UPPER EXTREMITY IMPAIRMENT, ACTIVITY LIMITATION, AND PARTICIPATION RESTRICTION IN INDIVIDUALS WITH CHRONIC STROKE

by

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Abstract

The upper extremity is used in virtually every aspect of daily life whether in self-care, work, or recreational activities. Upper extremity impairment following stroke is common and thus factors contributing to its function (e.g., strength, sensation, tone, hand dominance) following stroke could critically impact independence in daily activities and quality of life. The purpose of this study was to determine the relationship between variables of upper extremity impairment and activity limitation (assessed by performance on measures of ADL) and participation restriction (assessed by measures of satisfaction and quality of life), and to determine the effect of hand dominance on impairment and activity in individuals with chronic stroke. Ninety-three community dwelling individuals with chronic stroke participated in a clinical assessment of upper extremity function. The results of this study revealed that variables of upper limb impairment particularly muscle weakness and severity of motor impairment, did contribute to activity limitation and participation restriction in individuals with chronic stroke. Further, the results suggested that if the dominant hand (versus the non-dominant) was affected by the stroke, individuals incurred less impairment (strength, tone, and pain) but not activity limitation. It is suggested that clinicians working in stroke rehabilitation focus on strength training of the affected upper limb to minimize dependence in ADL and enhance community living. As well, clinicians need to consider whether the affected hand is dominant or non-dominant. Our results suggest that the affected non-dominant hand has greater impairment (versus affected dominant) thus enforcing the use of the affected non-dominant hand may reduce musculoskeletal changes and impairment, thereby enhancing motor performance post stroke.

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Contributions of the Author

This thesis contains one experiment that was conducted by the candidate under the supervision of Dr. Janice Eng (Associate Professor, Rehabilitation Sciences). The collection, analysis and documentation of the experiment were primarily the work of the candidate. The above statement was written by Jocelyn Harris and agreed upon by the undersigned.

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Janice J. Eng.

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Harris, JE, Eng JJ. (in review). The Influence of Upper Extremity Impairment on Activity Limitation and Participation Restriction in Individuals with Chronic Stroke. Archives of Physical Medicine and Rehabilitation.

Harris, JE, Eng JJ. (in review). Individuals with dominant hand affected following stroke demonstrate less impairment, but not activity. Stroke.

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Chapter 1: Introduction

There are 300,000 persons living with the effects of stroke in Canada with an incidence of 40,000-50,000 per year (Heart and Stroke Foundation of Canada, 2003). Stroke can impact virtually all areas of function: gross and fine motor skills, ambulation, basic and instrumental activities of daily living (ADL), mood, speech, perception, and cognition. Stroke predominantly affects older adults and with the demographic of the older adult population increasing, the number of individuals living with stroke-related disability will rise. Residual impairment is common following a stroke with up to 50% of individuals sustaining moderate to severe upper extremity deficits (Jorgensen et al., 1999) which affect performance in ADL. One of the fundamental goals of rehabilitation is the development and or maintenance of the ability to perform ADL and promotion of quality of life.

A large portion of individuals who have sustained a stroke, 85% in the acute stage and 40% in the chronic stage (Parker and Wade, 1986; Wade, 1989), have upper limb impairment. Most of the studies (De Haan et al., 1993; Inouye et al., 2000; Jorgensen et al., 1995; Lai et al., 1998; 2000; Patel et al., 2000; Pohjasvaara et al.; 1998; Roth et al., 1998) that have examined the effect of stroke impairment on functional outcome have examined global variables of impairment (e.g. neurological status and general paresis/paralysis) in the acute and sub-acute stages of stroke recovery. These global scales of stroke impairment are not precise enough to capture the contribution of specific upper extremity impairments and therefore little is known about its impact on post functional outcome. However, some studies (Chae et al., 1995; Nakayama et al., 1994; Parker and Wade, 1986; Wade, 1983) which have examined the impact of global upper extremity impairment (i.e. motor recovery) on performance in ADL and quality of life, have reported a significant relationship with measures of ADL in the sub-acute stage of recovery (≤ 6 months post stroke). Bohannon (1991), Feys et al. (2000), and Williams et al. (2001) have all evaluated the impact of specific upper extremity impairments (e.g. strength, tone, and sensation) on measures of ADL performance in individuals with stroke but none have investigated the impact of hand dominance on stroke recovery. These researchers found that specific upper extremity impairments contribute to functional outcome after stroke.

A relatively new treatment for the upper extremity is Constraint-Induced Movement Therapy (CIMT) (Taub et al., 1993). Studies using this treatment method have reported significant findings for improved arm movement and increased use of the affected arm in daily activities but not necessarily an increase on measures of ADL performance (Kunkel et al., 1999; Liepert et al., 2000; Miltner et al., 1999; Taub et al., 1993; van der Lee, et al., 1999; Wolf et al., 1989). To develop better treatment methods for the affected upper extremity, we need to know how factors of upper extremity function influence outcome.

This thesis focuses on the relationship between upper extremity impairments and activity and participation with the hope of gaining an understanding of this relationship and insight into which impairments, if amendable to treatment, would result in the best outcome. Specifically, there are two studies in this thesis, the first examines the influence of hand dominance on activity and participation and the second examines the relationship between upper extremity impairment and activity and participation.

1.1 Conceptual Model

The International Classification of Impairments, Disabilities and Handicap (ICIDH) (World Health Organization, 1980) was designed by the World Health Organization (WHO) to help health professionals define and classify aspects of health and to go beyond the medical model to include aspects of disability and handicap. The ICIDH provides a framework to organize and communicate information. There are three dimensions in the ICIDH: 1) Body Structure/Function, 2) Disability, and 3) Handicap. Several studies involving individuals with stroke used the ICIDH as a conceptual model and found it beneficial for explaining the impact of stroke (Clarke et al., 1999; De Haan et al., 1993; Ferrucci et al., 1993; Jorgensen et al., 1999; Kauhanen et al., 2000; Kim et al., 1999; Pohjasvaara et al., 1998; Segal et al., 1995; Sonoda et al., 1997; Roth et al., 1998; Viitanen et al., 1988; Wolfe et al., 1991). In 2001, a revised version of the classification system was introduced called the International Classification of Functioning, Disability, and Health (ICF) (World Health Organization, 2001). There are still three dimensions but the names were changed to reflect more neutral language: 1) Body Structure/Function, 2) Activity, and 3) Participation (Table 1.1). Several studies on stroke recovery have utilized the ICF as a conceptual framework and to examine the relationship between impairment, activity, and participation (Carod-Artal et al., 2002; Celani et al., 2002; Gottlieb et al., 2001; Johnson and Pollard, 2001; Mackenzie and Chang, 2002; Patel, 2001; Rentsch et al., 2003; Strum et al., 2002; Williams et al., 2001).

Table 1-1: Dimensions of the International Classification of Functioning and Disability (adapted from the World Health Organization, 2003)

	Body Function/Structure	Activity	Participation
Definition	Physiological/ psychological functions of body systems, parts of the body such as organs, limbs and their components (e.g. strength, tone, joint mobility)	Performance of a task or action by an individual (e.g. coordinated movement, dressing, meal preparation)	Involvement in life situations related to health conditions, body functions and structure, and activities (e.g. accessibility of resources, acceptance of others, involvement in life roles)
Problem in the dimension	Impairment – a loss, reduction, deviation in body function or structure	Activity limitation – difficulty in performance of activities	Participation limitation – problem in manner, extent or involvement in life situations

The ICF was chosen as the conceptual model for this thesis as it has not only been used in previous studies involving stroke but also encompasses all aspects of the consequences of disease, from pathology to quality of life. This second aspect was of particular importance, as we wanted to explore the possible impact of upper extremity impairment on ADL and quality of life by determining the relationship between the ICF dimensions. The measurement tools were chosen to reflect components of the dimensions, e.g. measurement of tone (body structure), measurement of self-care (activity), and measurement of ability to perform family roles (participation). There is some difficulty in finding measurement tools that are exclusive to the dimension of participation (Johnston and Pollard, 2001) and therefore for this thesis, measurement tools that evaluate performance in ADL will be classified under activity and measurement tools that evaluate satisfaction with performance and or quality of life are classified under participation.

1.2 Literature Review

1.2.1 Variables of upper limb functioning following stroke

Deficit in the Body Structure/Function dimension of the ICF is termed impairment. Impairment is a manifestation of deficits in body systems or anatomical parts (e.g. muscle weakness, spasticity, joint mobility). Physical impairments such as altered tone are the most visible long-term effects of stroke (Christie, 1982). Impairments following stroke are numerous and usually include problems with tone, range of motion, strength, sensation, and pain. Since performance in ADL tasks are reliant on the efficient workings of body structure and function (De Haan et al, 1993; Sonoda et al., 1997), impairment measures could be used to define the factors contributing to functional limitations in individuals with stroke and guide treatment goals. Three of the most commonly cited residual upper extremity deficits following stroke are motor recovery, muscle weakness, and altered tone.

Assessment of motor recovery is used to measure an individual's level of neuromuscular capacity following stroke. Deficits in motor recovery of the upper limb are prevalent with 40% of individuals continuing to experience impaired motor function after the acute stage of stroke recovery (Parker and Wade, 1986). The most common measures of upper limb motor recovery are the upper extremity portion of the Fugl-Meyer Motor Impairment Scale and the Motricity Index. A strong relationship between upper extremity motor impairment and measures of ADL performance has been found (Chae et al., 1995; Parker and Wade, 1986). These findings indicate the importance of assessing and treating upper extremity motor recovery in stroke rehabilitation.

Muscle weakness is a common clinical finding in individuals who have experienced a stroke. After stroke, maximal voluntary force is reduced, reorganization of the central nervous system takes place, and peripheral muscle changes occur (e.g. muscle weakness) (Sunnerhagen et al., 1999). Upper extremity weakness following stroke is prevalent (Bohannon and Smith, 1987; Fearnhead, 1999; Kopp et al., 1997; Lincoln et al., 1999; Richards & Pohl, 1999; Wade, 1989) with as many as 77% of people experiencing weakness (Lawrence et al., 2001). One of the factors involved in the ability to perform a physical task is being able to produce sufficient muscular strength (Brill et al., 2000). If one is lacking requisite upper extremity strength, as is the case for many stroke survivors, the ability to perform and complete various ADL tasks may be compromised.

Altered muscle tone, particularly in the upper extremity of individuals with stroke has been extensively studied (Bohannon et al 1991; Dietz et al., 1986; Katz and Rymer, 1989, 1992). Tone, defined as the degree of resistance given by a joint when being passively moved through range of motion, results from spasticity (Katz and Rymer, 1989). Over time increased tone can lead to changes in muscle function (imbalance between agonists and antagonists) and tissue properties (e.g. shortening of tendons) causing further difficulty in daily activities,

Intuitively, one might expect that a stroke, which affects one's dominant versus non-dominant hand might have differing effects on an individual's recovery. However, no studies have examined this issue in upper extremity recovery in stroke. There is evidence that hand dominance is a factor in movement (i.e. speed, precision, and accuracy) in healthy adults where the dominant hand demonstrates superior motor skill versus the non-dominant hand (Annett, 1992; Bestelmeyer and Carey, 2004; Kauranen and Vanharanta, 1996). As well studies involving individuals with Parkinson's disease (Nutt et al., 2000) and hand injuries (Helm et al., 1986; Walsh et al., 1993) indicate a motor performance advantage if the dominant hand is affected versus the non-dominant hand. These studies did not assess whether this advantage carried over into performance in ADL. Individuals with stroke may also exhibit better motor performance if the dominant hand is affected versus the non-dominant and this may impact both assessment and treatment post stroke.

1.2.2 Activity Limitation

Deficits in the ICF dimension of activity are termed activity limitation and are manifested by the inability to perform daily or desired activities (i.e. dressing, laundry or socialization). Activity limitation is one of the most common outcomes measured in stroke (Feys et al., 2000; Inouye et al., 2000; Jorgensen et al., 1995; Kwakkel et al., 1996; Lai et al., 1998; Patel et al., 2000) and is most frequently assessed through ADL measures. These studies indicate that persons with stroke report an increase in ADL difficulty and subsequently a decrease in independence.

Functional limitations are an important indicator of quality of life and of independence in older persons (Brill et al., 2000). A person's level of dependence can be defined as the degree of difficulty in the performance of ADL tasks (Jehkonen et al., 2001; Patel, 2001). At 6 months post stroke, 25-53% of individuals are reported to be dependent in one or more ADL tasks (Anderson et al., 1990; Gresham et al., 1975; O'Mahony et al., 1999), many of which involve the use of unilateral or bilateral arm movement. While investigating factors that impact stroke recovery, Grimby and colleagues (1988) found the most difficult items for stroke survivors to perform on the Functional Independence Measure (FIM) was bathing and dressing. One of the difficulties in using the typical ADL scales (e.g. Barthel Index (BI) and FIM) for evaluating independence is these measures rely not only on arm function, but also on the recovery of the lower limb. This makes it impossible to determine the specific impact upper extremity impairment has on performance of ADL. Since the performance of many daily tasks depends on normal arm function (Wade and Hewer, 1987), it is critical that the role of upper extremity impairment is evaluated to improve treatment programs for those with stroke.

1.2.3 Participation Restriction

Deficits in the ICF dimension of participation are termed participation restriction and are manifested by personal and or environmental problems engaging in life roles, situations or events (e.g. being a grandparent, accessing leisure activities, or attending social events). Many studies have measured participation using a measurement of quality of life (Carod-Artal et al., 2000; Clarke et al., 2002; Clarke et al., 2002; De Haan et al, 1993; Gottlieb et al., 2001; Kauhanen et al., 2000; Kim et al., 1999; Mackenzie and Chang, 2002; Segal and Schall, 1995; Shimoda and Robinson, 1998; Strum et al., 2002; Viitanen et al., 1988; Wolfe et al., 1991; Wyller et al., 1988). Findings of these studies have indicated that the scores on functional assessments are strong predictors of quality of life.

The dimension of participation restriction has been a strong focus of stroke studies. Viitanen and colleagues (1988) state that as many as 61% of persons surveyed reported that their stroke led to a decrease in general life satisfaction. Wyller and colleagues (1988) also investigated life satisfaction in stroke survivors, comparing the results to a control group of similar age. They found a significant difference between the groups, with the stroke survivors demonstrating a significant decrease in life satisfaction. When investigating more specific influences on quality of life (QoL) in stroke survivors, physical and cognitive disabilities negatively affected social functioning (Shimoda and Robinson 1998) and sense of well being (Clarke et al., 2002).

1.2.4 Relationships between the ICF Dimensions (for details see Appendix XIII)

A number of studies examine the relationship between the three dimensions of the ICF. It becomes clear that the dimensions of body structure/function and activity are significantly correlated in studies involving stroke recovery (Brosseau et al., 2001; Chae et al., 1995; De Haan et al., 1993; Feys et al., 2000; Inouye et al., 2000; Lai et al., 1998; Lawerence et al., 2001; Loewen et al., 1990; Nilsson et al., 2000; Paciaroni et al., 2000; Parker and Wade, 1986; Pohjasvaara et al., 1998; Taub et al., 1994; Tennant et al., 1997; Wade et al., 1983; Williams et al., 2001). Impairment has been stated to be the most strongly associated factor of ADL independence (Lai et al., 1998; Pohjasvaara et al., 1998).

The impact of impairment on the dimension of participation is less clear. Clarke et al. (1999), Desrosiers et al. (2003) and Viitanen et al. (1988) reported that severity of motor impairment contributed to a decrease in quality of life scores in chronic stroke. Conversely, Johnson and Pollard (2001) found no evidence that impairment determined subsequent Participation restriction. Jongbloed (1986), in a review of prediction of post stroke function, found conflicting results of the relationship and prediction strength of impairment measures on participation. De Haan and colleagues (1993) reported that when correlating body structure/function variables with activity and participation variables, the association becomes weaker as one progresses from activity to participation.

Many studies have evaluated the relationship between activity and participation in individuals with chronic stroke. Strong positive and significant correlations between severity of ADL function and level of QoL have been found (Desrosiers et al., 2003; Gottlieb et al., 2001; Harwood et al., 1997; Kauhanen et al., 2000; Kim et al., 1999; Machenzie and Chang, 2002;

Strum et al., 2002). Additional studies with individuals in the chronic stage of stroke recovery report that ADL scores can account for 50% (Strum et al., 2002), and 22-73% (Bays, 2001) of the variance in participation measures. Figure 1.1 illustrates the reported relationships between the three dimensions of the ICF in studies evaluating individuals with stroke.

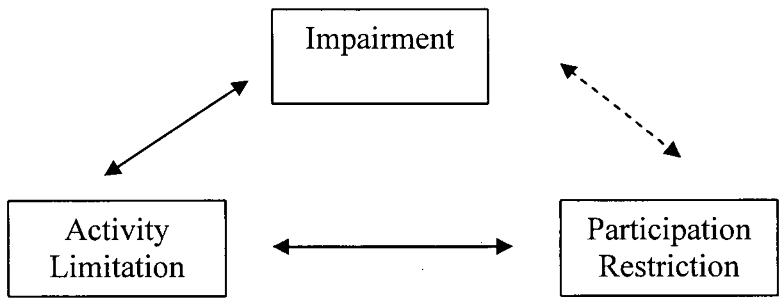

Figure 1-1: The reported relationship between the International Classification of Functioning and Disability in studies using individuals with stroke.

1.3 Purpose

The purpose of this study was to determine 1) the effect of the dominant hand being affected post stroke (versus non-dominant) and severity of upper extremity motor impairment on measures of impairment, activity limitation and participation restriction and 2) the relationship among variables of upper extremity impairment, activity limitation and participation restriction in individuals with chronic stroke.

1.4 Research Questions

1.4.1 Research question for chapter two

1. Does the dominant hand being affected post stroke (versus the non-dominant) and or severity of upper extremity motor impairment effect measures of upper extremity impairment, activity limitation, and participation in individuals with chronic stroke?

Hypotheses

1. If the dominant hand (versus the non-dominant) is affected by the stroke individuals will experience less impairment, activity limitation, and participation restriction.

2. The more severe the motor impairment of the upper extremity the greater the impairment, activity limitation, and participation restriction.

1.4.2 Research question for chapter three

1. Is there a relationship among variables of upper extremity impairment, activity limitation, and participation restriction in individuals with chronic stroke?

Hypothesis

1. There will be significant relationships among variables of upper extremity impairment, activity limitation, and participation restriction.

Chapter 2: Individuals with dominant hand affected post stroke demonstrate less impairment but not activity limitation.

