one study delineating 55% of its CVA sample as having two or more comorbidities (Chae, Johnston, Kim, & Zorowitz, 1995; Chae, Zorowitz, & Johnston, 1996). Another study found 49% of its sample had one to three comorbidities and another 29% with four or greater (Ween, Alexander, D'Esposito, & Roberts, 1996). Common outcome measures included hospital length of stay (LOS), functional independence measures of self-care and mobility (e.g., FIM or the Barthel Index), motor skill assessment scales (e.g., the Fugl-Meyer scale or the motor measure of the FIM), and discharge to home rates.

Stroke is classified by its major etiology into two categories: hemorrhagic and ischemic (or non-hemorrhagic) according to Bartels (1998), Chae et al. (1996), Kelley (1998), Saladin (1996), and others. Some experts assert that hemorrhagic origins of

stroke yield greater neurologic and functional outcomes during hospital stays compared to the non-hemorrhagic/ischemic origin groups studied (Kinkel, 1990; Ring, Feder, Schwartz, & Samuels, 1997; Ween et al., 1996). Other research, however, found that both groups made significant gains in functional skills outcomes as well as found similar motor skill gains and discharge to home rates (Chae et al., 1996). To illustrate the complexity of this issue, it was found that patients post-hemorrhagic CVA had a significantly shorter LOS and therefore achieved more efficiency in functional gains (i.e., a faster rate of improvement) according to Chae et al. (1996).

Non-hemorrhage (i.e., ischemia), as a cause of CVA, is purported to account for 80-85% of all CVAs whereas hemorrhagic origins comprise the remaining 15-20% (Bartels, 1998; Kelley, 1998; Saladin, 1996). These findings are corroborated in more recent experimental and retrospective document review studies. Chae et al. (1996) described a sample which included 18% hemorrhagic and 82% non-hemorrhagic; Chae et al. (1995) reported a study sample that included 85% non-hemorrhagic post-stroke patients; and Jorgensen et al.'s 1995 study sample included 93% non-hemorrhagic and 7% hemorrhagic origins of stroke.

There exists some descriptive research in regard to hemispheric prevalence in stroke pathology. Most of the research described a rather equal distribution of right or left hemispheric involvement, with 5% or fewer subjects having bilateral CVAs. Granger, Hamilton, and Fiedler (1992) reported a sample that included 43% with left CVA, 46% with right CVA, and 3% with bilateral strokes. A similar distribution was found by Stineman, Fiedler, Granger, and Maislin (1998): 43% left CVA, 44.3% right,

and 2.8% bilateral CVA. Other studies report slightly more left CVA than other pathology, for example, 53% in the sample studied by Chae et al. (1995).

Study results related to hemispheric location of CVA appear to be more clinically pertinent than the descriptive information alone. Chae et al. (1996) found that persons with hemorrhagic strokes had a higher proportion of left-sided lesions (56%) than those with non-hemorrhagic lesions (24%). Stineman, Maislin, et al. (1997) found that persons with left CVA were more likely to reach a modified functional independence level thus requiring less physical assistance than those with right-sided lesions. Granger et al. (1992) reported that persons with right CVA had slightly higher admission and discharge functional rating scores; however, the persons with left CVA made greater functional gains within their hospital stay. Greater efficiency of FIM gains among persons with left CVA was corroborated by Ween et al. (1996). Yet others find no significant relationship between side of stroke and rate of motor recovery (Horgan & Finn, 1997) or ADL gain specifically (Ring et al., 1997; Wagner & Cushman, 1994). Ring et al. (1997) attributed the greater efficiency in functional recovery by certain patients to be a function of greater LOS.

Age as descriptive variable is reported in most outcome studies of stroke rehabilitation. The ages of individuals post-stroke reported in research studies range from 16 to 85 years, with the mean age generally reported as 70 to 74 years (Chae et al., 1995; Heinemann, Linacre, Wright, Hamilton, & Granger, 1994; Jorgensen et al., 1995; Ween et al., 1996). Granger et al. (1992) reported the following stroke prevalence by age groupings for their study: individuals <65 years (24%), those sampled between ages 65-79 years (53%), and individuals >79 years (23%). Other age groupings reported were

55-70 and 71-85 years of age by Pohjasvaara, Erkinjuntti, Vataja, and Kaste (1997) and <50, 51-70, and >70 years of age by Oczkowski and Barreca (1997), indicating no consensus for age groupings in stroke outcome research.

In two studies, patient age did not correlate with hospital length of stay (LOS) (Chae et al., 1995; Chae et al., 1996). Granger et al. (1992) found that as age increased, LOS decreased along with overall functional scores. One interpretation of the latter study is that the older individuals were not hospitalized long enough to realize functional gains. Further, younger age correlated with better functional outcomes in most studies (Granger et al., 1992; Pohjasvaara et al., 1997; Stineman, Maislin et al., 1997; Stineman et al., 1998). However, this could be interpreted as a result of longer LOS or other factors rather than youth alone. Chae et al. (1995) did not find a significant correlation between age and function scores at discharge from the hospital. In two studies, younger age was found to correlate with improved motor outcome (Horgan & Finn, 1997; Stineman, Goin, Granger, Fiedler, & Williams, 1997). Younger age was also associated with better home/community discharge rates, which may either be indicative of the better functional ability at discharge or support systems to warrant this decision (Sandstrom, Mokler, & Hoppe, 1998; Stineman et al., 1998).

Gender is often reported descriptively in stroke outcome research, yet it is rarely associated with findings of significance. For example, Horgan and Finn (1997) did not find gender to be of significance in terms of motor recovery post-stroke. Wade, Hewer, and Wood (1984) did not find an interaction between gender and side of lesion following stroke. In many studies, male subjects comprise from 47-55% and females from 45-53% of the total sample of CVA patients (Chae et al., 1995; Heinemann et al., 1994; Jorgensen

et al., 1995; Sandstrom et al., 1998; Stineman et al., 1998). Granger et al. (1992) described the study's sample by age group and gender: Of those <65 years of age, 57% were male; of those between 65-79 years of age, 48% were male; and of those >79 years of age, 37% were male. Of the six studies reported here, the average percentage of males in the studies was 49%; females on the average comprised 51% of the stroke samples studied. Therefore, a relatively equivalent number of males and females comprises most stroke populations sampled.

Onset to rehabilitation admission interval (OAI) refers to the time between the acute hospitalization for a stroke and the admission to a rehabilitation setting for comprehensive services, including OT. This parameter is often collected in stroke outcome studies. In a number of studies of persons post-stroke, the mean OAI ranged from 16 hours (Jorgensen et al., 1995) in Copenhagen, Denmark, where rehabilitation is initiated immediately to the more common range in the United States of 19 days (Sandstrom et al., 1998), 21.6 days (Chae et al., 1995), 22 days (Granger et al., 1992), 29 days (Chae et al., 1996), up to 33.6 days reported by Heinemann et al. (1994). Generally, the shorter the OAI time, the better the functional outcome post-stroke, as demonstrated by the Stineman et al. study in 1998. They established that subjects with OAI time less than 60 days had a threefold better "odds ratio" of achieving a higher self-care and mobility status than persons with greater time since stroke onset.

Along with OAI, hospitalization time on a rehabilitation unit is collected, often referred to as length of stay or LOS. Length of stay is reported as being the longest in the Copenhagen study at 41 days, perhaps measured in a different manner or necessary due to the very short OAI span of time. In the United States, studies report mean LOS

ranging from 24.3 days by Sandstrom et al. in 1998 up to 31.8 days reported by Chae et al. in 1995, indicating the decline in overall LOS in rehabilitation hospitals in more recent years.

Length of stay and OAI both have been correlated with each other or with other factors in stroke outcome studies. Chae et al. (1996), in looking at 25 matched pairs of persons with hemorrhagic and non-hemorrhagic etiologies of stroke, found a significant correlation between length of stay and onset to admission interval. When the groups were analyzed separately, the hemorrhagic group had a higher correlation than the non-hemorrhagic group. In an earlier study reported by Chae et al. in 1995, length of stay was not significantly correlated with OAI. In the latter study, neither age nor OAI correlated significantly with functional ability at discharge.

Less commonly than LOS or OAI, disposition status is described in the research. Disposition status refers to the setting where stroke patients are discharged after their acute rehabilitation hospitalization stay has ended. Commonly, the setting choices are home, extended care facilities (for further, less intense rehabilitation services), or long-term care nursing facilities. Often, disposition status is linked to overall independence level and is important to the continuum of care provided by OTs and other rehabilitation service providers. Sandstrom et al. in 1998 established that even though the persons who returned home had residual functional ability deficits, their "burden of care" was at 50% or less compared to the group discharged elsewhere who required greater than 50% care levels. This finding supported their conclusion that persons who returned home tended to require lesser amounts of caregiver assistance. Stineman et al. (1998) reported similar findings from their sample of 26,339 stroke survivors. They

reported that those persons requiring greater amounts of assistance at discharge had the smallest likelihood of being discharged to home settings.

Less commonly, disposition status is correlated with other outcome factors. Chae et al. (1996) did not find a significant difference between persons who sustained hemorrhagic versus non-hemorrhagic strokes and their respective discharge to home rates. Granger et al. (1992) found that persons over the age of 79 years were less likely to be discharged home to their communities (64%) than were persons less than 65 years of age (83%). Of the sample Sandstrom et al. (1998) studied which included patients ranging in age from 16 to 75 years, the majority (46%) were discharged to their home, whereas 26% went to extended care facilities, and 28% were discharged to long-term care nursing facilities. They also found that the mean age of persons who went home was less (i.e., younger) than those persons who went to settings with continued professional care. Further noted in this study was that 49% of the women and 43% of the men were discharged home, therefore not a perceived difference between gender on return to home rates.

Cognitive and Perceptual Effects of Stroke

Cognitive and perceptual dysfunction are some of the least studied phenomena post-stroke in the research literature, perhaps due to the complexity of the matter including accurate measures of cognitive skills. Of the studies discussed thus far, few conclusive findings relate cognitive-perceptual function with stroke outcomes.
Of interest to this research, Stineman, Maislin, et al. (1997) reported that stroke patients with higher cognitive FIM scores achieved the better motor outcomes at rehabilitation discharge. Wagner and Cushman (1994) demonstrated a significant group difference on

Mini-Mental State Exam scores between stroke survivors with cortical lesions versus sub-cortical; and also persons with left hemispheric lesions were found to be significantly more impaired than right. They also found the presence of insufficient safety awareness requiring the need for physical restraints among the cortical group (73%) compared to the sub-cortical group (19%). On this safety criterion, however, there was not a significant difference between right and left hemispheric lesions; therefore, safety issues may be of concern for either stroke typology.

To further illustrate the complexity of the issue of cognition, in the Chae et al. 1996 study, the hemorrhagic group had lower FIM-cognition scores, however not at a level of significance compared to the non-hemorrhagic group. In the cited study, the hemorrhagic group had a higher incidence of left-sided lesions that were associated with language deficits such as aphasia. The conclusion can be drawn that language impairments confound cognitive measurement, especially among persons with left-sided brain involvement.

