STUDIES OF UPPER LIMB FUNCTION IN INDIVIDUALS WITH SUB-ACUTE STROKE: A MULTI-SITE SINGLE BLIND RANDOMIZED CONTROLLED TRIAL

by

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Abstract

Introduction

Approximately 70% of individuals with stroke have upper limb impairment. Inability to use the upper limb can lead to difficulties in activities of daily living. Increased time spent in therapy improves outcome of the upper limb post stroke however, length of stay in rehabilitation has decreased. Innovative ways of increasing therapy intensity need to be explored.

Purpose

1) To undertake a meta-analysis to determine the treatment effect of upper limb strengthening on strength, function and activities of daily living.

2) To determine the effectiveness of a four week self-administered in-patient homework exercise program (GRASP) on upper limb function and depressive symptoms in individuals in the sub-acute stage of stroke recovery.

3) To determine modifiable predictors of upper limb function in individuals in the sub-acute stage of stroke recovery.

Methods

Design: Chapter 2 is a meta-analysis of upper limb strength training in individuals with stroke. Electronic databases were searched from 1950-September 2008. 14 articles were reviewed.

Chapter 3-5 involved a four week multi-site single blind randomized controlled trial of a self-administered upper limb exercise program (GRASP) compared to control.

Subjects: 103 individuals with stroke were recruited from four rehabilitation units.
Results

Chapter 2: The meta-analysis showed strength training is effective in increasing paretic upper limb strength and function but not performance in activities of daily living. Chapters 3-5: The GRASP program improved upper limb function significantly more than the control group (p<0.001) and reported less depressive symptoms (p<0.001). Baseline Fugl-Meyer, change in grip strength, treatment intensity and family involvement were significant predictors of upper limb function (R²=0.507 to 0.597, p<0.001).

Conclusions

Strength training is a viable method to improve upper limb function in individuals with stroke. The randomized controlled trial showed that a self-administered homework exercise program for the upper limb is an effective method for 1) improving upper limb function and 2) decreasing depressive symptoms among individuals with sub-acute stroke. The trial provided evidence that modifiable variables are significant determinants of upper limb function among individuals with stroke. Further studies to evaluate the GRASP protocol within other conditions and treatment settings are warranted.
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Co-Authorship Statement

Sections of this thesis have been published as multi-authored papers in referred journals. Details of authors’ contributions are provided, where relevant.

Published Papers


**Contribution: 80%** - Provided study concept and design, study coordinator, data analysis, and manuscript preparation. Janice Eng was the key editor on this paper. Drs Miller and Dawson provided feedback at all steps of process including manuscript revisions.

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Chapter One: Introduction and Literature Review

1.1 Epidemiology of Stroke

Worldwide, stroke is ranked as the fourth leading cause of disease burden, and along with heart disease is the leading cause of death (Lopez et al., 2006). Strong et al. (2007) estimated a world stroke incidence rate of 16 million, a prevalence rate of 62 million, and 5.7 million stroke deaths for 2005. The incident rate is 50,000 in Canada (Heart and Stroke Foundation of Canada, 2008) and 700 thousand in the United States (American Heart Association, 2008). The annual cost to the United States and Canadian economy is 68 billion dollars with approximately 70% attributed to hospital services incurred during inpatient stay (American Heart Association, 2008; Heart and Stroke Foundation of Canada, 2008). Global initiatives to prevent stroke has reduced stroke related mortality (Murray et al., 2003) but in turn has increased the number of individuals living with stroke-related disability, and increased the demand for rehabilitation services.

1.2 Major Determinants of Stroke Outcome

Large population based studies have found that intracerebral hemorrhage accounts for approximately 20% of all strokes and leads to poor outcome, including high mortality rates within the first year (Feigin et al., 2003; Sacco et al., 2009). Gender differences have also been found for post stroke outcome. Several studies have found that women have worse functional outcome than men (Di Carlo et al., 2003; Holroyd-Leduc et al., 2000; Kapral et al., 2005; Reid et al., 2008), including higher mortality rates (Ayala et al., 2002; Weimar et al., 2002). Clinical predictors of
better post stroke functional outcome (e.g. Barthel Index, Functional Independence Measure, and Rankin Scale) from three months to one year include younger age (<75) (Johnston et al., 2007; Kissela et al., 2009; Kammersgaard et al., 2004; Skidmore et al., 2006), lower initial stroke severity (Hardie et al., 2003; Hashimoto et al., 2007; Johnston et al., 2007; Kissela et al., 2009), and higher post stroke ADL scores (Kissela et al., 2009; Johnston et al., 2007; Unchino et al., 2001). There is evidence that those with left hemisphere lesion experience greater difficulty performing motor and functional tasks, particularly when limb apraxia is present (Haaland et al., 2000; Koski et al., 2002; Smania et al., 2000; Wetter et al., 2005; Winsten et al., 1995; van Heugten et al., 2000). Upper limb function could contribute to several of the identified predictive factors of improved functional outcome since it has an integral role in ADL, social and vocation role engagement, and leisure activities.

Timing and intensity of post stroke rehabilitation have been cited as important predictors of outcome. Earlier treatment initiation has been associated with greater functional outcome at discharge and long-term outcome. Several studies have indicated that those individuals who start rehabilitation within 15 days of stroke had greater scores on measures of ADL compared to those individuals whose treatment was initiated beyond 15 days (Horn et al., 2005; Musicco et al., 2003, Paolucci et al., 2000; Salter et al., 2006). In two systematic reviews, (Kwakkel et al., 1997, 2004), increase in therapy time did have a positive effect on functional outcome evaluated by ADL measures. However, the increase had to exceed an additional 16 hours of treatment over the rehabilitation stay for improvement in lower limb function to be
seen (Kwakkel et al., 2004). Two large population based studies found that increased time spent in physical and occupational therapy was a significant predictor in multiple regression models of discharge FIM and FIM motor scores ($p<0.01$, $p<0.001$) (Horn et al., 2005; Jette et al., 2005). Both studies found that a minimum of two hours per day of rehabilitation was required to produce a significant effect.

1.3 Epidemiology of Upper Limb Dysfunction Post Stroke

It is estimated that up to 88% of individuals with stroke experience upper limb paresis in the sub-acute stage of stroke (two weeks to six months post stroke) (Foulkes et al., 1988; Duncan et al., 1994; Jorgenson et al., 1999; Parker et al., 1986) and of those people, it is estimated that 40% live with residual impairment. Those individuals who sustain severe upper limb impairment (e.g. Fugl-Meyer score between 10-26, indicating little to no hand movement, movement within synergies only) have a low probability (11% to 18%) of re-gaining function of the paretic upper limb (Hatakenaka et al., 2007; Kwakkel et al., 2003; Nakayama et al., 1994).

Time course of upper limb recovery is well documented (Broeks et al., 1999; Heller et al., 1987; Wade et al., 1983; Parke et al., 1986; Nakayama et al., 1994). The mean time of recovery for motor impairment (e.g. active range of motion, strength, and decrease in abnormal tone) is three weeks post stroke but differs according to arm severity. Those with moderate severity (measured by the Scandinavian Stroke Scale) tend to plateau on measures of motor impairment within six weeks and those with severe severity recover within nine weeks. Functional recovery (measured using the Barthel Index) is typically later than motor recovery by an average of two weeks for each severity category. However, improvement in
paretic upper limb ability and use in ADL has been found in several randomized upper limb intervention trials with individuals in the chronic (< one year post) stage of stroke recovery (Bourbonnais et al., 2002; Cauraugh et al., 2000; Fasoli et al., 2004; Luft et al., 2002; Page et al., 2004; Pang et al., 2006). Such evidence indicates that rehabilitation to improve upper limb function should be explored at each stage of stroke recovery.

The ability to use the upper limb is an important aspect of many daily activities, therefore, residual impairment can negatively impact activities of daily living (ADL), involvement in social and recreational activities, and participation in essential and meaningful life roles (Clarke et al., 1999; Desrosiers et al., 2003, 2008; Lincoln et al., 1999; Nakayama et al., 1994; Shimoda and Robinson, 1998; Viitanen et al., 1988; Wyller et al., 1997). The return of upper limb function has been identified as an important rehabilitation goal by clients (Bohannon et al., 1988; Barker and Brauer, 2005; Broeks et al., 1999), and is one function that is often neglected (Barker and Brauer, 2005). Intervention studies are needed to clarify the aspects of effective upper limb treatment post stroke in order to decrease the burden of disability on the individual, family, and society.

1.4 Determinants of Upper Limb Recovery

Several outcome variables have shown to be predictive of upper limb motor and function scores. One of the more prevalent factors associated with poor arm function (ranging from four weeks to two years post stroke) is initial upper limb motor scores. Of the individuals with initial severe upper limb paresis, only 13% were able to develop functional use as scored on the Barthel Index (Nakayama et al., 1994).
Upper limb motor scores taken two weeks post admission have accounted for between 50 and 54% of the variance of discharge score on the Functional Independence Measure (Kwakkel et al., 2003; Meldrum et al., 2004) as well as contributing to significant predictor models of upper limb function (Desrosiers et al., 2003; Feyset al., 2000; Hatakenaka et al., 2007; Kwakkel and Kollen 2007; Skidmore et al., 2006). Additionally, specific upper limb deficits such as upper limb weakness (Boissy et al., 1999; Canning et al., 2004; Harris et al., 2007; Hashimoto et al., 2007; Mercier et al., 2004), poor dexterity (Canning et al., 2004), sensory deficits (Tyson et al., 2008; Wagner et al., 2006), and range of motion (Lang et al., 2007; Smania et al., 2007) have predicted poor upper limb function (e.g. Action Research Arm Test, TEMPA, Motor Assessment Scale-upper limb portion) from four weeks to five years post stroke.

The role of hemisphere damage to upper limb recovery has been studied. In studies evaluating ipsilesional upper limb movement, left hemisphere damage tends to produce problems in object transport and those with right hemisphere damage have difficulty with object placement (Haaland et al., 2004; Schaefer et al., 2007; Sunderland et al., 2000; Wetter et al., 2005; Winstein et al., 1995; Yarosh et al., 2004). In addition sequencing of upper limb movement was more difficult in those with left hemisphere damage compared to those with right (Haaland et al., 2004; Harrington et al., 2004). Upper limb apraxia, which has been associated with left hemisphere damage (Donkervoort et al., 2000; Koski et al., 2002; Smania et al., 2000; van Heugten et al., 2000; Zwinkels et al., 2004, 2006), has a negative impact on the ability of the individual to move and use the upper limb in ADL. Lesion
locations, cortical or sub-cortical, seem to have a differing impact on upper limb function. Cortical lesions of the motor and sensory cortices affect several movement parameters such as motor planning, sequencing, and execution (Delvaux et al., 2003; Fridman et al., 2004; Gass et al., 2001; Kim et al., 2005; Velicki et al., 2000) while lesions involving sub-cortical structures can affect the movement and function of proximal upper limb muscles (Hatekenaka et al., 2007; Marx et al., 2005; Youstry et al., 1997). Importantly, tasks that require bimanual movement require interaction between the right and left hemisphere and cortical and sub-cortical structures, thus reflecting the importance of both in the coordination, planning, and execution of movement (Hatakenaka et al., 2007; Sabate et al., 2004; Sainburg et al., 2006).

The benefits of increased amount of upper limb therapy time on upper limb function are illustrated by the results of Constraint Induced Movement Therapy (CIMT) studies. CIMT consists of the unaffected upper limb being constrained while the affected upper limb is required to perform all daily activities in conjunction with six hours of upper limb treatment per day. In addition, CIMT provides intensive therapy via increasing the amount of use of the affected upper limb during treatment sessions. In a recent systematic review of randomized controlled trials, Bonaiuti et al., 2007, found that CIMT was an effective treatment intervention for the improvement of upper limb function. However, it was noted that trials consisted of small sample size and heterogeneous demographic parameters which can negatively impact cumulative analysis. Alternatively, systematic reviews investigating upper limb recovery post stroke found that increased time spent in upper limb treatment was associated with better ADL and upper limb function scores.
(Barreca et al., 2003; van Peppen et al., 2004). The impact of increased time in
treatment or increased focused use of the upper limb on recovery has not been
clearly determined (Page et al., 2003).

1.5 The Impact of Specific Upper Limb Impairments on Upper limb Function
and Activities of Daily Living

Three of the most commonly cited residual upper limb deficits following stroke
are motor recovery, muscle weakness, and altered tone (Fearnhead et al., 1999). 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 85% of individuals experiencing impaired motor function in
the sub-acute stage of stroke recovery (Parker and Wade, 1986). A strong
relationship (r=0.73-0.78, odds ratio 3.40, p<0.01) between motor recovery scores
(using the FMA and the Orpington Prognostic Score) and measures of ADL have
been found (Fonget al., 2000; Kwakkel et al., 2003; Meldrum et al., 2004). Upper
limb motor function has also been shown to account for 50% of the variance of the
Functional Autonomy Measurement System (a measure based on impairment,
activity and participation) and 39% of the Assessment of Motor and Process Skills
(Mercier et al., 2001).

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 limb
weakness following stroke is prevalent (Andrews and Bohannon, 2000; Fearnhead,
1999; Lincoln et al., 1999; Richards and 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 limb strength, as is the case for many stroke survivors, the ability to perform and complete various ADL tasks may be compromised. Weakness has been found to significantly correlate with poor performance on measures of ADL ($r^2=0.40-0.77$, $p<0.01$) (Bohannon et al., 1991; Boissy et al., 1999; Canning et al., 2004; Harris et al., 2007; Meldrum et al., 2004; Mercier and Bourbonnais, 2004).

The prevalence of altered tone, defined as resistance to passive movement caused by increased stretch reflexes and altered mechanical properties of muscle tissue (O'Dwyer et al., 1996), has been reported to range between 19% and 42.5% two to twelve months following stroke (Formisano et al., 2005; Sommerfeld et al., 2004; Watkins et al., 2002). 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. Though tone has been cited as a major contributing factor to paretic upper limb performance post stroke (Bobath, 1990), recently conflicting results of the impact of tone have been reported. Increased tone has been associated ($r<0.50$, $p<0.05$) with lower scores on ADL measures (Sommerfeld et al., 2004; Watkins et al., 2002; Welmer et al., 2006), while Bohannon and colleagues 1991, found no association between hand to mouth movement and increased tone. In a study done by Pandyan et al. (2003) altered tone was a factor in lower scores on the Action Research Arm Test; however, group
differences (those with altered tone and those without) were only seen at baseline measurement of the ARAT.