2.1 Abstract

Background and Purpose: Hand dominance is an important factor in motor performance but has not been studied in relation to stroke. The purpose of this study was to determine the effects of hand dominance (i.e., dominant versus non-dominant hand affected following stroke) on measures of upper extremity impairment and activity/participation in individuals with chronic stroke. **Methods:** This cross-sectional study of ninety-three community-dwelling individuals was conducted at a tertiary hospital. The upper extremity portion of the Fugl-Meyer Motor Impairment Scale represented a global measure of the severity of impairment (Severity). Measures of upper extremity function included the Modified Ashworth Scale (MAS), isometric strength of the upper extremity, sensation, the Brief Pain Inventory, the Arm and Hand Activity Index (AHAI), Motor Activity Log (MAL), and the Reintegration to Normal Living (RNL) Index. **Results:** The MANOVA demonstrated no significant Dominance x Severity interaction for either the impairment (Wilk's $\lambda = 0.88$, $p = 0.10$) or activity/participation model (Wilks's $\lambda = 0.99$, $p = 0.75$). There was a significant main effect of Dominance (Wilk's $\lambda = 0.85$, $p = 0.03$) for the impairment model. All dependent variables except pain ($p = 0.64$) were significantly affected by Severity. **Conclusion:** Individuals with the dominant hand affected demonstrated less impairment than if the non-dominant hand was affected but activity was not influenced by hand dominance. Severity of motor impairment did significantly affect activity. Clinicians may need to promote the use of the non-dominant affected hand not only during treatment session but during all ADL. This may lead to the reduction of musculoskeletal changes and impairment, and enhanced motor performance.

2.2 Introduction

Hand dominance (handedness) has been cited as an important factor in the development (Pratt and Allen, 1989) and performance of motor skills (Hopkins and Russell, 2004; Provins, 1997). From an early age, individuals use their dominant hand for many daily and recreational activities. In the initial stages of recovery, persons with stroke experience impairment of the upper extremity, and of these individuals, up to 70% live with residual impairment (Richards and Pohl, 1999; Wade, 1989). Impairments of the dominant upper limb caused by conditions such as stroke, could compromise participation in many of these essential and meaningful tasks. There is strong indication that the severity of upper extremity motor recovery is a contributing factor to post-stroke abilities (Lai et al., 1998; Page, 2000; Pohjasvaara et al., 1998). Whether the dominant hand was affected following stroke versus the non-dominant, as an influencing factor in upper extremity performance in activities of daily living (ADL) has not been studied. Given the predictive nature of stroke severity, it is necessary to also consider the interaction effects of upper extremity motor recovery when evaluating the effect of hand dominance.

In healthy adults, potential differences in motor performance have been evaluated between the dominant and non-dominant hand. Speed, precision, and coordination (Annett, 1992; Bestelmeyer and Carey, 2004; Kauranen and Vanharanta, 1996; Nutt et al., 2000), as well as fatigue (Farina et al., 2003), and muscle properties (Farina et al., 2003; Sainberg and Kalakanis, 2000; Tanaka et al., 1984) have been found to differ between the dominant and non-dominant hand. Studies have suggested that the left-hemisphere governs motor control (Haaland and Harrington, 1996, 2004; Sainberg and Kalakanis, 2000) so those who are right-handed and left-hemisphere dominant have an advantage in motor performance. Others (Farina et al., 2003; Sainberg and Kalakanis, 2000; Tanaka et al., 1984) suggest that the extensive use of the dominant hand leads to enhanced muscle properties such as increased type II muscle fiber, motor units, and firing rates.

Performance differences between the dominant and non-dominant hand have been found in studies of orthopedic and neurological injury. In studies of hand injuries (Helm et al., 1986; Peterson et al., 1989; Walsh et al., 1993) researchers found that if the dominant hand (versus the non-dominant hand) was affected, superior performance in ADL and quality of life scores were reported. In individuals with Parkinson's disease, Nutt et al. (2000) found that tapping speed was significantly faster in the dominant compared to the non-dominant hand. It was also found that if the dominant hand was more affected by Parkinsonism, subjects performed faster on motor tasks compared to the non-dominant affected hand. Given these findings, we hypothesized that in individuals with stroke, motor recovery and whether the dominant hand was affected (versus non-dominant) would affect measures of impairment, activity, and participation. Specifically, we proposed that individuals with their dominant hand affected by the stroke would experience less impairment, greater performance in ADL, and increased ratings of quality of life.

The purpose of this study was to examine the factors of dominant hand affected (versus non-dominant hand affected following stroke) (Dominance) and upper extremity motor recovery (Severity) (as measured by the upper extremity portion of the Fugl-Meyer Motor Impairment Scale) to determine their effect on measures of upper extremity impairment and activity/participation in individuals with chronic stroke.

2.3 Methods

2.3.1 Participants

Ninety-three community-dwelling persons with chronic stroke and residual unilateral upper extremity impairment were recruited on a voluntary basis using advertisements in community centers and local newspapers. Inclusion criteria consisted of 1) time since onset of stroke at least one year, 2) only one incidence of stroke, and 3) able to provide informed consent. Persons with significant musculo-skeletal or neurological conditions other than incidence of stroke and persons with receptive aphasia were excluded from the study. Ethics approval was obtained from the local university and hospital review boards. Participants took part in a 90 minute evaluation. An occupational therapist with clinical experience in individuals with stroke and one trained research assistant assessed all participants (Table 2.1).

Information on pre-stroke hand dominance was obtained by asking the individual which hand they preferred to use for writing and throwing a ball prior to their stroke. This information was then coded into 0 (dominant hand affected) or 1 (non-dominant hand affected). Upper extremity motor recovery was measured using the upper extremity portion of the Fugl-Meyer Motor Impairment Scale (0 -66) (Fugl-Meyer et al., 1975). The mean score of our sample (44.0) was used to classify the participants into two categories: 0 (moderate to severe impairment < 44) and 1 (mild impairment ≥ 44). Our range of FM scores is consistent with other studies involving individuals with chronic stroke (Desrosiers et al., 2003; Duncan et al., 1992; van der Lee et al., 2001).

2.3.2. Outcome Measures (for details see Appendix III-XII)

Impairment Measures

The Modified Ashworth Scale (Bohannon and Smith, 1987) measures resistance to passive movement (i.e. tone) when moving a relaxed joint through passive range of motion. For this study, tone of the wrist and elbow was measured. Upper extremity isometric muscle strength of both the affected and less affected side (including grip strength) was tested using hand-held dynamometry. Shoulder flexion and abduction, elbow flexion and extension, and wrist flexion and extension were assessed. For upper extremity muscle strength a composite score was determined by summing all muscle scores. The composite score of the affected limb was divided by the composite score of the less affected limb to calculate an arm strength ratio score. Sensation (tactile sensitivity) of the hand was assessed with a pressure aesthesiometer kit comprised of eight monofilaments. Filaments were presented from thick to fine (#8 to#1) and deformed to half its length until the participant was not able to detect the pressure (Perry et al., 2000). The Brief Pain Inventory (BPI) (Cleeland and Ryan, 1994) was used to assess both the intensity of pain and the degree to which pain interfered with daily life. The BPI was modified such that participants were asked to report whether they had pain of the upper extremity (shoulder, arm, and hand) only.

Activity Limitation and Participation Restriction Measures

The Chedoke Arm and Hand Activity Index (AHAI) (Barreca et al., 1999) was used to evaluate the degree of contribution of the more affected upper extremity in the completion of ADL. The AHAI consists of 13 bilateral tasks of daily living (e.g. open a jar, pour a glass of water, buttons). The Motor Activity Log (MAL) (Taub et al., 1993) was designed to measure a person's perception of how much and how well they use their more affected hand during ADL. The Reintegration to Normal Living (RNL) Index (Wood- Dauphinee et al., 1988) was used to measure quality of life and consists of 11 items regarding their physical, emotional, and social lives.

For ease of the discussion of the conceptual models we chose to use the term 'activity' to encompass both measures of activity and participation for the remainder of the paper.

2.3.3 Statistical Analysis

Descriptive data are reported for variables using mean and standard deviation (SD). Data were evaluated using multivariate analysis (MANOVA). MANOVA is a statistical method that can be used to simultaneously compare the means between variables of interest while controlling for Type I error inflation (Zar, 1999). A 2x2 MANOVA was used for two models; 1) an impairment model which incorporated six dependent variables (arm strength ratio, grip strength, pain, tone of elbow and wrist, and sensation) and two independent variables (hand dominance and upper extremity motor recovery) and 2) an activity model with three dependent variables (AHAI, MAL, RNL) and two independent variables (hand dominance and upper extremity motor recovery). Main effects of the dependent variables are reported using univariate analysis (ANOVA). A value of $p \leq 0.05$ was considered significant in all calculations. SPSS statistical software 11.5 for Windows was used for all analyses.

2.4 Results

Descriptive data for the measures and participant characteristics can be found in Table 2.1. Participants had a mean age of 68.7(yrs)±9.4, a mean time since stroke of 5.1(yrs)±4.1 and were predominantly male (66%). No significant difference was found for any of the dependent or independent variables between participants whose right hemisphere or left hemisphere was the site of injury, therefore data were pooled. Only 12% of the participants were left-handed. Fifty-three (57%) individuals experienced a right hemisphere stroke and 42 (45%) of the participants had the dominant arm affected by the stroke (only two of these individuals were left handed). Fifty-seven (61%) participants were classified as mildly impaired (≥44 FM) with 36 (39%) classified as moderately to severely impaired (<44 FM).

The MANOVA for the impairment model demonstrated no significant Dominance x Severity interaction (Wilk's $\lambda = 0.88$, $p = 0.10$) (Table 2.2). However, there was a significant main effect of Dominance (Wilk's $\lambda = 0.85$, $p = 0.03$). The post-hoc tests showed that the dependent variables wrist tone, grip strength, and pain were all significantly affected by dominance; indicating less impairment if the dominant hand was affected by the stroke (Table 2.3). There was a significant main effect of Severity (Wilk's $\lambda = 0.27$, $p < 0.0001$). All dependent variables except pain ($p = 0.64$) were significantly affected ($p < 0.0001$) by severity.

The MANOVA for the activity model showed no significant interaction for Dominance x Severity (Wilks's $\lambda = 0.99$, $p = 0.75$) (Table 2.2). There was a significant main effect of Severity (Wilk's $\lambda = 0.22$, $p < 0.0001$). The AHAI and the MAL were both significantly affected by severity ($p < 0.0001$), as was the RNL ($p = 0.03$). There was no main effect of Dominance (Wilk's $\lambda = 0.99$, $p = 0.72$) (Table 2.3).

Table 2-1: Subject Characteristics (n=93) and Measurement Descriptives

Variable	n	Mean(STD)	Range
Sex (M/F)	61/32		
Age		68.7(9.4)	50-93
Time Since Stroke (yrs)		5.1(4.1)	1-27
Dominance (R/L)	85/8		
Side of Paresis (R/L)	40/53		
Dominant Affected/Unaffected	42/51		
Stroke Type (Ischemic/Hemorrhagic/Unknown)	34/18/41		
Fugl-Meyer Upper Extremity Motor Scale (0-66)		43.9(21.1)	4-66
Modified Ashworth Scale Wrist (0-4)		0.66(1.1)	0-4
Modified Ashworth Scale Elbow (0-4)		0.89(1.0)	0-4
Muscle Strength of Upper Extremity*		0.64(.33)	†0-1.1
Grip Strength (kg)		13.0(11.1)	0-43.7
Sensation (1-8)		4.1(2.2)	1-8
Brief Pain Inventory (0-120)		9.9(17.3)	0-88
Arm and Hand Activity Index (13-91)		62.1(31.8)	13-91
Motor Activity Log (0-5)		3.1(1.6)	0-5
Reintegration to Normal Living Index (11-33)		29.2(3.6)	19-33

* Ratio: calculated by dividing total composite score of unaffected by affected arm muscles
† 0 represents individuals who were not able to produce any arm movement in order to register a strength measurement on the hand held dynamometer.

Table 2-2: The interaction effects of Dominance and Severity On Measures of Impairment and Activity/Participation

Impairment Dominance x Severity, Wilk's $\lambda_{(6,84)}$=0.88, p=0.10		Activity/Participation Dominance x Severity, Wilk's $\lambda_{(3,87)}$=0.01, p=0.75	
Variable	P value	Variable	P value
Manual Muscle	0.49	Arm and Hand Activity Index	0.79
Grip	0.15	Motor Activity Log	0.93
Pain	0.45	Reintegration to Normal Living Index	0.30
MAS elbow	0.47		
MAS wrist	0.23		
Sensation	0.08		

Table 2.3: Descriptive statistics and MANOVA post-hoc results for Dominance for the models of Impairment and Activity/Participation.

IMPAIRMENT MODEL					**ACTIVITY/PARTICIPATION MODEL**				
Variable		Mean	95% CI	P value	Variable		Mean	95% CI	P value
Isometric Strength	D*	0.61	0.54-0.67	0.23	Arm and Hand Activity Index	D	62.7	52.0-72.0	0.41
	ND	0.55	0.50-0.61			ND	61.6	53.0-71.0	
Grip	D	13.5	10.8-16.2	0.05	Motor Activity Log	D	2.9	2.6-3.2	0.45
	ND	9.8	7.3-12.3			ND	2.7	2.4-3.0	
Pain	D	4.8†	-0.46-10.0	0.02	Reintegration to Normal Living Index	D	28.7	27.6-29.8	0.45
	ND	13.6	8.7-18-4			ND	29.3	28.2-30.3	
MAS elbow	D	0.93	0.71-1.18	0.09					
	ND	1.2	0.99-1.4						
MAS wrist	D	0.59	0.33-0.85	0.02					
	ND	1.0	0.77-1.3						
Sensation	D	4.5	3.9-5.1	0.49					
	ND	4.2	3.7-4.7						

* D = dominant hand affected, ND = non-dominant hand affected

† A lower score indicates less pain and less pain interference with daily life

2.5. Discussion

It was not surprising to find that the degree of motor recovery (Severity) affected impairment and activity scores. However, our hypothesis regarding dominance hand affected (versus non-dominance hand)(Dominance) was only partially realized as Dominance affected impairment but not activity scores.

No differences in measurement scores were found between individuals who had sustained a left versus a right hemisphere stroke. This is in contrast to other studies that found hemispheric differences for individuals with stroke (Debaere et al., 2001; Harrington and Haaland, 1991, Haaland et al., 2004; Priori et al., 1999; Sabate et al, 2004; Zemke et al., 2003). This study was not designed to determine the effect of handedness in relation to side of lesion. Only 12% of our sample was left-handed. However, the majority of individuals studied in research concerning stroke and hemisphere differences are right hand dominant (Debaere et al., 2001; Haaland et al., 2004; Harrington and Haaland, 1991; Sainbury and Kalakanis, 2000). Performance difference between left and right hand dominant individuals with stroke on measures of impairment and activity would be useful to study in the future.

A limitation to this study is that our findings can only be generalized to individuals in the chronic stage of stroke recovery and those individuals without significant cognitive impairment. However, over half of individuals who have sustained a stroke are discharged home (Jorgensen et al., 1999) with a significant portion having residual upper extremity impairment (Parker and Wade, 1986). Individuals in the chronic stage of stroke recovery continue to require rehabilitation and these individuals identify that performance in ADL activities, many of which require use of the more affected arm, is still a priority problem (Harris and Eng, in press, 2004).

This study found a main effect of Dominance on the impairment model, indicating less impairment when the dominant hand is affected by the stroke. There are several reasons why dominance may have demonstrated an overall effect on impairment scores. It is evident that many tasks require bimanual movement and handedness does not preclude the use of the non-dominant hand to complete tasks. However, Provins (1997) in his review of motor skills concluded that there is a preference to utilize the dominant arm more often during daily activities. Thus individuals with their dominant hand affected post stroke may be more inclined to incorporate the affected dominant hand (versus non-dominant) in rehabilitation. In addition, studies involving healthy adults (Farina et al., 2003; Provins, 1997; Tanaka et al., 1984; Zijdewind et al., 1990) have demonstrated a dominant hand effect on arm pointing accuracy, movement speed, and precision.

The propensity to use the dominant hand may lead to a better pre-stroke neuromuscular condition of dominant hand (e.g., stronger muscles, more efficient motor unit recruitment) compared to the non-dominant hand. Therefore, if the dominant hand is affected by the stroke it may produce less impairment. The decreased impairment seen if the dominant hand is affected may also be caused by the inclination to use the dominant hand for daily tasks both before and after the stroke. If the dominant hand has been affected by the stroke, individuals may be more motivated to use their dominant hand during treatment since they are not used to using their non-dominant hand for daily tasks. In contrast, if the non-dominant hand is affected, individuals may have little motivation to use this hand in daily tasks making it difficult to promote the use of the non-dominant hand in therapy. This conclusion has been supported by the literature on learned non-use in individuals with stroke (Taub et al., 1993; Leipert et al. 2000; van der Lee et al. 1999).

We found that if the dominant hand was affected by the stroke, individuals recorded less tone (MAS) than if the non-dominant hand was affected. Tone, defined as the degree of resistance given by a joint when being passively moved through range of motion, can result from both spasticity and mechanical/viscoelastic changes in the muscle (Katz and Rymer, 1989).

Some clinicians may avoid using the affected hand if tone is present based on the prominent theory of Neurodevelopment Treatment (NDT) as it advocates the inhibition of movements, which may increase tone (Bobath, 1977). However, the tendency to use the dominant hand in daily activities, even if affected by the stroke, may limit some of the musculoskeletal changes, which contribute to increased tone. Thus, it is possible that a greater use of the affected hand may diminish tone and facilitate movement.

Thirty-seven percent of our study sample reported upper extremity pain, though pain was reported at very low levels (sample mean of 9.9 out of a possible 120 on the BPI). The mean difference for arm pain reported between the dominant and non-dominant arm was 8.8 points on the BPI and indicates a change from 'no pain or pain interference' to 'mild pain and interference.' One explanation for the low intensity of pain reported is that as the individual recovers, pain diminishes through the natural time course of recovery (our sample being in the chronic stages of recovery) and the frequency and intensity of reported pain decreases.

Pain scores were affected by Dominance as individuals with their dominant arm affected reported less pain regardless of severity of motor impairment. The reduced pain when the dominant arm is affected may occur because individuals attempt to use their dominant hand more frequently after stroke regardless of whether it is affected and thus minimize secondary joint changes that often produce pain (i.e. shoulder capsulitis, contractures, and subluxation). Additionally, the greater pre-stroke conditioning of the dominant arm may make it less prone to the mechanisms that can cause pain. Though individuals reported only mild levels of pain and pain interference with daily activities if the non-dominant arm is affected, it is still an important issue in stroke rehabilitation (Katrak, 1990; Ratnasabapathy et al., 2003; Roy et al., 1994). It suggests that clinicians incorporate and encourage movement of the affected non-dominant arm and hand both in and outside of treatment.

In contrast to our findings of a Dominance effect with impairment measures, we found no effect on measures of activity. Nor did we find a Dominance x Severity effect for activity. This finding may suggest that hand dominance is not influence by global impairment (as measured by the Fugl-Meyer) and that other more prominent issues contribute to hand use post-stroke. Discrepancies between impairment and activity measures have been found previously in stroke. For example, Desrosiers et al., (1996) reported that individuals with left hemiparesis had better motor recovery (FM) but not better performance on functional measures. It may be that if the hand, whether it be the dominant or non-dominant, is severely affected by the stroke (e.g. flaccid or contracted) the individual will not use it in the completion of daily activities and resort to the less affected hand, adaptive equipment, or care-giver aid. Similarly, once tasks become more complex (e.g. dressing), persons with stroke may begin to use compensatory strategies including adaptive equipment, thus minimizing the effect of hand dominance. It is also apparent in ADL tasks that bimanual movement and coordination are often used and the required contribution of the dominant hand is inconsequential.