In another study, shorter length of stay was associated with less cognitive function at admission to rehabilitation; however, this was not found to be a significant relationship (Heinemann et al., 1994). Kalra, Perez, Gupta, and Wittink (1997) found that visuospatial deficits, however, did significantly lengthen hospital stay and therapy services consumed. They also demonstrated a significant association between visual neglect and lower initial activities of daily living rating on the Barthel Index. In a 1992 study conducted by Tatemichi et al. of a stroke cohort consisting of subjects over the age of 60 years, it was demonstrated that poor performance on the mini-mental status examination at one-week post-ischemic stroke predicted disability persisting at three

months. In a later publication of the same subjects stroke, 35.2% were found to have cognitive impairments three months post-stroke, primarily in the areas of attention, orientation, memory, and language (Tatemichi et al., 1994).

Giles (1996) summarizes the current thinking regarding cognitive rehabilitation post-stroke:

> Outcome studies from comprehensive cognitive rehabilitation programs are not available nor is large-scale outcome research on cognitive rehabilitation after stroke. Because people with CVA show natural recovery and have diverse cognitive problems, it is difficult to establish a general treatment effect. (p. 4)

To illustrate the variety of cognitive-perceptual deficits possible post-stroke, a description is provided. "Following stroke, impairments may be evident in the areas of: language, attention, perception, recognition of object meaning and use, visuospatial and constructive skill, memory and learning, emotional/psychiatric functioning, the execution of skilled movement, and higher cognitive functioning" (Giles, 1996, p. 2). Clinicians tend to view poor cognition as having an effect upon stroke outcomes, yet few controlled comprehensive cognitive studies of this patient population clearly guide practice.

Localization of specific deficits post-stroke is classically related to the site of the stroke within the brain. Because the longitudinal motor and sensory tracts within the central nervous system cross primarily at the brainstem (or spinal cord), a lesion within the left hemisphere of the brain will cause motor and sensory loss on the right side of the body. Conversely, the reverse scenario occurs when the right hemisphere sustains a lesion. The human brain also specializes in its functional capacities related to cognition and perception. For example, a stroke within the left hemisphere will often lead to speech and language impairments, apraxias, perseveration, and emotion or mood

disturbances such as frustration or depression. If the right hemisphere sustains a CVA event, other impairments may result such as inattention, unilateral neglect of body and space, visuospatial dysfunction, visual field deficit of the contralateral side, and higher cognitive skills deficits (Arnadottir, 1998; Bernspang & Fisher, 1995; Giles, 1996; Gresham et al., 1995; Manes, Paradiso, Springer, Lamberty, & Robinson, 1999; McKeough, 1996; Saladin, 1996; Tham & Tegner, 1997). Although the constellation of impairments presented are the classic syndrome especially found after middle cerebral artery strokes, much more complexity related to the process of recovery of individuals is inherent. Giles (1996) cautions that "only a few persons following CVA actually present the classic syndrome, and most can be thought of as approximating, to a greater or lesser degree, the classical presentation" (p. 11).

Activities of Daily Living Recovery Issues

Although fewer studies specifically link perceptual-cognitive deficits post-stroke to ADL abilities (Kalra et al., 1997; Sea, Henderson, & Cermak, 1993; Wagner & Cushman, 1994), a greater number of studies describe ADL ability ratings and outcome prediction models for stroke survivors. A synthesis of the recent research findings related to ADL function post-stroke is presented in the following paragraphs.

Generally, it has been found that older persons post-stroke made fewer ADL gains post-stroke; however, the issue of shorter LOS identified earlier was not considered in studies which reported this finding (Pohjasvaara et al., 1997; Ween et al., 1996). Wagner and Cushman (1994) reported that persons post-cortical stroke (versus sub-cortical) had the greater impairment in self-care abilities. Utilizing the Barthel Index as a measure of ADL achievement and with a sample of 50% of persons sustaining a mild stroke,

Jorgensen et al. in the 1995 Copenhagen stroke study reported a timeline for best ADL recovery as 12.5 weeks for 95% of the sample and 6 weeks for 80% of the sample studied. In a motor recovery experimental study performed by Duncan, Goldstein, Matchar, Divine, and Feussner (1992) with ADL achievement measured by the Barthel Index, ADL improvement paralleled motor recovery among all motor subgroups of stroke survivors. Duncan et al. (1992) found that persons with initially severe motor ratings did not achieve complete ADL recovery, whereas 58% of the overall sample did. This sample of patients studied included 104 patients with non-hemorrhagic strokes.

In studies utilizing the FIM, researchers consistently found that stroke patients made significant gains in self-care (or motor) abilities from admission to discharge (Chae et al., 1996; Granger et al., 1992; Heinemann et al., 1994; Oczowski & Barreca, 1997; Ring et al., 1997; Stineman et al., 1998; Ween et al., 1996). Two studies' findings indicated that the admission FIM total score was the best predictor of outcome, such as independence in self-care (Chae et al., 1995; Ween et al., 1996). In another study, a very specific skill was determined to be a predictor of LOS. Stineman et al. in 1994 conducted a study to predict LOS based on various components of the FIM. In the complete model, toilet transfer ability was found to be the best predictor of LOS, presumably because of its complexity in skill level and its relationship to other types of mobility.

Yet other studies take a different approach. These studies' results rank self-care skills from easiest to most difficult with eating identified as the easiest, dressing and transferring ability as intermediate, with stair climbing as the most difficult skill (Heinemann, Linacre, Wright, Hamilton, & Granger, 1993; Linacre, Heinemann, Wright, Granger, & Hamilton, 1994; Stineman et al., 1998). Stineman et al. (1998) further

classified persons into three ability levels: lower, middle, and upper. The lower band (or more involved) group progressed to ‸ ervised level in the easier areas of eating, grooming, and bowel/bladder control. The middle band commonly became independent in the previous areas and added abilities in dressing and transfers. The upper band patients were mobile in most tasks but required safety principles or supervision for daily living activities participation.

The performance of ADLs requires the interplay and integration of performance components (Aquaviva, 1996; Duncan et al., 1992): sensory, neuromusculoskeletal, motor, cognition, and psychological entities. Each patient post-stroke portrays a unique combination of impairments leading to disability in ADL performance. It is the intent of this research project to examine general relationships among these various entities or factors on occupational therapy rehabilitation (self-care) outcome; however, the motor system is the focus of this research and the ensuing paragraphs address the current rehabilitation philosophy and literature to guide practice.

Motor System Literature

Motor System Functioning and Recovery Issues

Occupational therapists are currently faced with numerous motor system philosophies and research findings from which to select "best practice" for each individual patient. Gillen (1998) summarized the dilemma and included advice for practitioners:

> As the body of knowledge concerning motor behavior continues to grow, therapists must critically analyze research findings as well as their own clinical practices. . . . When faced with a choice between conventional and new approaches, the occupational therapist should consider the following questions: Is this treatment really effective? How does it work and on what principles is it

> based? Is it accomplishing what is needed for this patient? Are some of the older treatment methods more solidly based, more effective, or cheaper? Are there other better ways to meet this patient's needs? (p. 110)

Gillen further advised that occupational therapists will best serve patients by focusing on interventions leading toward the ultimate improvement of function in performance areas such as ADLs, work/productive activities, and leisure activities.

The current state of practice for motor intervention with persons post-brain injury includes a move away from hierarchical models of motor control to a contemporary approach which favors a systems model approach. In the systems model(s) of motor control, the environment is considered as well as the redundancy and plasticity of the human nervous system, therefore allowing the potential for recovery. Three terms related to the systems model approach to motor control are discussed by Held and Pay (1999): recovery, sparing, and compensation. These terms are described then discussed in relation to current neuroscience research of the nervous system and its "recovery" post CNS injury.

Recovery. Although the term, recovery, can be interpreted to mean a variety of things, for the purposes of the present research, recovery shall refer to a resumption of normal limb usage, in a same or similar manner. Neurophysiologically, when various other "unassigned" regions of the brain "take over" the lost function, the motor system can return to its "original" function with little disturbance. For example, it has been suggested that surrounding the infarcted region of the brain lie intact tissues which can "reorganize" or be "unmasked" to perform certain functions.

Elucidating experimental studies have recently been performed on persons post-CVA and in comparison to aged-matched subjects without CNS impairments using

Positron Emission Tomography (PET) and functional MRI scanning procedures. These procedures allow the visual investigation of brain regional activation at rest or during mental and/or physical motion, such as hand movements. Weiller et al. (1992) utilized PET technology to compare the changes in brain activity in sub-cortical CVA patients and normal subjects associated with a finger-thumb motion task set to the timing of a metronome. They and other researchers using like technology found that both groups activate the expected pattern of the contralateral (i.e., opposite) hemispheric sensorimotor cortex; but with the CVA patients, there also existed a bilateral (i.e., both) hemispheric activation, usually with a greater effect observed in the ipsilateral (i.e., same) hemisphere than the damaged contralateral hemisphere. In addition to the expected motor areas activated, usually ipsilateral (but sometimes bilateral) prefrontal, premotor, cingulate, parietal, and cerebellum areas are activated depending upon the demands of the task (Cao et al., 1998; Chollet et al., 1991; Cramer et al., 1997; Humberstone et al., 1997; Nelles et al., 1999; Weiller et al., 1992). The additional cortical engagement is thought to occur because of the heightened cortical demand of motor activity to persons post-CVA as they "relearn"; but, moreover, these studies illustrate the recovery potential of the human brain via functional reorganization.

Sparing. Sparing, according to Held and Pay (1999), is defined as "the absence of a functional deficit immediately after central nervous system (CNS) damage" (p. 420). This concept is based upon the mechanism of "redundancy" within the human CNS. Redundancy refers to the theory that functions are represented in various sites within the CNS and that they are able to perform in place of the damaged area of cortical tissue. An example would be that uncrossed motor pathways (i.e., corticospinal tracts), at the level

of the medulla (in the brainstem), contribute to motor function. It is generally accepted that 10-25% of the motor corticospinal tracts remain uncrossed at the level of the medullary pyramids in the brainstem (Fredericks, 1996; Held & Pay, 1999; Waxman, 1996). Therefore, one neuroanatomical explanation of sparing is that the uncrossed (or ipsilateral) motor pathways of the spared hemisphere are able to perform some of the lost motor function of the contralateral hemisphere damaged by the stroke.

Compensation. Held and Pay (1999) describe compensation as a concept which purports that "the person has switched to different means of accomplishing the same task" (p. 420). The person no longer performs in the same way, but has discovered alternative means or methods for performance of a task. In the example of buttoning one's shirt, a person changes from use of both hands simultaneously to the use of a one-handed method. In essence, the person uses the stronger residual limb and increased ingenuity to accomplish daily life tasks.

Occupational therapists often use compensatory strategies along with motor remediation (or recovery) strategies in rehabilitation of persons post-stroke. Methods of self-care independence and strategy selection are taught to patients for use while the motor recovery process is occurring (Sabari, 1998).

Nakayama, Jorgensen, Raaschou, and Olsen in 1994 published a study whereby they followed the Copenhagen study with an investigation of the severity of the affected post-stroke limb and the ability to regain "functional improvement" which was measured by a combination of feeding and grooming outcome subscores of the Barthel Index. They concluded that the teaching of compensatory techniques during rehabilitation should be a high priority for certain patients post-stroke. Their conclusion was based on

the finding that particular patients post-stroke regained "function" despite little to no motor recovery in their affected limb. This subgroup consisted of patients who were younger; had higher Barthel Index scores initially and at hospital discharge; had higher orientation cognitive scores; and had smaller, sub-cortical lesions.