Sensory impairment post stroke are common with up to 70% experiencing some form of deficit (Carey, 1995; Connell et al., 2008; Sommerfield et al., 2004; Tyson et al., 2008), though studies have found variation in the prevalence and incidence of type of sensory deficit (Connell et al., 2008; Carey et al., 1995). Sensory deficits post stroke have a significant association with upper limb movement and in multivariate analysis have been found to be a significant predictor of upper limb function (Feys et al., 2000; Han et al., 2002; Sanchez-Blanco et al., 1999; Smania et al., 2003; Sommerfield et al., 2004). For example, joint position sense of the upper limb was found to be significantly associated with upper limb speed ($r^2=0.34$) and accuracy ($r^2= -0.32$) (Wagner et al., 2006). Deficits in tactile and proprioception were found to have a negative impact on ADL at both the acute ($r =0.51$) and chronic stage ($r=0.533$) of stroke recovery (Tyson et al., 2008).

1.6 The Impact of Upper Limb Dysfunction on Health Related Quality of Life

Many studies have measured health related quality of life in individuals with stroke (Bourdeau et al., 2008; Carod-Artal et al., 2000; Clarke et al., 2003; 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. 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 (1998) 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 decrease in life satisfaction. When investigating more specific influences on health related quality of life in stroke survivors, physical and cognitive disabilities negatively affected social functioning (Shimoda and Robinson, 1998), sense of well being (Clarke et al., 2002; Wyller et al., 1998), and health-related quality of life (Bourdeau et al., 2008; Pan et al., 2008; Weimer et al., 2002).

The impact of impairment on the dimension of participation is less clear. Clarke et al., 1999 and Viitanen et al., 1988, reported that severity of motor impairment contributed to a decrease in health related quality of life scores in chronic stroke. Several studies have found a significant relationship between upper limb motor deficit and health related quality of life ($r=0.27$ to $r=43$, $p=0.029$ to $p<0.001$) (Bourdeau et al., 2008; Desrosiers et al., 2003; 2006; Nichols-Larson et al., 2005; Welmer et al., 2006). Conversely, Johnson and Pollard (2001) and Jongbloed (1986) found no evidence that motor impairment determined health related quality of life in people with stroke.

1.7 **Summary of the Impact of Upper Limb Dysfunction**

Evidence has shown that impairment of the paretic upper limb following stroke is a significant factor in upper limb performance in ADL and, to a lesser extent, health related quality of life post stroke. Specific impairments such as decreased motor recovery, weakness, altered tone, and loss of sensation are prevalent post stroke and are the most noted variables associated with decreased
scores in ADL measures across the continuum of stroke recovery (i.e. acute to chronic). Remediation of these impairments may decrease the impact of these stroke related disabilities. Rehabilitation clinicians are instrumental in the assessment and treatment of upper limb motor and sensory disturbances in individuals with stroke. With the time course of recovery of the paretic upper limb ranging from three to twelve weeks, inpatient rehabilitation interventions need to be effective and efficient in order to maximize functional outcome.

1.8 Treatment Interventions for the Paretic Upper Limb during Rehabilitation

Over the past decade there has been increased interest in the recovery of upper limb function post stroke. Studies have evaluated several different types of intervention, and varied duration of therapy to try and determine a superior method of promoting recovery and the optimal amount of time needed to achieve upper limb function. The main treatment methods evaluated are: electrical stimulation, robotics, mental imagery, repetitive task/exercise, and constraint-induce movement therapy.

Recent reviews (Teasell et al., 2005; Barreca et al., 2003; Urton et al., 2007; van der Lee et al., 2001; van Peppen et al., 2004) of upper limb treatment post stroke concluded that there was sufficient evidence to support the effectiveness of exercise therapy for upper limb function, using such measures as the Action Research Arm Test and the Wolf Motor Function Test, but conflicting evidence for ADL performance. Much of the conflicting evidence may be based on the heterogeneity of study design (e.g. RCT versus cross-sectional), selection of outcome measures, baseline characteristics of subjects (e.g. stroke severity, age,
and time since stroke), intensity of treatment (e.g. NDT, bilateral, motor-reeducation) and timing of treatment (acute, sub-acute, and chronic).

A meta-analysis (Hiraoka 2001) of upper limb treatment post stroke indicated favorable results for exercise (d=0.51) and EMG biofeedback (d=0.75) and Ada et al. (2006) indicated an overall significant effect of strength training on activity (SD 0.32, p=0.002). However, the analysis by Ada et al. (2006), combined upper and lower limb strength training program, thus the independent effect of upper limb strengthening on activity cannot be determined. Using Sackett’s level of evidence (Sackett et al., 2000), Urton et al. (2007) found level 1 evidence for upper limb exercise, level 2 for electrical stimulation and goal directed treatment, and level 3 for bilateral upper limb training. However, more than half of the studies reviewed were of low quality rated by lack of outcome validity, blinding, and intention to treat analysis. Van Peppen et al. (2004), found a significant summary effect size for constraint induced movement therapy (SES 0.46, CI 0.07 to 0.91) for improving upper limb function but non-significant findings for exercise on improved dexterity. In a pooled Z score analysis, Barreca et al. (2003) indicated repetitive training, constraint induced movement therapy, sensorimotor training, and electrical stimulation produced significant improvement in upper limb function (p<0.05), however, increased time in therapy did not (p>0.05). Reasons indicated for this finding is that the additional time spent in therapy was based on neurofacilitative approaches; this technique has not proven to be effective in improving upper limb function (Gelber et al., 1995; Hiraoka et al., 2001; Lincoln et al., 1999; Sunderland et al., 1992). In a meta-analysis for robot assisted therapy, Kwakkel et al. (2008), found
a non-significant effect size for improved upper limb function and ADL, however, sensitivity analysis did find significance when examining shoulder-elbow robotics (d=0.35, p=0.026).

Included in the recommendations of these reviews was the need to identify those groups of people who would most benefit from upper limb exercise programs. One of the limitations of the review studies is the combining of the sub-acute and chronic stroke population. It may be beneficial to examine what factors are effective for upper limb improvement separately for these two stroke populations.

1.9 Sub-acute Trials Evaluating Upper Limb Treatment

Individual randomized controlled intervention trials to improve upper limb function in the sub-acute stage of recovery, have demonstrated a significant benefit (Alon et al., 2007; Blennerhassett and Dite, 2004; Butefisch et al., 1995; Dahl et al., 2008; Desrosiers et al., 2005; Dromerick et al., 2000; Faghri et al., 1994; Feys et al., 1998; Francisco et al., 1998; Heckmann et al., 1997; Hesse et al., 2005; Kowalczewski et al., 2007; Kwakkel et al., 1999; Langhammer et al., 2000; Lincoln et al., 1999; Lui et al., 2004; Masiero et al., 2007; Muller et al., 2007; Myint et al., 2008; Page et al., 2005; Platz et al., 2001, 2005; Ploughman et al., 2004; Popovic et al., 2003; Powell et al., 1999; Rodgers et al., 2003; Sunderland et al., 1992; Volpe et al., 2000; Weinstein et al., 2004; Wolf et al., 2006; Yozbatiran et al., 2006).

Many of the studies incorporate a variety of treatment methods such as repetitive, task oriented, and strengthening in their treatment protocol, while others focus on a specific treatment intervention (e.g. CIMT and robotics). Subsequently,
some studies are reviewed in more than one treatment classification (e.g. repetitive practice and strengthening).

Several in-patient exercise based randomized controlled trials using repetitive practice (sawing motion, rocking motion) or task focused movement (e.g. reaching for various objects, folding clothes, sorting cards, and buttoning shirts) have found significant improvements in upper limb motor and functional recovery (Blennerhassett and Dite, 2004; Butefisch et al., 1995; Duncan et al., 1998, 2003; Desrosiers et al., 2005; Feys et al., 1998, 2004; Jongbloed et al., 1988; Kwakkel et al., 1999; Langhammer et al., 2000, 2007; Morris et al., 2008; Platz et al., 2001, 2005; Rogers et al., 2003; Sunderland et al., 1992; Turton et al., 1990; Vliet et al., 2006; Weinstein et al., 2004). Eleven studies evaluated the effect of the intervention on ADL with only two (Fang et al., 2003; Langhammer, 2007) demonstrated a significant group difference. Many of these trials examined the effect of usual rehabilitation in addition to the treatment intervention (Blennerhassett and Dite, 2004; Butefisch et al., 1995; Desrosiers et al., 2005; Feys et al., 1998, 2004; Jongbloed et al., 1988; Langhammer et al., 2000; Lincoln et al., 1999; Platz et al., 2001, 2005; Morris et al., 2005; Rogers et al., 2003; Weinstein et al., 2004), others were equivalency trials (Duncan et al., 1998, 2003; Langhammer et al., 2007; Turton and Fraser, 1990; van Vliet et al., 2005), and two were intervention versus no rehabilitation (Fang et al., 2003; Kwakkel et al., 1999).

Constraint-induced Movement Therapy (CIMT) is a specific treatment method for paretic upper limb recovery that is based on neuroplasticity and theories of motor learning. It is based on the assumptions that individuals may experience ‘learned
non-use’ of the paretic limb post stroke (Wolf et al., 1989). This method of treatment consists of restraining the non-paretic hand for 90% of the waking day and six hours of intervention (based on graded, repetitive task focused activities) per day for two weeks (Taub et al., 1993). Modifications of this treatment protocol have been studied, but regardless of protocol, CIMT has shown to be effective in the chronic stroke population. In recent reviews (van Peppen et al., 2004; Barreca et al., 2003) CIMT was found to produce significant results in both motor recovery and specific upper limb function tests including moderate to large effects sizes, though there are conflicting results for measures of ADL. Positive cortical re-organization of the infarct hemisphere has been found after CIMT (Liepert et al., 1998, 2000; Taub et al., 2002).

Initially most CIMT studies involved individuals with chronic stroke; however, more recently, studies have evaluated the effect of CIMT in the sub-acute stroke population. Five studies have been completed in hospital (Boake et al., 2007; Dahl et al., 2008; Dromerick et al., 2000; Page et al., 2005; Ploughman et al., 2004); four studies involved usual rehabilitation plus additional treatment (Boake et al., 2007; Dahl et al., 2008; Dromerick et al., 2000; Ploughman et al., 2004) while four were equivalency trials (Page et al., 2002, 2005; Myint et al., 2008; Wolf et al., 2006) included usual rehabilitation in addition to the intervention. Dromerick et al. (2000) found a significant (p<0.05) difference between groups for the Actions Research Arm Test and on two sections of the Functional Independence Measure, (upper extremity dressing (p=0.04) and grooming (p=0.07). The results from Page et al. (2005), are similar with significant increases (p<0.01) on the FMA and the Action Research Arm
Test for the CIMT group but not the control group. Significant group difference in favor of CIMT compared to usual care was found by Dahl et al. (2008) for the Wolf Motor Function Test (time scale) but not for the Motor Activity Log or the Functional Independence Measure. Conversely, other studies did not find significant group differences on measures of upper limb function compared to usual care (Ploughman et al., 2005; Boake et al., 2007). Three studies (Myint et al., 2008; Page et al., 2002; Wolf et al., 2006) investigated CIMT in sub-acute stroke but with individuals living in the community and found significantly better results for upper limb function and use (Motor Activity Log).

Six clinical intervention trials have examined the effectiveness of robot assisted therapy and upper limb improvement and found positive results for upper limb motor recovery (Fugl-Meyer Scale) but limited evidence for improvement in upper limb function and ADL (Lum et al., 2006; Hesse et al., 2005; Masiero et al., 2006, 2007; Rabadi et al., 2008; Volpe et al., 2000). All trials involved usual rehabilitation in addition to the robotic intervention.

Two randomized controlled trials have found no difference between unilateral and bilateral treatment interventions in addition to usual rehabilitation, on upper limb function or measures of ADL (Desrosiers et al., 2005; Morris et al., 2008).

Biofeedback in addition to usual rehabilitation has not shown positive results for upper limb function compared to usual treatment (Armagan et al., 2003; Basmajian et al., 1982; Bate and Matyas, 1992; Hurd et al., 1980; Wolf, 1983).

Sixteen clinical trials have been completed on electrical stimulation for improved upper limb function; all trials studied the intervention in addition to usual
rehabilitation. Several studies found significant group differences in favor of electrical stimulation compared to usual treatment on the measures of upper limb impairment (Alon et al., 2007, 2008; Chae et al., 1998; Faghri et al., 1994, 1997; Francisco et al., 1998; Hesse et al., 2005) and upper limb function tests (Alon et al., 2007; Popovic et al., 2003; Powell et al., 1999). Conversely, Church et al. (2006) found group differences in favor of the control group for upper limb function while other studies found no group difference (Alon et al., 2008; and Chae et al., 1998; Hemmen and Seelen, 2007; Kowalczewski et al., 2007). Conflicting evidence for electrical stimulation of the upper limb on improving score on measures of ADL have been found with Francisco et al. (1998) finding positive results, and Chae et al. (1998) and Heckmann et al. (1997) finding no effect.

Eleven trials were identified as incorporating strength training as a significant component of the treatment intervention. (Blennnerhassett and Dite, 2004; Butefisch et al., 1995; Dickstein et al., 1986; Duncan et al., 1998, 2003; Gelber et al., 1995; Langhammer et al., 2007; Logigian et al., 1983; Platz et al., 2005; Turton and Fraser, 1990; Weinstein et al., 2004). Three of the studies were equivalency trials (Duncan et al., 1998, 2003; Turton and Fraser, 1990), the remainder were intervention in addition to usual rehabilitation. Out of the seven trials that evaluated upper limb motor changes (e.g. range of motion, Fugl-Meyer Scale), four found a significant group difference (Butefisch et al., 1995; Duncan et al., 1998; Platz et al., 2005; Weinstein et al., 2004). Six studies evaluated strength as an outcome with only two studies showing a significant group difference (Butefisch et al., 1995; Weinstein et al., 2003). Eight studies included measures that were specific to upper limb function
(e.g. Action Research Arm and the Wolf Motor Function Test); only two studies found a non-significant group difference on these measures (Gelber et al., 1995; Turton and Fraser 1990). Three studies found no group differences on any measures (Dickstein et al., 1986; Gelber 1995; Logigian et al., 1983). Five studies used a measure of ADL with only one finding a significant group difference (Langhammer et al., 2007).

1.10 Summary of Treatment for the Paretic Upper Limb

There are several methods used in the rehabilitation of the paretic upper limb post stroke. A review of the literature for individuals in the sub-acute stage of stroke recovery seems to favor approaches that are based on principles of motor control and learning, and neuroplasticity such as CIMT and repetitive practice. Further, it appears that therapy which utilizes repetitive, task and or goal oriented methods have significantly greater improvement in motor and functional recovery of the upper limb compared to therapies which use a more passive facilitative approach. Electrical stimulation appears to improve upper limb motor recovery but not necessarily upper limb function. Very few studies have found significant improvement on measures of ADL. In addition, studies indicate that increased amount of one on one upper limb treatment (approximately one hour of inpatient upper limb treatment ) has a positive effect on upper limb function. Limitations noted in the intervention studies were small sample sizes, non-blinding, insufficient contrast between experimental and control group protocols, and lack of intention to treat analysis.
1.11 Activity Level of Individuals While on Rehabilitation Units

Patient inactivity during inpatient rehabilitation stay is a concern. The main goal of rehabilitation units is to begin focused and extensive treatment as early as possible, especially when this is linked to positive changes in brain plasticity (Dobkin, 2004; Liepert et al., 2004; Ward, 2004) and function (Kwakkel et al., 2004). However, studies have shown that individuals spent approximately, 10% of the day in contact with therapists (Bernhardt et al., 2004, 2007; De Weerdt et al., 2000; Newall et al., 1997). A recent study by De Wit et al. (2005), found that, on average, clients spent eight hours per week in physical and occupational therapy combined and up to 89% inactive.