Severity of motor impairment did affect measures of activity, with individuals scoring in the moderate to severe range reporting greater difficulty in ADL, less use of and satisfaction with the affected hand in daily tasks, and a decrease in quality of life scores. Significant correlations have been found between measures of impairment and activity (Feys et al., 2000; Lai et al., 1998; Nakayama et al., 1994) and impairment and participation measures (Carod-Artal et al., 2000; Clarke et al., 2002). As well upper extremity impairment scores have been shown to be predictive of functional outcome after stroke (Nakayama et al., 1994; Wade, 1989; Wade and Parker, 1986).

2.6 Summary

In conclusion, if the dominant hand was affected there was an impact on measures of impairment but not on measures of activity. Severity of motor impairment was a significant factor in the performance of ADL and in quality of life measures. Though it can be difficult when the non-dominant hand is affected by the stroke, clinicians need to re-enforce its use during treatment session and in all ADL. This may reduce musculoskeletal changes and impairment, and enhance motor performance in individuals with stroke.

Chapter 3: The Influence of Upper Extremity Impairment on Activity Limitation and Participation Restriction in Individuals with Chronic Stroke

3.1 Abstract

Background and Purpose: The upper extremity is vital to activities of daily living (ADL) and impairments of the upper limb can compromise participation in many of these essential and meaningful tasks. The purpose of this study was to determine 1) the strength of the relationship among upper extremity impairment, activity limitation, and participation restriction and 2) the strongest explanatory variable(s) of upper extremity activity limitation and participation restriction in individuals with chronic stroke. **Methods:** This is a cross-sectional study of ninety-three community-dwelling individuals with chronic stroke. Individuals participated in a 90 minute assessment; measures included the Modified Ashworth Scale (MAS), Isometric strength of the upper extremity, sensation, Brief Pain Inventory, Arm and Hand Activity Index (AHAI), Motor Activity Log (MAL), and the Reintegration to Normal Living (RNL) Index. **Results:** Muscle strength of the upper extremity ($r=0.89$, $p<0.01$, $r=0.86$, $p<0.01$) and MAS ($r=0.80$, $p<0.01$, $r=0.70$, $p<0.01$) were the most highly associated impairment variables with the AHAI and the MAL. In regression models of activity limitation, isometric strength accounted for 75% ($p<0.001$) of the variance of the AHAI and 71% ($p<0.001$) of the MAL. In regression models of participation restriction, isometric strength accounted for 75% ($p<0.001$) of the variance of the MAL. **Conclusion:** Muscle strength is a strong explanatory variable for activity limitation and participation restriction in individuals with chronic stroke. Further randomized clinical trials should be undertaken to evaluate strength training in the affected upper extremity.

3.2 Introduction

Stroke can impact every aspect of a person's physical, emotional, and social life and is one of the leading causes of disability in the older population. As stroke mortality rates decline (Heart and Stroke Foundation of Canada, 2003) individuals are increasingly likely to live with residual impairments and disabilities. In the initial stages of recovery, persons with stroke experience some impairment of the upper extremity, and of these individuals, 70% live with residual impairment (Richards and Pohl, 1999; Wade, 1989). The upper extremity is vital to activities of daily living (ADL) and impairments of the upper limb can compromise participation in many of these essential and meaningful tasks. Persons with stroke have identified the return of upper extremity function as an important goal (Bohannon et al., 1988). Knowledge of upper limb impairment and its relationship to ADL and health related quality of life (QoL) is necessary in order for clinicians to plan effective and efficient rehabilitation.

Upper limb impairments following stroke can affect motor function, tone, muscle strength, sensation, dexterity, and coordination. Recently Desrosiers and colleagues (2003) demonstrated a significant relationship between upper extremity motor functioning using the Fugl-Meyer Motor Impairment Scale (FM) and participation restriction measured by the Assessment of Life Habits (LIFE-H). Lai and colleagues (1998) used the National Institute of Health Stroke Scale to demonstrate the predictive nature of arm motor function on the Barthel Index (BI) and Nakayama and colleagues (1994) used the Scandinavian Stroke Scale (SSS) to determine the impact of arm motor function on ADL. However, these studies assessed global measures of upper limb impairment in their analysis omitting specific impairments such as strength, altered tone, and sensation, in the determination of ADL performance. Quantifying the contribution of specific impairments to upper extremity function could assist clinicians in targeting treatment priorities during rehabilitation.

There have been only a few studies that have looked at the relationship between specific impairment dimensions such as altered tone (Williams et al., 2001) and muscle weakness (Bohannon, 1987) with performance on measures of ADL. Both weakness and tone correlated significantly with performance and were predictors of ADL scores. Only one study (Feys et al., 2000) has assessed the value of several predictors (motor, tone, and sensation) in a multivariate approach in order to establish the largest factor. Motor impairment, measured by the FM, was found to be the most significant predictor of ADL performance using the Barthel Index. However, the Barthel Index score is heavily weighted on general mobility functions and a high score (indicating independence) can be achieved without adequate recovery of the affected upper extremity (Loewen et al., 1990). There have been studies (Carod-Artal et al., 2000; Clarke et al., 2002) that have evaluated the effect of global motor impairment (i.e. SSS) on health related QoL, but these studies did not separate the lower and upper extremity motor scores. Global motor impairment was found to be a significant factor in health related QoL and maintaining and or improving QoL is one of the most important goals in stroke rehabilitation.

The International Classification of Functioning, Disabilities, and Health (ICF) (World Health Organization, 2001) can be a useful conceptual model for categorizing the outcomes of stroke. There are three dimensions in the ICF used to categorize the consequences of a condition: body functions/structures (impairments), capacity and performance in the execution of day-to-day tasks (activity limitation), and involvement in life situations, functioning at the societal level (participation restriction). The ICF can be seen as a model where the classifications influence each other and where impairments can lead to activity limitations and activity limitations can lead to participation restrictions (World Health Organization, 2001). This type of model can provide both a structural and analytical framework for the exploration of the relationship between upper extremity impairment with activity limitation and participation restriction in individuals with stroke.

The purpose of this study was to determine 1) the strength of the relationship (i.e. correlations) among upper extremity impairment, activity limitation and participation restriction and 2) the strongest explanatory variable(s) of activity limitation and participation restriction using multiple regression analysis.

It is important to ascertain the specific contribution of upper limb impairment on measures of activity limitation and participation restriction. In this way treatment protocols for the upper limb can be targeted to facilitate recovery within the spectrum of health issues following stroke.

3.3 Methods

2.3.1 Participants

Ninety-three community-dwelling persons with chronic stroke and residual unilateral upper extremity impairment were recruited on a voluntary basis using advertisements in community centers and local newspapers (see Appendix I). Inclusion criteria consisted of 1) time since onset of stroke at least one year, 2) only one incidence of stroke, and 3) able to provide informed consent. Persons with significant musculo-skeletal or neurological conditions other than incidence of stroke and persons with receptive aphasia were excluded from the study. Ethics approval was obtained from the local university and hospital review boards. Informed consent was received from all participants prior to their participation in the study (see Appendix II). Participants took part in a 90 minute evaluation. An occupational therapist with clinical experience in individuals with stroke and one trained research assistant assessed all participants for impairments, activity limitation, and participation restriction (Table 3.1).

Table 3-1: WHO Classification of Measurements

Classification	Instrument	Domain Assessed
Impairment	Modified Ashworth Scale	Tone
	Hand held dynamometry	Isometric strength
	Aesthesiometer kit	Sensation
	Protractor	Proprioception
	Brief Pain Inventory	Pain
Activity Limitation	Arm and Hand Activity Index	Performance of affected upper limb in daily activities
	Motor Activity Log - Amount of Use scale	Participant evaluation of how often they use the affected upper limb in daily activities
Participation Restriction	Reintegration to Normal Living Index	Quality of life
	Motor Activity Log – Satisfaction with Use scale	Participant evaluation of how satisfied they are with the performance of the affected upper extremity in daily activities

3.3.2 Outcome Measures (see Appendix XIX for psychometric properties)

Impairment Measures

The Modified Ashworth Scale (Bohannon and Smith, 1987) measures resistance to passive movement felt by an examiner (i.e. tone) when moving a relaxed joint through passive range of motion. For this study, tone of the elbow was measured. The MAS is an ordinal scale ranging from 0 (normal) – 4 (rigid). The MAS is the primary clinical measure of tone. The reliability and validity of this measure have been proven satisfactory (Pandyan et al., 2003). Upper extremity isometric muscle strength of both the affected and less affected side was tested using hand-held dynamometry.

Isometric strength of the muscles involved in shoulder flexion and abduction, elbow flexion and extension, and wrist flexion and extension were assessed. The participants were asked to hold the muscle contraction for three seconds for three trials. The average of the trials was used (The National Isometric Strength Database Consortium, 1996). For upper extremity muscle strength a composite score was determined by adding all muscle scores. An arm strength ratio score was devised by taking the composite score of the affected limb and dividing it by the composite score of the less affected limb. For grip strength, the participant was asked to squeeze the handle of a hand-held dynamometer for three seconds for three trials. Each trial was recorded and the average of the three trials was used. Excellent reliability for hand-held dynamometers has been reported (Ottenbacher et al., 2002).

Sensation (tactile sensitivity) was assessed with a pressure aesthesiometer kit comprised of eight monofilaments. Sensation was measured on the dorsal lateral aspect of the index finger of the more and less affected hand (for normalization measure). Filaments were presented from thick to fine (#8 to#1) and deformed to half its length until the participant was not able to detect the pressure (Perry et al., 2000). Placebo trials (i.e. where no depression of the filament was performed) were dispersed randomly within each filament presentation.

To assess proprioception, a large protractor with five-degree increments was constructed. The subject was seated with eyes closed in front of a table with the protractor. The more affected hand was placed outstretched and directly in front of the subject's body (0°) while their less affected hand was placed at 45° (midway between a forward and to the side position). Participants were asked to move their more affected hand to mirror the less affected hand's position. The difference in degrees was recorded.

The Brief Pain Inventory (BPI) was used to assess both the intensity of pain and the degree to which pain interfered with function (e.g. household chores, walking, sleeping). Participants were asked to report whether they had pain of the upper extremity (shoulder, arm, and hand) only. If they reported no upper extremity pain, a total score of zero was given. Both reliability and validity of this scale have been found satisfactory (Cleeland and Ryan, 1994).

Activity Limitation Measures

The Chedoke Arm and Hand Activity Index (AHAI) (Barreca et al., 1999) was used to evaluate the degree of contribution of the more affected upper extremity in the completion of ADL. The AHAI consists of 13 bilateral tasks of daily living (e.g. open a jar, pour a glass of water, buttons). Scoring is done on a 7-point ordinal scale (one indicating total assistance and seven indicating complete independence).

The Motor Activity Log (MAL) (Taub et al., 1993) was designed to measure how much and how well a person uses their affected upper limb during ADL. It is a semi-structured interview that consists of 30 ADL items (e.g. brushing teeth, buttoning a shirt, and eating). Scoring is completed using two scales 1) Amount of Use scale and 2) Quality of Movement scale (six point ordinal scales with zero indicating the more affected arm was not used at all and five indicating the weaker arm was used as much or as well as before the stroke). The MAL has been used as an outcome measure to evaluate change in arm use in ADL in individuals with chronic stroke (Liepert et al., 2000). Only the Amount of Use scale was used for evaluating activity limitation.

The AHAI and MAL represent different constructs within the domain of activity limitation. In the AHAI, the participant is asked to use the affected arm as much as possible to complete the tasks, however, in their home environment they may not normally use the affected arm to perform the activity requested. In contrast, the MAL Amount of Use scale asks the participant how much they actually use the more affected arm on a daily basis in his or her own environment.

Participation Restriction Measures

The Reintegration to Normal Living (RNL) Index consists of 11 items regarding their physical lives (e.g. "I move around my community as I feel is necessary"), emotional lives (e.g. "I feel that I can deal with life events as they happen") and social lives (e.g. "I participate in social activities with my family, friends as is necessary or desirable to me"). Items are scored on a three point ordinal scale (one indicating not able to participate and three indicating able to fully participate). Good reliability and validity have been reported (Wood-Dauphinee et al., 1988).

To measure an individuals' satisfaction with the quality of movement of the more affected extremity, a modified version of the Quality of Movement scale (subscale of the MAL) was used. In the original Quality of Movement scale, participants are asked to evaluate the quality of movement of their more affected arm during the activity in question. In this modified version the participant is asked to rate their satisfaction (zero indicating complete dissatisfaction and five indicating complete satisfaction with movement) with the quality of movement of their more affected arm in various ADL tasks. Hence, two variables of participation restriction were used to illustrate the impact of impairment variables on a specific upper extremity measure (MAL Satisfaction with Use scale) and a global measure (RNL) of participation restriction.

On a small subset of participants (n=12) we measured the test-retest reliability of each of the measures (MAS, isometric arm strength, grip strength, sensation, proprioception, BPI, AHAI, MAL and RNL). We measured the participants on two occasions one week apart with good results (ICC 0.81-0.99).

3.3.3 Statistical Analysis

Descriptive statistics were used to show participant demographics and study measures. Visual inspection of boxplots and histograms, as well as skewness values was used to determine variable normality and homoskedasticity. (see Appendix XIV-XVIII for scatter plots)

Bivariate correlations were established using Pearson's Product Moment Correlation for interval data and Spearman's Rho for ordinal data. Scatter-plots of explanatory variables against response variables were visually inspected to ensure outlier and influential data points did not compromise the results, and to determine linearity.

A total of 6 forward stepwise regressions were used to establish models of activity limitation and participation restriction. To ensure that the assumptions of multiple regression were met, scatter-plots of residuals against the model data set were inspected, as were tolerance values and the variance inflation factor for possible problems with outliers, influential data points, and multicollinearity (Cohen et al., 2003). To test the significance of subsets within the regression models, the values of the R^2 difference test were examined. Variable entry for the regression was set at 0.05 and removal was at 0.10. A value of $p \leq 0.05$ was considered significant in all calculations. SPSS statistical software 11.5 for Windows was used for all analyses.

Models of activity limitation utilizing impairment variables

Two models of activity limitation were established using impairment variables. The first model had the AHAI as the response variable and tone, arm muscle strength, grip strength, sensation, proprioception, and BPI as the explanatory variables. The second model had the MAL amount of use scale as the response variable and tone, arm muscle strength, grip strength, sensation, proprioception, and pain as the explanatory variables.

Models of participation restriction utilizing impairment variables

Two models relating impairments to participation restriction were established. The first model used the MAL Satisfaction with Use scale as the response variable and tone, arm muscle strength, grip strength, sensation, proprioception, and pain as the explanatory variables. The second model used the RNL as the response variable and tone, arm muscle strength, grip strength, sensation, proprioception, and pain as the explanatory variables.

Models of participation restriction utilizing activity limitation variables

Two models relating activity limitation to participation restriction were established. The first model used the MAL Satisfaction with Use scale as the response variable and the AHAI and

MAL Amount of Use scale as the explanatory variables. The second model used the RNL as the response variable and the AHAI and the MAL Amount of Use scale as the explanatory variables.

3.4 Results

Descriptive statistics for participant characteristics and assessment tools are found in Table 3.2. Three individuals were excluded after screening due to receptive aphasia. Ninety-three participants (mean ± SD, 68.7 ± 9.4 years of age; range, 50-93 and time since stroke 5.1 ± 4.1; range, 1-27 years, male 61, female 32) were included in the final analysis. The mean ± SD of the Fugl-Meyer Upper Extremity Motor score was 44.9 ± 21.1.

Correlation matrices using the Pearson product moment correlation and the Spearman's rank correlation (for ordinal data) are presented in Table 3.3 (Impairment), Table 3.4 (Activity and Participation). Table 3.5 illustrates the correlations between impairment measures and activity limitation and participation restriction measures.

Table 3-2: Subject Characteristics (n=93)

Variable	n	Mean(STD)	Range
Sex (M/F)	61/32		
Age		68.7(9.4)	50-93
Time Since Stroke (yrs)		5.1(4.1)	1-27
Dominance (R/L)	85/8		
Side of Paresis (R/L)	40/53		
Dominance Affected/Unaffected	42/51		
Stroke Type (Ischemic/Hemmoraghic/Unknown)	34/18/41		
Mini Mental Status Exam (0-30)		26.0(2.9)	15-29
Fugl-Meyer Upper Extremity Motor Scale (0-66)		44.9(21.1)	4-66
Modified Ashworth Scale Elbow (0-4)		0.89(1.0)	0-4
Muscle Strength of Upper Extremity*		0.64(.33)	0-1.1
Grip Strength (kg)		13.0(11.1)	0-43.7
Sensation (1-8)		4.1(2.2)	1-8
Proprioception (degrees of deviation)		7.8(7.5)	0-30
Brief Pain Inventory (0-120)		9.9(17.3)	0-88
Arm and Hand Activity Index (13-91)		62.1(31.8)	13-91
Motor Activity Log Amount of Use (0-5)		3.2(1.7)	0-5
Motor Activity Log Satisfaction of Use (0-5)		3.0(1.6)	0-5
Reintegration to Normal Living Index (11-33)		29.2(3.6)	19-33

* Ratio of isometric strength: devised by dividing total composite score of unaffected by affected arm muscles

Correlation Results

Significant correlations were found between many of the impairment variables (Table 3.3). Of particular note was the significant and strong relationship between isometric strength and elbow tone ($r=-0.73$, $p<0.01$) and grip ($r=0.72$, $p<0.01$). There were also moderate to low relationships, though significant between the isometric strength measures and measures of sensation (propioception). The only variables significantly related to pain were sensation ($r=0.21$, $p<0.05$) and proprioception ($r=0.24$, $p<0.05$), though the magnitude of the relationship was low.

The activity limitation variables were significantly and strongly correlated with each other as were the participation restriction variables (Table 3.4), though the magnitude of the relationship was low. Both activity limitation variables, the MAL Amount of Use scale ($r=0.96,p<0.01$) and the AHAI ($r=0.85,p<0.01$) were highly correlated with the MAL Satisfaction with Use scale. Only the AHAI was significantly correlated with the RNL ($r=0.29,p<0.01$).

Table 3-3: Correlation Matrix of Impairment Variables

Variable	Modified Ashworth Elbow	Isometric Strength	Grip	Brief Pain Inventory	Sensation
Modified Ashworth Elbow		-0.73**	-0.67**	0.15	0.14
Isometric Strength	-0.73**		0.72**	-0.08	-0.56**
Grip	0.67**	0.72**		-0.13	-0.40**
Brief Pain Inventory	0.15	-0.08	-0.13		0.21*
Sensation	0.14	-0.56**	-0.40**	0.21*	
Proprioception	0.08	-0.12	-0.26*	0.24*	0.28**

* $p<0.05$
** $p<0.01$

Table 3-4: Correlation Matrix for Activity and Participation Variables

Variable	Arm and Hand Activity Index	Motor Activity Log Amount	Motor Activity Log Satisfaction
Arm and Hand Activity Index		0.82**	0.85**
Motor Activity Log Amount	0.82**		0.96**
Motor Activity Log Satisfaction	0.85**	0.96**	
Reintegration to Normal Living Index	0.29**	0.20	0.28**

**p<0.01

Significant correlations were found between upper extremity impairment variables and activity limitation variables (Table 3.5). Muscle strength of the upper extremity ($r=0.89, p<0.01$) and MAS (elbow) ($r=0.80, p<0.01$) were the most highly correlated variables with the AHAI as well as with the MAL Amount of Use scale ($0.86, p<0.01$, $0.70, p<0.01$ respectively) with greater muscle strength relating to less activity restriction. The impairment variables of pain and proprioception were not significantly correlated with the AHAI or the MAL Amount of Use scale.