In the experimental study performed by Duncan et al. (1992) of 104 cortical non-hemorrhagic stroke survivors, the most dramatic motor recovery (as measured by the Fugl-Meyer) occurred in persons during the first 30 days post-stroke, regardless of severity of motor involvement. The motor recovery improved and was significantly associated with ADL improvement (as measured by the Barthel Index).

Motor System Summary

Neurophysiologically, the motor recovery post-stroke is under investigation with the exact mechanism of recovery unknown to date. As demonstrated throughout this literature review, there exist much complexity, variability, and conflicting conclusions as to the mechanism of recovery as well as the relationship of motor recovery to functional ability. A fair summary would be to state that the neurophysiological mechanism of motor recovery post-stroke is unknown, but believed to be a combination of recovery and sparing factors within the central nervous system. Compensation techniques to enhance functional performance have a role to play, particularly in the treatment of persons with very poor motor recovery.

In the next section of this literature review, a specific motor rehabilitation strategy for limb retraining post-stroke is examined.

Neuromuscular Electrical Stimulation for Limb Motor Retraining

In 1996, a meta-analysis of functional electrical stimulation used in post-stroke rehabilitation was conducted by Glanz, Klawansky, Stason, Berkey, and Chalmers. They found four randomized control studies which were analyzed and produced a positive effect size of 0.63 at a 95% confidence interval. Glanz et al. (1996) interpreted the results as electrical stimulation being clinically valuable; however, it must be noted that only one study of upper limb NMES usage was included. The upper limb study had an individual positive effect size of 0.864. Glanz et al. (1996) raised pertinent issues regarding bias in the NMES research. First, an issue identified was the inherent bias of a treatment being studied with a positive outcome anticipated. Secondly, the lack of published studies which produced negative effects led the researchers to convert the effect size of each study to a Z value by a Rosenthal method for their meta-analysis. Lastly, the authors advised readers to consider the results of NMES in a global regard only, that is to say that NMES produces gross muscular strength changes which cannot be directly associated with functional changes.

Other research of electrical stimulation effects has been conducted with samples of people who have conditions other than stroke and/or involved the musculature of the lower extremity only (Cabric & Appell, 1987; Milner-Brown & Miller, 1988). NMES for upper extremity treatment of post-stroke hemiplegia has been associated with a decrease in spasticity of musculature in other studies (Baker, Yeh, Wilson, & Waters, 1979; Hummelsheim, Maier-Loth, & Eickhof, 1997; Pandyan, Granat, & Stott, 1997), allowing for an increase in passive or active motion. In most cases, these studies do not document lasting relaxation of spastic muscle tone beyond 30 minutes (Baker et al., 1979).

Additional questions arise as to the long-term and/or functional significance of the effects.

Of particular interest was an experimental study conducted by Hummelsheim et al. (1997) of neuromuscular electrical stimulation with 12 post-stroke patients. These patients had sustained a middle cerebral artery stroke an average of 7.6 weeks prior to study participation. The study involved three phases: Phase A was the baseline (one to three weeks); phase B was the electrical stimulation period (two weeks in duration); and phase C involved a strength training phase (two weeks). During all three phases, traditional forms of physical and occupational therapy were provided. The results indicated that during the experimental phases (B and C), spasticity declined in the affected upper extremity; however, motor measures did not demonstrate significant improvement during the NMES phase but rather during the strength training. An additional trend observed was that the motor improvement was initiated during the NMES phase and perhaps in association with the decrease in spasticity.

In other experimental studies, the positive effect of NMES on motor recovery in acute post-CVA recovery was demonstrated (Chae et al., 1998; Powell, Pandyan, Granat, Cameron, & Stott, 1999). Yet in both studies, the gains in upper extremity motor function were not significantly associated with improvement in basic self-care activities as measured by the FIM (Chae et al., 1998) or Barthel Index (Powell et al., 1999). Perhaps the reason for the lack of association with function is due to measurement insensitivity to motor hand skill changes or the qualitative differences between one-handed self-care ability and bimanual contributions. Other possible contributing factors for lack of significance found were the small sample sizes in both studies and differing

etiology in one of the studies. In the Chae et al. (1998) study, the stroke type difference between the subgroups may have contributed; the control group had more cortical stroke survivors whereas the experimental group had more persons with sub-cortical stroke etiology. In the case of the Powell et al. (1999) study, the experimental group's motor gain lasted approximately 32 weeks before the control group's scores became similar.

Electromyography (EMG)-triggered NMES is another form of electrical stimulation that incorporates more voluntary motion and provides enhanced tactile and propriocentive cues to the patient. In an experimental study of post-CVA patients in acute rehabilitation (Francisco et al, 1998), the treatment group who received EMG-stim exhibited greater motor scores as measured by the Fugl-Meyer and realized higher FIM gain scores than the control group. This study demonstrated functional self-care results in addition to motor only improvement, demonstrating the efficacy of an enhanced feedback NMES system on rehabilitation outcomes. The researchers stated that the longitudinal effect was not studied and was therefore one of the study's limitations.

Summary

Chapter II provided a synopsis of the definition and types of stroke, illuminating the medical complexity presented to health care providers. To illustrate the rehabilitative underpinnings in the treatment decisions of stroke to improve an individual's functional capacity, an abridgment of the neuroanatomy of the brain was provided. In the final section of Chapter II, relevant and recent post-stroke outcome studies were reviewed with the salient issues forming the variables chosen for this study's intent. In Chapter III, the encompassing methodology and hypotheses of this research are described which have been informed by the literature review conclusions.

CHAPTER III

METHODOLOGY

The purpose of this study was to investigate the type of post-stroke variables such as demographic, medical rehabilitative, and specific occupational therapy treatment interventions that contributed to improved upper extremity motor and ADL outcomes. One specific sensorimotor treatment used by occupational therapists, upper extremity NMES, was studied for its impact upon overall motor and ADL improvement. Data were obtained from retrospective medical record review from an inpatient acute rehabilitation hospital in the Midwestern United States.

Hypotheses

The study was designed to test the following hypotheses. It was proposed that post-CVA inpatient rehabilitation patients who received neuromuscular electrical stimulation OT treatment experienced higher upper extremity motor and self-care outcomes than did those persons who received traditional OT motor treatment (H-01).

Secondly, persons who experienced higher quality of upper extremity motor return post-CVA realized higher performance outcomes in motor and self-care areas (H-02). Fundamental to the second hypothesis is that sensorimotor treatment techniques provided by occupational therapists promoted motor improvement of upper extremity (i.e., arm, forearm, and hand) function post-CVA from hospital admit to discharge (H-03).

Another hypothesis was that higher cognitive status was associated with higher sensorimotor and ADL outcomes (H-04). Finally, this study investigated which sensorimotor variable best predicted ADL (i.e., self-care) outcome post-CVA treatment (H-05).

Design of the Study

The relevant information from medical records of 154 persons post-acute cortical CVA was included in this retrospective document review study for descriptive, correlational, and exploratory purposes. This convenience sample was selected from the records of persons hospitalized in an acute rehabilitation setting in North Dakota during the time period of September 1, 1996, to June 1, 1999.

Selection of Sample

It is estimated that 550,000 people each year within the United States sustain a cerebrovascular accident (Gresham et al., 1995). Within the state of North Dakota during 1991, 1,168 people over the age of 65 years were hospitalized for stroke effects (Sanders & Bratteli, 1994). Of this approximate statewide CVA population yearly, a convenience sample of 154 cases was selected from a regional acute hospital within the state of North Dakota. To further substantiate the selection of sample size, the experimental research by Duncan et al. in 1992 served as a basis. Per Duncan et al. (1992), a sample size of 138 is required for prediction of 50% further improvement in motor function five days post-CVA with the condition of mild motor loss present.

All records of hospitalized patients post-CVA aged 30 to 80 years who received acute comprehensive rehabilitation services from September of 1996 through June of 1999 were included in the study. Starting with the date of June 1, 1999, all medical

records of persons between the ages specified were examined, working backward toward 1996. Persons who had sub-cortical CVAs or had incomplete records were eliminated from the study at the initial data gathering phase. A total of 154 cases was in the original sample gathered. From the initial analysis of the data, only 136 cases received motor treatments provided by the occupational therapists; therefore, the final sample included a total of 136 cases.

Data Collection

Medical record data were obtained from the medical record department of a regional hospital in North Dakota. Permission was granted prior to study inception from the joint Institutional Review Board process between the University of North Dakota and the regional hospital. A data collection tool was designed to objectively gather pertinent demographic, medical, and rehabilitation variables relative to this study's purpose (see Appendix). Patient confidentiality was protected by the use of identification numbers instead of names on the data collection tool. Only patient records with a designated stroke diagnosis per the 1996 ICD-9-CM International Classification of Diseases (1995) and within the age range of 30-80 years were utilized for data collection. Variables were numerically coded on the data collection tool, using a standard of 0 for absence of a characteristic and a higher number connoting a greater presence of the characteristic (Newton & Rudestam, 1999). This enabled ease of data entry into the SPSS 9.0 for Windows computerized program for further analysis (Norusis, 1999).

Instrumentation

The data collection form was designed to include demographic variables of pertinence to stroke outcomes based on a literature review of salient research. For

example, primary medical diagnostic information was compiled to enable subgroups of right and left brain etiology of stroke to be used in the statistical analysis. A thorough collection of descriptive information was deemed necessary to illuminate the analysis and interpretation phases of the research. Independent variables collected included types of occupational therapy treatment services provided (including self-care ADLs, sensorimotor treatments, and electrical stimulation) and a variety of demographic (e.g., age and marital status) and medical variables (e.g., diagnosis and type of stroke). Dependent variable measures collected included the Functional Independence Measure/Uniform Data System; grip and pinch strength measurements of both hands; and occupational therapist rating systems of upper extremity function, functional ability, and muscle tone. Additionally, occupational therapist ratings of the patients' degree of impairment initially and at discharge were collected (including visual, other sensory, perceptual, and cognitive impairments). For some analysis, composite subgroups were formed. For example, a composite self-care variable, right hand strength, and left hand strength were used along with muscle tone, Upper Extremity Function Test, and Functional Ability Rating variables in a regression model for prediction of self-care ability. In the ensuing paragraphs, a discussion of the validity and reliability of each measurement tool is presented.

The Functional Independence Measure

One common measure used nationally to record the self-care status of persons undergoing inpatient rehabilitation services is the Functional Independence Measure (FIM). It is "a measure of disability, not impairment. The FIM is intended to measure what the person with the disability actually does, whatever his or her diagnosis or

impairment" (Uniform Data System for Medical Rehabilitation, 1994, p. III-1). It includes a seven-level ordinal rating scale from total assistance required to complete independence. Each level has a complete definition for the rater to carefully follow when rating a client. There are 18 items rated in the categories of self-care, sphincter control, transfers, locomotion, communication, and social cognition. It is common for two rehabilitation professionals in each hospital setting to rate each client on the 18 items. In this hospital, the occupational therapist and nurse who are trained in administration of the measure each rate their assigned patient on the Functional Independence Measure items.