It has been reported that individuals in stroke rehabilitation are not involved in any structured activities for two-thirds of an eight hour day (Esmonde et al., 1997), and this unstructured time mainly involves sedentary activities (e.g. sitting, lying in bed, looking out the window). Others have reported even higher proportions of inactivity (>50% of the day) during inpatient stroke rehabilitation (Bernhardt et al., 2004, 2007, 2008; De Weerdt et al., 2001; Keith, 1980; Keith and Cowell, 1987; Lincoln et al., 1989; Mackey et al., 1996; Newell et al., 1997). What remains problematic is that though this trend of inactivity has been shown since 1980, recent studies have found no change of in-patient activity levels (Bernhardt et al., 2004, 2007, 2008; De Weerdt et al., 1999; De Wit et al., 2005).

Time spent in moderate or high energy expenditure activities (such as transferring, standing activities, and walking) only accounted for 12.8 % of the day, while 53% of the day was spent resting in bed (Bernhardt et al., 2004). However,
stroke severity appears to be a mediating effect on time spent in bed and at low intensity activities (Bernhardt et al., 2004, 2007). Further, the amount that patients use their paretic upper limb during unstructured time was found to be 1% (Esmonde et al., 1997). Additionally, upper limb treatment consisted of, on average, 15 minutes per day combining both physical and occupational therapy treatment, and with equal amount of time spent on unilateral and bilateral activities (Bernhardt et al., 2007). Observation of individuals outside of therapy time found that the paretic upper limb was mostly used for bilateral activities (16%) but for 67% of the day, it was not used at all (Bernhardt et al., 2007).

1.12 Summary of Activity Level in Rehabilitation

Studies have shown that individuals on stroke units spend a surprisingly small amount of time in rehabilitation. It has also been shown that even when on specialized stroke or rehabilitation units, people are spending more than 50% of their time in sedentary activities and alone. There is a need to develop strategies to increase involvement in therapeutic activity during in-patient rehabilitation.

1.13 The Use of Homework Based Treatment

A variety of self-administered exercise programs to improve mobility and physical function have been successfully prescribed for the home setting for diverse conditions such as low back pain (Descarreaux et al., 2002; Hayden et al., 2005), Parkinson’s disease (Lun et al., 2005), post-surgical knee conditions (Shaw et al., 2005), multiple sclerosis (Romberg et al., 2004), impaired balance and falls (Nelson et al., 2004) and arthritis (Baker et al., 2001). Several studies have examined home
based supervised exercise programs in individuals with sub-acute to chronic stroke. In two review studies involving individuals with stroke living in the community (Eldar, 2000; Outpatient Service Trialist, 2003), results indicated a positive outcome for home based exercise programs in measures of deterioration, ADL, instrumental activities of daily living, gait, and mobility, however, treatment frequency varied with visits by therapists ranging from once per week to two hours of therapy daily. Many studies have examined the effect of a home exercise program in people with stroke living in the community. Most studies have examined only lower limb exercise protocols and outcomes, finding significant results for motor recovery (Duncan et al., 1998; Holmqvist et al., 1998; Weiss et al., 2000), strength (Teixeira-Salmela et al., 1999; Weiss et al., 2000), mobility (Duncan et al., 1998; McClellan and Ada, 2004; Olney et al., 2006; Teixeira-Salmela et al., 1999; Weiss et al., 2000), ADL and health related quality of life measures (Holmqvist et al., 1998; Olney et al., 2006; Teixeira-Salmela et al., 1999). These programs consisted of supervised exercises (except for Olney et al., 2006) for 60-90 minutes three times per week, ranging from eight to twelve weeks.

Only five studies have looked at upper limb home based exercise protocols. Alon et al. (2003), found that five weeks of a daily self-administrated electrical stimulation and strengthening home program improved hand function and upper limb impairment in 77 subjects with chronic stroke (no control group). Turton and Fraser (1990), found that a eight week unsupervised upper limb exercise program (exercises not described) compared to no home treatment, resulted in significant group differences on dexterity (p<0.05) but not on motor recovery. Langhammer et
al. (2007) designed a longitudinal study to evaluate an additional 80 hours of supervised exercise treatment for both the upper and lower limb. Results indicated maintenance of improved gains in motor function, grip strength and ADL for the intense treatment group compared to usual outpatient therapy over one year. However, studies by Duncan et al. (1998, 2003) found no significant difference on upper limb function between a home based supervised protocol (with an upper limb component) and a usual care group. These study exercise protocol was primarily aimed at improving lower extremity function and mobility.

The study by Olney et al. (2006), compared supervised versus unsupervised home based exercise programs for lower extremity function. This study consisted of 90 minute supervised exercise sessions three times per week for 10 weeks versus an unsupervised home exercise protocol. No significant group differences were found for any of the variables of interest. This supports the notion that no adverse effects occur when exercise protocols are unsupervised and in fact individuals had similar gains on measures, though for this study the supervised exercise group showed gains earlier for health related quality of life measures than the unsupervised group. This may reflect the benefit individuals feel with social contact and support from therapist visits. Very few studies have looked at unsupervised exercise protocols for individuals with stroke, and no studies have examined the effects in an in-patient stroke population.

Developing a self-administered upper limb exercise program requires careful thought to ensure effectiveness, safety and adherence. There are few studies which have evaluated a supplementary exercise program in the inpatient setting. One
exception was a self-administered quadriceps strengthening exercise program (in addition to standard of care) which was initiated during inpatient care for anterior cruciate ligament reconstruction (Shaw et al., 2005) and resulted in better knee joint outcomes. Although no literature exists on the best way to structure rehabilitation homework, there is a body of literature on the best methods to facilitate exercise adherence (Hayden et al., 2005; Kazantzis et al., 2004). Individualizing the exercise sessions and monitoring the progress have been shown to produce greater functional results, as well as better adherence, compared to generic programs with no feedback or follow-up (Hayden et al., 2005). Educational psychology literature has shown that the therapist’s enthusiasm for the program, the client’s involvement and acceptance of the program play a large role in getting the client to adhere to therapy homework (Kazantzis et al., 2004). Further, this study emphasizes the importance of rating the quality of the homework completed not just the quantity. They suggest that researchers should use more than one method of compliance (i.e. log book, plus video-taping sessions) and should monitor compliance on a regular basis (at least once per week).

1.14 Summary of Homework Based Interventions

Studies have indicated that homework or home based programs are an effective method for producing change in function following injury. Home based supervised programs have been used with individuals in the chronic stage of stroke recovery with good results, though mainly for the lower limb and mobility measures. Only a few studies have looked at upper limb home based programs with mixed results. There are several factors that are important in considering compliance with
an unsupervised homework based program. Prescribed practice outside of regular therapy has never been undertaken during inpatient stroke rehabilitation.

**1.15 Theoretical Framework**

The need for treatment techniques to be based in science is paramount in the provision of evidence based practice. Over the past 15 years advancements in theories of movement science and brain plasticity have contributed to the development of effective treatment techniques in neurorehabilitation. In an article by Shepherd (2001), three main areas of scientific development are postulated as contributing to restorative treatment methods for individuals post stroke: neural plasticity, motor skill learning, and exercise science.

**1.15.1 Neural Plasticity and Stroke Recovery**

In response to a lesion adaptive change at the cellular and cortical level take place in the brain. This capacity of the brain to change is the main tenant in the definition of neural plasticity. Although plastic changes seem to be triggered by many events, it is clear that one of the most compelling predictors of cortical structure and function is behavioral experience (Feldman et al., 2005; Nudo et al., 2003). Cortical areas are constantly being shaped by demands placed on the individual to perform tasks. To learn a skilled motor activity the movement parameters (e.g. coordination, muscle contraction, accuracy) must be practiced many times, resulting in physiological and anatomical alterations in the organization of the cortex (Nudo, 2003). Knowledge that motor experience and skill acquisition
can modulate changes in the brain underlies many of the new treatment methods in neurorehabilitation.

Neural plasticity was first explored using animal models. In landmark studies using primates (Knapp et al., 1963; Taub et al., 1966; 1980; Pons et al., 1991) it was discovered that deafferentation of the upper limb led to disuse of the affected limb and subsequent loss of cortical representation of the arm and hand in the motor cortex. Treatment that forced the use of the affected upper limb in both rats and primates led to reversal of cortical loss, normalization of upper limb cortical representation, and improved ability to the use the affected limb in tasks (Greenough et al., 1985; Jenkinsa et al., 1990; Liepert et al., 1995; Nudo et al., 1996). These findings led to the hypothesis that such changes may occur in the human lesioned brain. Using imaging techniques, researchers found similar changes did occur post infarct in the human brain (Hallet , 1999; Weiller et al., 1992, 1993; Cramer et al., 1997). Subsequently, treatment techniques that demonstrated positive plastic and functional changes in animal models were designed and tested in human subjects with positive results (Wolf et al., 1989; Taub et al., 1993; Liepert et al., 1998). The main components of this effective technique, which is called Constraint-Induced Movement Therapy, is the active use of the affected upper limb in a variety of activities, intense amount of therapy time (at least 2 hrs/day), and the restriction of the use of the un-affected upper limb.

Other treatment methods were developed based on the principles of plasticity and the successful treatment paradigms used in early animal and human studies. A review of this literature was detailed in this chapter (section 1.8 and 1.9). A main
premise of treatment used in neurorehabilitation is that individuals with a brain lesion can learn or re-learn skills and abilities that will enable them to successfully engage in activities of necessity and choice. Review articles highlight the impact active movement therapy has on stroke recovery, revealing consistent relationships between motor recovery and cortical activation patterns associated with better recovery (Mountz, 2007; Ward and Cohen, 2004; Calautti and Baron, 2003; Stefan et al., 2000). It is evident that movement therapy has the potential to drive brain organization toward optimal functional performance.

1.15.2 Motor Learning and Stroke Recovery

Motor learning has been defined as the acquisition of a skill (Schmidt and Lee, 2005). Rehabilitation focuses on skill recovery. Motor learning is thus an important theory for professionals in the rehabilitation field. One of the propositions of motor learning is that learning leads to relatively permanent changes in a response (Shumway-Cook & Woollacott, 1995), as such a belief in neuroplasticity is required to accept the definition of motor learning. When applied to motor learning, neuroplasticity centers on the construct of learning. Several researchers (Fischer, 1967; Mulder and Hochstenbach, 2001; Nativ, 1993; Shumway-Cook and Woollacott, 1995) believe that learning changes the brain by improving or changing the connections between neurons and their circuitry. It is felt that through neuroplasticity a skill or movement is developed or adapted.

Learning is defined in motor learning literature as skill acquisition gained through mastery or experience involving sensory, cognitive, and motor organization and integration (Schmidt and Lee, 2005; Winstein, 1991). The construct of practice
is an integral part of the definition of motor learning. Practice is how an individual generates or formulates a plan of action to solve a motor problem (Schmidt and Lee, 2005; Shumway-Cook and Woollacott, 1995). Practice of a movement or skill can occur mentally using cognitive processes such as imagery or rehearsal, or physically using movement repetition or manual guidance techniques. Both of these tenants are an integral aspect of rehabilitation practice.

When an individual performs a movement or skill there are several sources of information available to them. Feedback is defined as information available to the individual as a result of movement and is an important part of skill acquisition (Schmidt and Lee, 2005). Intrinsic feedback is defined as all the sensori-perceptual information available to the individual during or after performance, for example, visual, auditory, and kinesthetic whereas extrinsic feedback is defined as information given at any time during or after a performance either verbal or non-verbal, and originating from a source outside an individual such as a biofeedback machine or a therapist (Schmidt and Lee, 2005). The environment or context in which a skill or task is developed or performed is a component of motor learning. The environment can provide information about the movement performance and play a role in determining how people organize movement (Gilmore and Spaulding, 2001; Jarus, 1994; Ma et al., 1999; Mulder and Hochstenbach, 2001; Poole, 1991). One of the most effective ways to improve motor performance is to practice the movement and or task repeatedly; however this is optimal for short term but not long term retention of skills (Winstein et al., 1999). The key to retention and generalization is task variability within the treatment session (Shea et al., 1991; Hanlon, 1996).
Recently studies have examined motor learning deficits post stroke and the use of motor learning principles in rehabilitation (Boyd and Weinstein, 2001; 2003, 2004, 2006; Cirstea et al., 2006). These studies have concluded that the ability to acquire a skill through practice of the skill is intact in individuals with stroke, though the successful learning of a task is influenced by lesion location and type of learning required. Though both intrinsic and extrinsic feedback is important to skill development, intrinsic feedback can be impaired in individuals with stroke (van Vliet et al., 2006) due to the neurological deficits in strength, tone, and sensation. This may require individuals with stroke to rely heavily on extrinsic feedback; this was supported in the study by Cirstea et al (2006).

Motor learning postulates that repetition is critical for skill development. In rehabilitation treatment is focused on practicing the skills necessary for motor and functional recovery. In addition, skill generalization is an important goal of rehabilitation. Motor learning principles stated that variability of tasks within sessions can facilitate generalization of a skill in individuals with stroke (Cauraugh et al., 2003; Halon, 1996). It is the role of the therapist to manipulate the contextual aspects of the task in order to facilitate optimal learning of a skill.

1.15.3 Exercise Science and Stroke Recovery

A major negative feature of stroke is weakness. Weakness post stroke is thought to be due to loss of motor unit activation, changes in recruitment ordering, and changes in firing rates (Tang and Rymer, 1981; Dietz et al., 1986). Weakness is compounded by adaptive mechanical changes of the affected joints; often resulting from decreased physical activity and disuse (Farmer et al., 1993; McComas, 1993).
It appears that some of the impairments post stroke (e.g., increased tone and abnormal movement patterns) are more likely to be the result of joint tissue adaptation and inappropriate muscle co-contraction (Delp et al., 1999; Thilmann et al., 1991; Carey and Burghardt, 1993). Understanding the contribution of adaptive structural and functional changes in muscles and knowing that these changes occur in response to muscle weakness, compounded by disuse and physical inactivity, enables the development of strategies (such as active exercise) to decrease muscle stiffness and preserve the functional extensibility of muscles.