Several impairment variables were significantly correlated with participation restriction variables (Table 3.5). The variable with the most significant correlation with MAL Satisfaction with Use scale was muscle strength of the upper extremity ($r=0.88, p<0.01$) followed by tone ($r=-0.73, p<0.01$) indicating that greater muscle strength and less tone related to increased participation. Proprioception and pain were not significantly correlated with the MAL Satisfaction with Use scale. The only impairment variable significantly correlated with the RNL was tone $r=-0.24$, $p<0.05$).

Models of activity limitation utilizing impairment variables

The first model of activity limitation used the AHAI as the response variable and tone, upper extremity muscle strength, grip strength, sensation, proprioception, and pain as the impairment explanatory variables. The variables of muscle strength, tone, and sensation accounted for 86% ($p<0.001$) of the variance in the AHAI (Table 3.6). Arm muscle strength was entered first into the equation and accounted for 75% ($p<0.001$) of the variance of the AHAI scale. For the second activity limitation model using MAL Amount of Use scale as the response variable, muscle strength was the only variable retained in the regression, accounting for 71% ($p<0.001$) of the variance (Table 3.6).

Table 3-5: Correlations between Variables of Impairment, Activity Limitation, and Participation Restriction.

Variable	Arm and Hand Activity Index	Motor Activity Log Amount of Use scale	Motor Activity Log Satisfaction with Use scale	Reintegration to Normal Living Index
Modified Ashworth - Elbow	-0.80**	-0.70**	-0.73**	-0.24*
Muscle Strength of upper extremity	0.89**	0.86**	0.88**	0.14
Grip	0.69**	0.61**	0.63**	0.08
Sensation	-0.42**	-0.43**	-0.43**	-0.09
Proprioception	-0.15	-0.13	-0.15	0.04
Brief Pain Inventory	-0.03	-0.06	-0.08	-0.04
Arm and Hand Activity Index		0.82**	0.85**	0.22*
Motor Activity Log Amount of Use Scale			0.96**	0.20
Motor Activity Log Satisfaction with Use scale				0.28**

*p<0.05
**p<0.01

Table 3-6: Models of Activity Limitation and Participation Restriction Utilizing Impairment Variables

	Variable	R^2	Std. Beta	Std. error of Beta	95% CI
Activity Limitation	Arm and Hand Activity Index*				
	Muscle strength of upper extremity	0.76	46.4	6.5	33.5-59.3
	Modified Ashworth - elbow	0.84	-11.9	1.7	-15.4-(-8.5)
	Sensation	0.86	-2.4	0.70	-3.8-(-1.0)
	Motor Activity Log – Amount of Use scale†				
	Muscle strength of upper extremity	0.71	4.5	0.32	3.8-5.1
Participation Restriction	Motor Activity Log – Satisfaction with Use scale‡				
	Muscle strength of upper extremity	0.75	4.3	0.27	3.8-4.8
	Reintegration to Normal Living Index ‖				
	Modified Ashworth - elbow	0.05	-0.71	0.35	-1.4-(-0.03)

* Variables excluded: grip strength, pain, proprioception
† Variables excluded: MAS, grip strength, sensation, pain, proprioception
‡ Variables excluded: MAS, grip strength, sensation, pain, proprioception
‖ Variables excluded: muscle strength, grip strength, sensation, pain, proprioception

Models of participation restriction utilizing impairment variables

The first model of participation restriction used the MAL Satisfaction with Use scale as the response variable and tone, arm muscle strength, grip strength, sensation, proprioception, and pain as the impairment explanatory variables. Arm muscle strength was the only variable retained in the model and accounted for 75% ($p<0.001$) of the variance (Table 3.7). For the second participation restriction model using the RNL as the response variable, tone was the only impairment variable retained accounting for 5% ($p=0.04$) of the variance (Table 3.7).

Models of participation restriction utilizing activity limitation variables

The first model of participation restriction used the MAL Satisfaction with Use scale as the response variable and the AHAI and the MAL Amount of Use scale as the explanatory variables (Table 3.7). The MAL Amount of Use scale and the AHAI accounted for 96% ($p<0.001$) of the variance with the MAL Amount of Use scale accounting for 95% of that variance. In the second model of participation restriction using the RNL as the response variable, the AHAI was the only variable retained accounting for 5% ($p=0.04$) of the variance.

Table 3-7: Models of Participation Restriction Utilizing Activity Limitation Variables

Variable	R^2	Std. Beta	Std. error of Beta	95% CI
	Motor Activity Log –Satisfaction with Use scale			
Motor Activity Log Amount of Use	0.95	0.81	0.04	0.72-0.89
Arm and Hand Activity Index	0.96	0.01	0.002	0.002-0.011
	Reintegration to Normal Living index*			
Arm and Hand Activity Index	0.05	0.03	0.01	0.001-0.05

* Variable excluded: Motor Activity Log – Amount of Use scale

3.5 Discussion

This is the first study to examine the relationship between specific upper extremity impairment dimensions using upper extremity ADL and QoL measures. The ICF was chosen for this study for its common language that can enhance communication, conceptual framework, and classification system. It is a useful model for health research as it encompasses the continuum of health conditions from impairment to participation restriction. A number of upper extremity impairment and activity limitation variables were detected that contributed to activity limitation and participation restriction in individuals with chronic stroke.

A limitation to this study is that our findings can only be generalized to individuals in the chronic stage of stroke recovery and those without significant cognitive impairment. However, over half of individuals who have sustained a stroke are discharged home (Heart and Stroke Foundation of Canada, 2003) with a significant portion having residual upper extremity impairment (Wade, 1989). Individuals in the chronic stage of stroke recovery continue to require rehabilitation and these individuals identify that performance in ADL activities, many of which require use of the more affected arm, is still a priority problem (Harris and Eng, in press, 2004).

The second limitation is our method of measuring arm strength. We used a composite score of isometric strength of the more affected arm relative to the less affected arm. We may have underestimated muscle strength impairment of the more affected arm because it has been demonstrated that there are slight deficits in muscle strength in the less affected arm (McCrea et al., 2003). Furthermore, many ADL tasks require concentric or eccentric muscle contractions and therefore strength testing using isokinetic or isotonic measures may be more relevant. However, isometric strength testing of the upper extremity has been shown to correlate with isokinetic and isotonic strength tests (Knapik et al., 1983).

Muscle strength of the more affected arm was not only highly correlated with measures of activity limitation and participation restriction, but was also a strong contributor in the multi-variate models accounting for between 71-76% of the variance of these measures. This finding suggests that strength training of the more affected arm may be an important rehabilitation intervention in individuals with stroke. Studies (Wade, 1989, Bohannon, 1987) have cited muscle strength as a contributing factor to the non-use of the more affected arm in stroke however, very few studies have focused on upper extremity strength training in stroke. Bourbonnais et al.(2002) (chronic population) and Butefisch et al. (1995) (sub-acute population) both found a significant increase in upper extremity isometric force after implementing a strength- training program. However, only Butefisch et al.(1995) found significant change on measures of arm function. In contrast, Trombly and Quintana (1983) found no group differences in finger or hand function after implementing 20 minutes of additional finger and wrist exercises to regular rehabilitation. There are difficulties with this study (Trombley and Quintana, 1983) as the intensity of the program was low and the study was underpowered with only five individuals in each group. Additional randomized controlled trials should be undertaken to clarify the role of muscle strengthening for improvement in upper extremity function.

Interestingly, grip strength was only moderately correlated with measures of ADL performance and QoL and did not contribute significantly to any of the regression models. This is in contrast with studies involving individuals with stroke that have shown that grip strength is a good prognostic factor for functional recovery (Boissy et al., 1999; Suderland et al., 1989) and a sensitive measure of initial arm recovery (Heller et al., 1987). Both Heller et al.(1987) and Sutherland et al.(1989) evaluated individuals in the acute stage of stroke recovery, which may account for their results given that adaptation and compensation may not have occurred. In the chronic stage of recovery, individuals may have learned ways to cope with impairment and thus are able to complete functional tasks. Boissy et al. (1999) evaluated individuals with chronic stroke, however the age of their sample was atypical with a young mean age of 47 years. It is also possible that when grip strength is regressed independently, as in the Boissy et al.(1999) study, it is a significant factor in ADL performance, however in the presence of other variables, (e.g. strength, sensation, tone), its effect on ADL performance is minor.

Arm pain has been associated with, and a prognostic indicator of, poor functional recovery (Katrak, 1990; Ratnasabapathy et al., 2003). Shoulder pain after stroke is commonly cited in the literature as both an acute and long-term management issue with rates reported up to 84% (Roy et al., 1994). In a recent population based study by Ratnasabapathy et al.(2003) rates of shoulder pain increased from 17% at one week, 20% at one month, to 23% at six months post stroke, although additional findings suggest that upper extremity pain starts to diminish in the chronic stage (Kong et al., 2004). Thirty-seven percent of our study sample reported upper extremity pain, though pain was reported at very low levels (mean of 9.9 out of a possible 120 on the BPI). Pain was not significantly correlated with any of the activity limitation or participation restriction measures. Further, pain was not a significant explanatory variable in any of the regression models. Two reasons could account for these findings. Upper extremity pain is related to stroke recovery and is therefore time dependent. As the individual recovers, pain diminishes through the natural time course of recovery and the frequency and intensity of reported pain decreases. It may also be that the individuals in the chronic stage of recovery have adapted to pain levels and impairment and thus do not report pain as an issue in measures of activity limitation or participation restriction.

We chose to use two measures of activity limitation and participation restriction. In the dimension of activity limitation, the AHAI was chosen to measure the contribution of the more affected arm/hand in the performance of ADL while the MAL Amount of Use scale was chosen to measure the actual use of the more affected arm/hand in ADL. It is possible that individuals when asked to utilize the more affected limb in a performance measure will attempt do so, but do not actually use the more affected limb when at home. The results of performance measures may then give misleading information. However, we did find a strong correlation between the two measures (r=0.82) indicating that performance on test measures of ADL may reflect actual use of the arm in daily activities. We found that several impairment variables were correlated with the specific upper extremity measure (MAL Satisfaction with Use scale) of participation restriction but not with the global measure (RNL). Both the activity limitation variables were correlated with the specific measure of participation restriction but only the AHAI was correlated with the global measure. This may indicate that although upper extremity impairment and performance is relevant to a person's perception of quality of arm movement, it is not relevant to how they are able to participate in life situations (e.g. travel, work) or roles (e.g. husband, grandparent). It may reflect that individuals in the chronic stage of stroke have compensated and adapted to any residual impairment and are able to overcome these limitations in order to participate in life roles and situations.

3.6 Summary

Our study found that there is a relationship between the ICF dimensions and upper extremity function in individuals with chronic stroke. Further, we found that muscle strength of the more affected limb was a strong explanatory variable for activity limitation and participation restriction. It is suggested that additional randomized clinical trials should be undertaken for strength training in the upper extremity to ascertain the duration, type, and intensity necessary for significant change in activity limitation and participation restriction. The findings from our study enable the clinician to know the impact upper extremity impairment has on ADL performance, and how upper extremity performance impacts QoL in individuals with chronic stroke. With this knowledge clinicians can target and prioritize specific areas for treatment and produce more effective and efficient rehabilitation.

Chapter 4: General Discussion

4.1 Overview

Upper extremity impairment following stroke is common and can lead to difficulties in daily life. Upper limb function is influenced by several variables (e.g. strength, sensation, tone, and hand dominance). It is therefore important to understand the relationship these specific variables have to post-stroke activity and participation so that effective interventions can be developed. As well, upper extremity activity limitation can influence a person's involvement in life roles and situations, making it important to ascertain its specific relationship to participation post stroke. The work of this thesis has identified the impact of variables of upper extremity impairment on activity limitation and participation restriction in individuals with chronic stroke.

4.2 The ICF as a conceptual model

The ICF has been used in studies of stroke to classify the consequences of this condition. It is a model that proclaims to encompass all aspects of disease from the biological to the psychosocial. However, the validity of the model has not been thoroughly tested. Johnston and Pollard (2001) studied the validity of the ICF and found that it was not always possible to distinguish between the three dimensions. There is confusion about the boundary between the dimension of activity and participation leaving researchers to interrupt these constructs differently even using the same measurement tools to evaluate different dimensions. Does this mean that the main constructs of the model, body function/structure, activity, and participation, do not possess the clarity required for useful practice or is it that proper measurement tools have not been developed to reflect each dimension independently? Further research into these questions is needed.

We found it difficult to find measures that would evaluate each dimension without overlap. We also found it difficult to agree on what constitutes an activity limitation and a participation restriction. It was especially challenging to decide where measures of quality of life fit within the model. Is it a part of participation? Depending on the type of questions perhaps; or is it an over-riding construct encompassing all aspects of the model? In the end we chose to include quality of life measures under participation as many of the questions inquired about the resumption of life roles (an aspect of participation). It appears that the ICF as a valid model for the classification of the consequences of disease may need to be further evaluated and the dimensions may need more concise and explicit operational definitions. It is also important to develop measurement tools that truly reflect each dimension of the model distinctly thus maximizing the interpretation of the findings. Further, for studies involving the assessment of rehabilitation measures or outcomes other models of disability may be more effective in describing the consequences of disease.

In 1997 Law and colleagues introduced the Canadian Model of Occupational Performance (CMOP). The model was designed to guide occupational therapy practice and to illustrate the interaction between person, environment, and occupation. The core of the model is the person who is shaped by affective, cognitive, physical, and spiritual components (performance components). The CMOP depicts occupational performance (self-care, productivity, and leisure) as being intimately affected by the performance components and the socio-cultural and physical environments. Each construct has its own operational definition and there is no known documentation of confusion over construct boundaries; making it easier for the researcher to chose instruments that will independently measure each construct. The CMOP was designed to be used in rehabilitation unlike the ICF, which is much more globally focused. It seems that the CMOP would be well suited to rehabilitation assessments and to the identification of disease specific consequences. Studies have been conducted on the validity and reliability of the measure (Canadian Occupational Performance Measure) designed to reflect the constructs of the CMOP and show satisfactory results (Chan and Lee, 1997; Cup et al., 2003; Law et al., 1994;

McColl et al., 2000; Ripat et al., 2001; Sewell et al., 2001; Yerxa et a;., 1988). Though like the ICF it needs further validation from research.

4.2.1 The issue of measuring quality of life

Measures of quality of life are often used to evaluate the dimension of participation. Yet there is still confusion pertaining to whether quality of life is a component of participation or whether participation is a component of quality of life. We chose to use quality of life measures to evaluate participation. However, this may not have been an accurate method of measuring either participation or quality of life. Definitions of quality of life are multifactorial and emphaze the individual's evaluation of their well-being, life satisfaction, happiness, goals, values, attitudes, expectations, and achievements. Often quality of life is not operationally defined in health research and it is unclear as to whether researchers are measuring health related quality of life (i.e. evaluate domains that would arise from a health issue), global quality of life (i.e. subjective evaluation of values, goals, expectations, and achievements) or disease specific quality of life (i.e. issues that would arise from a specific condition or disease). This may result in misleading information about an individual's or a group of individuals' quality of life. Researchers (Cella et al., 2002; Dijkers, 1997, 2003; Doyle, 2002, Johnson et al., 2002) have commented that there are both objective and subjective components to quality of life with health status being only one component. Most measures currently used in rehabilitation research involve only the objective aspect of quality of life e.g. physical, mental, and emotion status but do not reflect the subjective or evaluative component e.g. the individual's feeling about their health status, their life satisfaction, or their level of happiness (Dijkers, 1997, 2003). Yet these same studies relate their findings in terms of quality of life, which by definition is mutlifactorial encompassing both objective and subjective evaluations, and not in terms that may be more appropriate such as health related or disease specific quality of life which domains are usually restricted to physical, mental/emotional, and social.

Within the last decade, quality of life has been used as an important outcome measure in the evaluation of rehabilitation. However, the issue remains as to what type of measure is more appropriate to evaluate quality of life within a rehabilitation context and whether measures of participation reflect quality of life. Measurement tools that evaluate issues such as engagement in life roles, environmental constraints, and or access to adequate health care reflect the dimension of participation but from the definition of quality of life do not reflect all domains of this concept. Information from these measures can encompass important domains of quality of life but are not a proxy for quality of life measures. It is important that rehabilitation researchers operationally define concepts so as to make the distinction between measuring participation and measuring quality of life.

It appears that health related and or disease specific measures of quality of life are more applicable to rehabilitation research (Dijkers, 1997, 2003; Doyle, 2003; Johnson et al., 2002) but will not necessarily reflect components of participation. It is the onus of the investigator to first operationally define quality of life and then choose the appropriate measure. Dijkers (2003) suggests that if the purpose is to measure issues such as life satisfaction, overall happiness, or achievement of life goals, then global measures of quality of life can be more revealing. Many individuals report satisfactory or high quality of life despite health related issues (Johnston et al., 2002). It becomes apparent that in chronic conditions such as stroke where a cure is not possible, the main issue may be the multifactorial quality of life which emphases the individual's perspective, and as such should perhaps be the primary outcome of rehabilitation research.

4.3 Implications for upper extremity rehabilitation

Rehabilitation of the upper extremity post stroke can present some challenges. The actions performed by the hand on a daily basis involve complex movement patterns (e.g. fine and gross motor skills, and manipulation). Improvement in one aspect of function (e.g. strength) may not translate into improvement in other areas (e.g. opening a jar). As well, the upper extremity can perform many tasks unilaterally, thus it becomes easy for individuals to substitute the less affected hand. It becomes the clinician's responsibility to create the opportunity to use the affected upper extremity in as many different contexts and movement patterns as possible.

One of the principles of practice that is inherent in rehabilitation is client-centeredness. There is a greater awareness for clients to be an active participant in goal generation and the rehabilitation process. Studies have indicated better results for upper extremity movement when treatment involved client selected goals and interests (Dean and Shepard, 1997; Nelson et al., 1996; Trombly and Wu, 1999) and when the movement was performed within a context (Nagle et al., 2000; Trombly and Wu, 1999; Wu et al., 2000) versus exercised based therapy. These results have implications for the findings of our study as muscle weakness, tone, and dominant versus non-dominant hand affected related to scores on ADL and quality of life measures.

Strengthening the affected upper limb or decreasing tone may not be cited as specific goals by clients however independence in ADL often is. Exercise based strength training may be an option if the client chooses but the clinician may also be able to incorporate strengthening into performing various activities. For example, wrist weights can be worn during any activity, eating, dressing, or playing cards, and stacking grocery items onto differing heights of shelves could also be used to increase strength of the affected arm. However, our findings are correlational and not causative, therefore it is still not clear whether strengthening of the upper extremity would result in improvement of ADL scores or result in greater quality of life. Research needs to be conducted into the effect of strengthening on activity and participation using daily life tasks performed within a familiar context compared to exercise based training.