One of the primary uses of the FIM is as a rehabilitation programmatic outcome and patient group research tool. Since the FIM's development, it has undergone extensive reliability and validity testing on large samples of inpatient rehabilitation patients, including stroke subgroups. Content and construct validity have been established by the research teams of Dodds et al. (1993) and Linacre, Heinemann, Wright, Granger, and Hamilton (1994). Linacre et al. (1994) established construct validity of the FIM items by the subsequent ordering of easy to more difficult motor and cognitive FIM items, corroborated by other clinical constructs and expert opinion. For example, eating and grooming were identified as "easier" items and stair climbing as the most difficult item on the FIM.

Inter-rater reliability was reported by the research of Heinemann et al. (1993) and Dodds et al. (1993). Additionally, Heinemann et al. (1993) found that the FIM subscales could be combined into motor and cognitive scales. One cautionary note for this study regards the cognitive scale but not the motor scale: "For the most part, one motor scale can accommodate all impairment groups, except patients with back pain and burns. One

cognitive scale is useful for all impairment groups except patients with strokes, brain dysfunction, and congenital impairments" (Heinemann et al., 1993, p. 571).

Measurement of Grip and Pinch Strength

Measurement of hand strength via grip and pinch strength is a standard assessment practice among occupational therapists for pre- and post-treatment measurement of the stroke rehabilitation population. Hand strength is tested by use of instrumentation and standardized protocols. In an experimental study of 628 volunteers, aged 20 to 94 years, comprised of equal samples of men and women, normative data were established for clinical usage with adults (Mathiowetz et al., 1985), complete with standardized procedures for administration. Results of the study indicated that for both men and women, grip strength was greatest among the 25 to 39 years age group followed by a gradual decline in strength. Pinch strength remained stable for both gender groups until a later age, 55-59 years, when a gradual decline ensued thereafter.

Occupational Therapy Departmental Measures

The occupational therapy evaluation measures (e.g., muscle tone, vision/hearing, sensation, perception, and cognition) were based on an established departmental protocol to ensure test-retest and inter-rater reliability. To assign a particular evaluation rating, the occupational therapists based their judgements upon a variety of testing methods, many of which have validity and reliability established (e.g., the Motor-Free Visual Perception Test) (Bouska & Kwatny, 1983).

The OT departmental scales do not have researched validity and reliability established. However, the ratings follow sound occupational therapy and other medical professional standards for post-stroke evaluation (Aquaviva, 1996; Gresham et al., 1995),

thereby with face and content validity. For example, the muscle tone rating scale used by the occupational therapists is an ordinal scale from 0-4, based on the Modified Ashworth Scale of muscle spasticity (Bohannnon & Smith, 1987). The ordinal scale, Upper Extremity Function Test, is based on functional range of motion principles of the Brunnstrom frame of reference (Sawner & LaVigne, 1992). The Functional Ability Rating is also an ordinal scale based on functional ADL observation principles and uses a hierarchical descriptive rating system with established qualifiers to guide rating choice.

Analysis

Descriptive analysis was conducted to provide frequencies, percentages, and Chi squares for the pertinent study variables. Independent t-Tests, Mann-Whitney U tests, Pearson r Correlation Coefficient tests, Spearman's rho Correlation Coefficient tests, Paired Sample t-Tests, and Multiple Regression were used in the analysis of the hypotheses. The independent variables were CVA type (i.e., right or left brain) and the use of NMES (i.e., electrical stimulation) or not in treatment provision. The dependent variables studied were individual and subgroups of FIM ratings for self-care and cognition, grip and pinch strength, the Upper Extremity Function Test, the Functional Ability Rating test, and degree of upper extremity muscle tone. Because of the multiple significance tests and the exploratory nature of this study, an alpha level of .01 was used throughout.

Summary

The methodology of the study was presented in Chapter III. A summary of the design with its sample and hypotheses were also provided. Instrumentation issues and

analysis procedures were outlined and are revisited in Chapter V. In the upcoming Chapter IV, a discussion of the results is provided.

CHAPTER IV

RESULTS

This chapter begins with descriptive statistical information about the sample under study. Three sets of data are presented in relation to the subsequent analyses. Data are presented for the entire sample (N=136), the non-electrical stimulation subgroup (N=41), and the electrical stimulation subgroup (N=18). Further, the analyses were often conducted on the basis of a left brain or right brain classification for purposes of more individual comparisons.

Documentation in the medical records did not include the presence or absence of electrical stimulation as a treatment for 77 cases or 56.6% of the entire sample. Only 9 cases or 6.6% were missing from the entire sample on the left brain and right brain subgroups.

Summary of Descriptive Information

The mean age of the persons in the entire sample was 67.7 years (s.d.=10.2). The mean age was 68.3 years (s.d.=10.9) for persons in the non-electrical stimulation subgroup and 67.6 years (s.d.=9.7) for the electrical stimulation subgroup. The mean length of stay in the hospital for the entire sample was 17.3 days (s.d.= 7.4). The mean length of hospitalization days for persons not receiving electrical stimulation as a treatment was 14.8 days (s.d.=6.2) compared to 24.2 days (s.d.=7.4) for persons receiving electrical stimulation (Table 1).

Table 1

Descriptive Statistics of the CVA Sample

Demographics	N	Minimum	Maximum	Mean	SD
Age (Years)					
Total	136	37	80	67.7	10.2
Non-E-Stim	41	37	80	68.3	10.9
E-Stim	18	42	79	67.6	9.7
Length of Stay					
Total	136	4	39	17.3	7.4
Non-E-Stim	41	4	29	14.8	6.2
E-Stim	18	10	39	24.2	7.4

There was no statistically significant difference found between the number of males and females in the non-electrical and electrical stimulation treatment subgroups (Chi square=.681, df=1, p=.409). Likewise, there was not a significant difference found between persons living alone or with others on non-electrical and electrical stimulation treatment received (Chi square=.216, df=1, p=.642) (Table 3).

Pre-stroke disability status was determined by a combination of the occupational therapist and physician admission notations. Overall, 79.4% of the patients did not experience a prior disabling condition (Table 2). There was no significant difference found in the presence or absence of pre-stroke disability on non-electrical and electrical stimulation treatment received (Chi square =2.79, df=1, p=.094) (Table 3).

As a whole, 77.2% of the subjects had experienced their first CVA (Table 2). There was no significant difference found between the occurrence of first stroke or not on non-electrical and electrical stimulation treatment (Chi square=.040, df=1, p=.841)

Table 2

Descriptive Medical Etiology for Entire Sample (N=136)

	Frequency	Percent
Pre-Stroke Disability		
No	108	79.4
Yes	28	20.6
First CVA		
No	29	21.3
Yes	105	77.2
Etiology of CVA		
Non-Hemorrhagic	68	50.0
Hemorrhagic	15	11.0
Location of CVA		
Right Brain	52	38.2
Left Brain	75	55.1

(Table 3). Further, it was found that most patients in this study had experienced a non-hemorrhagic stroke (50%) rather than a hemorrhagic stroke (11%) (Table 2). The remaining 39% of the cases were labeled with diagnoses of stroke not clearly in the realm of hemorrhagic or non-hemorrhagic, such as "acute but ill-defined" stroke (30.9%), "late effects of stroke" (2.9%), "hemiplegia" (2.2%), and a small percentage of unreported cases (2.9%). Moreover, there was no significant difference found between the number of persons with hemorrhagic or non-hemorrhagic stroke on non-electrical or electrical stimulation treatment received (Chi square=.789, $df=1$, $p=.374$) (Table 3).

In this study's entire sample, more patients experienced a left brain CVA (55.1%) than right brain (38.2%) stroke (Table 2). However, relatively equal groups of patients

with left brain (50.0%) and right brain (44.4%) stroke received electrical stimulation as a motor treatment (Table 3). Moreover, there was no difference between the number of persons who had left brain and right brain pathology and the non-electrical and electrical stimulation treatment (Chi square=.618, df=1, p=.432) (Table 3).

Table 3

Crosstabulations by Electrical Stimulation Subgroups

			Gender	
			Female	Male
Electrical Stimulation	No	Count (%)	23 (56.1)	18 (43.9)
	Yes	Count (%)	8 (44.4)	10 (55.6)
			Living Condition	
			Alone	With Others
Electrical Stimulation	No	Count (%)	9 (22.0)	32 (78.0)
	Yes	Count (%)	3 (16.7)	15 (83.3)
			Pre-Stroke Disability	
			No	Yes
Electrical Stimulation	No	Count (%)	28 (68.3)	13 (31.7)
	Yes	Count (%)	16 (88.9)	2 (11.1)
			First Time CVA	
			No	Yes
Electrical Stimulation	No	Count (%)	11 (26.8)	30 (73.2)
	Yes	Count (%)	5 (29.4)	12 (70.6)
			Hemorrhagic Etiology	
			No	Yes
Electrical Stimulation	No	Count (%)	22 (88.0)	3 (12.0)
	Yes	Count (%)	10 (76.9)	3 (23.1)
			Hemispheric Location of CVA	
			Right	Left
Electrical Stimulation	No	Count (%)	14 (34.1)	25 (61.0)
	Yes	Count (%)	8 (44.4)	9 (50.0)

In Table 4, data were summarized according to the type of treatment provided by the occupation therapists. In most cases, UE motor, ADL, and transfer treatments were provided. Electrical stimulation was provided in 13.2% of all cases. However, 56.6% of the data was not recorded in the medical records. Cognitive treatment intervention was necessary in 21% of all the cases in the entire sample. Data were missing in 57.4% of the cases in the entire sample.

Table 4

Treatment Provided by OT

	Frequency	Percent
Electrical Stimulation		
No	41	30.1
Yes	18	13.2
UE Motor		
No	0	0.0
Yes	136	100.0
ADL		
No	1	0.7
Yes	135	99.3
Transfer		
No	1	0.7
Yes	135	99.3
Cognitive		
No	29	21.3
Yes	29	21.3

In summary, this study's entire CVA sample was primarily comprised of older adults who sustained their first stroke of non-hemorrhagic etiology, affecting the left

hemisphere of the brain. The adults were non-impaired prior to the stroke, most often living with other persons in their home environment. Traditional UE motor, ADL, and transfer treatments were provided by the OTs to most post-CVA in the inpatient rehabilitation sample studied. Electrical stimulation was provided as an UE motor treatment to 13.2% of the entire sample.

With this information available for subsequent interpretation in Chapter V, a presentation of the data analyses corresponding to each research hypothesis comprises the remainder of this chapter. A probability level of .01 was set for tests of significance in these analyses.

Hypothesis One

The first hypothesis for this study was post-CVA inpatient rehabilitation patients who received neuromuscular electrical stimulation OT treatments experienced higher upper extremity motor and self-care outcomes than did those persons who received traditional OT motor treatment.

Analyses consisted of t-tests and Mann-Whitney U tests comparing the non-electrical stimulation and electrical stimulation subgroups. Next, an investigation of left and right brain differences was conducted. Dependent variables were grouped by OT treatment type across the analyses: UE motor (i.e., hand grip and pinch strength scores at discharge) and self-care (i.e., individual or composite basic ADL variables, including functional transfers). The OT rating measures of muscle tone, the UE Function Test, and the Functional Ability Rating were analyzed together because of their ordinal nature.