At the same time, task specific training (i.e., specific training of functional actions, such as walking, reaching, standing up) stimulates the regaining of motor control by training muscles to generate adequate force and timing (Carr and Shepherd, 2005). Increased understanding of the biomechanics of everyday actions has enabled the development of models of skilled motor performance which can guide movement analysis and the planning of intervention. Studies of the biomechanics required for everyday activities such as walking, standing up, reaching, and manipulation provide information regarding the execution of these actions. Exercise training in individuals with stroke has shown positive results for improved strength, fitness, and balance (Duncan et al., 2003; Texeira-Salmela et al., 1999; Olney et al., 2006; Pang et al., 2005).

1.15.4 Treatment Intensity and Specificity and Stroke Rehabilitation

The benefits of treatment methods for individuals with stroke that influence neural plasticity, incorporate the science of exercise and the theory of motor learning has been described in section 15. However, equally important in the development of
treatment is information regarding the type of tasks performed and the intensity required to drive neural organization, motor and functional gains. Several reviews of these concepts has described the need for tasks to be designed that are goal or purpose oriented and ideally to be done within real-life environments (Kwakkel et al., 2004; Nudo et al., 2003; Turkstra et al., 2003; Page, 2003; Teasell et al., 2004; Ma and Trombly, 2002). It was further concluded that repetition is not sufficient to drive the neural adaptations necessary for functional recovery; meaningful tasks are required.

Constraint-Induced Movement Therapy (CIMT) is rehabilitation technique used to improve upper limb function post stroke. By forcing the use of the affected limb during several hours of rehabilitation a day, CIMT is an example of intensive and task specific therapy. The impressive benefits of this treatment have been documented in section 1.8 and 1.9. In a meta-analysis of augmented exercise post stroke Kwakkel et al 2004 determined that an additional 16 hours of rehabilitation was required for improved lower limb performance. Studies that examine the effect of a particular treatment are usually additive, where the experimental treatment is in addition to already existing treatment. The average amount of additive treatment is one hour per a five day week over a six week period of time.

1.15.5 Theoretical Framework and the Development of the Treatment Program for this Study

A review of the literature suggests that treatment methods that incorporate active movement, repetitive protocols, and focus on goal oriented activities are beneficial in improving upper limb function and recovery post stroke. The activities
and exercises developed for the randomized controlled trial (GRASP) that formed the basis of this study were formulated to reflect neuro-rehabilitative theory and clinical trials providing evidence for these theoretical constructs. Each activity was chosen to reflect the purpose of the upper limb in daily activities: reach, transport, and manipulate. Additionally, they were chosen to promote active movement of the affected upper limb, graded to allow for success and improvement, performed repetitively to promote skill acquisition and plasticity, and when possible incorporated daily activities to provide motivation and context (e.g. buttons, jars, and towels). The prescription of 60 minutes of upper limb exercise per five day week over four weeks is congruent with treatment intensity required to drive change and recovery.

1.16 Rationale, Objectives, and Hypotheses of Thesis

In this section of chapter one, I will outline the rationale, objectives, and hypotheses of the studies that comprise this thesis, followed by the scientific contribution each study makes.

1.16.1 Chapter Two

Rationale

Upper limb weakness following stroke is prevalent in acute (Andrews and Bohannon, 2000) and chronic stages of recovery (Canning et al., 2004). Studies have shown that sufficient strength in the upper limb is related to the ability to adequately perform many ADL (Chae et al., 2002; Harris et al., 2007) A recent review of upper limb strength training in stroke (Ada and Canning, 2006) found no
adverse effects of strength training. Despite this knowledge, there is still controversy surrounding strength training in stroke. Providing clinicians with evidence of the effectiveness of upper limb strength training on upper limb function and ADL would add to evidence based practice for upper limb treatment post stroke. In addition, evidence for or against strength training would assist in deciding whether strength training should be incorporated into the upper limb program proposed in this thesis.

Objective

The primary study objective was to examine the evidence for strength training of the paretic upper limb in improving a) grip strength b) upper limb function, and c) ability to perform ADL in individuals in the sub-acute and chronic stage of recovery.

Hypothesis

Meta-analysis of upper limb strength training will demonstrated improved grip strength and upper limb function but not ability to perform ADL.

Contribution

This study will demonstrate the pooled treatment effect of upper limb strength training on improved grip strength and upper limb function in individuals with stroke. This study will contribute to the body of evidence for treatment interventions to improve upper limb recovery post stroke.

1.16.2 Chapter Three

Rationale

Over 70% of individuals who have a stroke experience upper limb deficits that impact daily activities. Increased amount of upper limb therapy has positive effects; however, practical and inexpensive methods of therapy are needed to deliver this
increase in therapy. Reviews (Barreca et al., 2003; van Peppen et al., 2004) indicate that interventions that incorporate repetitive, task oriented activities show improved upper limb function outcomes. It is not known whether an inexpensive, home-work based program that used repetitive task activities could improve upper extremity function.

**Objective**

To determine if a four week self-administered graded repetitive arm supplementary program (GRASP) can significantly improve scores on the Chedoke Arm and Hand Activity Inventory compared to those in the control group.

**Hypothesis**

A four week self-administered graded repetitive arm supplementary program (GRASP) will produce statistically (p<0.05) and clinically significant improvement (in comparison to the control group the GRASP group will improve 20% more in paretic upper limb ability as measured by the CAHAI rating scale) in the Chedoke Arm and Hand Activity Inventory greater than standard of care for the upper limb at the end of the four week intervention.

**Contribution**

This study will demonstrate the effect of an innovative program (GRASP) on upper limb function and use in individuals in the sub-acute stage of stroke recovery. This information will add to the body of evidence regarding effective treatment delivery systems in stroke and possibility in other conditions and settings.
1.16.3 Chapter Four

Rationale

Depression early after stroke is common, with studies reporting a prevalence rate ranging between 23% and 72% in hospital settings (Hackett et al., 2005). Studies have found that stroke related depression has a negative impact on activities of daily living (Goodwin and Devanand, 2008) and health related quality of life (Pan et al., 2008). Consequently, depression may impede full participation in stroke rehabilitation. Although poor upper limb function and depression have been linked in a number of health conditions such as upper limb trauma and arthritis (Keogh et al., 2000), no studies have quantified whether an upper limb program would improve depressive symptoms in stroke.

Objective

To determine the effect of a four week self-administered graded repetitive arm supplementary program (GRASP) on ratings of depressive symptoms compared to those in the control group.

Hypothesis

A four week self-administered graded repetitive arm supplementary program (GRASP) will significantly improve (p<0.05) ratings of depressive symptoms compared to those in the control group.

Contribution

This study will demonstrate the effect of an inpatient upper limb treatment program (GRASP) on depressive symptoms. This information will contribute to the literature on post stroke recovery and its impact on depressive symptoms. It will
clarify whether treatment focused on specific dysfunction can have an impact on depressive symptoms during inpatient rehabilitation.

1.16.4 Chapter Five

Rationale

Many of the most significant predictors of upper limb recovery post stroke cannot be altered (e.g. initial scores and impairment level) (Desrosiers et al., 2003; Feys et al., 2000); this is problematic for clinicians whose goal is to provide interventions designed to remediate stroke related disability. Thus, it would be useful to determine whether modifiable variables such as family support and improvement in upper limb impairment and ability can influence recovery of upper limb. In addition, finding those individuals who responded best to GRASP will help clinicians and researchers to determine suitable persons in which to implement this protocol.

Objective

To determine therapeutically modifiable predictors of upper limb recovery (Chedoke Arm and Hand Activity Inventory and Motor Activity Log) at the end of the four week GRASP intervention.

Hypothesis

Therapeutically modifiable factors, including improved grip strength, increased treatment intensity, and family involvement in treatment, will be indentified and found to be significant predictors (< 20% of model variance, p<0.05) of post intervention Chedoke Arm and Hand Activity Inventory and Motor Activity Log scores.
Contribution

This study will determine modifiable predictors of upper limb improvement in individuals who received the GRASP protocol. This finding will help clinicians and researchers in determining which components of upper limb treatment may further improve outcome during inpatient rehabilitation and possibly other treatment settings (e.g. outpatient and community).
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Chapter Two: Strength Training Improves Upper Limb Function in Individuals with Stroke: A Meta-analysis.¹

2.1 Introduction

Stroke is a leading cause of long term disability and health care cost (American Heart Association, 2008). Upper limb weakness following stroke is prevalent in acute (Andrews and Bohannon, 2000) and chronic stages of recovery (Canning et al., 2004) with up to 40% never regaining functional use of the upper limb in daily activities (Parker et al., 1986). Numerous activities of daily living (ADL) are dependent on sufficient upper limb function and such a loss of ability can negatively impact engagement in community life (Domerick et al., 2006; Nichols-Larsen et al., 2005). Treatment that can minimize upper limb deficits and ease the burden on the individual, the family, and society is a primary goal of stroke rehabilitation.

After stroke, maximal voluntary force is reduced, reorganization of the central nervous system takes place, and peripheral muscle changes occur (e.g. muscle weakness) (Andrews, 2000). 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). Studies have shown that sufficient strength in the upper limb is related to the ability to adequately perform many ADL (Chae et al., 2002; Harris et al., 2007; Kamper et al., 2006; Mercier and Bourbonnais, 2004). In addition, Pang and Eng (2005) found that strength of the paretic upper limb was a determinant of upper limb

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bone mineral content. A recent review of upper limb strength training in stroke (Ada et al., 2006) found no adverse effects of strength training. Despite this knowledge, there is still controversy surrounding strength training in stroke as prominent neurological rehabilitation frameworks hold the view that strengthening the paretic upper limb will increase tone and pain (Bobath, 1990).

There have been several reviews that report the effect of upper limb strength training on upper limb strength, function, and ADL (Ada et al., 2006; Eng, 2007; Kluding and Billinger, 2005; Ng and Shepherd, 2000; Morris et al., 2004; Van Peppen et al., 2004). Four of the studies are systematic reviews where a search strategy and method of study evaluation was transparent (Eng, 2007; Morris et al., 2004; van Peppen et al., 2004; Ada et al., 2006) while the remaining two provide a syntheses of the literature on strength training in stroke (Kluding and Billinger, 2005; Ng and Shepherd, 2000). Of the six reviews, four found significant evidence that upper limb strength training improves strength and upper limb function (Ada et al., 2006; Eng, 2007; Kluding and Billiger, 2005; Ng and Shepherd, 2000). However, Morris et al. (2004) and Van Peppen et al. (2004) found no significant difference of upper limb strength training on upper limb function but only included two studies in their review. No review found a significant treatment effect for ADL.

There are several issues with the previous reviews. Morris et al. (2004) calculated the effect size of two upper limb trials (Butefisch, 1995; Bourbonnais, 2002) and reported a positive effect of strength training on upper limb muscle strength and function; however this is in contrast to Van Peppen (2004) who reported on the same two trials and concluded there was no evidence for improved
strength and dexterity. Eng (2007) also qualitatively described these trials and reported positive results. The qualitative literature syntheses on strength training in stroke report a positive effect of upper limb strength training on strength and function (Kluding and Billinger, 2005; Ng and Shepherd, 2000). A problem with the above reviews is a lack of pooled estimates of effect size for strength training in stroke. In addition the results do not consider the effect of sample characteristics, treatment parameters, and lower levels of evidence. These factors can threaten the validity of study findings (Egger, 2005).

Ada et al. (2006) is the only review that calculated a pooled effect size for randomized controlled trials of strength training in stroke. Of 21 studies included in this meta-analysis, 13 focused on upper limb strength training. Overall, a small but positive effect on strength and functional measures was found. However, the pooled estimate for these outcomes included both upper and lower limb strength training trials and measures of both upper and lower limb function (e.g. gait speed and hand use). In addition, different modalities of strength training were combined (e.g. resistance training, robotics, and electrical stimulation). The effect of strength training for the upper and lower limb on respective functional measures is not comparable, for example, lower limb strengthening can take into account the weight-bearing of the paretic limb during ambulation and thus the impact may be greater. In addition, the inclusion of interventions that use different modalities or technology to guide treatment (e.g. electrical stimulation and robotics) cannot be assumed to have similar effects as interventions only using resistive exercises.
To provide clinicians with evidence of the effects of upper limb strength training in an adult population of stroke survivors, our primary study objective was to examine the evidence for strength training of the paretic upper limb in improving a) grip strength b) upper limb function, and c) ability to perform ADL. A secondary objective was to examine the effect of duration of injury (acute versus chronic) and motor severity (severe versus moderate/mild) on upper limb function and ADL. In addition we explored the evidence concerning adverse effects of strength training (soft tissue injury, pain, increased tone).

2.2 Methodology

An electronic database search was conducted using the Cochrane Database of Systematic Reviews; MEDLINE (1950 to present day); Cumulated Index to Nursing and Allied Health Literature (1982 to September 2008); EMBASE (1980 to September 2008); and Physical Therapy Evidence Database (PEDro). The following general search strategy was used for MEDLINE and adapted as needed for the other databases: Cerebrovascular accident/stroke, hemiparesis, rehabilitation, exercise, strength, activities of daily living, upper limb, and randomized controlled trials. We limited the search to human subjects, English language, and studies published in peer reviewed journals. We also hand searched relevant journals, reference lists from systematic reviews, and the reference list from studies cited in the systematic reviews.

We included only randomized controlled trials in the review. Studies which examined the effect or additional effect of a graded strengthening program compared to uni- or multi-dimensional programs were included. One arm of the trial
had to include a component of strength/resistance training as an element of the intervention and be compared to a control group. It was important that study authors used the term ‘strength’, ‘resistance’ or ‘exercise’ as part of the intervention description. We defined strength training as an intervention that incorporated exercises that required resistance. This may have been accomplished using resistance bands, weights, or gravity resisted exercises. Exercises could be either isometric, isotonic or isokinetic. Additional inclusion criteria were 1) confirmed diagnosis of stroke by CT, MRI, or clinical examination, 2) adult (age 18 and above), 3) focus of treatment must be upper limb rehabilitation, 4) must have a measure that evaluates upper limb function (e.g. Fugl-Meyer, Action Research Arm Test, 5) experimental and comparison group treatment had to be clearly defined (i.e. so a distinction can be made between treatment type).

We used different outcomes (e.g. Motor Assessment Scale and the Wolf Motor Function Test) to evaluate upper limb function post stroke. Studies comparing these outcomes have shown high correlations ($r^2=0.87-0.92$), (Ang and Man, 2006; Rabadi and Rabadi, 2006; Platz et al., 2005) indicating they measure the same underlying construct. From these findings we justified the pooling of outcome measures to estimate the effect of strength training on upper limb function.

We did not include studies that combined treatment methods (e.g. biofeedback and exercise). Studies of repetitive practice, constraint-induced movement therapy, or studies that used a mechanical means of facilitating upper limb movement (such as robot-assisted, electrical stimulation) were also excluded. These treatment methods have been examined by recent systematic reviews and
the effectiveness of these modalities on upper limb function has been reported
(Brewer et al., 2007; Bonaiuti et al., 2007; Sheffler and Chae, 2007). Conference
abstracts and thesis were not included.