In chapter two our results suggested that tone was affected by dominance. Less tone was measured in individuals whose dominant hand (versus non-dominant) was affected by the stroke. We suggested that this may be because of the propensity and motivation to use the dominant hand (versus the non-dominant) in daily activities thus minimizing the mechanical changes that can lead to increased tone. Clinicians can utilize this information to continue to encourage the use of the affected limb in treatment activities, especially if it is the non-dominant hand. Though this task could be difficult, the benefits of preventing the non-use of the affected hand have been well documented in the literature (Dromerick et al., 2000; Taub et al., 1993; van der Lee et al., 1999; Wolf et al., 1989).

Our study found that severity of upper limb impairment not only affected activity but also participation. It may be that in the rehabilitation phase of recovery, clinicians are too quick to offer compensatory techniques and or equipment when clients become frustrated with the affected limb. This may result in non-use of the affected upper extremity and perhaps even further impairment (e.g. contractures, pain, and decreased range of motion). The issue of remediation versus compensation in upper extremity recovery has been commented on by Nakayama et al. (1994). They concluded that for individuals with severe paresis of the upper extremity, compensatory strategies should be taught using the less affected limb and that possibly rehabilitation of the severely impaired upper limb should not be considered. This type of message is troublesome. Individuals with stroke need time to recover and to allow alternative or adaptive movement strategies to form and be tested within different environments (Latash and Anson, 1996). If the affected upper extremity is treated for a short period of time (approximately 4 weeks) and the less affected arm is encouraged to compensate, this may mask the potential for the more affected upper extremity to recover function (e.g. cortical plasticity). For clinicians, this may suggest a need for more intense treatment methods for the upper extremity, for longer periods of time, and within many different environmental in order to minimize the influence of impairment. These findings support the need for community based treatment programs focused on upper limb function. Community based treatment programs have been shown to be effective with individuals with chronic stroke (Eng et al., 2003; Dean et al., 2000; Teixeira-Salmela et al., 1999) though none have studied the effect of an upper extremity program.

4.4 Suggested future work

Though our study found a strong relationship between arm strength and ADL, the results of studies that have examined the effect of upper extremity strength training on ADL are mixed (Bourbonnais et al., 2002; Butefisch et al.,1995; Trombly et al., 1983). Our study also found that if the dominant hand was affected by the stroke, it influenced measures of impairment but not measures of ADL or quality of life. It may be that we are not seeing the benefit of treating upper extremity impairment on measures of ADL and quality of life due to the lack of intensity and duration of treatment. One of the more prominent treatment methods for the upper extremity gaining recognition and popularity is Constraint-Induced-Movement Therapy (CIMT). The traditional premise of this treatment is to bind the less affected hand for 90% of the day and have the individual involved in approximately six hours of therapy per day for 2 weeks (Taub et al., 1993). The findings of research studies using this method of treatment has shown consistent benefit for ADL performance, increased arm use in ADL, and increased satisfaction with arm use with individuals recovering from stroke (Dromerick et al., 2000; Taub et al., 1993; van der Lee et al., 1999). This intense method of treatment could be a model upon which both researchers and clinicians plan upper extremity treatment sessions to address issues such as muscle weakness, tone, and dominance. Future research concerning the upper extremity should focus on treatment intensity and duration in order to help determine best practice for clinicians. As well researchers using CIMT may want to consider the influence of the affected hand being dominant or non-dominant on their findings.

4.5. Conclusions

According to the World Health Organization (WHO), its International Classification of Functioning and Disability (ICF) can provide a conceptual framework for health conditions. The dimensions of the ICF have been outlined and discussed in this thesis in the context of upper extremity function and rehabilitation in stroke. The concepts of the ICF are not foreign to clinicians working with individuals with stroke as the focus of rehabilitation encompasses such issues as physical/mental deficits (impairment), performance in activities of daily living (activity), and the resumption of life roles (participation). As clinicians we can use this framework to compliment existing theories, models, and approaches used in stroke rehabilitation. Clinicians believe that by treating impairment following stroke it will allow individuals to perform tasks that they deem necessary and important, including involvement in life roles (e.g., parent, worker, and grandparent). Our findings support the influence that impairment can have on activity limitation and participation restriction. It is hoped that this study will contribute to the literature pertaining to upper limb impairment, activity limitation, and participation restriction in individuals with stroke and stimulate further research into the treatment of post stroke upper extremity impairment.

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Appendix 1: Flyer for Recruitment

RESEARCH STUDY

Study for Individuals with Stroke

Persons with stroke are invited to take part in a study undertaken by the School of Rehabilitation Sciences, University of British Columbia in conjunction with the GF Strong Rehab Centre. This study will examine the effect of arm deficits on the ability to complete daily and community activities. An occupational therapist will conduct the assessments. Participants will need to be assessed only once for approximately 2 hours. During the test session, you will be asked to perform various arm movements and strength tasks, as well as answer questions about your ability to complete daily and important activities in your life. Transportation can be arranged.

For more information or to participate in this study, contact study coordinator: **Jocelyn Harris** (Occupational Therapist) at the GF Strong Rehab Centre at (604) 714-4109

Appendix II: Consent Form

Informed Consent Form:
Upper Extremity Function in Individuals with Stroke

Principle Investigator/Faulty Advisor:
Dr. Janice Eng
School Rehabilitation Sciences
University of British Columbia
Phone: 604-714-4105

Co-Investigator/Graduate Student:
Jocelyn Harris
Department of Rehabilitation Sciences
University of British Columbia
Phone: 604-714-4108

Co-Investigator:
Dr. Bill Miller
School of Rehabilitation Sciences
University of British Columbia

Co-Investigator:
Dr. Lyn Jongbloed
School of Rehabilitation Sciences
University of British Columbia

Background:
You are being invited to participate in this study because you have weakness of your left or right arm due to a stroke. Your arm movement and strength will be evaluated in this study.

Purpose:
The purpose of this study is to measure arm function after a stroke and how it affects performance in daily living tasks and participation in the community. We hope that the findings of this research study will help to develop new and improved community-based programs for arm movement and function in persons with stroke.

Study Procedures:
A registered occupational therapist will assess all participants. Assessments of arm, hand and finger strength and movement will be competed. How you use your affected arm and how happy you are with how you use your arm in daily activities will also be tested.

What the study Involves:
This study will take place at the Rehab Research Laboratory at G.F. Strong Rehab Centre or in your home; this decision depends on your proximity to G.F. Strong and your preference. One hundred and fifty individuals with stroke will be recruited to participate on a voluntary basis.

A registered occupational therapist will perform all subject measurements. Measurements of arm, hand and finger strength and movement will be completed. How you use your affected arm and how happy you are with how you use your arm in daily activities will also be measured. There will be questionnaires asking about how having a stroke has affected your life. These measurements are standard measures of function and disability which are used extensively in the clinical setting, however, they are not intended to be a form of therapy. You will complete all measurements during one two-hour session. Rest breaks can be taken at any time.

If you agree to take part in this study, during one measurement session you can expect the following measurements.

Muscle Strength Measurement: You will hold an instrument in your hand that determines hand strength when you squeeze it. Your hand strength will be measured while holding your arm in different positions.
Spasticity Measurement: Spasticity is how stiff a joint is based on muscle tightness. You arm will be moved by the investigator to determine the spasticity.
Grip Strength Measurement: You will squeeze an instrument with your hand as hard as you can to measure your grip strength.
Use of Limb Measurement: This measure is an interview in which you will be asked questions about your various activies that you perform daily.
Measurement of Independence in Daily Living Activies: This is a questionnaire that you will complete. It contains questions regarding tasks such as feeding, bathing, and dressing.
Arm Impairment Measurement: During this test the investigator will lead you through a series of arm and hand movements to determine your coordination and your degree of arm impairment.
Measurement of Arm Use in Community Activities: This is a questionnaire that you will complete. It contains questions regarding tasks such as visiting friends, shopping, and outings in the last 3-6 months.

Exclusions:
Individuals who have musculoskeletal conditions, which affect their arm function in addition to the stroke and who have had more than one stroke will not be included in the study.

Benefits:
There are no direct benefits for you personally from this study. It is hoped that this information will contribute to the understanding of upper extremity recovery in persons with stroke.

Risks:
There is a slight chance that you may have some muscle soreness from the strength testing. You may also feel fatigued at the end of the session due to the arm movement required.

Confidentiality:
Your confidentiality will be respected. No information that discloses your identity will be released or published without your specific consent to the disclosure. However, research records and medical records identifying you may be inspected in the presence of the Investigator or his or her designate by representatives of Health Canada and the UBC Research Ethics Board for the purpose of monitoring the research. However, no records which identify you by name or initials will be allowed to leave the Investigators' offices.

Remuneration/Compensation:
You will be provided with an exercise sheet for your arm or hand that will help to maintain movement. The exercises on the sheet will focus on range of motion and/or strengthening for your arm or hand. One or two pieces of exercise accessories for your hand or arm will be provided to you.
Compensation for Injury:
Signing this consent form in no way limits your legal rights against the sponsor, investigators, or anyone else.

Contact:
If you have any questions or desire further information with respect to this study or if you experience any adverse effects, contact Dr. Janice Eng (Principal Investigator) at 604-714-4105. <u>If you have any concerns about your rights as a research subject and/or your experiences while participating in this study, contact the Research Subject Information Line in the UBC Office of Research Services at 604-822-8598.</u>

Consent:

I understand that participation in this study is entirely voluntary and I may refuse to participate or I may withdraw from the study at any time without any consequences to my continuing medical care.

I have received a copy of this consent form for my own records.

I consent to participate in this study.

Participant Signature Date

Witness Signature Date

Principal Investigator Signature Date

Appendix III – Modified Ashworth Scale (adapted from Bohannon and Smith, 1987)

To be done on the affected side only.
Instructions: Take the affected arm and support the elbow by placing your hand just proximal to the joint. Place your other hand just proximal to the wrist and rapidly move the forearm in a flexion, extension pattern for 5 repetitions. For the wrist, support the wrist proximal to the joint, place your hand over the palmar surface of the hand and rapidly move the wrist in a flexion, extension pattern for 5 repetitions. Please explain the process to the participant.

Description	Elbow Flexion	Wrist Flexion
No increase in muscle tone	0	0
Slight increase in muscle tone, manifested by a catch and release or by minimal resistance at the end of the ROM when the affected part is moved in flexion or extension	1	1
Slight increase in muscle tone, manifested by a catch, followed by minimal resistance throughout the remainder (less than half) of ROM	1+	1+
More marked increase in muscle tone through most of ROM, but affected part easily moved	2	2
Considerable increase in muscle tone, passive movement difficult	3	3
Affected part rigid in flexion or extension	4	4

Appendix IV – Isometric Strength

Instructions: Positions are indicated in the chart below for all tests. Tests will be completed in sitting. Start with the unaffected side. Rotate after each muscle action from the unaffected to the affected side. **Each muscle group is to be tested 1x at sub-max level (so they get the feel) and then 2x at max.** Ask participant to hold the contraction for 3 seconds. **Record both max level scores.** Participants can have a 5-8 second break between trials, if needed.

Manual Muscle Test Chart

Muscle Action	**Position**	**Unaffected**		**Affected**	
		1	**2**	**1**	**2**
Shoulder Flexion	shoulder 0° abduction, elbow 0° extension				
	Mean score				
Shoulder Abduction	shoulder 0° abduction, elbow 0° extension				
	Mean score				
Elbow Flexion	shoulder 0° abduction, elbow 90°				
	Mean score				
Elbow Extension	shoulder 0° abduction, elbow 90°				
	Mean score				
Wrist Flexion	forearm on table, elbow extended, wrist neutral, palm down				
	Mean score				
Wrist Extension	as above, forearm on table, palm up				
	Mean score				

Appendix V – Grip Strength

Jamar Dynamometer

Instructions: Have person sit in chair. With shoulder at 0° abduction, elbow at 90°, wrist between 0°-30° dorsiflexion and 0°-15° ulnar deviation. Start with the unaffected side. **"I want you to hold the handle like this (demonstrate) and squeeze as hard as you can for 3 seconds. I'm going to say ready, set, go. Ready. Set. Go. Squeeze. Relax.** Do this 3x, record each score in kgs below. Make sure to zero the dial after each trial.

Unaffected	Affected
Trial 1________	Trial 1________
Trial 2________	Trial 2________
Trial 3________	Trial 3________
Mean_________	Mean_________

Appendix VI – Fugl-Meyer Motor Impairment Scale – Upper Extremity Portion (adapted from Fugl-Meyer et al., 1975)

Test	Scoring Criteria	Max	Sco
I Reflexes	0 - no reflex 2 - reflex elicited	**4**	
Biceps		2	
Triceps		2	
IIa Flexor Synergy	Contralateral knee to ear 0 - cannot be performed 1 – performed partly 2 – performed faultlessly	**12**	
Elevation		2	
Retraction		2	
Abduction (at least 90)		2	
External Rotation		2	
Elbow Flexion		2	
Forearm Supination		2	
IIb Extensor Synergy	Ear to contralateral knee.(outside)	**6**	
Adduction/Intern. Rotation	0 - cannot be performed 1 - performed partly 2 - performed faultlessly	2	
Elbow Extension		2	
Forearm Pronation		2	
III Mixing Synergies		**6**	
Hand to Lumbar spine	0 - No specific action performed 1 - Hand passes anterior superior illiac spine 2 - Action is performed faultlessly	2	
Shoulder Flexion to 90, elbow at 0	0 - Arm immediately abducted or elbow flexes 1 - Abduction or elbow flexion occurs late in motion 2 - Faultless motion	2	
Pronation/Supination of forearm with elbow at 90 and shoulder at 0	0 - Incorrect position and/or no pronation/supination 1 - Correct position with minimal pronantion/supination 2 - Correct position and complete pronation and supination	2	
IV Out of Synergy		**6**	
Shoulder abduction to 90, elbow at 0 and forearm pronated	0 - Initial elbow flexion or deviation from pronated forearm 1 - Motion performed partly or if during motion elbow is flexed or forearm not kept in pronation 2 - Faultless motion	2	
Shoulder flexion, 90 - 180, elbow at 0, and forearm in midposition	0 - Initial flexion of elbow or shoulder abduction occurs 1 - Elbow flexion or shoulder abduction, occurs during shoulder flexion 2 - Faultless motion	2	
Pronation/Supination of forearm elbow at 0 and shoulder between 30 - 90 of flexion	0 - Supination/Pronation not possible or elbow and shoulder postion cannot be attained 1 - Elbow and shoulder properly positioned, pron/supin limited 2 - Faultless motion	2	

V Normal Reflex Activity	*****Only evaluated if stage IV has a score of 6*****	**2**	
Biceps and/or finger flexors and triceps	0 - at least 2 of the 3 reflexes are hyperactive 1 - one reflex is hyperactive or 2 reflexes are lively 2 - no more than one reflex is lively and none are hyperactive	2	
VI Wrist		**10**	
Stability, elbow 90, shoulder 0	0 - Cannot dorsiflex wrist to required 15 1 - Dorsiflexion is accomplished, but no resistance is taken 2 - Position can be maintained with some resistance	2	
Stability, elbow 0, shoulder 30		2	
Flex/Ext elbow 90, shoulder 30		2	
Flex/Ext elbow 90, shoulder 0	0 - Volitional movement does not occur 1 - Cannot actively move wrist joint through out total ROM 2 - Faultless smooth movement	2	
Circumduction	0 - Cannot be performed 1 - Jerky or incomplete circumduction 2 - Complete motion with smoothness	2	
VII Hand		**14**	
Finger mass flexion	0 - No flexion occurs 1 - Some flexion, but not full motion 2 - Complete active flexion (compared with unaffected hand)	2	
Finger Mass Extension	0 - No extension occurs 1 - Patient can release an active mass flexion grasp 2 - Full active extension	2	
G1: MP joints ext and PIPs & DIPs flexed.	0 - Required position cannot be performed 1 - Grasp is weak 2 - Grasp maintained against reasonable resistance?????	2	
G 2: Adduct thumb, IP & MP 0	0 - Function cannot be performed 1 - Paper (can, ball) can be held in place but not against a tug 2 - Paper (can, ball) is held against tug	2	
G 3: Thumb oppose indexfinger		2	
G 4: Grasp can		2	
G 5: Grasp tennis ball		2	
Co-ordination/Speed		**6**	
Tremor - Finger to nose	0 - Marked tremor 1 - Slight tremor 2 - No tremor	2	
Dysmetria - Finger to nose	0 - Pronounced or unsystematic dysmetria 1 - Slight or pronounced dysmetria 2 - No dysmetria	2	

Speed - Finger to nose	0 - Activity is more than 6 seconds longer than unaffected hand 1 - 2 - 5 seconds longer than affected hand 2 - less than 2 seconds	2	
Total		**66**	

Appendix VII – Cutaneous Sensation Testing/Proprioception

Instructions: Have participants close their eyes. Apply monofilament for less then a second and deform to half its length starting with #8 and working towards #1. Have participant respond with a **"yes"** if they are able to feel you applying the monofilament. You will need to have a sham trial to determine if the participant is really able to fill the monofilament. Stop once the person has not felt two monofilaments in a row. **Location**: radial side of digit 2 (palmar view). **Please see attached diagram**

SENSATION:

Digit 2

	Right		Left	
Filament #	Yes	No	Yes	No
8	ρ	ρ	ρ	ρ
7	ρ	ρ	ρ	ρ
6	ρ	ρ	ρ	ρ
5	ρ	ρ	ρ	ρ
4	ρ	ρ	ρ	ρ
3	ρ	ρ	ρ	ρ
2	ρ	ρ	ρ	ρ
1	ρ	ρ	ρ	ρ

PROPRIOCEPTION:

Instructions: Have the participant place both arms on the board with elbows slightly bend, palms facing down. Move the individuals less affected arm so that their middle finger is along the 45° line. If they cannot open their hand measure it from the middle knuckle. Then state **"Close your eyes and I would like you to move your other arm to the same position."** Record the degree difference in the space below, i.e. if they are able to move their arm to the 25° mark, then you would record a 20° difference.

Difference______________

Appendix IX – Brief Pain Inventory (adapted from Cleeland and Ryan, 1994)

If they participant answers "no" to the first question, go to the second question. This way you can make sure that they understand what is being asked. You can point to the diagram and state "so you could not point out any place on this body where you experience pain?"

After they have finished the questions, please return to question #2 (the body) and ask them if the pain they have marked is related to the stroke or caused by another conditions or injury. Then mark it down in the space provided.

Throughout our lives, most of us have had pain from time to time (such as minor headaches, sprains, and toothaches). Have you had pain other than these everyday kinds of pain today?

1. Yes 2. No

On the diagram provided, shade in the areas where you feel pain. Put and 'x' on the area that hurts the most.

Please rate your pain by circling the one number that best describes your pain at its **worst** in the past 24 hours.

0	1	2	3	4	5	6	7	8	9	10
No pain										Pain as bad as you can imagine

Please rate your pain by circling the one number that best Describes your pain at its **least** in the past 24 hours.