There were no significant differences in UE motor hand strength at hospital discharge between the persons without electrical stimulation in their treatment plans and

those with electrical stimulation (Tables 5, 6, and 7). A consistent finding of no significant difference was maintained when left and right brain subgroups and change scores were used in the analyses. When subgroups were formed by left and right brain etiology, significance level was approached by the left brain etiology subgroup only.

Table 5

The t-Tests of Motor Hand Strength by Non-E-Stim and E-Stim Groups

	Non-E-Stim			E-Stim				
	N	Mean	SD	N	Mean	SD	t	Sig.
Right Grip Strength	30	42.2	20.0	10	32.7	27.6	1.39	.244
Left Grip Strength	33	45.1	29.1	9	39.6	40.9	.21	.650
Right Pinch Strength	28	11.1	5.8	8	11.3	10.7	.00	.953
Left Pinch Strength	30	11.6	6.6	6	8.4	8.9	1.09	.304

Regarding self-care ADL ability at discharge from the hospital, there were no significant differences at hospital discharge between the persons without electrical stimulation in their treatment plans and those who received electrical stimulation (Tables 8 and 9). Significant differences were found between the electrical stimulation and non-electrical stimulation subgroups when analyzed by change scores (i.e., admit to discharge scores) with right and left brain etiology of stroke (Table 10). Specifically, when change scores were used in t-test analyses no significant differences existed for the right brain etiology subgroup. However, significant differences were observed at a .01 level for left brain etiology on the following self-care variables: eating, upper and lower extremity dressing, and bed and toilet transfers, with higher scores at discharge (Table 10).

Table 6

The t-Tests of Motor Hand Strength by Non-E-Stim and E-Stim (Left and Right Brain Subgroups)

	Non-E-Stim			E-Stim				
	N	Mean	SD	N	Mean	SD	t	Sig.
Left Brain								
Right Grip Strength	20	38.2	17.7	5	16.4	16.8	2.48	.021
Left Grip Strength	20	56.6	25.7	3	76.3	31.9	-1.20	.241
Right Pinch Strength	19	9.4	5.0	4	2.5	5.0	2.50	.021
Left Pinch Strength	19	13.9	5.7	2	18.7	3.8	-1.13	.271
Right Brain								
Right Grip Strength	8	46.1	23.8	4	60.0	14.6	-1.05	.318
Left Grip Strength	11	25.0	20.2	5	8.8	12.5	1.64	.123
Right Pinch Strength	8	14.3	6.5	4	20.1	6.3	-1.45	.176
Left Pinch Strength	10	6.7	5.6	4	3.2	4.5	1.10	.292

Table 7

The t-Tests of Motor Hand Strength Change Scores (Admit to Discharge) by Non-E-Stim and E-Stim (Left and Right Brain Subgroups)

	Non-E-Stim			E-Stim				
	N	Mean	SD	N	Mean	SD	t	Sig.
Left Brain								
Right Grip Strength	20	30.3	19.3	5	8.0	17.8	2.33	.028
Left Grip Strength	20	54.8	25.7	3	74.6	30.1	-1.22	.235
Right Pinch Strength	20	8.0	5.7	4	0.0	0.0	2.75	.012
Left Pinch Strength	19	11.0	5.9	2	10.7	15.2	0.05	.961
Right Brain								
Right Grip Strength	8	46.0	29.5	5	56.6	14.9	-0.82	.428
Left Grip Strength	11	21.9	19.5	6	5.6	8.7	1.90	.076
Right Pinch Strength	8	13.8	6.5	5	18.8	6.2	-1.36	.201
Left Pinch Strength	10	5.9	5.5	5	0.4	0.8	2.17	.049

Table 8

The t-Tests of Self-Care Ability by Non-E-Stim and E-Stim (N=136)

	Non-E-Stim			E-Stim				
	N	Mean	SD	N	Mean	SD	t	Sig.
Eating Ability	41	5.7	1.7	18	5.7	1.1	.13	.895
Grooming	41	5.9	1.4	18	5.5	1.2	1.23	.221
Bathing	40	4.1	1.6	18	4.0	1.2	.40	.685
UE Dressing	41	5.2	1.7	18	4.5	1.3	1.49	.142
LE Dressing	41	5.0	1.9	18	4.0	1.4	1.98	.061
Bed Transfer	41	5.2	1.8	18	4.6	1.1	1.19	.238
Toilet Transfer	41	5.1	1.6	18	4.8	1.1	.61	.542
Bathtub Transfer	41	4.4	1.8	18	4.0	1.4	.96	.341
Self-care (composite)	41	54.8	17.6	18	50.7	12.8	.89	.373

Regarding the additional UE motor variables (i.e., UE Function Test, Functional Ability Rating, and upper extremity muscle tone), some significant differences were observed. Mann-Whitney U tests determined significant differences between the non-electrical and electrical stimulation subgroups for right UE muscle tone (Table 11). With further t-test analyses by left and right brain comparisons and by change scores, additional significant differences were observed (Tables 12 and 13). Specifically, only the left brain etiology yielded significant differences at the .01 level between treatment subgroups; no significant differences were found for the right brain etiology subgroup.

Table 9

The t-Tests of Self-Care Ability by Non-E-Stim and E-Stim (Left and Right Brain Subgroups)

	Non-E-Stim			E-Stim				
	N	Mean	SD	N	Mean	SD	t	Sig.
Left Brain								
Eating Ability	25	6.1	1.3	9	5.7	.9	.67	.504
Grooming	25	6.2	1.2	9	5.4	1.0	1.77	.086
Bathing	24	4.5	1.5	9	4.2	1.0	.55	.584
UE Dressing	25	5.7	1.2	9	4.7	.8	2.15	.039
LE Dressing	25	5.5	1.4	9	4.2	.9	2.42	.020
Bed Transfer	25	5.7	1.3	9	4.7	.8	2.06	.048
Toilet Transfer	25	5.6	1.1	9	4.8	1.0	1.58	.124
Bathtub Transfer	25	5.0	1.2	9	4.5	.8	.95	.349
Self-care (composite)	25	60.0	13.2	9	52.3	11.4	1.53	.134
Right Brain								
Eating Ability	14	5.4	1.7	8	6.0	1.0	-.83	.412
Grooming	14	5.6	1.6	8	5.8	1.1	-.36	.722
Bathing	14	3.6	1.5	8	4.0	1.3	-.54	.590
UE Dressing	14	4.6	1.9	8	4.6	1.6	.02	.983
LE Dressing	14	4.4	2.2	8	4.2	1.6	.19	.849
Bed Transfer	14	4.4	2.2	8	4.7	1.3	-.36	.722
Toilet Transfer	14	4.3	2.1	8	5.0	1.2	-.79	.438
Bathtub Transfer	14	3.7	2.2	8	3.6	1.7	.09	.923
Self-care (composite)	14	48.0	20.6	8	52.1	12.4	-.51	.614

Table 10

The t-Tests of Self-Care Ability Change Scores (Admit to Discharge) by Non-E-Stim and E-Stim (Left and Right Brain Subgroups)

	Non-E-Stim			E-Stim				
	N	Mean	SD	N	Mean	SD	t	Sig.
Left Brain								
Eating Ability	25	5.2	1.2	9	3.5	1.9	3.01	.005
Grooming	25	5.7	1.2	9	4.6	0.8	2.53	.016
Bathing	24	3.1	1.3	9	2.5	0.8	1.16	.255
UE Dressing	25	4.9	1.2	9	3.7	0.7	2.79	.009
LE Dressing	25	4.7	1.3	9	3.1	0.7	3.37	.002
Bed Transfer	25	4.9	1.0	9	3.6	1.0	3.36	.002
Toilet Transfer	25	4.9	0.9	9	3.6	1.0	3.24	.003
Bathtub Transfer	25	3.8	1.2	9	3.3	1.0	1.02	.312
Self-care (composite)	25	51.4	11.0	9	40.3	10.0	2.62	.013
Right Brain								
Eating Ability	14	4.3	1.4	8	4.3	2.3	-.02	.982
Grooming	14	5.0	1.1	8	4.8	1.3	.22	.831
Bathing	14	3.0	1.3	8	2.5	0.9	.95	.352
UE Dressing	14	4.1	1.4	8	3.6	1.2	.69	.495
LE Dressing	14	3.7	1.7	8	3.2	1.2	.65	.523
Bed Transfer	14	3.9	1.8	8	3.8	1.4	.15	.882
Toilet Transfer	14	3.8	1.7	8	4.0	1.4	-.28	.783
Bathtub Transfer	14	2.9	1.6	8	3.0	1.8	-.09	.927
Self-care (composite)	14	41.7	15.9	8	42.6	11.9	-.14	.887

For the left brain subgroup, the significant dependent variables were the right UE Function Test, right Functional Ability Rating, and right UE muscle tone.

Table 11

Mann-Whitney U Comparison of Non-E-Stim and E-Stim Treatments on Other Motor Measures

	Non-E-Stim N	Non-E-Stim Mean Rank	E-Stim N	E-Stim Mean Rank	Mann-Whitney U	Sig.
Right UE Function Test	41	32.28	18	24.81	275.50	.088
Left UE Function Test	41	30.59	18	28.67	345.00	.659
Right Functional Ability Rating	41	32.73	18	23.78	257.00	0.43
Left Functional Ability Rating	41	31.76	18	26.00	297.00	.186
Right UE Muscle Tone	41	33.30	18	22.47	233.50	.003
Left UE Muscle Tone	41	31.29	18	27.06	316.00	.182

In summary, no significant differences were observed for the non-electrical and electrical stimulation subgroups on hand strength or self-care. Significant differences between treatment subgroups were observed for right UE muscle tone only. Additional significant differences were found between the treatment subgroups on some ADL and motor dependent variables only when the variables were analyzed by CVA type (i.e., either right or left brain damage) and/or when change scores were used in combination with CVA type. No significant differences were found at the .01 level for the right brain etiology subgroup, but were found for the left brain subgroup for eating, dressing, transfers, and the right UE (i.e., UE Function Test, Functional Ability Rating, and muscle tone). These results are interpreted further for clinical relevance in Chapter V.