Planned sub-group analysis was performed for duration of injury post stroke
(acute <6 months and chronic >6 months) and level of upper limb motor impairment
(severe and moderate/mild). Level of upper limb motor impairment was determined
using impairment outcomes measured at baseline (e.g. Fugl-Meyer or grip strength).
Participants who had a baseline score of less than half of the impairment outcome
were classified in the severe group. Those individuals with severe impairment
generally had no hand movement and gravity assisted range of motion; whereas
those in the moderate/mild had hand movement and were able to move against
gravity. These sub-group analyses were undertaken to minimize threats to external
validity. Comparison groups were constructed for: 1) grip strength, 2) upper limb
function, 3) ADL, and 4) acute and chronic participants, 5) severe and moderate/mild
motor impairment.

One reviewer (JEH) searched the databases independently and excluded
obviously irrelevant articles using title and abstract. This was checked by the
second reviewer (JJE). Both reviewers evaluated each abstract based on the
inclusion and exclusion criteria. If there was disagreement regarding eligibility a
third reviewer was used. Data extraction and methodological quality of the studies
was done by the primary author and reviewed by the second author. Overall quality
of the included studies was used to minimize the effect of internal validity and was
evaluated using the PEDro scale (Sherrington et al., 2000). In addition we evaluated
the studies on allocation concealment, equality of baseline characteristics, blinding, intention to treat analysis, and description of attrition.

2.2.1 Statistical Analysis

All of the outcome measures used continuous scales. When possible we extracted the mean difference and standard deviation of the change score from baseline to post intervention. When the median and inter-quartile range was provided we converted it to the mean and standard deviation using the method explained by Hozo and colleagues (2005). Tables of comparison were derived for all outcomes of interest as well as forest and funnel plots (RevMan 5.0 software). If there was an insufficient amount of trials to complete a meta-analysis (<3), then we provided a narrative description of the findings.

The standard mean difference (SMD) with 95% confidence intervals was used to determine treatment effect. Weighted effect sizes based on the precision of each study’s results (95% confidence interval of the standardized mean difference) were calculated. The degree of heterogeneity was evaluated using the $I^2$ test for each outcome. $I^2$ measures the amount of heterogeneity across studies relative to the variability of the effect estimate (Sutton and Higgins, 2007). Non-significance indicates that the results of the different studies are similar ($p>0.05$). Heterogeneity between studies was expected as various treatment outcomes and parameters were used; to minimize this issue we evaluated the pooled treatment effect using a random effects model (Egger et al., 2005).

Sensitivity analysis was used to determine the robustness of our results. To assess sensitivity we compared random effects models to fixed effects models. In
addition we examined the effect of deleting low quality studies (< 5 on PEDro scale) from the analysis. Funnel plots were used to detect possible publication bias. To illustrate the cumulative effect of strength training on outcome measures, forest plots were constructed.

2.3 Results

Overall we identified 649 studies from the databases searched using our key search terms. After removal of duplicates and articles that were not relevant to upper limb treatment, 389 articles progressed to abstract inspection. We identified a further 308 articles that did not meet our inclusion criteria, mostly due to a treatment method not involving strength training or studies not involving randomization. We retrieved the full text of the remaining 81 articles. Fourteen trials were identified as meeting our inclusion criteria (Blennerhassett et al., 2004; Bourbonnais et al., 2002; Butefisch et al., 1995; Dickstein et al., 1986; Dean et al., 2000; Duncan et al., 1998; Duncan et al., 2003; Gelber et al., 1995; Langhammer et al., 2007; Logigian et al., 1983; Platz et al., 2005a; Pang et al., 2006; Turton and Fraser, 1990; Winstead et al., 2004). The 67 excluded trials did not meet our intervention criteria of a strength training component.

Description of the included studies is found in Table 2.1. Quality of the included trials is indicated in Table 2.2. Funnel plots were constructed for upper limb function comparisons as these were the only data sets large enough to produce valid plots (Egger et al., 2005). The funnel plots indicated that studies with negative findings were under-represented in our meta-analysis.
2.3.1 Grip Strength

Five trials (Dean et al., 2000; Duncan et al., 2003; Langhammer et al., 2007; Pang et al., 2006, Weinstein et al., 2004) recruiting 289 participants were used to produce the random effects model of grip strength. A significant effect was seen: SMD 0.60, 95% CI 0.04 to 1.16, p=0.04; I²=79% (Figure 2.1).

2.3.2 Upper Limb Function Comparisons

Twelve studies recruiting 475 participants were used to produce the random effects model for upper limb function (Blennerhassett and Dite, 2004; Bourbonnais et al., 2002; Butefisch et al., 1995; Dean et al., 2000; Duncan et al., 1998; Duncan et al., 2003; Gelber et al., 1995; Langhammer et al., 2007; Pang et al., 2006; Platz et al., 2005b); Turton and Fraser, 1990; Weinstein et al., 2004). Outcomes included the Action Research Arm, Wolf Motor Function Test and Motor Assessment Scale upper limb portion. Strength training indicated a significant effect: SMD 0.48, 95% CI 0.30 to 0.67, p<0.001; I²=55% (Figure 2.2). Two trials (Dickstein et al., 1986; Logigian et al., 1983) did not evaluate upper limb function and therefore are not included in any of the comparisons involving upper limb function models.

2.3.3. Duration of Injury: Acute Versus Chronic

Nine studies included participants in the acute stage of recovery (Butefisch et al., 1995; Blennerhassett et al., 2004; Duncan el al., 1998, 2003; Gelber et al., 1995; Langhammer et al., 2007; Platz et al., 2005a; Turton and Frasler, 1990; Weinstein et al., 2004); participants were living in the community in three of the studies (Duncan et al., 1998, 2003; Turton and Fraser, 1990). One trial (Langhammer et al., 2007) is
a longitudinal study and therefore provided two sets of data (one for the acute and one for the chronic stage of injury). Four trials included participants in the chronic stage of stroke recovery where treatment was delivered in a community setting (Bourbonnais et al., 2002; Dean et al., 2000; Langhammer et al., 2007; Pang et al., 2006).

The treatment effect for the nine trials involving 391 participants in the acute phase of injury duration was significant for upper limb function, SMD of 0.61, 95% CI 0.25 to 0.97, p<0.001; \( I^2 = 62\% \) (Figure 2.3). The treatment effect for the four trials involving 156 participants in the chronic phase of injury duration was not significant, SMD 0.30, CI: -0.02 to 0.61 p=0.07, \( I^2 = 0\% \) (Figure 2.4).

2.3.4 Motor Impairment Level: Severe Versus Moderate/Mild

Four studies recruited 144 participants with severe motor impairment (Butefisch et al., 1995; Duncan et al., 1998; Platz et al., 2005a; Winstein et al., 2004) and eight studies (Blennerhassett et al., 2004; Bourbonnais et al., 2002; Dean et al., 2000; Duncan et al., 1998, 2003; Gelber et al., 1995; Langhammer et al., 2007; Pang et al., 2006; Turton and Fraser, 1990) recruited 335 participants with moderate/mild motor impairment.

A significant treatment effect was found for those with severe motor impairment: SMD 0.39, 95% CI: 0.13 to 0.69, p=0.01, \( I^2 = 57\% \) (Figure 2.5). A significant treatment effect was found for those with moderate/mild motor impairment, SMD 0.67, 95% CI: 0.18 to 1.20, p<0.001; \( I^2 = 0\% \) (Figure 2.6).
2.3.5 Activities of Daily Living

Five studies (Duncan et al., 1998; Gelber et al., 1995; Langhammer et al., 2007; Logigian et al., 1983; Winstein et al., 2004) recruiting 210 participants were used to produce the random effects model for ADL. The two measures used to evaluate ADL were the Functional Independence Measure and the Barthel Index. All trials involved individuals in the acute stage of recovery. Though Dickstein et al. (1986) measured ADL using the Barthel Index, they did not report any data and consequently no effect size for this trial can be determined. The impact of strength training indicated no treatment effect: SMD 0.20, 95% CI -0.07 to 0.47, p=0.15; $I^2=0\%$ (Figure 2.7).

2.3.6 Adverse Effects

No studies report long term adverse effects. Of the studies that measured tone at baseline (Bourbonnais et al., 2002; Butefisch et al., 1995; Platz et al., 2005a, none report an increase in tone at completion of the study. Several studies reported on pain (Langhammer et al., 2007; Platz et al., 2005 (a or b); Winstein et al., 2004) and found no significant increase in pain for the strength training group, in contrast Platz et al. (2005a) found that pain increased significantly in the Bobath group compared to impairment oriented training (BASIS) and usual therapy. Two studies reported on satisfaction with treatment (Dean et al., 2000; Pang et al., 2006) and found high ratings for the upper limb strength program.
2.3.7 Sensitivity Analysis

We conducted sensitivity analysis using fixed effects models and deleting low quality studies as indicated by a score less than five on the PEDro scale. Fixed effect models showed no difference in the significance of the treatment effects for any of our planned comparisons. When we removed the studies with a PEDro score of less than five, no difference in the significance of the treatment effects was found for any of our comparisons. These results support the robustness of our findings.

2.4 Discussion

This is the first study to determine the pooled effect size of upper limb strength training on upper limb strength, function and activities of daily living in individuals with stroke. Our review was able to pool a large number of participants in each outcome of interest (e.g. 475 for upper limb function) with the majority of included studies representing moderate to high quality randomized controlled trials.

2.4.1 The Effect of Strength Training on Upper Limb Function

The ability to improve upper limb function post stroke is a primary goal of rehabilitation clinicians. Many studies have shown a strong relationship between grip strength and upper limb function post stroke (Boissy et al., 1999; Harris et al., 2007; Mercier and Bourbonnais, 2004). In addition grip strength has shown to be a predictor of disability (Bourdeau et al., 2008; Syddall et al., 2003) and mortality (Rantanen et al., 2000) in older adults. Thus remediation of low grip strength should be an important aspect of treatment for individuals with stroke. We demonstrated a large effect size (SMD 0.69) for strength training on grip strength.
The pooled estimates for those with severe and those with moderate/mild motor impairment showed a significant treatment effect on upper limb function. The magnitude of the cumulative estimate was higher for those with moderate/mild impairment (SMD 0.61 compared to 0.30), which may indicate that strength training for those with moderate/mild impairment may be more effective. Alternatively, it may suggest that those with severe impairment may require a more intensive strength training delivery model such as robotics. Previous studies in acute and chronic stroke found that those with less severe impairment in the upper extremity benefit more from treatment (Pang et al., 2006; Parry et al., 1999; Stein et al., 2004). However, our findings support the effectiveness of strength training for all levels of upper limb motor impairment, including those individuals with severe motor impairment.

Stage of recovery showed a significant treatment effect on upper limb function for individuals in the acute stage and a trend (p=0.07) for those in the chronic stage. The small number of trials in the chronic sub-group analysis (n=4) may explain the lack of significant findings and alternatively be due to type II error rate. Additionally, it may be that those in the chronic stage of recovery need treatment interventions that are focused on meaningful and context based activities that can be further developed in the home environment rather than impairment focused strategies (Lin et al., 1997; Ma et al., 1999) to improve upper limb function. Greater intensity of strength interventions applied to the paretic upper limb may be required to produce the requisite improvement in upper limb function and counter the learned non-use of the affected upper limb (Taub et al., 1993).
2.4.2 The Effect of Strength Training on Activities of Daily Living

One of the main tenants of treatment outcome in rehabilitation is to promote independence in activities of daily living. Despite this, only five (Duncan et al., 1998; Gelber et al., 1995; Langhammer et al., 2007; Logigian et al., 1983; Winstein et al., 2004) of the fourteen studies included an ADL outcome. Results of the pooled estimates were consistent; strength training was not effective in significantly increasing scores on measures of ADL. An explanation for our finding is that the outcome measures used (FIM and BI) are highly dependent on lower limb function (transfers and ambulation sub-scales) and thus changes in upper limb function may not translate to an increase in overall score. It would be useful if ADL sub-scales dependent on upper limb ability (e.g. eating and dressing) were used as the primary outcome. Additionally, ADL are comprised of complex movements that include strength, range of motion, coordination, and motor control that all need to be performed in a synchronized manner. If one of the components required is insufficient, then the whole task may prove to be difficult to complete.

In the studies reviewed for our analyses, there was a lack of description of the intensity and progression of the strengthening program. Guidelines for strength training have been developed from the American College of Sports Medicine (ACSM) which outline the intensity and duration of muscle training required to improve strength (ACSM, 2000). Bourbonnais et al. (2002) was the only study that provided a description of the progression of the maximal voluntary effort (MVE) required during the training program. Other studies provided a brief description of the type of resistance provided (e.g. against gravity or free weights), and the number
of repetitions and sets completed (Butefisch et al.,1995; Pang et al., 2006; Weinstein et al., 2004) but it is unclear whether they followed appropriate muscle training and progression guidelines. Future studies investigating strength training post stroke should utilize appropriate muscle strength prescription and progression, thus it will be clear that the strengthening component of the program was optimal.

In the past, muscle strength training in persons with spasticity has been controversial. Bobath (1990) advocated that decreased muscle function was not due to weakness but to the opposition of spastic antagonists and that strenuous activity would increase spasticity and reinforce abnormal movement, and negatively affect daily activities. Thus, intensive upper limb muscle strengthening programs are rarely implemented in stroke rehabilitation, and consequently much of the treatment has been aimed at tone inhibition and facilitation of normal movement patterns (Bobath). The findings from this meta-analysis do not support the idea that strength training increase tone and pain.

2.4.3 Limitations

This review used a systematic and comprehensive search strategy, however we did limit our search to English language and those studies published in a peer reviewed journal. Significant statistical heterogeneity was found for two comparisons; therefore, some caution is recommended before applying our findings. Two possible explanations for the heterogeneity are differences in sample and treatment characteristics. In studies evaluating rehabilitation interventions, it has been noted that due to the complexity of participant and treatment parameters (e.g. dosage, ethics of placebo/sham treatment, and withdrawal of treatment)
heterogeneity is difficult to minimize (van den Ende et al., 2006). However, we addressed these issues by undertaking sensitivity analyses (including planned subgroup analyses), which indicated our findings were robust.

We included studies in our review that described resistance training as a component of upper limb treatment post stroke. Seven studies (Logigian et al., 1983; Pang and Eng, 2005; Winstein et al., 2004; Langhammer et al., 2007; Bourbonnais et al., 2002; Butefisch et al., 1995; Platz et al., 2005a) indicated that strength training was a significant focus of the intervention with minimal additional modalities (e.g. functional activities). The remaining studies described strength training as a component but also included task focused and ADL practice as part of the intervention. In these latter studies it is difficult to determine which component produced the significant treatment effect or whether it was the combination of treatment modalities that generated improvement in upper limb function.