0	1	2	3	4	5	6	7	8	9	10
No pain										Pain as bad as you can imagine

Please rate your pain by circling the one number that best Describes your pain on the **average.**

0	1	2	3	4	5	6	7	8	9	10
No pain										Pain as bad as you can imagine

Please rate your pain by circling the one number that tells how much pain you have right **now.**

0	1	2	3	4	5	6	7	8	9	10
No pain										Pain as bad as you can imagine

What treatments or medications are you receiving for your pain?

____

____

____

In the past 24 hours, how much relief have pain treatments or medications provided? Please circle the one percentage that most shows how much.

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
No relief										complete relief

Circle the one number that describes how, during the past 24 Hours, pain has interfered in with your:

General Activity:

0	1	2	3	4	5	6	7	8	9	10
does not interfere										completely interferes

Mood:

0	1	2	3	4	5	6	7	8	9	10
does not interfere										completely interferes

Circle the one number that describes how, during the past 24 hours, pain has interfered in with your:

Walking ability

0	1	2	3	4	5	6	7	8	9	10
does not interfere										completely interferes

Normal work (includes outside the home and housework)

0	1	2	3	4	5	6	7	8	9	10
does not interfere										completely interferes

Relations with other people.

0	1	2	3	4	5	6	7	8	9	10
does not interfere										completely interferes

Sleep.

0	1	2	3	4	5	6	7	8	9	10
does not interfere										completely interferes

Enjoyment of life.

0	1	2	3	4	5	6	7	8	9	10
does not interfere										completely interferes

Appendix X – Arm and Hand Activity Index (adapted from Barreca et al., 1999)

Activity Scale	
1. total assist (weak U/L < 25%)	5. supervision
2. maximal assist (weak U/L = 25-49%)	6. modified independence (device)
3. moderate assist (weak U/L = 50-74%)	7. complete independence (timely, safely)
4. minimal assist (weak U/L > 75%)	

Inventory Item	Activity Score
1. open jar of coffee	
2. zip up the zipper	
3. call 911	
4. draw a line with a ruler	
5. put toothpaste on toothbrush	
6. cut medium consistency putty	
7. wring out washcloth	
8. clean a pair of eyeglasses	
9. pour a glass of water	
10. do up five buttons	
11. dry back with towel	
12. place container on table	
13. go up stairs carrying bag	
Total Score	

Comments

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Appendix XI – Motor Activity Log (adapted from Taub et al., 1993)

1A. Turn on a light with a light switch

____ Yes

  ____ Amount

  ____ How Well

____ No (skip to section B)

1B. Why did you not do the activity or use the affected arm as you did the activity, since the last visit? (Check all that apply)

____ I used the unaffected arm entirely.

____ Someone else did it for me.

____ I never do that activity, with or without help from someone else.

____ I sometimes do that activity, but did not have the opportunity since the last time I answered these questions.

____ Other.

2A. Open a drawer

____ Yes

  ____ Amount

  ____ How Well

____ No (skip to section B)

2B. Why did you not do the activity or use the affected arm as you did the activity, since last visit? (Check all that apply)

____ I used the unaffected arm entirely.

____ Someone else did it for me.

____ I never do that activity, with or without help from someone else.

____ I sometimes do that activity, but did not have the opportunity since the last time I answered these questions.

____ Other.

3A. Remove an item of clothing from a drawer

____ Yes

    ____ Amount

    ____ How Well

____ No (skip to section B)

3B. Why did you not do the activity or use the affected arm as you did the activity, since the last visit? (Check all that apply)

____ I used the unaffected arm entirely.

____ Someone else did it for me.

____ I never do that activity, with or without help from someone else.

____ I sometimes do that activity, but did not have the opportunity since the last time I answered these questions.

____ Other.

4A. Pick up a phone

____ Yes

    ____ Amount

    ____ How Well

____ No (skip to section B)

4B. Why did you not do the activity or use the affected arm as you did the activity, since the last visit? (Check all that apply)

____ I used the unaffected arm entirely.

____ Someone else did it for me.
____ I never do that activity, with or without help from someone else.

____ I sometimes do that activity, but did not have the opportunity since the last time I answered these questions.

____ Other.

5A. Wipe off a kitchen counter or other surface

____ Yes

____ Amount

____ How Well

____ No (skip to section B)

5B. Why did you not do the activity or use the affected arm as you did the activity, since the last visit? (Check all that apply)

____ I used the unaffected arm entirely.

____ Someone else did it for me.

____ I never do that activity, with or without help from someone else.

____ I sometimes do that activity, but did not have the opportunity since the last time I answered these questions.

____ Other.

6A. Get in / out of a car

____ Yes

____ Amount

____ How Well

____ No (skip to section B)

6B. Why did you not do the activity or use the affected arm as you did the activity, since the last visit? (Check all that apply)

____ I used the unaffected arm entirely.

____ Someone else did it for me.

____ I never do that activity, with or without help from someone else.

____ I sometimes do that activity, but did not have the opportunity since the last time I answered these questions.

____ Other.

7A. Open a refrigerator

____ Yes

____ Amount

____ How Well

____ No (skip to section B)

7B. Why did you not do the activity or use the affected arm as you did the activity, since the last visit? (Check all that apply)

____ I used the unaffected arm entirely.

____ Someone else did it for me.

____ I never do that activity, with or without help from someone else.

____ I sometimes do that activity, but did not have the opportunity since the last time I answered these questions.

____ Other.

8A. Open a door by turning a door knob

____ Yes

____ Amount

____ How Well

____ No (skip to section B)

8B. Why did you not do the activity or use the affected arm as you did the activity, since the last visit? (Check all that apply)

____ I used the unaffected arm entirely.

____ Someone else did it for me.

____ I never do that activity, with or without help from someone else.

____ I sometimes do that activity, but did not have the opportunity since the last time I answered these questions.

____ Other.

9A. Use a T.V. remote control unit

____ Yes

____ Amount

____ How Well

____ No (skip to section B)

9B. Why did you not do the activity or use the affected arm as you did the activity, since the last visit? (Check all that apply)

____ I used the unaffected arm entirely.

____ Someone else did it for me.

____ I never do that activity, with or without help from someone else.

____ I sometimes do that activity, but did not have the opportunity since the last time I answered these questions.

____ Other.

10A. Wash your hands

____ Yes

____ Amount

____ How Well

____ No (skip to section B)

10A. Wash your hands

____ Yes

____ Amount

____ How Well

____ No (skip to section B)

10B. Why did you not do the activity or use the affected arm as you did the activity, since the last visit? (Check all that apply)

____ I used the unaffected arm entirely.

____ Someone else did it for me.

____ I never do that activity, with or without help from someone else.
____ I sometimes do that activity, but did not have the opportunity since the last time I answered these questions.

____ Other.

11A. Dry your hands

_____ Yes

_____ Amount

_____ How Well

_____ No (skip to section B)

11B. Why did you not do the activity or use the affected arm as you did the activity, since the last visit? (Check all that apply)

_____ I used the unaffected arm entirely.

_____ Someone else did it for me.

_____ I never do that activity, with or without help from someone else.

_____ I sometimes do that activity, but did not have the opportunity since the last time I answered these questions.

_____ Other.

12A. Put on your socks

_____ Yes

_____ Amount

_____ How Well

_____ No (skip to section B)

12B. Why did you not do the activity or use the affected arm as you did the activity, since the last visit? (Check all that apply)

_____ I used the unaffected arm entirely.

_____ Someone else did it for me.

_____ I never do that activity, with or without help from someone else.

_____ I sometimes do that activity, but did not have the opportunity since the last time I answered these questions.

_____ Other.

13A. Take off your socks

_____ Yes

_____ Amount

_____ How Well

_____ No (skip to section B)

13B. Why did you not do the activity or use the affected arm as you did the activity, since the last visit? (Check all that apply)

_____ I used the unaffected arm entirely.

_____ Someone else did it for me.

_____ I never do that activity, with or without help from someone else.

_____ I sometimes do that activity, but did not have the opportunity since the last time I answered these questions.

_____ Other.

14A. Put on your shoes

_____ Yes

_____ Amount

_____ How Well

_____ No (skip to section B)

14B. Why did you not do the activity or use the affected arm as you did the activity, since the last visit? (Check all that apply)

_____ I used the unaffected arm entirely.

_____ Someone else did it for me.

_____ I never do that activity, with or without help from someone else.

_____ I sometimes do that activity, but did not have the opportunity since the last time I answered these questions.

_____ Other.

15A. Take off your shoes

_____ Yes

____ Amount

____ How Well

____ No (skip to section B)

15B. Why did you not do the activity or use the affected arm as you did the activity, since the last visit? (Check all that apply)

____ I used the unaffected arm entirely.

____ Someone else did it for me.

____ I never do that activity, with or without help from someone else.

____ I sometimes do that activity, but did not have the opportunity since the last time I answered these questions.

____ Other.

Motor Activity Log (MAL)

Part 2

16A. Get up from a chair with armrests

____ Yes

____ Amount

____ How Well

____ No (skip to section B)

16B. Why did you not do the activity or use the affected arm as you did the activity, since the last visit? (Check all that apply)

____ I used the unaffected arm entirely.

____ Someone else did it for me.

____ I never do that activity, with or without help from someone else.

____ I sometimes do that activity, but did not have the opportunity since the last time I answered these questions.

____ Other.

17A. Pull chair away from a table before sitting down

____ Yes

____ Amount

____ How Well

____ No (skip to section B)

17B. Why did you not do the activity or use the affected arm as you did the activity, since the last visit? (Check all that apply)

____ I used the unaffected arm entirely.

____ Someone else did it for me.

____ I never do that activity, with or without help from someone else.

____ I sometimes do that activity, but did not have the opportunity since the last time I answered these questions.

____ Other.

18A. Pull a chair toward a table after sitting down

____ Yes

____ Amount

____ How Well

____ No (skip to section B)

18B. Why did you not do the activity or use the affected arm as you did the activity, since the last visit? (Check all that apply)

____ I used the unaffected arm entirely.

____ Someone else did it for me.

____ I never do that activity, with or without help from someone else.

____ I sometimes do that activity, but did not have the opportunity since the last time I answered these questions.

____ Other.

19A. Pick up a glass

____ Yes

____ Amount

____ How Well

____ No (skip to section B)

19B. Why did you not do the activity or use the affected arm as you did the activity, since the last visit? (Check all that apply)

____ I used the unaffected arm entirely.

____ Someone else did it for me.

____ I never do that activity, with or without help from someone else.

____ I sometimes do that activity, but did not have the opportunity since the last time I answered these questions.

____ Other.

20A. Brush your teeth

____ Yes

____ Amount

____ How Well

____ No (skip to section B)

20B. Why did you not do the activity or use the affected arm as you did the activity, since the last visit? (Check all that apply)

____ I used the unaffected arm entirely.

____ Someone else did it for me.

____ I never do that activity, with or without help from someone else.

____ I sometimes do that activity, but did not have the opportunity since the last time I answered these questions.

____ Other.

21A. Put on makeup / shave

____ Yes

  ____ Amount

  ____ How Well

____ No (skip to section B)

21B. Why did you not do the activity or use the affected arm as you did the activity, since the last visit? (Check all that apply)

____ I used the unaffected arm entirely.

____ Someone else did it for me.

____ I never do that activity, with or without help from someone else.

____ I sometimes do that activity, but did not have the opportunity since the last time I answered these questions.

____ Other.

22A. Use a key to open a door

____ Yes

  ____ Amount

  ____ How Well

____ No (skip to section B)

22B. Why did you not do the activity or use the affected arm as you did the activity, since the last visit? (Check all that apply)

____ I used the unaffected arm entirely.

____ Someone else did it for me.

____ I never do that activity, with or without help from someone else.

____ I sometimes do that activity, but did not have the opportunity since the last time I answered these questions.

____ Other.

23A. Write on paper (if dominant arm was most affected, do you use it to write?; if non-dominant arm was most affected, do you use it to stabilize the paper when writing?)

____ Yes

____ Amount

____ How Well

____ No (skip to section B)

23B. Why did you not do the activity or use the affected arm as you did the activity, since the last visit? (Check all that apply)

____ I used the unaffected arm entirely.

____ Someone else did it for me.

____ I never do that activity, with or without help from someone else.

____ I sometimes do that activity, but did not have the opportunity since the last time I answered these questions.

____ Other.

24A. Steady yourself while standing

____ Yes

____ Amount

____ How Well

____ No (skip to section B)

24B. Why did you not do the activity or use the affected arm as you did the activity, since the last visit? (Check all that apply)

____ I used the unaffected arm entirely.

____ Someone else did it for me.

____ I never do that activity, with or without help from someone else.

____ I sometimes do that activity, but did not have the opportunity since the last time I answered these questions.

25A. Carry an object from place to place

____ Yes

____ Amount

____ How Well

____ No (skip to section B)

25B. Why did you not do the activity or use the affected arm as you did the activity, since the last visit? (Check all that apply)

____ I used the unaffected arm entirely.

____ Someone else did it for me.

____ I never do that activity, with or without help from someone else.

____ I sometimes do that activity, but did not have the opportunity since the last time I answered these questions.

____ Other.

26A. Use a fork or spoon for eating

____ Yes

____ Amount

____ How Well

____ No (skip to section B)

26B. Why did you not do the activity or use the affected arm as you did the activity, since the last visit? (Check all that apply)

____ I used the unaffected arm entirely.

____ Someone else did it for me.

____ I never do that activity, with or without help from someone else.

____ I sometimes do that activity, but did not have the opportunity since the last time I answered these questions.
____ Other.

27A. Comb your hair

____ Yes

____ Amount

____ How Well

____ No (skip to section B)

27B. Why did you not do the activity or use the affected arm as you did the activity, since the last visit? (Check all that apply)

____ I used the unaffected arm entirely.

____ Someone else did it for me.

____ I never do that activity, with or without help from someone else.

____ I sometimes do that activity, but did not have the opportunity since the last time I answered these questions.

____ Other.

28A. Pick up a cup by a handle

____ Yes

____ Amount

____ How Well

____ No (skip to section B)

28B. Why did you not do the activity or use the affected arm as you did the activity, since the last visit? (Check all that apply)

____ I used the unaffected arm entirely.

____ Someone else did it for me.

____ I never do that activity, with or without help from someone else.

____ I sometimes do that activity, but did not have the opportunity since the last time I answered these questions.

____ Other.

29A. Button a shirt

____ Yes

____ Amount

____ How Well

____ No (skip to section B)

29B. Why did you not do the activity or use the affected arm as you did the activity, since the last visit? (Check all that apply)

____ I used the unaffected arm entirely.

____ Someone else did it for me.

____ I never do that activity, with or without help from someone else.

____ I sometimes do that activity, but did not have the opportunity since the last time I answered these questions.

____ Other.

30A. Eat half of a sandwich or finger foods

____ Yes

____ Amount

____ How Well

____ No (skip to section B)

30B. Why did you not do the activity or use the affected arm as you did the activity, since the last visit? (Check all that apply)

____ I used the unaffected arm entirely.

____ Someone else did it for me.

____ I never do that activity, with or without help from someone else.

____ I sometimes do that activity, but did not have the opportunity since the last time I answered these questions.

____ Other.

Amount Scale

0 – Did not use my weaker arm (not used).

1 – Occasionally tried to use my weaker arm (very rarely).

2 – Sometimes used my affected arm, but did most of the activity with my stronger arm (rarely).

3 – Used my weaker arm about half as much as before the stroke (half prestroke).

4 – Used my weaker arm almost as much as before the stroke (3/4 prestroke).

5 – Used my weaker arm as much as before the stroke (same as prestroke).

How Well Scale

0 – The weaker arm was not used at all for that activity (never).

1 – The weaker arm was moved during that activity, but was not helpful (very poor).

2 – The weaker arm was of some use during that activity, but needed some help from the stronger arm, moved very slowly, or with difficulty (poor).

3 – The weaker arm was used for the purpose indicated, but movements were slow or were made only with some effort (fair).

4 – The movements made by the weaker arm were almost normal, but not quite as fast or accurate as normal (almost normal)

5 – The ability to use the weaker arm for that activity was as well as before the stroke (normal)

Appendix XII – Reintegration to Normal Living Index (adapted from Wood-Dauphinee et al., 1988)

Instructions: "The following questionnaire asks general questions about your satisfaction with your involvement at home and in your community." Have the participant circle the number that best describes their situation; if they are unable to fill out the form themselves then circle the corresponding number for them.

I move around my home as I feel is necessary (wheelchairs, other equipment or resources may be used).

1	**2**	**3**
Does not describe my situation	Describes my situation a little	Fully describes my situation

I move around my community as I feel is necessary (wheelchairs, other equipment or resources may be used).

1	**2**	**3**
Does not describe my situation	Describes my situation a little	Fully Describes my situation

I am able to take trips out of town as I feel are necessary (wheelchairs, other equipment or resources may be used).

1	**2**	**3**
Does not describe my situation	Describes my situation a little	Fully Describes my situation

I am comfortable with how my self-care needs (dressing, feeding, toileting, bathing) are met. (Adaptive equipment, supervision, and/or assistance may be used).

1	2	3
Does not describe my situation	Describes my situation a little	Fully Describes my situation

I spend most of my days occupied in a work activity that is necessary or important to me. (Work activity could be paid employment, housework, volunteer work, school, etc. Adaptive equipment, supervision, and/or assistance may be used).

1	2	3
Does not describe my situation	Describes my situation a little	Fully Describes my situation

I am able to participate in recreational activities (hobbies, craft, sports, reading, television, games, computers, etc.), as I want to. (Adaptive equipment, supervision, and/or assistance may be used).

1	2	3
Does not describe my situation	Describes my situation a little	Fully Describes my situation

I participate in social activities with my family, friends and/or business acquaintances as is necessary or desirable to me. (Adaptive equipment, supervision, and/or assistance may be used).

1	2	3
Does not describe my situation	Describes my situation a little	Fully Describes my situation

I assume a role in my family that meets my needs and those of other family members. (Family means people with whom you live and/or relatives with whom you don't live but see on a regular basis. Adaptive equipment, supervision, and/or assistance may be used).

1	2	3
Does not describe my situation	Describes my situation a little	Fully Describes my situation

In general, I am comfortable with my personal relationships.

1	2	3
does not describe my situation	Describes my situation a little	Fully Describes my situation

In general, I am comfortable with myself when I am in the company of others.

1	2	3
Does not describe my situation	Describes my situation a little	Fully Describes my situation

I feel that I can deal with life events as they happen.