Table 12

The t-Tests of Other Motor Measures by Non-E-Stim and E-Stim (Left and Right Brain Subgroups)

	Non-E-Stim N	Non-E-Stim Mean	Non-E-Stim SD	E-Stim N	E-Stim Mean	E-Stim SD	t	Sig.
Left Brain								
Right UE Function Test	25	2.3	1.0	9	1.0	0.7	3.54	.001
Left UE Function Test	25	2.7	0.7	9	3.1	0.3	-1.30	.203
Right Functional Ability Rating	25	3.0	1.2	9	0.8	0.9	4.87	<.000
Left Functional Ability Rating	25	3.8	0.4	9	4.0	0.0	-1.45	.155
Right UE Muscle Tone	25	3.5	1.0	9	2.2	1.2	3.07	.004
Left UE Muscle Tone	25	4.0	0.0	9	4.0	0.0	0.00	1.000
Right Brain								
Right UE Function Test	14	2.7	0.6	8	3.1	0.3	-1.73	.099
Left UE Function Test	14	1.6	1.1	8	1.1	0.9	1.06	.300
Right Functional Ability Rating	14	3.7	0.6	8	4.0	0.0	-1.30	.206
Left Functional Ability Rating	14	2.2	1.6	8	0.9	0.8	2.14	.044
Right UE Muscle Tone	14	4.0	0.0	8	4.0	0.0	0.00	1.000
Left UE Muscle Tone	14	3.3	1.1	8	2.7	1.1	1.18	.250

Table 13

The t-Tests of Other Motor Measures Change Scores (Admit to Discharge) by Non-E-Stim and E-Stim (Left and Right Brain Subgroups)

	Non-E-Stim			E-Stim				
	N	Mean	SD	N	Mean	SD	t	Sig.
Left Brain								
Right UE Function Test	25	2.1	0.9	9	0.5	0.3	5.21	<.000
Left UE Function Test	25	2.6	0.7	9	3.1	0.3	-1.57	.125
Right Functional Ability Rating	25	2.9	1.2	9	0.4	0.4	5.58	<.000
Left Functional Ability Rating	25	3.7	0.5	9	3.9	0.1	-1.18	.244
Right UE Muscle Tone	25	3.6	0.8	9	2.1	1.1	4.06	<.000
Left UE Muscle Tone	25	3.9	0.2	9	4.0	0.0	-0.59	.557
Right Brain								
Right UE Function Test	14	2.7	0.6	8	3.0	0.4	-1.42	.169
Left UE Function Test	14	1.6	1.1	8	1.0	1.0	1.26	.222
Right Functional Ability Rating	14	3.6	0.8	8	3.9	0.1	-1.09	.288
Left Functional Ability Rating	14	2.1	1.5	8	0.6	0.6	2.44	.024
Right UE Muscle Tone	14	4.0	0.0	8	4.0	0.0	0.00	1.000
Left UE Muscle Tone	14	3.3	1.1	8	2.8	1.0	1.06	.300

Hypothesis Two

The second hypothesis for this study stated that persons who experienced improved quality of upper extremity motor return post-CVA also realized higher performance outcomes. This hypothesis was tested based on results of correlation coefficients attained at a .01 level and discussed in the following paragraphs.

Overall, composite self-care and hand strength dependent variables for the entire sample were significantly correlated at a .01 level. Significant positive relationships between right or left hand strength and self-care ability were established (Table 14). Further statistically significant positive relationships were found between the hand strength, self-care, and transfer variables (Table 15). For example, significant positive relationships were established between transfer ability and all other self-care abilities and between transfer ability and grip strength, particularly left grip strength.

Upper and lower extremity dressing variables were found to have a positive significant relationship with each other, as well as with all other self-care ADLs individually. Grooming and bathing were significantly associated with both left and right grip strength; dressing ability correlated only with left grip strength. Eating was seemingly not significantly associated with grip or pinch strength, but was positively correlated with all self-care ADL abilities. As may be expected clinically, same-sided grip and pinch strength were associated with each other. For example, right pinch strength was positively correlated with right grip strength.

Other motor measures rated by the occupational therapists added confirmation of hypothesis two. All three motor scales were significantly related to each other, indicating a correlation between the UE Function Test, the Functional Ability Rating, and upper extremity muscle tone (Table 16). These variables further contributed to the construct of improved upper limb function and to the interrelationships among the motor and function variables, which was the intent of hypothesis two.

In summary, significant positive relationships were found at the .01 level to support the retention of hypothesis two. First, significant positive relationships were

Table 14

Pearson r Correlation Coefficients Among Self-Care and Hand Strength Variables

(N=136, two-tailed)

	Self-Care D/C	Right Hand Strength	Left Hand Strength
Self-Care D/C	1.00		
(R) Hand Strength	0.290*	1.00	
(L) Hand Strength	0.349*	0.119	1.00

* sig. at .01 level (two-tailed)

Table 15

Pearson r Correlation Coefficients Among Hand Strength, Self-Care, and Transfer

Variables (N=136, two-tailed)

	(R) Grip	(L) Grip	(R) Pinch	(L) Pinch	Eat	Groom	Bathe	U/E Dress	L/E Dress	Transfers: Bed	Toilet	Bath
(R) Grip	1.00											
(L) Grip	0.11	1.00										
(R) Pinch	0.81*	-0.03	1.00									
(L) Pinch	0.10	0.85*	0.17	1.00								
Eat	0.08	0.18	0.08	0.22	1.00							
Groom	0.30*	0.27*	0.27	0.24	0.61*	1.00						
Bathe	0.29*	0.36*	0.04	0.39*	0.52*	0.71*	1.00					
U/E Dress	0.16	0.31*	-0.08	0.17	0.53*	0.76*	0.73*	1.00				
L/E Dress	0.25	0.30*	-0.01	0.15	0.53*	0.75*	0.74*	0.91*	1.00			
Transfers:												
Bed	0.24	0.29*	0.04	0.24	0.52*	0.76*	0.74*	0.81*	0.87*	1.00		
Toilet	0.29*	0.30*	0.05	0.24	0.51*	0.75*	0.77*	0.82*	0.87*	0.96*	1.00	
Bathtub	0.22	0.33*	0.01	0.29*	0.49*	0.61*	0.67*	0.74*	0.80*	0.82*	0.82*	1.0

* sig. at .01 level (two-tailed)

found between right or left hand strength and self-care ability (Table 14). To distinguish further, significant positive relationships were found for right grip strength with grooming, bathing, and toilet transfers. The left grip strength significantly correlated with the above three variables with the addition of left pinch strength, dressing (UE and LE), and bed and bathtub transfers (Table 15). Other motor variables (i.e., muscle tone, UE Function Test, and Functional Ability Rating measure) established further positive significant relationships (Table 16). Therefore, most motor and self-care variables form significant positive relationships in support of hypothesis two. Further clinical implications are discussed in Chapter V.

Table 16

Spearman's rho Correlation Coefficients Among Other Motor Measures (N=136, two-tailed)

	Muscle Tone	UE Function Test	Functional Ability Rating
Muscle Tone	1.00		
UE Function Test	0.50*	1.00	
Functional Ability Rating	0.66*	0.66*	1.00

* sig. at .01 level (two-tailed)

Hypothesis Three

The third hypothesis stated that sensorimotor treatment techniques provided by occupational therapists promoted sensorimotor improvement of the upper extremity function post-CVA. This hypothesis was tested based on the results of admit to discharge paired samples t-test analyses for the entire sample, with the exception of muscle tone.

To test this hypothesis, admit to discharge motor scores were compared for the entire sample. Additional t-test comparisons were conducted within the non-electrical

and the electrical stimulation subgroups. Self-care measures and other motor measures were analyzed in the same sequence.

Significant differences in admit to discharge motor hand strength (i.e., grip and pinch strength) at the .01 level were found in the entire sample (Table 17). A significant difference in grip strength was demonstrated for the non-electrical stimulation subgroup; however, no significant differences were established for pinch strength. There were no significant differences found in admit to discharge hand strength comparisons for the electrical stimulation group.

Significant differences were demonstrated on the self-care admit to discharge performance scores. The significant differences were found for the entire sample as well as both treatment subgroups, thus further supporting hypothesis three (Table 18). Significant differences at the .01 level in admit to discharge performance scores on two of the OT functional motor measures were found for the entire sample (Table 19). The UE Function Test and the Functional Ability Rating, for both the right and left extremities, yielded significant differences on the scores. The non-electrical stimulation subgroup had significant differences from admit to discharge scores on only the Functional Ability Rating measure, both right and left extremities. The electrical stimulation subgroup had significant differences on the right UE Function Test only. Muscle tone did not significantly differ from admit to discharge across the three groups (Table 19).

In summary, t-test analyses demonstrated that patients experienced improvement in their motor and self-care performance scores from admit to hospital discharge, thus supporting hypothesis three. Overall, patients' grip and pinch strength scores improved.

Table 17
The Paired Samples t-Tests of Admit to Discharge Motor Hand Strength Differences (N=136)

N=136:	Admit			Discharge				
	N	Mean	SD	N	Mean	SD	t	Sig.
Right Grip Strength	96	38.8	25.8	96	44.8	23.5	-5.50	<.001
Left Grip Strength	100	39.3	30.8	100	44.7	29.2	-5.97	<.001
Right Pinch Strength	81	11.1	7.2	81	12.4	6.7	-3.83	<.001
Left Pinch Strength	81	9.5	6.5	81	11.2	6.3	-4.33	<.001

Non-E-Stim:	Admit			Discharge				
	N	Mean	SD	N	Mean	SD	t	Sig.
Right Grip Strength	30	36.7	22.6	30	42.2	20.0	-3.29	.003
Left Grip Strength	33	41.0	30.1	33	45.1	29.1	-3.06	.004
Right Pinch Strength	28	10.3	6.3	28	11.1	5.8	-1.99	.057
Left Pinch Strength	29	9.9	6.2	29	11.2	6.2	-2.60	.015

E-Stim:	Admit			Discharge				
	N	Mean	SD	N	Mean	SD	t	Sig.
Right Grip Strength	10	27.8	31.2	10	32.7	27.6	-1.79	.107
Left Grip Strength	9	35.6	39.5	9	39.6	40.9	-2.08	.070
Right Pinch Strength	8	9.9	11.4	8	11.3	10.7	-1.11	.304
Left Pinch Strength	6	3.9	8.6	6	8.4	8.9	-1.60	.169

Table 18

The Paired Samples t-Tests of Admit to Discharge Self-Care Differences (N=136)

N=136:	Admit			Discharge				
	N	Mean	SD	N	Mean	SD	t	Sig.
Eating Ability	136	4.5	1.8	136	5.6	1.6	-8.15	<.001
Grooming	136	4.4	1.7	136	5.7	1.4	-10.58	<.001
Bathing	135	2.8	1.1	135	4.1	1.4	-15.25	<.001
UE Dressing	136	3.5	1.3	136	5.0	1.6	-14.03	<.001
LE Dressing	136	3.0	1.4	136	4.7	1.7	-13.69	<.001
Bed Transfer	136	3.4	1.3	136	4.9	1.6	-13.88	<.001
Toilet Transfer	136	3.4	1.6	136	4.8	1.5	-10.64	<.001
Bathtub Transfer	136	2.0	1.6	136	4.1	1.7	-13.90	<.001
Self-care (composite)	136	36.5	12.3	136	52.9	16.2	-18.78	<.001

N=136:	Admit			Discharge				
	N	Mean	SD	N	Mean	SD	t	Sig.
Eating Ability	41	4.9	1.5	41	5.7	1.7	-4.23	<.001
Grooming	41	4.9	1.4	41	5.9	1.4	-6.13	<.001
Bathing	40	3.0	1.3	40	4.1	1.6	-7.28	<.001
UE Dressing	41	3.8	1.3	41	5.2	1.7	-6.64	<.001
LE Dressing	41	3.5	1.5	41	5.0	1.9	-7.39	<.001
Bed Transfer	41	3.8	1.3	41	5.2	1.8	-7.39	<.001
Toilet Transfer	41	2.3	1.7	41	4.4	1.8	-6.88	<.001
Bathtub Transfer	41	2.3	1.7	41	4.4	1.8	-9.80	<.001
Self-care (composite)	41	39.8	11.9	41	54.8	17.6	-9.80	<.001