2.5 Conclusion

Strength training of the upper limb is an effective treatment method for improving upper limb function for individuals with stroke. In our review of strength training trials no adverse effects were reported. We recommend that future trials investigate the effect of intensive upper limb strengthening on ADL. In addition, particular focus on those with severe upper limb motor impairment and those in the chronic stages of stroke recovery is needed. It would be useful for future controlled studies to determine what muscle strength training intensity and frequency is required to improve upper limb function and performance in ADL in individuals with stroke.
Table 2.1: Characteristics of included studies, N=14

<table>
<thead>
<tr>
<th>Study</th>
<th>Participant</th>
<th>Treatment Type</th>
<th>Intensity</th>
<th>Outcome</th>
<th>Results</th>
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<tr>
<td>Logigian et al., 1983</td>
<td>N= 42, mean age 61.6, 7 weeks post</td>
<td>Both groups received inpatient rehabilitation in addition to: Exp (n=21): Traditional techniques described as muscle re-education, volitional control of movement by patient included resistive exercises and weights or Facilitation (n=21): Rood, Brunnstrom, Bobath</td>
<td>1h/day of additional allocated group treatment No duration of programs given</td>
<td>Manual Muscle Testing Barthel Index (BI)</td>
<td>Significant difference over time for both measures but no group differences</td>
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<tr>
<td>Dickstein et al., 1986</td>
<td>N=196, mean age=70.5, 2-3 weeks post</td>
<td>Exp (n=57): conventional described as exercise, resistance, weights or Proprioceptive Neurofacilitation (n=36) or Neurodevelopmental Treatment (n=38)</td>
<td>Treated 5d/week, each session 30-45 minutes 6 week program</td>
<td>BI, Tone, Active range of motion, Manual muscle testing</td>
<td>N=131, no group differences on any of the measures of note: higher percentage in conventional group attained normal tone, higher tone found in PNF group</td>
</tr>
<tr>
<td>Turton and Fraser, 1990</td>
<td>N=22, mean age=58.5, 20 weeks post</td>
<td>Exp (n=12): based on motor re-learning, described as exercises or Outpatient therapy if required (n=10)</td>
<td>2-3x/day for exercises, 8-11 week program</td>
<td>Southern Motor Assessment 10 Hole Peg Test</td>
<td>Significant between group for peg test in favor of home exercise group no difference for the Southern Motor Assessment</td>
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<tr>
<td>Study</td>
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<td>Gelber et al., 1995 (acute, inpatient)</td>
<td>N=27, mean age=71.8, 2-4 weeks post</td>
<td>Traditional (n=12) – functional tasks, range of motion, resistance exercises or NDT(n=15): Bobath</td>
<td>No length of treatment sessions was given, 4 week program</td>
<td>Functional Independenc e Measure (FIM), Box and Block Test, 9HPT Done at discharge, 6 and 12 months</td>
<td>No group differences found at any test period Significant difference in favor of Traditional for reaching several FIM milestones more quickly than NDT group at discharge</td>
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<tr>
<td>Butefisch et al., 1995 (acute, inpatient) Randomized cross-over design</td>
<td>N=27, mean age=61.5, 3-19 weeks post</td>
<td>Both group received experimental protocol and usual treatment Exp (n=27): grip strength, isometric and isotonic hand extension Control: (n=15), unspecified standardized treatment using TENS</td>
<td>Exp: 2x/d for 15 minute periods TENS: 2x/d for 15 minutes for 2 weeks then received Exp treatment</td>
<td>Rivermead Motor Assessment Scale, strength Measured at baseline, start and end of training phases</td>
<td>Decrease muscle tone found for Exp, significance found for Exp for RMA, grip strength, peak force and acceleration</td>
</tr>
<tr>
<td>Duncan et al., 1998 (acute, community)</td>
<td>N= 20, mean age=67.5, 9 weeks post</td>
<td>Exp (n=10): Home based treatment to improve strength, endurance and ADL performance of upper limb (lower limb exercises as well) Control (n=10): outpatient treatment as required</td>
<td>Exp: 1.5h x 3/weeks x 8 weeks, supervised by therapist then asked to do on own for 4 weeks Control: visited every 2 weeks by research assistant</td>
<td>Fugl-Meyer Motor Impairment Scale for Upper Limb (FM), BI, SF-36</td>
<td>Exp improved more on FM and SF-36 Physical scale No group differences on Jebsen or BI</td>
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<tr>
<td>Study</td>
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<td>Dean et al., 2000 (chronic, community)</td>
<td>N=12, mean age=64.3, 1.8yrs post</td>
<td>Both groups were task-related circuit training. Exp (n=6): strengthening and mobility activities for lower limb Control (n=6): upper limb strengthening, dexterity, range of motion</td>
<td>Treatment for both groups was 1h/d, 3d/w x 4 weeks Exercises were progressed by increasing repetitions and complexity of tasks</td>
<td>Grip, Purdue Peg Board Post and 2 month follow-up assessment</td>
<td>Upper limb group did improve more on arm measures, group differences for these measures not reported as focus was lower limb outcomes</td>
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<tr>
<td>Duncan et al., 2003 (acute, community)</td>
<td>N=100, mean age=69, 11 weeks post</td>
<td>Exp (n=50): strength, ROM, balance and ADL (combined lower and upper limb activities) Control (n=50): outpatient services if required</td>
<td>Exp: 36, 90 minute sessions over 12-14 weeks Control: 54% received home therapy</td>
<td>FM, Wolf Motor Function Test (WMFT), Jamar</td>
<td>Significant group differences found for overall effectiveness of program If a higher baseline on WMFT = significant difference at post treatment for exp group</td>
</tr>
<tr>
<td>Bourbonnais et al., 2002 (chronic, community)</td>
<td>N=25, mean age=46, 3yrs post</td>
<td>EXP (n=13): used a static dynamometer to elicit force production at shoulder and elbow, 16 combinations of movement Control (n=12): same program but for lower limb</td>
<td>Both groups had treatment 3x/w for 6 weeks 6-8 reps at 20-35% of maximum voluntary effort (MVE) progressed to 40-60% of MVE</td>
<td>FM, Motor Assessment Scale, TEMPA, Box and Block Test Testing done at 2 and 6 weeks and 2 month follow-up</td>
<td>Significant improvement at each time period for exp group on FM, box and block, and finger to nose Strength of upper limb increased significantly at 2 and 6 weeks, grip strength (p=0.087) No increase in tone noted</td>
</tr>
<tr>
<td>Study</td>
<td>Participant Total</td>
<td>Treatment Type</td>
<td>Intensity</td>
<td>Outcome</td>
<td>Results</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>-------------------</td>
<td>--------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Winstein et al., 2004 (acute, inpatient)</td>
<td>N=64, age between 35-75 16.1 days post</td>
<td>Exp (n=21): Strength training using resistance training, thera-band, free weights or Functional Task (n=22) using systematic and repetitive practice with a functional goal, motor learning focus or Standard Care (n=21): neurofacilitation, electric stimulation, stretching, ADL</td>
<td>Functional task group was 1h/d, 5d/w for 4 weeks Strength: 1h x 3d/w, other 2 days same exercises but with less resistance and focus was speed</td>
<td>FM, isometric torque, grip, pinch, Functional Test of the Hemiplegic Upper Extremity, FIM</td>
<td>At 4 weeks significant difference for isometric torque and FM No differences between groups at 9 months Those less severe impairment significant difference for FM, torque and FTHUE at 4 weeks</td>
</tr>
<tr>
<td>Blennerhassett and Dite, 2004 (acute, inpatient)</td>
<td>N=30, mean age 55.1 4-7 weeks</td>
<td>Both groups received usual care in addition to: Exp(n=15): Mobility training Control (n=15): Upper limb training Both groups used a circuit training model</td>
<td>1h/d, 5d/w, for 4 weeks</td>
<td>MAS, Jebsen checkers, small and large objects Tested at 4 weeks and 6 months</td>
<td>Over time significant difference on Jebsen, MAS arm between initial and post and initial and 6 months, Treatment effect (d=0.36) found for upper limb group for Jebsen at 4 weeks</td>
</tr>
<tr>
<td>Platz et al., 2005a (acute, inpatient)</td>
<td>N=62, mean age= 61 4-6 weeks post</td>
<td>Usual care in addition to: Exp (n=21): BASIS = training using range of motion, resistance, weights, coordinated movement Or Bobath (n=21)</td>
<td>20 additional training sessions 45 minutes each x 4 weeks</td>
<td>FM, Action Research Arm Test, Ashworth Scale</td>
<td>Significant group difference found for BASIS on FM, no increase in tone</td>
</tr>
<tr>
<td>Study</td>
<td>Participants</td>
<td>Treatment Type</td>
<td>Intensity</td>
<td>Outcome</td>
<td>Results</td>
</tr>
<tr>
<td>-------------------------------------</td>
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<td>--------------------------------------------------------------------------------</td>
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<td>----------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Pang et al., 2006 (chronic, community)</td>
<td>N=63, mean age=65.5 ± 5.1 years,</td>
<td>Exp (n=30): circuit based, resistance training with theraband, weights, range of motion, functional tasks</td>
<td>1h/d, 3x/w for 19 weeks</td>
<td>WMFT, FM, Motor Activity Log, Jamar</td>
<td>Significant group difference in favor of Exp for WMFT and FM</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Control (n=30): mobility, balance, cardio respiratory fitness, lower limb strength</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Langhammer et al., 2007 (acute to chronic, from inpatient to community)</td>
<td>N=75, mean age=74 No time since stroke given</td>
<td>At discharge randomized into: Intense exercise (n=35): high intensity of endurance, strength (weights, pulleys, chair push-ups) and balance training Control (n=40): outpatient treatment as needed</td>
<td>Minimum of 80 hours of intense rehab every over 1 year – usually 2x/w with a Physiotherapist</td>
<td>MAS, BI, Jamar Tested at admission, discharge, 3, 6, and 12 months</td>
<td>Significant group difference from admission to discharge for MAS and some BI in favor of Exp group Significant group difference in favor of Exp from 3-6m for grip, from 6-12m for MAS</td>
</tr>
<tr>
<td>Study</td>
<td>PEDro/10</td>
<td>Concealment</td>
<td>Equality of baseline</td>
<td>Blinding</td>
<td>Intention to treat</td>
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<tr>
<td>-----------------------------</td>
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<tr>
<td>Logigian et al., 1983</td>
<td>3</td>
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<td>Dickstein et al., 1986</td>
<td>4</td>
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<tr>
<td>Turton and Fraser, 1990</td>
<td>2</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Gelber et al., 1995</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Butefisch et al., 1995</td>
<td>4</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duncan et al., 1998</td>
<td>7</td>
<td>+</td>
<td>+</td>
<td>assessor</td>
<td>+</td>
</tr>
<tr>
<td>Dean et al., 2000</td>
<td>5</td>
<td>+</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Duncan et al., 2003</td>
<td>8</td>
<td>+</td>
<td>+</td>
<td>assessor</td>
<td>+</td>
</tr>
<tr>
<td>Bourbonnais et al., 2002</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Winstein et al., 2004</td>
<td>6</td>
<td>+</td>
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<td></td>
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</tr>
<tr>
<td>Blennerhassett and Dite, 2004</td>
<td>8</td>
<td>+</td>
<td>+</td>
<td>assessor</td>
<td>+</td>
</tr>
<tr>
<td>Platz et al., 2005</td>
<td>8</td>
<td>+</td>
<td>+</td>
<td>assessor</td>
<td>+</td>
</tr>
<tr>
<td>Pang et al., 2006</td>
<td>7</td>
<td>+</td>
<td></td>
<td>assessor</td>
<td>+</td>
</tr>
<tr>
<td>Langhammer et al., 2007</td>
<td>8</td>
<td>+</td>
<td>assessor subjects</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Study or Subgroup</td>
<td>Strength Mean (SD)</td>
<td>Control Mean (SD)</td>
<td>Weight</td>
<td>Std. Mean Difference IV, Random, 95% CI</td>
<td></td>
</tr>
<tr>
<td>-------------------</td>
<td>-------------------</td>
<td>-------------------</td>
<td>--------</td>
<td>---------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Dean 2000</td>
<td>2.4 (11)</td>
<td>-1.1 (13.1)</td>
<td>10.8%</td>
<td>0.25 [-1.07, 1.58]</td>
<td></td>
</tr>
<tr>
<td>Duncan 1998</td>
<td>2.06 (0.7)</td>
<td>1.76 (0.86)</td>
<td>24.1%</td>
<td>0.40 [0.01, 0.80]</td>
<td></td>
</tr>
<tr>
<td>Langhammer 2007</td>
<td>0.54 (0.39)</td>
<td>0.46 (0.34)</td>
<td>23.2%</td>
<td>0.22 [-0.24, 0.67]</td>
<td></td>
</tr>
<tr>
<td>Pang 2006</td>
<td>16.5 (10)</td>
<td>4.1 (2)</td>
<td>21.1%</td>
<td>1.71 [1.13, 2.29]</td>
<td></td>
</tr>
<tr>
<td>Winston 2004</td>
<td>1.7 (3.45)</td>
<td>0.5 (4.38)</td>
<td>20.7%</td>
<td>0.30 [-0.31, 0.91]</td>
<td></td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td><strong>146</strong></td>
<td><strong>143</strong></td>
<td><strong>100.0%</strong></td>
<td><strong>0.60 [0.04, 1.16]</strong></td>
<td></td>
</tr>
</tbody>
</table>

Heterogeneity: Tau² = 0.30; Chi² = 18.71, df = 4 (P = 0.0009); I² = 79%
Test for overall effect: Z = 2.09 (P = 0.04)

Figure 2.1: Random effect model: Upper limb strength training on grip strength
### Table 2.1: Upper Limb Strength Training on Upper Limb Function