1	2	3
Does not describe my situation	Describes my situation a little	Fully Describes my situation

Appendix XIII: Studies reporting the relationship between upper extremity impairment with activity limitation and participation restriction

Note: Abbreviations: Impairment (I), Activity (A), Participation (P)

Author/Journal	Population	Design/Measures	Analysis	Results	Discussion
Desrosier, J et al. Clin Rehab, 2003	Measured discharge and then 6 months later N=102	-relationship between I and A measures of arm and leg at d/c with a measure of P administered 6m later -Fugl-Meyer (FM), Finger to Nose test for coordination, TEMPA, LIFE-H	-Pearson's, correlation equality test	At d/c: FM with P (r=.43), coordination (r=.47), sensation (r=.24), TEMPA (r=.48) -at 6m: FM (r=.43), coordination (r=.48), TEMPA (r=.48)	-ADL tests consider use of both arms, contribution of less affected may compensate or substitute for affected and lead to improved performance. -strong relationships bt I and A -leg I more strongly associated with P than arm, leg A the same as arm -found that A was not more strongly correlated with P then I -motor control (FM) has more impact than expected on long term functional outcomes
Strum et al., Stroke, 2002	Measured P 3 and 12 months post N=113	-BI, London Handicap Scale	Pearson's correlation	P scores correlated significantly with A scores, 3 m r=0.8 and 12 m r=0.7	-half the variance in P score was attributed to A score -reducing impairment and improving function will impact positively on measures of P. P is prevalent in survivors of stroke.
Chae J et al. Muscle and Nerve, 2002	Chronic N=26	-FM and Arm motor abilities test (AMAT)	correlation, relationship between initiation, termination of contraction and clinical measures	Greater correlation between muscle initiation and FM and AMAT then in termination	-recovery of proximal is reasonable but not distal (u/e) -correlation between muscle impairment in u/e and disability -ADL tasks require prompt and coordinated initiation of movement

Author/Journal	Population	Design/Measures	Analysis	Results	Discussion
Mackenzie A and Chang A, Disability and Rehabilitation, 2002	Longitudinal, N=215	Measured at 48 hrs from admission, 2 weeks, and 3 months post -Sickness Impact Profile (SIP), Modified Barthel Index (MBI), Social Support Questionnaire (SSQ)	Pearson's correlation, point biserial correlation for continuous with dichotomous variables, stepwise regression to predict quality of life at 2 weeks and 3 months post	Significant moderate correlation between A and P r=-0.54 but only at the 3 month mark -A was a significant predictor (47% of variance) of P at 3 months -A was significant at 2 weeks, 53%	-Functional ability was the strongest predictor of quality of life at 3 months -need for pycho-social interventions within stroke rehabilitation -quality of life is important at all stages of stroke recovery and should be part of clinical decision making
Williams BK et. Al. Australian J of Physio, 2001	Acute to discharge (d/c) from Rehab N=153	-retro, chart audit over 2 yrs Motor Assessment Scale (MAS) Functional Independence Measure (FIM) score for upper body dressing	Wilcoxon signed rank (for change scores), scatter plots, spearman's	-cluster effect on scatter plots with MAS and FIM -MAS score on d/c with FIM dressing on d/c r=.53-.61 -cluster effect on scatter plot at 6 months for MAS and 7 months for FIM, they concluded no true relationship existed	-importance of measuring both movement and function of u/e -level of functional movement in arm is ultimately determined by available wrist and hand movement -movement of the u/e was not related to ability to perform a functional task -full u/e limb movement was not needed to be able to score a 6 or 7 for FIM dressing
Gottlieb H et al., Aging and clinical experimental research, 2001	Chronic N=100	relationship between I, A and P, severity scale, FIM, London Handicap Scale, Life Satisfaction Index	Pearson's and Spearman's correlation -multiple regression	-correlation bt I and A (r=-.5), I and P (r=-.34), A and P (r=.72) -regression: A strong predictor for P (r^2=.52)	-positive correlation between the ICF dimensions for stroke -the more disabled a person was the more participation restriction they recorded (decrease quality of life) -a strong need for social support once discharged to community

Author/Journal	Population	Design/Measures	Analysis	Results	Discussion
Lawrence ES et al. Stroke, 2001	Acute to sub-acute N=1259	Retrospective Stroke registry, chart review Barthel Index (BI)	Chi square and logistical regression (OR)	-77.4% had presence of u/e motor deficit (acute) -but was not a predictor of disability (BI) at 3 months	-high prevalence of u/e impairment but not related to function -community based studies include all individuals with mild stroke which hospital based studies tend not to
Brosseau, L et al. Top Stroke Rehab 2001	Rehab N=421	Retrospective, chart review, looked at time course of recovery of independence	Cox proportional hazards model	-mean time of recovery for u/e motor 26 days -u/e affected bed mobility, eating, transfers, dressing, ambulation, home activities	-motor control of u/e recover more rapidly if used in ADL's -with this info may be able to treat the specific physical characteristics and decrease length of stay and recovery time
Kauhanen M et al., Arch Phys Med Rehabil, 2000	One year post stroke, prospective study N=85	-correlates of quality of life, -assessed at 3 and 12 months post -SSS, MMSE, BI, Rankin Scale, RAND 36 item health survey	Logistical regression	-depression correlated significantly with P at 3 and 12 months -SSS correlated significantly with A and P at 3 and 12 months -only depression was a significant predictor in the regression for P	-need to incorporate more social support networks, counseling post stroke in rehabilitation -some controversy over the strength of the relationship between I and P and even between A and P, more specifically quality of life measures

Author/Journal	Population	Design/Measures	Analysis	Results	Discussion
Nilsson, A et al. Top Stroke Rehab, 2000	Chronic N=68 Follow-up study 2yrs post	National Institute of Health Stroke Scale (NIHSS), FIM Instrumental activity measures (IADL), Questionnaire of satisfaction, Nottingham Health Profile	Chi-square, Mann-Whitney, Rasch-analysis	-needs: self-care, -deficits: u/e motor, sensation, 50% dissatisfied with ADL, IADL's	-rehab intervention for self-care identified by >1/3 of clients -dependence in IADL common
Feys, H et al. Phys Ther Res Int, 2000	From acute to chronic N=90	FM, Ashworth scale (tone), tactile and deep sensation, pain, BI demographic data Predict motor recovery of arm at 2,6,12 months	Correlation Multiple stepwise regresssion <46 on FM indicated obvious motor deficit	-significant correlation bt baseline measures and 2,6,12m and with 2m and 6 and 12m, and with 6m and 12m - motor (FM), largest predictor in all models	-as the models went from acute to more chronic, variables were able to account for more of the variance in motor performance -participants were also involved in an u/e intervention study -motor score is a strong determinant of motor performance.
Inouye, M et al. Am J Phys Med Rehab. 2000	retrospective Used FIM on admission (ad) and d/c to predict disability N=464	FIM and demographic data	Spearmen's correlation Stepwise regression	-d/c and ad FIM scores highly correlated d/c FIM correlated with length of stay -all variables contributed to significantly to regression.	-rate and quality of improvement are variable, need to identify and evaluate the factors that predict functional recovery -certain subgroups may benefit from different treatment -early post-stroke limitations have been shown to be the strongest predictor of long-term outcome

Author/Journal	Population	Design/Measures	Analysis	Results	Discussion
Paciaroni M et al., European Neurology, 1999	At d/c evaluated disability in stroke N=3156	Rankin Scale, plus several Impairment measures and demographics	Univariate, multivariate, backward logistical regression,. discriminant function	-risk factors: limb weakness, apraxia -limb weakness OR=3.0, apraxia OR=2.7 OR=odds ratio	-importance of stratification in studies as their results showed that impairments were predictors of severe disability (Rankin score) only -helps with treatment planning
Kim P et al., Quality of Life Research, 1999	Chronic N=50	Influenced of quality of life post stroke -Quality of Life Index, FIM, Social support inventory, Depression Scale	Pearson's correlation, stepwise regression	- A variables significantly correlated with P variables (r=.33--.5) -depression (32% of variance), social support, functional status predictors (61% of variance) of P	-reported an overall low quality of life -functional subscales generated the lowest scores -long-term psycho-social and physical management would be beneficial for stroke survivors -integrate psycho-social concerns into rehabilitation
Pohjasvaara T et al. Cerebrovascular diseases, 1998	Subacute N=486	-3 months post -stroke, BI, Scandinavian Stroke Scale (SSS), Rankin	Chi squared and t-tests, stepwise discriminant analysis, logistical regression	-more neurologically affected the worst the A and P scores	-physical handicap has an effect on dependence, ADL, and cognitive decline -strong contribution (physical impairment) to handicap 51.5% of variance
Lai, SM et al. Stroke, 1998	1,3,6 months post N=184	-prospective study -NIHSS, Orpington Prognostic Scale, BI, SF-36	-descriptive, correlation, regression .forward stepwise	-I 35% of variance in BI at 6m, I for P 11% of variance at 6m, arm deficit accounted for 6% of BI score and 3% in P, arm strength accounted for 48% of BI and 27% of P	-I are more strongly related to A than P -variance explained by I decreases over time (1-6m), I may be minimized over time d/t compensatory strategies and environmental adaptations

Author/Journal	Population	Design/Measures	Analysis	Results	Discussion
Tennant, A et al. Disability and Rehab, 1997	Chronic N=415	Survey -indicate I at time of stroke and I now, used NHP, BI	-frequency, logistical regression	- ADL difficulties in over 50% at f/u, -logistical regression for I: left hemiplegia OR 2.1, for A: not able to cut food OR 24.8, for P: left hemiplegia OR 2.6	-issue of consequence of disease on a group of people -uses ICIDH as conceptual model -quality of life lies beyond P on the continuum -is a linear relationship over-simplistic?
Harwood R et al., Disability and Rehabilitation, 1997	Chronic N=58, completed all assessments at 1 and 3 years post	-examine the determinants of handicap -stroke severity, BI, Nottingham Extended ADL scale, Geriatric Depression scale, London Handicap scale	Correlation, regression	-depression, stroke severity correlated with A and P at 1 and 3 yrs	-handicap was prevalent after stroke at both 1 and 3 yrs -physical disability an important factor in P -central importance of disability to post stroke quality of life -rehabilitation should target disability
Kwakkel G et al. Age Ageing, 1996		Review of predicting disability in stroke			-degree of motor paresis, strong predictor of disability -assess natural recovery as some of the issues resolve or at least diminish over time
Chae J et al Am J Phys Med Rehab, 1995	Admission to discharge N=48	-role of motor impairment and disability as predictors of independence -FM (u/e and l/e) and FIM	Spearmen's correlation	FM (u/e) correlated significantly with self-care, mobility, locomotion (but only at d/c), FIM total (.64-.57)	-understand the basis of disability and recovery to know which patients will benefit from treatments -functional limitations strongest predictor of long term function -need to stratify based on function, may lead to specific therapies for specific levels of motor I

Author/Journal	Population	Design/Measures	Analysis	Results	Discussion
Duncan, P Phys Ther, 1994	Stroke	Review, measurements used, conceptual models, treatment process	Review on disability	-recovery of functional skills may be from I recovery or compensation -recovery of u/e function does not always = function	-good survival rate (50%) so need to understand disabilities -understanding predictors is important for establishing realistic goals and appropriate treatment -primary step in reducing disability is to examine the relationship bt impairment and disability
Taub NA et al. Stroke, 1994	3 months and 12 months post N=392	-what predicted patients disability at 3 and 12 months post BI	-chi squared -logistical regression	-initial paralysis predictor of disability at 3 month	-studies are showing that 6-12 months post stroke people are exhibiting I and A deficits -issue for allocation of services and funding (community programs)
De Haan R et al. Stroke, 1993	6 months post N=87	-comparison of I scales to A and P scales –used SSS, NIHSS, Orgogozo, Canadian Neurological Scale, BI, Rankin, Sickness Impact Profile	-Pearsons correlation, multiple regression backward elimination, Regression weights	-I scales all related -I scales all related to A and Pmeasures -arm motor function, hand movements/function were explanatory of Rankin and SIP	-decreasing correlation from I-A-P -didn't demonstrate a relationship bt arm/hand power & disability -correlation patterns give support to the heirarchial nature of the ICIDH
Loewen S et al. Stroke, 1990	-indicators of motor function, arm and walking recovery at d/c N=50	-prospective -Motor Assessment Scale, BI, tested 1 week and 1month after admission and d/c	-spearman's correlation, stepwise regression	-arm score (MAS) not correlated with BI at d/c -predictors of u/e function at d/c: u/e function at 1 week and 1 month	-in clinics often rely on experience and intuition then on predictors, need to know predictors so we can help plan treatment and outcome -the lack of correlation bt arm scores and BI at d/c validates people are able to achieve ADL independence by compensation

Author/Journal	Population	Design/Measures	Analysis	Results	Discussion
Parker and Wade, Int Disabil Studies, 1986	3 and 6 months post N=187	-frequency of problems in u/e and recovery of lost function -Motricity Index, BI, aesthesiometer (depth sense), Frenchay Arm Test (FAT), Nottingham Health Profile, handwriting	-frequency -chi square -correlation	-21% reported pain when abducted over 90 -significant association bt sensory function and poor ADL function -significant association bt motor loss and poor FAT score, FAT 49% of variance in BI	-many of the skills we perform daily are depend upon normal arm function, lost after stroke -40% impaired function in affected arm at 3 months -because of strong correlation bt I and A scales, clinicians could choose either to focus on to help recovery
Wade, D et al. J of Neuro, Neuros and Psych. 1983	Acute to chronic N=55	Arm function test – 7 items	correlation, stepwise regression	-3 I measures correlated significantly with poor recovery: initial motor deficit, loss of position sense, initial loss of arm function -regression: degree of initial motor I best predictor of arm function at 12m	-initial 3 month largest amount of recovery but still see recovery at 6 and 12 months -most ADL scales do not measure the function of the affected limb and can then perform well on ADL tasks with little to no recovery of arm movement

Appendix XIV: Scatter Plots of Impairment Variables Versus Activity Limitation Variable, Motor Activity Log – Amount

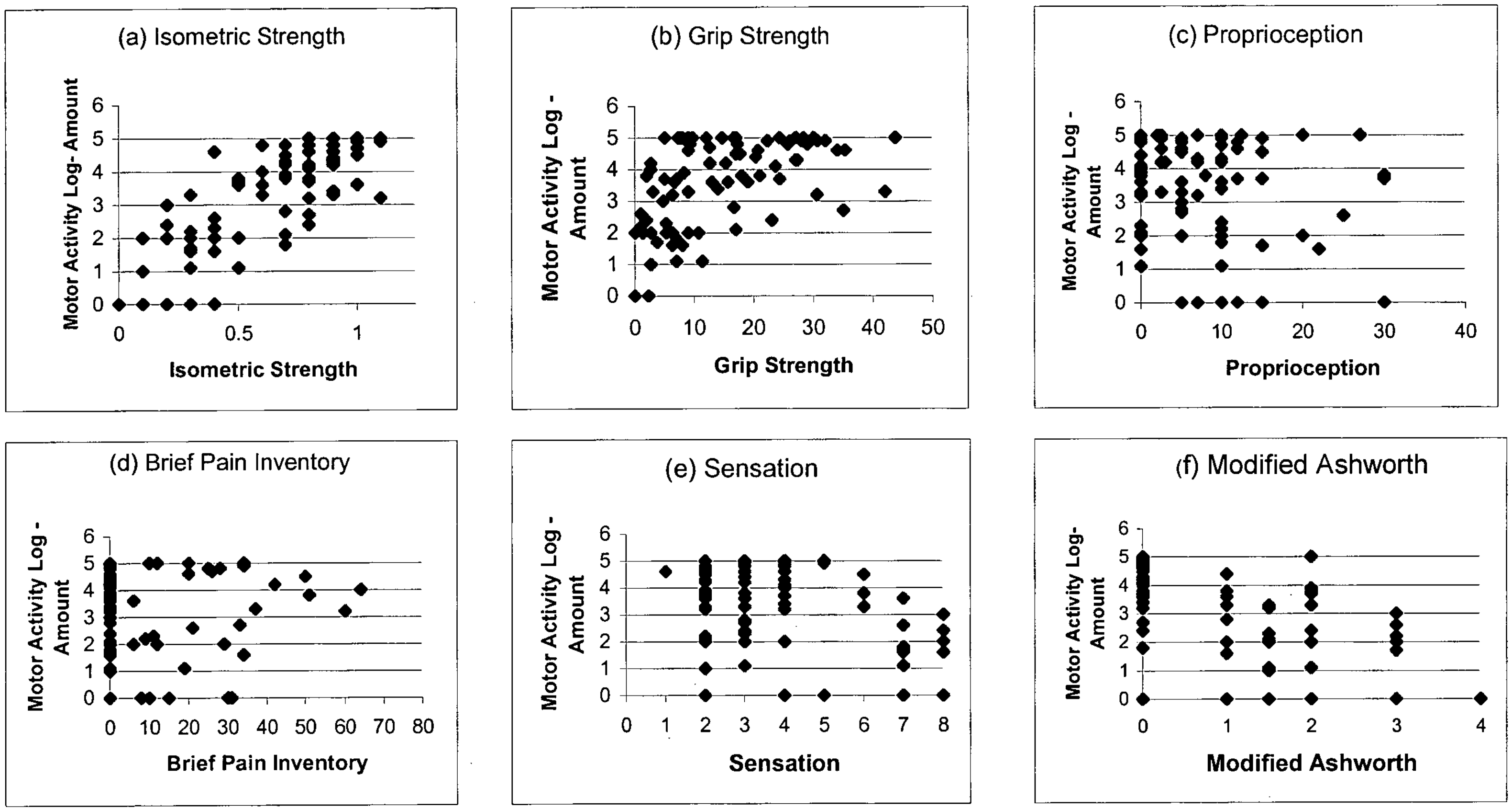

Figure 1: Scatter plots of impairment variables versus activity limitation variable Motor Activity Log – Amount of Use Scale for (a) Isometric strength, (b) Grip strength, (c) Proprioception, (d) Brief Pain Inventory, (e) Sensation, and (f) Modified Ashworth Scale.