E-Stim:	Admit			Discharge				
	N	Mean	SD	N	Mean	SD	t	Sig.
Eating Ability	18	3.7	2.1	18	5.7	1.1	-4.15	.001
Grooming	18	3.6	1.6	18	5.5	1.2	-4.80	<.001
Bathing	18	2.4	0.9	18	4.0	1.2	-8.42	<.001
UE Dressing	18	2.6	0.9	18	4.5	1.3	-7.43	<.001
LE Dressing	18	2.1	1.1	18	4.0	1.4	-5.45	<.001
Bed Transfer	18	2.6	1.5	18	4.6	1.1	-6.92	<.001
Toilet Transfer	18	2.6	1.7	18	4.3	1.1	-7.10	>.001
Bathtub Transfer	18	2.1	1.7	18	4.0	1.4	-5.46	<.001
Self-care (composite)	18	29.7	12.4	18	50.7	12.8	-8.62	<.001

Table 19

The Paired Samples t-Tests of Admit to Discharge Differences for Other Motor Measures (N=136)

N=136:	Admit			Discharge				
	N	Mean	SD	N	Mean	SD	t	Sig.
Right UE Function Test	135	2.1	1.1	135	2.2	1.0	-4.41	<.001
Left UE Function Test	135	2.2	1.0	135	2.3	1.0	-4.68	<.001
Right Function Ability Rating	136	2.6	1.5	136	2.9	1.4	-5.29	<.001
Left Function Ability Rating	135	2.7	1.4	135	3.0	1.3	-5.03	<.001
Right UE Muscle Tone	136	3.6	0.8	136	3.6	0.8	0.00	1.000
Left UE Muscle Tone	135	3.5	0.9	135	3.5	0.9	-0.62	.534

Non-E-Stim:	Admit			Discharge				
	N	Mean	SD	N	Mean	SD	t	Sig.
Right UE Function Test	41	2.3	0.8	41	2.4	0.9	-2.20	.033
Left UE Function Test	41	2.2	1.1	41	2.3	1.1	-1.95	.058
Right Function Ability Rating	41	3.0	1.3	41	3.2	1.0	-2.89	.006
Left Function Ability Rating	41	3.0	1.4	41	3.2	1.3	-2.72	.010
Right UE Muscle Tone	41	3.8	0.5	41	3.7	0.8	1.96	.057
Left UE Muscle Tone	41	3.6	0.9	41	3.6	0.9	-1.00	.323

E-Stim:	Admit			Discharge				
	N	Mean	SD	N	Mean	SD	t	Sig.
Right UE Function Test	18	1.3	1.5	18	1.9	1.2	-3.34	.004
Left UE Function Test	18	2.0	1.3	18	2.1	1.2	-1.45	.163
Right Function Ability Rating	18	1.7	1.9	18	2.2	1.7	-2.69	.015
Left Function Ability Rating	18	2.2	1.8	18	2.5	1.6	-2.08	.052
Right UE Muscle Tone	18	2.8	1.3	18	2.9	1.3	-0.36	.717
Left UE Muscle Tone	18	3.5	0.9	18	3.4	0.9	0.29	.772

Further, the non-stimulation group experienced significant hand strength changes, whereas the electrical stimulation subgroup did not. Self-care skills improved significantly across all groupings for analyses. Significant gains were experienced on the UE Function Test and the Functional Ability Rating motor measures; however, no significant gains were realized on the UE muscle tone measure. Clinical explanations are presented in Chapter V.

Hypothesis Four

The fourth hypothesis stated that the higher cognitive scores, the higher motor and ADL outcomes. Although not the primary intent of this motor research, the cognitive variable's relationship to motor and self-care outcomes was investigated for its clinical relevance.

To test this hypothesis, regression analysis was performed with the composite motor and self-care variables run against the FIM cognitive dependent variable using first a full model and, if significant, followed by a stepwise forward restricted model. Results of the full sample model were significant, with the strongest predictive relationship among variables established for self-care (Tables 20, 21, and 22). These findings supported the fourth hypothesis.

In summary, using statistical regression modeling, the relationships between the motor and self-care variables with the dependent variable, cognition, were explored. Self-care ability was found to be predictive of higher cognitive ability. No motor variables were found as significant predictors of higher cognition. These results are interpreted clinically in Chapter V.

Table 20

Full Model Summary of Cognitive Discharge Rating with Motor and Self-Care Variables (N=136)

Model	R	R2	F	Sig.
1	.643	.402	9.507	<.001

Table 21

Full Model Summary of Coefficients (Dependent Variable: Cognition)

	Beta	t	Sig.
Self-care	.556	4.64	<.001
Right Hand Strength	.113	1.24	.217
Left Hand Strength	-.224	-2.38	.020
Muscle Tone	-.037	-0.34	.735
Functional Ability Rating	.150	1.12	.265
UE Function Test	-.004	-0.02	.977

Table 22

Restricted Model (Stepwise Forward) Summary: Cognition

	Beta	t	Sig.
1 Self-care	.587	6.87	<.001

Hypothesis Five

Hypothesis five proposed that some sensorimotor measures used by the occupational therapists would predict the discharge ADL ability of post-stroke patients. Using full and stepwise forward regression models to address this hypothesis, there was a significant relationship demonstrated between self-care outcome and the UE Function Test and/or Functional Ability Rating test as predictors. Therefore, this hypothesis was supported by the findings.

In this regression analysis, the motor composite variables were run with the overall FIM self-care score as the dependent variable to find the best predictor of self-care ADL ability. The full model and stepwise forward procedures were used on the entire sample to investigate the hypothesis. The entire sample full model's results were significant, and the stepwise restricted model further established that the UE Function Test and Functional Ability Rating test were the best predictors of self-care outcome (see Tables 23, 24, and 25).

Table 23

Full Model Summary of Self-Care Outcome by Predictor Variables (N=136)

Model	R	R2	F	Sig.
1	.720	.519	15.289	<.001

Table 24

Full Model Summary of Coefficients (Dependent Variable: Self-Care)

	Beta	t	Sig.
Right Hand Strength	.048	0.59	.557
Left Hand Strength	.052	0.61	.539
Muscle Tone	.023	0.23	.813
Function Ability Rating	.325	2.82	.006
UE Function Test	.105	1.27	.204

Table 25

Restricted Model (Stepwise Forward) Summary

	Beta	t	Sig.
1 UE Function Test	.656	8.25	<.001
2 UE Function Test	.431	4.48	<.001
Function Ability Rating	.356	3.70	<.001

Regarding hypothesis five, significant predictors of self-care ability for the entire post-stroke sample emerged as the UE Function Test and the Functional Ability Rating test. Clinical significance and discussion of this finding are discussed further in Chapter V.

Summary

Overall, no significant differences were observed between the electrical stimulation treatment subgroups on hand strength or self-care. Right UE muscle tone was the only variable on which significant differences were found between non-electrical and electrical stimulation treatment subgroups. Beyond these observations, a primary finding of this study was that CVA type was associated with findings of significant differences when examining the effects of the provision of electrical stimulation or not in a treatment regime. For the sample investigated, the left brain etiology yielded more findings of significant differences, especially for self-care and other motor measures of function, rather than hand strength.

Patients in the entire sample experienced significant gains in motor and self-care ratings from admit to discharge from the hospital, with the exception of muscle tone. In this regard, the non-electrical stimulation group realized significant gains in motor and self-care areas, whereas the electrical stimulation group gained significantly in self-care areas but made few motor improvements.

Another major finding of this research was in regard to the associations made with self-care ability. Hand strength and cognitive ability were correlated to self-care skill in the entire sample. Additionally, the motor measures known as the UE Function Test and the Functional Ability Rating were identified as predictors of self-care ability in post-stroke rehabilitation. In summary, the results of this study substantiated the research hypotheses, and the clinical implications are addressed in Chapter V.

CHAPTER V

SUMMARY, DISCUSSION, AND RECOMMENDATIONS

The purpose of this study was to investigate the type of post-stroke variables that contributed to and predicted improved upper extremity and ADL outcomes within the context of an acute rehabilitation inpatient hospital setting. Further, one specific sensorimotor technique, upper extremity NMES, was studied for its impact upon overall motor and ADL outcomes. It was postulated that the post-stroke patients who received electrical stimulation would experience greater gains in upper extremity motor and self-care outcomes than their counterparts who did not receive this particular motor treatment. The treatment subgroups were compared on the motor and self-care outcome measures to determine the efficacy of the treatments on the overall functional outcomes. Additionally, occupational therapy measures were investigated for their ability to predict patients' self-care ability at discharge from the hospital.

This study used an acute care hospital's medical record documents as the primary data source for this retrospective document review. One hundred thirty-six CVA patient medical records from the dates of September 1, 1996, through June 1, 1999, were included in the study. The criteria for inclusion were patients' post first-time acute and cortical cerebrovascular accident, aged 30-80 years, who were treated by occupational therapists while participating in a comprehensive inpatient acute rehabilitation program.

The supporting stroke outcome literature for this study indicated that hemispheric location of the CVA provided the most clinically relevant information related to the prediction of post-stroke functional outcome, such as self-care. Other factors were studied in the stroke research literature (i.e., type of stroke, age, gender, onset to admission, LOS, cognition, co-morbidities, and discharge to home rates); however, there existed no clear consensus as to the associative or predictive nature of these factors to overall outcome. This would seem to indicate that individual variation exists and is reflected in the research conducted.

The current neuroanatomical and neurophysiological basis for rehabilitation guided the purpose of this study and its concomitant literature review. The exact mechanism of motor return of upper limb function post-stroke is unknown, but is thought to be a combination of the following three processes. "Recovery" of the central nervous system involves the recruitment of additional cortical areas post-stroke in the performance of motor tasks. "Sparing" was discussed as the natural existing redundancy within the CNS that is engaged to perform motor tasks post-stroke. Lastly, "compensation" refers to the alternative methods found by learning to use the same limb in a different manner or to use the opposite limb to perform a necessary motor task post-stroke.

The mechanism of motor recovery was not studied per se in the electrical stimulation post-stroke research, but rather its treatment effect upon motor and self-care outcomes. Essentially, electrical stimulation studies have not documented long-term effects of treatment; yet they report shorter term results in terms of a decrease in

abnormally high muscle tone and in motor gains. Only one study reported an improvement in functional self-care (Francisco et al., 1998).

Limitations of the Study

Limitations of generalizability to the overall stroke population are very probable with inherent bias of unknown proportions due to the convenience sampling method of this retrospective document review. Other limitations of this study included the small sample size; incomplete documentation or accuracy; possible therapist inter-rater inconsistency of documentation (and interpretation of testing); possible therapist inexperience level in assessment and treatment (especially in use of NMES); validity (and reliability) not established for some patient tests used by the OTs; and finally, the effects of unknown confounding variables such as patient motivation, patient daily performance fluctuations, and patient emotional response during the rehabilitation period of time.

Summary of Findings and Discussion

The purpose of this research was to study traditional motor treatments and electrical stimulation usage upon the functional recovery of acute post-stroke patients. The supporting hypotheses behind this purpose were also investigated, including the issue of rehabilitation functional recovery for all stroke patients and the significance of cognition upon outcome, if any. The connection to occupational therapy practice was explored through examination of which assessments best predicted the functional self-care outcome of acute, cortical stroke CVA patients. A summary of the findings with discussion of interpretation follows.