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Strength Mean (SD)</th>
<th>Control Mean (SD)</th>
<th>Std. Mean Difference IV, Random, 95% CI</th>
<th>Weight IV, Random, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blennerhassett 2004</td>
<td>17.5 (19.4)</td>
<td>8.8 (32.7)</td>
<td>0.31 [-0.41, 1.04]</td>
<td>8.3%</td>
</tr>
<tr>
<td>Bourbonnais 2002</td>
<td>2 (21.7)</td>
<td>1.1 (18.5)</td>
<td>0.04 [-0.74, 0.83]</td>
<td>7.6%</td>
</tr>
<tr>
<td>Butefisch 1995</td>
<td>1.6 (0.7)</td>
<td>0.78 (0.2)</td>
<td>1.36 [0.63, 2.10]</td>
<td>8.2%</td>
</tr>
<tr>
<td>Dean 2000</td>
<td>1.5 (3.8)</td>
<td>0.6 (3.5)</td>
<td>0.22 [-1.10, 1.54]</td>
<td>3.8%</td>
</tr>
<tr>
<td>Duncan 1998</td>
<td>8.4 (3.3)</td>
<td>2.2 (0.8)</td>
<td>2.47 [1.25, 3.70]</td>
<td>4.3%</td>
</tr>
<tr>
<td>Duncan 2003</td>
<td>4.48 (0.81)</td>
<td>4.04 (0.9)</td>
<td>0.51 [0.11, 0.91]</td>
<td>12.7%</td>
</tr>
<tr>
<td>Gelber 1995</td>
<td>8 (4.2)</td>
<td>9.3 (3.3)</td>
<td>-0.33 [-1.17, 0.51]</td>
<td>7.1%</td>
</tr>
<tr>
<td>Langhammer 2007</td>
<td>3.4 (2.6)</td>
<td>1.8 (2.4)</td>
<td>0.63 [0.17, 1.10]</td>
<td>11.7%</td>
</tr>
<tr>
<td>Pang 2006</td>
<td>0.3 (1.6)</td>
<td>0 (1.5)</td>
<td>0.19 [-0.36, 0.74]</td>
<td>10.5%</td>
</tr>
<tr>
<td>Platz 2005</td>
<td>10.7 (8.8)</td>
<td>7.8 (9.3)</td>
<td>0.31 [-0.31, 0.94]</td>
<td>9.5%</td>
</tr>
<tr>
<td>Turton 1990</td>
<td>4 (6.6)</td>
<td>-1 (2.4)</td>
<td>0.93 [0.04, 1.83]</td>
<td>6.6%</td>
</tr>
<tr>
<td>Weinstein 2004</td>
<td>4.26 (4.33)</td>
<td>3.35 (3.63)</td>
<td>0.22 [-0.40, 0.84]</td>
<td>9.8%</td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td>247</td>
<td>228</td>
<td>100.0%</td>
<td>0.50 [0.21, 0.80]</td>
</tr>
</tbody>
</table>

Heterogeneity: $\tau^2 = 0.14$; $\chi^2 = 24.29$, df = 11 (P = 0.01); $I^2 = 55$

Test for overall effect: $Z = 3.35$ (P = 0.0008)

---

**Figure 2.2:** Random effect model: Upper limb strength training on upper limb function.
<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Experimental Mean</th>
<th>SD</th>
<th>Total</th>
<th>Control Mean</th>
<th>SD</th>
<th>Total</th>
<th>Weight</th>
<th>IV, Random, 95% CI</th>
<th>Std. Mean Difference</th>
<th>IV, Random, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blennerhassett 2004</td>
<td>17.5</td>
<td>19.4</td>
<td>15</td>
<td>8.8</td>
<td>32.7</td>
<td>15</td>
<td>10.8%</td>
<td>0.31 [-0.41, 1.04]</td>
<td>0.31 [-0.41, 1.04]</td>
<td></td>
</tr>
<tr>
<td>Butefisch 1995</td>
<td>1.6</td>
<td>0.7</td>
<td>27</td>
<td>0.78</td>
<td>0.2</td>
<td>13</td>
<td>10.7%</td>
<td>1.36 [0.63, 2.10]</td>
<td>1.36 [0.63, 2.10]</td>
<td></td>
</tr>
<tr>
<td>Duncan 1998</td>
<td>8.4</td>
<td>3.3</td>
<td>10</td>
<td>2.2</td>
<td>0.8</td>
<td>10</td>
<td>6.0%</td>
<td>2.47 [1.25, 3.70]</td>
<td>2.47 [1.25, 3.70]</td>
<td></td>
</tr>
<tr>
<td>Duncan 2003</td>
<td>4.48</td>
<td>0.81</td>
<td>50</td>
<td>4.04</td>
<td>0.9</td>
<td>50</td>
<td>15.5%</td>
<td>0.51 [0.11, 0.91]</td>
<td>0.51 [0.11, 0.91]</td>
<td></td>
</tr>
<tr>
<td>Gelber 1995</td>
<td>8</td>
<td>4.2</td>
<td>11</td>
<td>9.3</td>
<td>3.3</td>
<td>11</td>
<td>9.3%</td>
<td>-0.33 [-1.17, 0.51]</td>
<td>-0.33 [-1.17, 0.51]</td>
<td></td>
</tr>
<tr>
<td>Langhammer 2007</td>
<td>3.4</td>
<td>2.6</td>
<td>35</td>
<td>1.8</td>
<td>2.4</td>
<td>40</td>
<td>14.5%</td>
<td>0.63 [0.17, 1.10]</td>
<td>0.63 [0.17, 1.10]</td>
<td></td>
</tr>
<tr>
<td>Platz 2005</td>
<td>10.7</td>
<td>8.8</td>
<td>21</td>
<td>7.8</td>
<td>9.3</td>
<td>21</td>
<td>12.3%</td>
<td>0.31 [-0.29, 0.92]</td>
<td>0.31 [-0.29, 0.92]</td>
<td></td>
</tr>
<tr>
<td>Turton 1990</td>
<td>4</td>
<td>6.6</td>
<td>12</td>
<td>-1</td>
<td>2.4</td>
<td>10</td>
<td>8.8%</td>
<td>0.93 [0.04, 1.83]</td>
<td>0.93 [0.04, 1.83]</td>
<td></td>
</tr>
<tr>
<td>Weinstein 2004</td>
<td>4.25</td>
<td>4.33</td>
<td>20</td>
<td>3.35</td>
<td>3.63</td>
<td>20</td>
<td>12.2%</td>
<td>0.22 [-0.40, 0.84]</td>
<td>0.22 [-0.40, 0.84]</td>
<td></td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>201</td>
<td>190</td>
<td>100.0%</td>
<td>100.0%</td>
<td>0.61 [0.25, 0.97]</td>
<td>0.61 [0.25, 0.97]</td>
<td></td>
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</tbody>
</table>

Heterogeneity: $\tau^2 = 0.18$; $\chi^2 = 21.33$, df = 8 ($P = 0.006$); $I^2 = 62$
Test for overall effect: $Z = 3.34$ ($P = 0.0008$)

Figure 2.3: Random effect model: Upper limb strength training on upper limb function for those trials done in the sub-acute stage of recovery
<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Experimental Mean</th>
<th>SD</th>
<th>Total</th>
<th>Control Mean</th>
<th>SD</th>
<th>Total</th>
<th>Weight</th>
<th>Std. Mean Difference</th>
<th>IV, Random, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bourbonnais 2002</td>
<td>2</td>
<td>21.7</td>
<td>13</td>
<td>1</td>
<td>18.5</td>
<td>12</td>
<td>16.4%</td>
<td>0.05</td>
<td>[-0.74, 0.83]</td>
</tr>
<tr>
<td>Dean 2000</td>
<td>1.5</td>
<td>3.8</td>
<td>4</td>
<td>0.6</td>
<td>3.5</td>
<td>5</td>
<td>5.8%</td>
<td>0.22</td>
<td>[-1.10, 1.54]</td>
</tr>
<tr>
<td>Langhammer 2007</td>
<td>4</td>
<td>2.6</td>
<td>35</td>
<td>2.8</td>
<td>2.4</td>
<td>35</td>
<td>44.6%</td>
<td>0.47</td>
<td>[-0.00, 0.95]</td>
</tr>
<tr>
<td>Pang 2006</td>
<td>0.3</td>
<td>1.6</td>
<td>30</td>
<td>0</td>
<td>1.5</td>
<td>22</td>
<td>33.2%</td>
<td>0.19</td>
<td>[-0.36, 0.74]</td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>82</td>
<td></td>
<td>74</td>
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<td></td>
<td></td>
<td>100.0%</td>
<td>0.30</td>
<td>[-0.02, 0.61]</td>
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</tbody>
</table>

Heterogeneity: $\tau^2 = 0.00$; $\chi^2 = 1.08$, df = 3 ($P = 0.78$); $I^2 = 0$

Test for overall effect: $Z = 1.82$ ($P = 0.07$)

Figure 2.4: Random effect model: Upper limb strength training on upper limb function for those trials done in the chronic stage of recovery.
<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Experimental Mean</th>
<th>SD</th>
<th>Total</th>
<th>Control Mean</th>
<th>SD</th>
<th>Total</th>
<th>Weight</th>
<th>IV, Random, 95% CI</th>
<th>Std. Mean Difference IV, Random, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butefisch 1995</td>
<td>1.6</td>
<td>0.7</td>
<td>27</td>
<td>0.78</td>
<td>0.2</td>
<td>13</td>
<td>24.2%</td>
<td>1.36 [0.63, 2.10]</td>
<td></td>
</tr>
<tr>
<td>Platz 2005</td>
<td>10.7</td>
<td>8.8</td>
<td>21</td>
<td>7.8</td>
<td>9.3</td>
<td>21</td>
<td>28.2%</td>
<td>0.31 [-0.29, 0.92]</td>
<td></td>
</tr>
<tr>
<td>Turton 1990</td>
<td>4</td>
<td>6.6</td>
<td>12</td>
<td>-1</td>
<td>2.4</td>
<td>10</td>
<td>19.9%</td>
<td>0.93 [0.04, 1.83]</td>
<td></td>
</tr>
<tr>
<td>Weinstein 2004</td>
<td>4.25</td>
<td>4.33</td>
<td>20</td>
<td>3.35</td>
<td>3.63</td>
<td>20</td>
<td>27.7%</td>
<td>0.22 [-0.40, 0.84]</td>
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</tr>
<tr>
<td>Total (95% CI)</td>
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<td>80</td>
<td>64</td>
<td></td>
<td>100.0%</td>
<td></td>
<td>0.67 [0.13, 1.20]</td>
<td></td>
</tr>
</tbody>
</table>

Heterogeneity: $\tau^2 = 0.17$; $\chi^2 = 6.97$, df = 3 ($P = 0.07$); $I^2 = 57$
Test for overall effect: $Z = 2.44$ ($P = 0.01$)

Figure 2.5: Random effect model: Upper limb strength training on upper limb function for those trials done with individuals with severe motor impairment.
<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Experimental Mean</th>
<th>SD</th>
<th>Total</th>
<th>Control Mean</th>
<th>SD</th>
<th>Total</th>
<th>Weight</th>
<th>IV, Random, 95% CI</th>
<th>Std. Mean Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blennerhassett 2004</td>
<td>17.5</td>
<td>19.4</td>
<td>15</td>
<td>8.8</td>
<td>32.7</td>
<td>15</td>
<td>9.2%</td>
<td>0.31 [-0.41, 1.04]</td>
<td></td>
</tr>
<tr>
<td>Bourbonnais 2002</td>
<td>2</td>
<td>21.7</td>
<td>13</td>
<td>1.1</td>
<td>18.5</td>
<td>12</td>
<td>7.7%</td>
<td>0.04 [-0.74, 0.83]</td>
<td></td>
</tr>
<tr>
<td>Dean 2000</td>
<td>1.5</td>
<td>3.8</td>
<td>4</td>
<td>0.6</td>
<td>3.5</td>
<td>5</td>
<td>2.7%</td>
<td>0.22 [-1.10, 1.54]</td>
<td></td>
</tr>
<tr>
<td>Duncan 2003</td>
<td>4.48</td>
<td>0.81</td>
<td>50</td>
<td>4.04</td>
<td>0.9</td>
<td>50</td>
<td>30.0%</td>
<td>0.51 [0.11, 0.91]</td>
<td>-0.33 [-1.17, 0.51]</td>
</tr>
<tr>
<td>Gelber 1995</td>
<td>8</td>
<td>4.2</td>
<td>11</td>
<td>9.3</td>
<td>3.3</td>
<td>11</td>
<td>6.7%</td>
<td>0.63 [0.17, 1.10]</td>
<td></td>
</tr>
<tr>
<td>Langhammer 2007</td>
<td>3.4</td>
<td>2.6</td>
<td>35</td>
<td>1.8</td>
<td>2.4</td>
<td>40</td>
<td>22.0%</td>
<td>0.19 [-0.36, 0.74]</td>
<td></td>
</tr>
<tr>
<td>Pang 2006</td>
<td>0.3</td>
<td>1.6</td>
<td>30</td>
<td>0</td>
<td>1.5</td>
<td>22</td>
<td>15.7%</td>
<td>0.93 [0.04, 1.83]</td>
<td></td>
</tr>
<tr>
<td>Turton 1990</td>
<td>4</td>
<td>6.6</td>
<td>12</td>
<td>-1</td>
<td>2.4</td>
<td>10</td>
<td>6.0%</td>
<td>0.39 [0.18, 0.61]</td>
<td></td>
</tr>
</tbody>
</table>

Total (95% CI): 170 165 100.0% 0.39 [0.18, 0.61]

Heterogeneity: $\tau^2 = 0.00$; $\chi^2 = 7.01$, df = 7 (P = 0.43); $I^2 = 0$
Test for overall effect: Z = 3.53 (P = 0.0004)

Figure 2.6: Random effect model: Upper limb strength training on upper limb function for those trials done with individuals with moderate/mild motor impairment.
<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Strength Mean</th>
<th>SD</th>
<th>Total</th>
<th>Control Mean</th>
<th>SD</th>
<th>Total</th>
<th>Weight</th>
<th>Std. Mean Difference</th>
<th>IV, Random, 95% CI</th>
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</thead>
<tbody>
<tr>
<td>Duncan 2003</td>
<td>13</td>
<td>12.6</td>
<td>10</td>
<td>13.3</td>
<td>16.7</td>
<td>10</td>
<td>9.7%</td>
<td>-0.02</td>
<td>[-0.90, 0.86]</td>
</tr>
<tr>
<td>Gelber 1995</td>
<td>22.5</td>
<td>5.8</td>
<td>12</td>
<td>23.3</td>
<td>3.8</td>
<td>15</td>
<td>12.9%</td>
<td>-0.16</td>
<td>[-0.92, 0.60]</td>
</tr>
<tr>
<td>Langhammer 2007</td>
<td>17.4</td>
<td>24.6</td>
<td>35</td>
<td>8.9</td>
<td>13.6</td>
<td>40</td>
<td>35.4%</td>
<td>0.43</td>
<td>[-0.03, 0.89]</td>
</tr>
<tr>
<td>Logigian 1983</td>
<td>39</td>
<td>20.58</td>
<td>24</td>
<td>31</td>
<td>15.63</td>
<td>24</td>
<td>22.7%</td>
<td>0.43</td>
<td>[-0.14, 1.00]</td>
</tr>
<tr>
<td>Weinstein 2004</td>
<td>16.15</td>
<td>5.81</td>
<td>20</td>
<td>17</td>
<td>5.17</td>
<td>20</td>
<td>19.3%</td>
<td>-0.15</td>
<td>[-0.77, 0.47]</td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td><strong>101</strong></td>
<td></td>
<td><strong>109</strong></td>
<td><strong>100.0%</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>0.20</strong></td>
<td><strong>[-0.07, 0.47]</strong></td>
</tr>
</tbody>
</table>

Heterogeneity: $\tau^2 = 0.00$; $\chi^2 = 3.94$, df = 4 ($P = 0.41$); $I^2 = 0$

Test for overall effect: $Z = 1.42$ ($P = 0.15$)

Figure 2.7: Random effect model: Upper limb strength training on activities of daily living.
Reference List


Chapter Three: A Self-administered Graded Repetitive Arm Supplementary Program (GRASP) Improves Arm Function during Inpatient Stroke Rehabilitation: A Multi-site randomized Controlled Trial.2

3.1 Introduction

Stroke is the leading cause of serious long term disability in older adults with approximately 750 thousand individuals in North America experiencing a new stroke each year (American Heart Association, 2008). The annual cost to the economy is 68 billion dollars with approximately 70% attributed to hospital services incurred during inpatient stay (American Heart Association, 2008). Over 70% of individuals experience upper limb paresis post stroke (Nakayama et al., 1994). In a qualitative study of upper limb recovery after stroke, participants stated that use of the paretic upper limb is critical to life engagement but is neglected by health care professionals (Barker and Brauer, 2005). Further, a strong relationship between upper limb function and ability to perform activities of daily living, social and recreational activities has been found (Dromerick et al., 2006; Nichols-Larsen et al., 2005).