Appendix XV: Impairment Variables Versus Activity Limitation Variable, Arm and Hand Activity Index

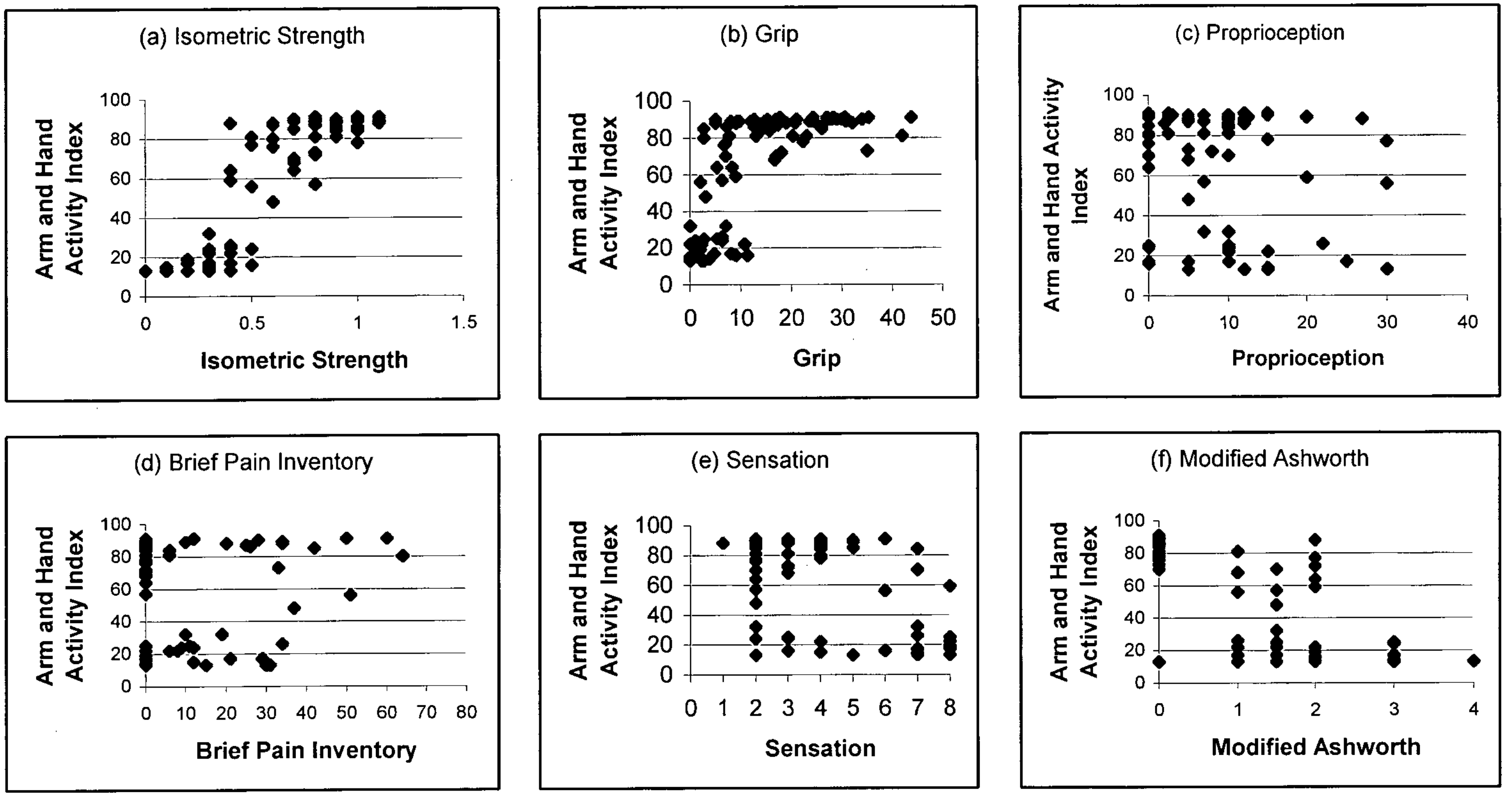

Figure 2: Scatter plots of impairment variables versus activity limitation variable Arm and Hand Activity Index for (a) Isometric strength, (b) Grip strength, (c) Proprioception, (d) Brief Pain Inventory, (e) Sensation, and (f) Modified Ashworth Scale.

Appendix XVI: Impairment Variables Versus Participation Restriction Variable, Motor Activity Log – Satisfaction

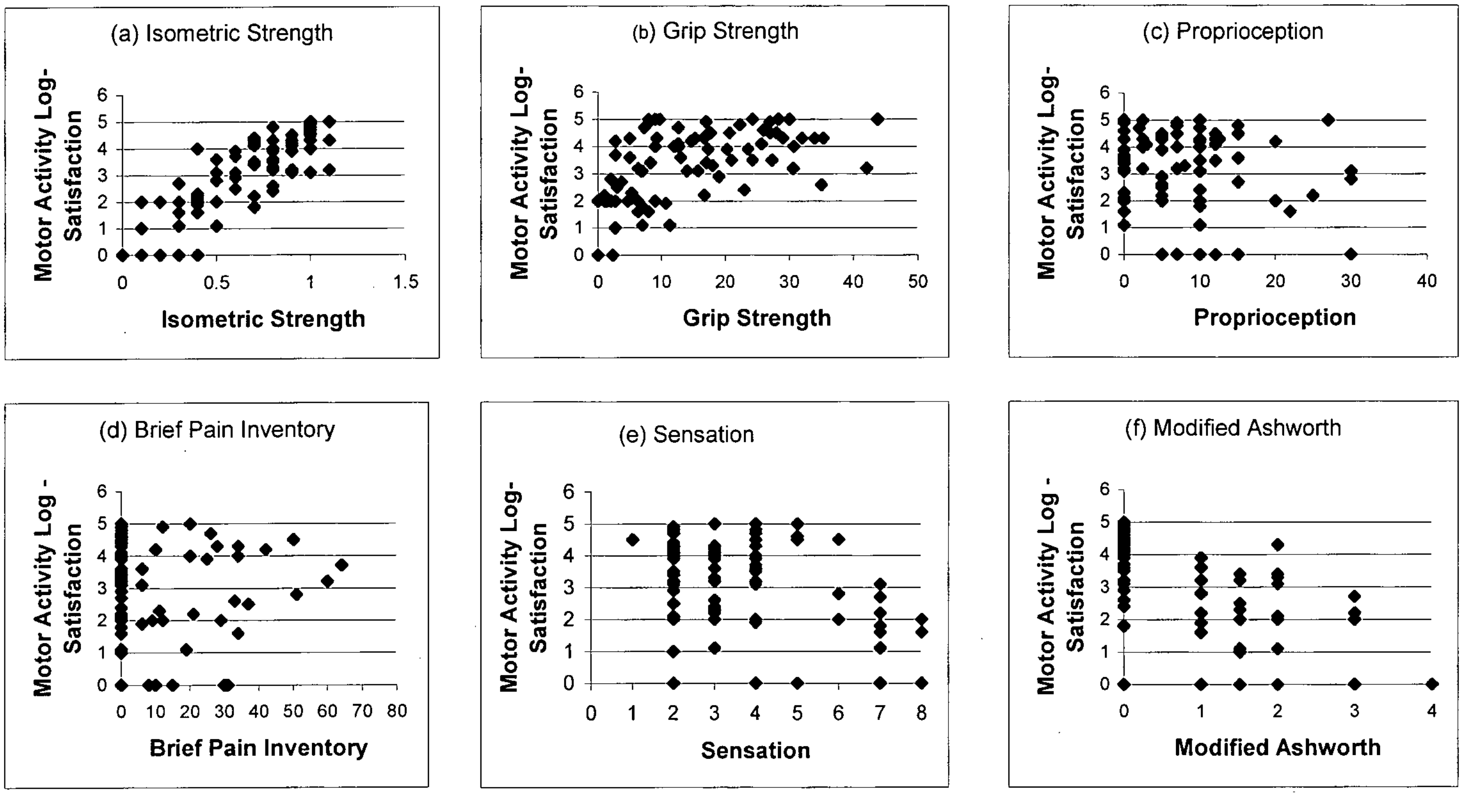

Figure 3: Scatter plots of impairment variables versus participation restriction variable Motor Activity Log – Satisfaction with Use Scale for (a) Isometric strength, (b) Grip strength, (c) Proprioception, (d) Brief Pain Inventory, (e) Sensation, and (f) Modified Ashworth Scale.

Appendix XVII: Scatter Plots of Impairment Variables Versus Participation Restriction Variable, Reintegration to Normal Living Index

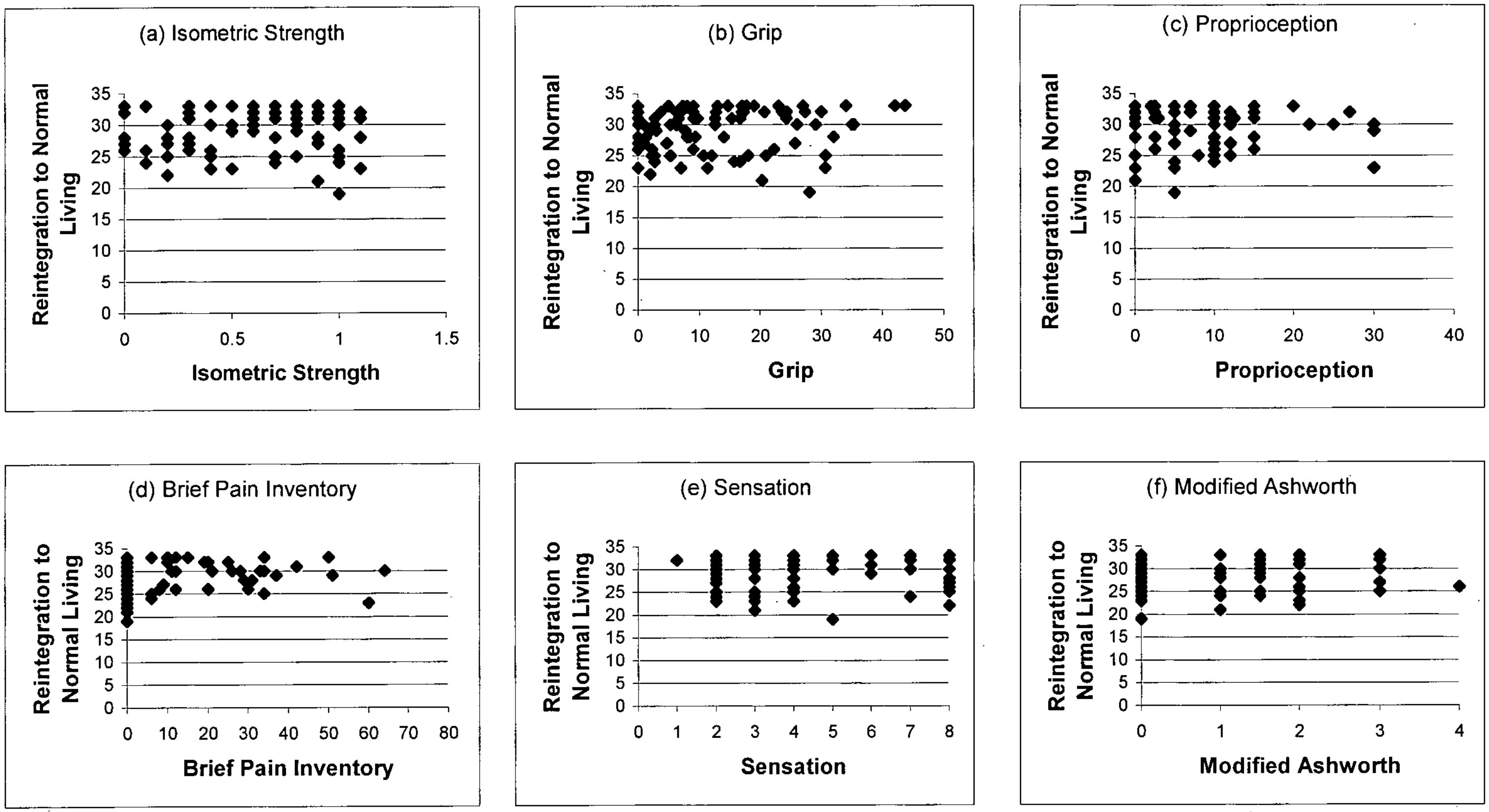

Figure 4: Scatter plots of impairment variables versus participation restriction variable Reintegration to Normal Living Index for (a) Isometric strength, (b) Grip strength, (c) Proprioception, (d) Brief Pain Inventory, (e) Sensation, and (f) Modified Ashworth Scale.

Appendix XVIII: Scatter Plots of Activity Limitation Variables Versus Participation Restriction Variables

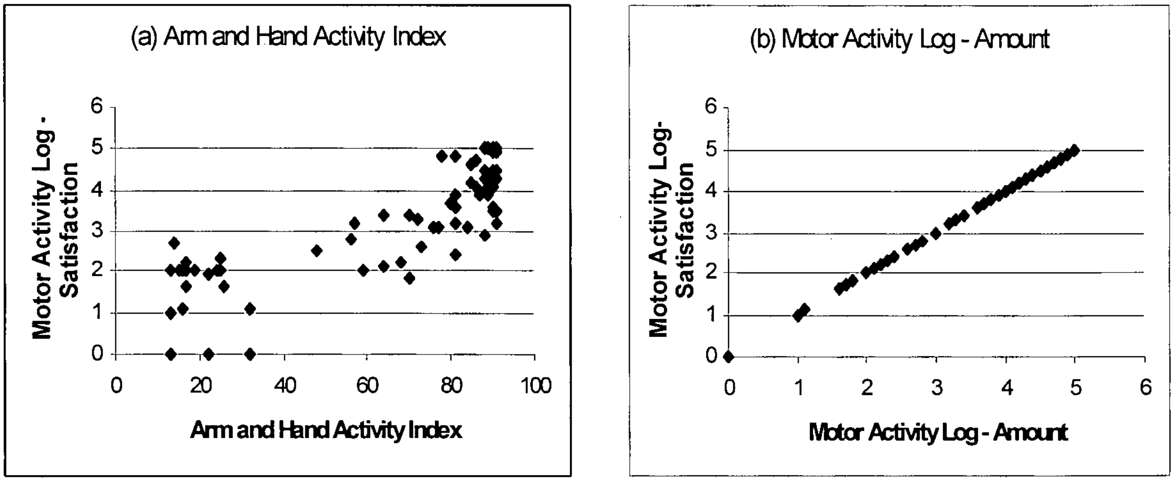

Figure 5: Scatter plots of activity limitation variables versus participation restriction variable Motor Activity Log – Satisfaction with Use Scale for (a) Arm and Hand Activity Index and (b) Motor Activity Log – Amount of Use Scale.

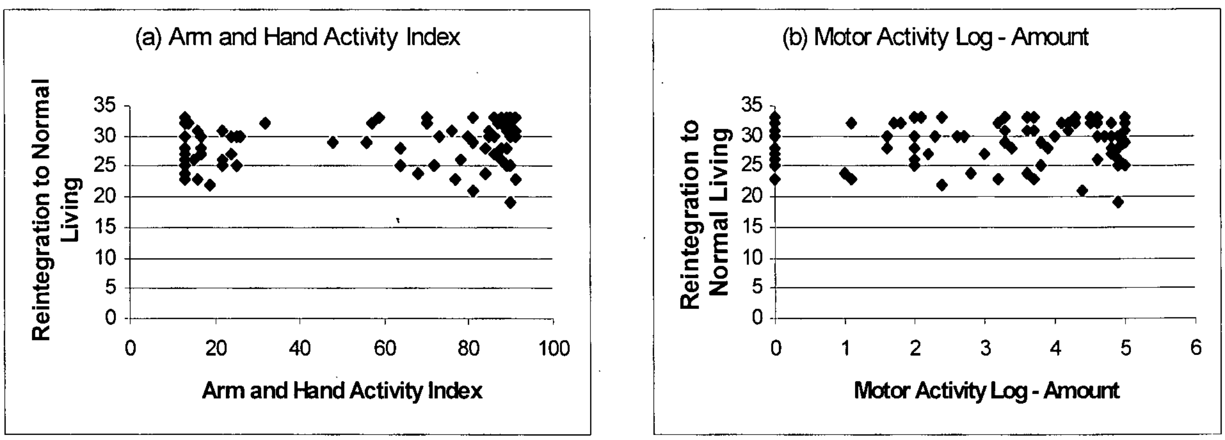

Figure 6: Scatter plots of activity limitation variables versus participation restriction variable Reintegration to Normal Living Index for (a) Arm and Hand Activity Index and (b) Motor Activity Log – Amount of Use Scale.

Appendix XIX: Psychometric Properties of Outcome Measures

Note: unless specified all studies involve individuals with stroke

Outcome Measure	Reliability	Validity
Fugl-Meyer Motor Impairment Scale	Intra-rater reliability – r=0.98-0.99) Inter-rater reliability – r=0.98-0.99) (Duncan et al.,1983) Inter-rater reliability – ICC-0.97 (Sanford et al.,1993)	-Construct validity – r=0.75-0.94 (Dettman et al., 1987; DeWeerdt et al., 1985; Fugl-Meyer et al., 1980; Wood-Dauphinee et al., 1990) -Concurrent validity – r=0.95, p<0.001 (Gowland et al., 1993) -Responsiveness – r=0.44-0.57, p<0.01(Sheldone et al., 2000; Wood-Dauphinee et al., 1990)
Hand held dynamometer	-Internal consistency – Cronbach's alpha = 0.91-0.95 (Bohannon, 1995, 1997) -Inter-rater reliability – r=0.97 -Test-retest reliability – r=0.80-.98 (Mathiowetz et al., 1984, Ottenbacher et al., 2002)	-Accuracy measure indicated ± 1-3% (LaStayo and Hartzel, 1999; Mathiowetz et al., 1984)
Modified Ashworth Scale	-Inter-rater reliability – r=0.85, p<0.001 (Bohannon and Smith, 1987), r= 0.90 (Sloan et al., 1992) -Cohen's κ = 0.83-0.75 (Pandyan et al.,1999) -Intra-rater reliability – r= 0.82 (Allison et al., 1992)	-Validity studies have shown that this scale is a measure of tone and not spasticity, however, very few 'gold standards' to compare the measure to (Pandyan et al., 1999). -Validity – measured against biomechanical measure of passive resistance to movement, r=0.51 (Pandyman et al., 2003)
Aesthesiometer kit	-Test-retest reliability – ICC = 0.89, reliability coefficient, r=0.94 (thesis data)	- was not able to locate any studies for validity
Protractor	-Test-retest reliability – r=0.88-0.92 (Carey et al., 1996, 2002)	-Discriminative validity – was able to discriminate between stroke and elderly population (Carey et al., 1996)

Brief Pain Inventory *All studies but Tyler et al., 2002 (cerebral palsy) involve individuals with cancer	-Internal consistency – cronbach's alpha $r=0.75-0.91$ (Caraceni et al., 1996), $r=0.89-0.95$ (Wang et al., 1996), $r=0.89$ (Tyler et al., 2002)	-Content validity – panel of experts, theoretical models, and clients with cancer, factor analysis (Cleeland and Ryan, 1994) -Construct validity – 2 factor loading – low correlation (0.27) between factors indicating separate issues -Criterion validity – value of test statistic for correlated correlations 2.40, $p<0.05$ (Caraceni et al., 1996) -Content validity – 2 factor loading, eigenvalue 72% of variance -Concurrent validity – $r=0.60$, $p<0.05$ (Wang et al., 1996) -Concurrent validity – $r=0.66$, $p<0.05$ (Tyler et al., 2002)
Arm and Hand Activity Index	-No reliability studies have been published, reliability studies are under review.	-Item generation/selection completed using experts, clients ($n=81$) -Inter-item correlation mean $r=0.64$, correlation coefficient between scales $r=0.49-0.90$, factor analysis (Barreca et al., 1999) -Responsiveness – standard response mean, items were able to detect change ($p\leq0.05$, $p\leq0.01$) total score $p\leq0.0001$ (Barreca et al., 2001)
Motor Activity Log	-Interrater reliability, $r=0.90$ (Miltner et al., 1999) $r=0.94$ (Uswatte and Taub, 1999) -Internal-consistency – 0.88-0.91 (van der Lee et al., 2004)	-Construct validity – $r=0.63$ (van der Lee et al., 2004)
Reintegration to Normal Living Index	- Internal consistency, $n=109$, Cronbach's alpha = 0.90-0.95 -Factor analysis supports one factor explaining 45% of variance -Inter-rater reliability – $r=0.62$ (respondent and spouse) (Wood-Dauphinee et al., 1988)	-Construct validity – total score between measures (used the Spitzer Quality of Life Index) $r=0.72$ -Low correlation ($r=0.07$, $p=0.31$) between sub-scales of measures with sub-scale one measuring daily functioning and sub-scale two perception of self (Wood-Dauphinee and Williams, 1987) -Content validity – experts, clinicians, and clients -Criterion validity – related to work status and disease status (no figures given) (Wood-Dauphinee et al., 1988)