Inquiry into the demographics of this study's sample revealed that the age of the patients was slightly younger at 67.7 years than the research literature mean age reported

between 70 to 74 years. Age was not a clear predictor of outcome according to the literature, often correlated with LOS or other factors such as socio-emotional support. LOS in this study was also shorter at a mean of 17.3 days than the research range in the United States from 24.3 to 31.8 days. The overall younger age and decreased hospital length of stay may be a regional trend, and may be reflective of general health, medical viewpoints, personal and societal values, or other economic factors, not in the purview of this study. For example, LOS may relate to the fact that the vast majority of patients in this sample lived with another person (74.3%) compared to those who did not (25.7%).

The numbers of males and females were found to be roughly equal in the overall CVA population in studies conducted in the United States, and gender was not associated with significant differences in stroke outcome studies. This research sample is similar to the national finding of roughly equal numbers of males and females (i.e., within a range of 45-55% for each group). Further, no significant difference was found in the number of males or females selected to receive electrical stimulation as a motor treatment in this study. Therefore, it may be assumed that gender bias was not part of the selection process for electrical stimulation treatment.

Regarding the medical history of this CVA sample, the vast majority did not sustain more than one CVA (i.e., 77.2%), nor did they report any disabling conditions prior to the stroke (79.4%). Although patient reports may not be accurate, the majority of this study's sample did not have a prior disability. Those patients who did sustain a prior CVA were ultimately included in this study and, therefore, contributed to difficulty in interpretation and generalization of the results (i.e., external validity) due to threat of

multiple treatment interference (in addition to the sample not being randomly selected) (Gay, 1996).

Non-hemorrhagic stroke comprised the majority of the stroke population nationally with the hemorrhagic cause usually less than 20%, according to the research literature reviewed. This held true with this study's sample, with the hemorrhagic etiology subgroup reported at 11%. More important clinically is the notation of CVA type by hemispheric location. In this sample, 55.1% of the patients sustained a left brain CVA and 38.2% a right brain stroke. Three studies reported in the literature review found that persons post-left CVA made greater and faster functional gains than the patients post-right CVA. This result is corroborated by the results of this study, as discussed later in this chapter.

The results from this study's hypothesis testing are presented in the following paragraphs. The researcher in this study found very little difference between the patients who received electrical stimulation and those who did not on the motor and self-care outcomes comparison. The only variable found to be significantly different was right upper extremity muscle tone. However, significant differences were found for the Functional Ability Rating when comparisons were made with left and right brain etiological subgroups. More significant differences were revealed for the left brain CVA subgroup in five self-care variables when change scores were calculated. As may be noted in the research literature, left and right brain etiological considerations yielded clinically relevant findings, including the finding that persons post-left CVA experienced faster and greater gains. This latter finding for the CVA population was corroborated by the results of this study, chiefly through the use of change scores that reflected the rate of

patient improvement. The change scores in combination with right-left brain etiology subgroup may also be more sensitive to "small changes" such as fine musculature required for pincer grasp and in the quality of self-care performance.

This study's findings supported earlier research of the connection between upper extremity motor function and self-care performance (Duncan et al., 1992). Overall composite self-care and hand strength dependent variables for the entire sample were significantly correlated and, therefore, a significant positive relationship existed between right or left hand strength and self-care ability. Further, significant positive relationships were established with clinical relevance to the practice of occupational therapy. Specifically, that same-sided grasp and pinch strength were correlated, and that grip strength more so than pinch strength correlated with all other self-care abilities. Most notable, however, was the finding that all self-care variables as measured by the FIM were associated with each other, some at higher levels of significance. Transfer type variables correlated highly, as did upper extremity and lower extremity dressing. These associations make sense practically and clinically. Further, this study's information helps to establish the relationships in a statistical manner for empirical research reporting.

The significant positive relationships established between the UE Function Test, the Functional Ability Rating, and upper extremity muscle tone have numerous clinical implications. First, they provide pilot testing data to establish the tests as measures with potential for reliability and validity to use with the post-stroke population. These tests also may be useful as descriptive and statistically sensitive measures of upper limb usage regarding the construct of "function." Secondly, there was a demonstrated relationship between more normalized muscle tone and better upper extremity function on these two

tests, therefore adding further evidence to the research discussion regarding the connection between motor return and upper limb function.

Fundamental to the intent of this study was the investigation of the entire sample outcome to add credence to the examination of subgroups within the sample as a whole. The results of the paired samples t-tests of all subjects' admit to discharge scores demonstrated that significant gains were made in hand strength, self-care, and the other functional motor measures, except muscle tone. Muscle tone is clinically difficult to assess, and it did not change from initial to discharge rating in this study's sample. Self-care gains for post-stroke patients were found to be significant for this study's sample, which was consistent with other FIM self-care research findings of significance reported in Chapter II.

When the treatment subgroups were compared on paired samples t-test analyses, the non-electrical stimulation subgroup had more trends toward significant differences on the admit to discharge measures than the electrical stimulation subgroup. The electrical stimulation results may be due to the smaller subgroup. Another explanation may be the short hospitalization LOS, which may not be of sufficient length for the effects of electrical stimulation to be realized.

The results of the study indicating that persons in the electrical stimulation treatment subgroup made significant gains in self-care ADLs from admit to discharge are important clinically and to the research body of knowledge regarding electrical stimulation with this patient population. Only one study of an association with functional gains post-electrical stimulation was reported in the review of literature presented here (Francisco et al., 1998).

The relationship between cognition with motor and self-care measures was explored via multiple regression. The strongest relationships existed between self-care and the higher cognitive functioning variable. This has been a clinically observed concept but has not been demonstrated in empirical research. Therapists recognized the complexity of supporting skills that enable self-care performance, including the contribution of cognition (Aquaviva, 1996; Duncan et al., 1992). Motor measures, conversely, did not correlate highly with the cognitive dependent variable. This study's findings contradicted the research reported in the review of literature (Stineman, Maislin et al., 1997). Yet the emergence of self-care ability in relation to higher cognition may support the theory of compensation and learning taking place in the recovery of stroke survivors.

The findings of this research related to cognition should be interpreted very tentatively because of the limited cognitive measurement (i.e., the FIM rating alone). Cognition as a construct is extremely broad and encompassing, making it inherently difficult to "measure." Additionally, Heinemann et al. (1993) cautioned against the use of the FIM cognitive scale used alone in stroke sample research. The complexity of human cognition and individual variation among stroke survivors has been recognized by clinicians (Giles, 1996). The need for further but cautious research in this area continues.

Finally, this research investigated the occupational therapy motor measures which best served as predictors of self-care outcome among post-stroke survivors. From the multiple regression analysis, the best predictors were the UE Function Test and the Functional Ability Rating. The two tests that appeared as predictors of self-care were positively correlated to each other, so their association as predictors in this model may be

further explained by this event. The clinical relevance of these predictors of self-care appear to relate to the potential for a measure to help bridge the gap between motor, cognitive, and functional variables in prediction of self-care for post-stroke patients. This interpretation would require much additional future research to define the functional measurement concept and methodology for study in the rehabilitation field.

Recommendations

Several recommendations for further research and documentation are provided based upon this study's review of medical literature and its exploration of the issues related to stroke functional outcomes. First, it would seem advantageous for the rehabilitation sciences to jointly determine key outcome variables most important for study of the stroke patient population. Following that decision and for the benefit of patients post-stroke, the rehabilitation sciences should keep records of the variables in a consistent manner to facilitate outcomes-based research of admit to discharge progress achieved. Within each rehabilitation profession and health care setting, a commitment to the intent of outcomes-based research would need to be declared in order for consistency in record-keeping and outcomes-based research to follow. Further, this study's findings support the use of CVA type subgroups when analyzing outcomes research to yield more clinically relevant results.

Additional research regarding the use of electrical stimulation and its efficacy with patients post-stroke is warranted and should be investigated following experimental designs with much larger samples of patients. The future research should be preceded by clear purposes determined for the use of electrical stimulation (e.g., for spasticity reduction or muscle re-education), documentation of stroke typology, time in treatment,

and the use of gold standard measures of upper limb strength and function pre- and post-treatment. Longitudinal studies of the effects of the treatment are also recommended.

Further, this study's results lead to the possibility of future test development of the UE Function Test and the Functional Ability Rating measures as pre- and post-test measurements of upper limb function in post-stroke patients. Additional areas for further development would be in areas of muscle tone measurement, cognitive assessment, and patient perceptions of treatments' benefit in relation to their everyday functional needs. The rehabilitation of post-stroke survivors is complex and requires more study and commitment by teams of professionals. The ultimate goal is for the further refinement of measurement and treatment techniques to best assist patients reach their highest level of function possible.

OUTCOMES OF OT TREATMENT WITH STROKE PATIENTS

1. ID Number ________________
2. CVA Onset Date __/__/__
3. Discharge Date: __/__/__
4. LOS: _____ days
5. Gender: M 1; F 2
6. Age: ____________________
7. Ethnic/Race ________________
8. Marital Status ______________
9. Surgical: Yes 1; No 0
10. First Time CVA: Yes 1; No 0
11. Employed: Yes 1; No 0
    (Prior to Admit)
12. Living With ________________
    (Prior to Admit)
13. Location (city): _____________
14. Primary ICD-9: _____________
    ____
15. Stroke Type:(R) 1; (L) 2; Other 3
16. Admit From: ________________
17. Discharge To: _______________
18. With Services: Yes 1; No 0
19. Handedness: R_____L____B_____
20. Pre-stroke Disability: Yes 1; No 0
    OT Treatments Received:________
21. ADL: Yes 1; No 0
22. UE Motor: Yes 1; No 0
23. Transfers: Yes 1; No 0
24. Cognitive Sessions: Yes 1; No 0
25. Perceptual: Yes 1; No 2
26. E-Stim Sessions: Yes 1; No 2
27. Grip (Admit): R _____ L ______
28. Grip: (D/C): R _____ L ______
29. Pinch (Admit): R _____ L ______
30. Pinch (D/C): R _____ L ______

FIM:

31. Eating: A____ D_____
32. Grooming: A_____ D_____
33. Bathing: A_____ D_____
34. Dress UE: A_____ D_____
35. Dress LE: A_____ D_____
36. Toilet: A_____ D_____
37. B & B: A_____ D_____
38. Trans: Bed A_____ D_____
39. Trans: Toilet A_____ D_____
40. Trans: Tub A_____ D_____
41. Walk: A_____ D_____
42. Auditory: A_____ D_____
43. Visual: A_____ D_____
44. Vocal: A_____ D_____
45. Social: A_____ D_____
46. Cognitive: A_____ D_____
47. Memory: A_____ D_____
48. Meal: A_____ D_____
49. Driving: A_____ D_____

OT Note Information:

50. Cognition: Intact 2; Impaired 1
51. Perception: Int 2; Imp 1; Absent 0
52. Sensation: Int 2; Imp 1; Absent 0
53. Vision/Hear: Int 2; Imp 1; Absent 0
54. Func Ability Rating:
    (Admit) R______L______
    (D/C) R______L______
55. UE Func Test:
    (Admit) R______L______
    (D/C) R______L______
56. Muscle Tone:
    (Admit) R______L______
    (D/C) R______L______

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