There is evidence that early admission to stroke units and thus involvement in rehabilitation is strongly associated with improved functional recovery (Horn et al., 2005; Salter et al., 2006). In reviews of early rehabilitation treatment for the paretic upper limb, it is apparent that increased treatment intensity using repetitive task oriented methods improves motor and functional recovery compared to facilitative approaches (Barreca et al., 2003; Van Peppen et al., 2004). Despite the knowledge that increased

2 A version of this chapter has been accepted for publication. Harris, J.E.; Eng, J.J.; Miller, W.C.; Dawson, A.S. A self-administered graded repetitive arm supplementary program (GRASP) improves arm function during inpatient stroke rehabilitation: A multi-site randomized controlled trial. Stroke, June 2009.
therapeutic activity leads to better outcomes post stroke, patient inactivity during inpatient rehabilitation is a concern. Studies in acute and sub-acute settings have shown that individuals were involved in therapy for 5.3% of the day (approximately 47 minutes/day) with upper limb treatment accounting for only four to eleven minutes (Bernhardt et al., 2007, 2008). In addition, these individuals spend over 60% of the day resting and alone (Bernhardt et al., 2007). These findings indicate considerable time during the day when individuals could engage in therapeutic activity outside of standard therapy time.

A possible way to engage individuals in activity during this time is by developing a self-administered homework based exercise program that is supplementary to what is received in therapy. Self-administered exercise programs have been successfully prescribed for the upper limb for the home setting with favorable results for improved upper limb function in chronic stroke (Holmqvist et al., 1998; Turton and Fraser, 1990). Studies which evaluate supplementary inpatient exercise programs are rare. One exception was a self-administered quadriceps strengthening program which was initiated during inpatient care for anterior cruciate ligament reconstruction (Shaw et al., 2005) with results of better knee joint outcomes.

We designed an innovative self-administered program for upper limb recovery that increased the hours of repetitive goal oriented tasks without increasing costly therapy time or requiring expensive equipment. Our primary hypothesis was that individuals with sub-acute stroke who received the supplementary GRASP protocol would attain greater upper limb function at the end of four weeks compared with those...
who received only usual inpatient care. Self-administered treatment outside of regular therapy has never been evaluated during inpatient stroke rehabilitation.

3.2 Methods

This was a multi-site randomized, single-blind, controlled trial. Four sites participated in this study. Each site was assigned an on-site coordinator and assessor. Standardized protocols were developed and all site coordinators and assessors were trained.

Ethical approval was given by all health authorities involved and the university board of ethics. Participants were inpatients recruited from September 2006 to December 2007 from consecutive hospital admissions. Retention data collection was completed by March 2008. The inclusion criteria were:

1. confirmed infarct or hemorrhage by a neurologist using either magnetic resonance (MRI) or computed axial tomography (CT scan),
2. presence of active scapular elevation (shoulder shrug) against gravity and palpable wrist extension (grade 1),
3. Fugl-Meyer Upper Limb Motor Impairment Scale (Fugl-Meyer et al., 1975) score between 10 and 57.

The exclusion criteria were unstable cardiovascular status, significant upper limb musculo-skeletal or neurological condition other than stroke, a Mini Mental Status Exam (Folstein et al., 1975)<20, or receptive aphasia.

Individuals were admitted to an acute care facility and then transferred to one of the four participating sites for rehabilitation at approximately two weeks post-stroke. All individuals who sustained a stroke and were admitted to one of the four sites were
screened for study eligibility and interest within 72 hours. Participants who met inclusion criteria and who consented were randomly assigned to either the control or experimental group using a computerized program which generated random blocks of varying sizes. Concealment of group assignment was done by using an independent data management consultant. Participants were not blinded to group assignment however; the principle investigator was blinded to group assignment. Participants in the study were told not to reveal to the unit clinicians if they were involved in the research project. Clinicians on the rehabilitation unit (e.g., physicians, physical therapists) were aware that a study was occurring, but were unaware of group assignment.

Note, in some cases, patients did not meet study eligibility criteria at rehabilitation admission (due to absence of arm and hand movement), but regained adequate movement within ten days of rehabilitation admission and were entered at this point in time.

3.2.1 Measures

Several measures of participant characteristics (e.g. age, type of lesion, and neglect) were recorded for descriptive and comparative purposes. We tested inter-rater reliability for all outcome measures between the site assessors on inpatients with stroke who met eligibility criteria for this study and found intra-class correlation coefficients between 0.97-0.99. A site assessor who was blinded to group allocation evaluated participants at baseline, post intervention and retention. Three of the site assessors were external to the hospitals and one was external to the rehabilitation unit; all had no contact with study participants outside of the designated evaluation time.
Post intervention testing was the primary planned comparison taken after four weeks of the allocated program because no study has ever assessed the feasibility of a self-administered inpatient program. To inform future studies, retention testing was taken three months after the post intervention test session, but the study was not designed, nor powered for the retention analysis.

3.2.2 Primary Outcome Measure

The Chedoke Arm and Hand Activity Inventory-9 (CAHAI) (Barreca et al., 2006) was used to evaluate the performance of the paretic upper limb in the completion of activities of daily living (ADL). Tasks involve use of both upper limbs (e.g., doing up buttons, putting toothpaste on a tooth brush) as the majority of ADL tasks require bilateral upper limb. Scoring is based on the percentage of contribution to each task by the paretic upper limb with higher scores meaning greater use. Strong measurement properties have been established for this measure in stroke (Barreca et al., 2005, 2006).

3.2.3 Secondary Outcome Measures

The Action Research Arm Test (ARAT) (Lyle, 1981) is a measure of upper limb function post stroke. It is a 19 item scale divided into four subscales (grasp, grip, pinch, and gross movement) that measure movement of the paretic upper limb only. The reliability and validity of this measure has been well established (Lang et al., 2006).

The Motor Activity Log-14 (MAL) (Uswatte et al., 2005) was used to measure each participant’s perception of how much (Amount of Use) and how well (Quality of Movement) they used their paretic upper limb activities of daily living (ADL). Uswatte
and colleagues (2005) established satisfactory measurement properties of the MAL in individuals with stroke.

Isometric strength of the paretic hand was tested using a hand grip dynamometer. The average of three trials was used to determine the final recorded score. Reliability and validity has been well established for hand held dynamometry in the stroke population (Bertrand et al., 2007).

The Medical Outcomes Study Short Form -12 (Ware et al., 1996) was used to measure health related quality of life. The reliability and validity of the SF-12 in the stroke population has been established (Bohannon et al., 2004).

A pain analogue and fatigue severity scale was used to monitor adverse effects. The participants were required to mark on a diagram the region of upper limb pain and then rate the pain on a visual analogue scale from zero (no pain) to ten (extreme pain). Fatigue was monitored using the Fatigue Severity Scale (Krupp et al., 1989) which has nine items rated on a seven point Likert scale with the total ranging from 1 to 7 (worst fatigue). In addition we asked each participant to fill out a questionnaire to rate the programs on ease, equipment and kits, exercises, benefit, and overall satisfaction based on an ordinal scale of one to five (e.g. 1=poor, 3=good, 5=excellent).

3.2.4 Study Protocol

Participants in the study received rehabilitation by the unit multidisciplinary team in addition to the experimental or control group protocols. Time spent in usual therapy (physical therapy and occupational therapy) was recorded.
3.2.5 Experimental Group

The experimental group received the GRASP protocol which is a self-administered home-work based exercise program designed to improve paretic upper performance, and to encourage the use of the paretic upper limb in ADL. Three exercise protocols were developed into exercise books and kits based on the Fugl-Meyer Motor Impairment Scale (mild, moderate, severe). Each exercise book contained written and pictorial instructions for each exercise and the kits contained inexpensive equipment (e.g. ball, bean bag, towel, paper clips) to complete the exercises. Each exercise was graded by varying repetitions to meet each participant’s need. Exercises included strengthening of the arm and hand (small wrist weight, putty, hand gripper), range of motion (stretching, active exercises), and gross and fine motor skills (e.g. blocks, Lego, pegs). Repetitive goal and task oriented activities were designed to simulate partial or whole skill sets required in ADL (e.g. folding, buttoning, pouring, and lifting).

The site coordinator taught and monitored (once per week) the GRASP protocol. Each participant was asked to complete the exercises six days per week for 60 minutes each day. A log sheet was included in each exercise book for participants to track the amount of time and number of days the protocol was completed, as well as any pain and fatigue experienced. At the end of the four week program (which coincided approximately with discharge from the rehabilitation unit), participants kept the exercise book and kit, and were asked to continue with the program at home until the next assessment session in three months time (retention). No monitoring or follow-up was provided during the three month community period. The participants were given log
sheets to track their exercise routine at home. At the time of retention testing all participants were living at home.

3.2.6 Control Group

The control group received an education book with four modules. The modules contained information on stroke recovery and general health. At the end of each module was a homework assignment related to the topic. Control group participants met with the site coordinator once per week to review the information and the homework assignment. The control and experimental group received the same amount of time from the site coordinator over the four week intervention period (Table 3).

3.2.7 Analysis

The sample size was computed using pilot data (n=10, mean change = 6, standard deviation = 12) from the Chedoke Arm and Hand Activity Inventory (our primary measure). Using a significance level of 0.05, power of 0.80, and dropout rate of 15%, a study sample of 48 individuals per group was needed.

Descriptive statistics, independent sample t-test, and chi-square tests were used to analyze characteristics of the sample. Intention-to-treat analysis was performed for all measures and at all three evaluation periods. Any missing values at post intervention and retention were imputed using last–value-observed-carried-forward. Group differences for the primary variable were tested using analysis of covariance (ANCOVA), a method shown to be superior to change score, percentage of change, and repeated measure analyses (Vickers et al., 2001, 2005). For the secondary variables, ARAT, grip, and MAL, we used multivariate analysis of covariance.
(MANCOVA) in order to control for type I error, multiple comparisons, and correlation between dependent variables. Post hoc univariate analysis of covariance was completed for the dependent variables. At each evaluation period, the baseline score was used as the covariate. All analyses were completed using SPSS 15.0 and at 0.05 significance.

3.3 Results

A total of 542 individuals were admitted to the four sites. Of these admissions, 144 (26.6%) were eligible for our study. Sites had similar rehabilitation admission and discharge criteria, therapist to patient ratio, treatment methods, time spent in treatment, and unit environment. 103 subjects were recruited and randomized to the treatment (n=53) or the control (n=50) group. Reasons for exclusion are illustrated in Figure 3.1. A total of nine participants withdrew from the study prior to post intervention testing (a completion rate of 91%): three from the experimental group (two were admitted to acute care, one developed complex regional pain syndrome) and six from the control group (three declined after being randomized to the control group instead of the exercise group, two were admitted to acute care, and one withdrew due to arthritis pain).

For descriptive characteristics of the study sample, see Tables 3.1 and 3.2. At baseline there was no significant difference between groups on demographic, clinical or study characteristics. Mean time between randomization and a) baseline measurement was 72 hours and b) post intervention testing was four weeks for both arms of the trial.

A total of 103 individuals were included for the primary and secondary analyses. Results for the primary outcome measure are illustrated in Table 3.3. The GRASP group achieved a significantly greater post intervention score on the CAHAI compared
to those in the control group ($p<0.001$, effect size $d=0.45$). Mean difference between groups for the CAHAI was 6.6 (CI: 3.7-9.0, $p<0.01$).

A significant MANCOVA model for the secondary variables was found in favor of the GRASP protocol (Wilk’s $\lambda=0.89$, $p=0.031$). Significant post hoc univariate effects were found for grip strength, paretic upper limb function (ARAT), and paretic upper limb use in daily activities (MAL) in favor of the GRASP group (Table 3.4). No group difference was found on the SF-12.

The retention testing took place four months post randomization for both study arms. The GRASP group maintained a significantly larger score on the CAHAI than the control group at retention (50.4; CI: 49.6 to 58.5 versus 45.4; CI: 44.9 to 52.5, $p=0.037$). However, the retention results should be interpreted with caution as we had a completion rate of 58% (60/103 participants).

During the intervention, participants reported high levels of satisfaction with the GRASP protocol (Table 3.2). No serious adverse effects were recorded. Pain analogue scale showed 15 participants (28%) receiving the GRASP protocol reported some level of pain during the study ranging from two (mild) to eight (severe). However, pain was only reported during the first two weeks of the program and dissipated to mild or nonexistent by week three. Reports of fatigue were low, mean (standard deviation) = 3.0 (0.75) out of a possible 7.0, over the four weeks of the intervention.

3.4 Discussion

Our results show that a low cost, self-administered exercise program requiring minimal therapist involvement is not only feasible in an inpatient setting but can effectively maximize time spent improving upper limb function. This multi-site
randomized controlled trial had a low drop-out rate (9%). Our innovative program demonstrated significant improvement over the control group in three important areas of upper limb function: 1) the ability to use the paretic upper limb in ADL (CAHAI), 2) the ability to reach and grasp objects (ARAT), and 3) the increased use of the paretic upper limb during ADL outside of therapy time (MAL).

The GRASP protocol is feasible for a wide range of individuals as no wrist or hand movement was required. In contrast, Constraint-induced movement therapy (CIMT), requires 20° of active wrist movement and 10° of finger movement (Taub et al., 1993). Because of the strict inclusion criteria for CIMT, a low percentage of individuals admitted to rehabilitation units (10%) are eligible for this treatment (Dobkin, 2007). In our study, 40% (212/524) of those admitted for stroke rehabilitation with upper limb impairment were eligible for the GRASP protocol, indicating a significant number of individuals who could benefit. Our effect size of 0.45 is similar to that reported in the large multi-site trial comparing CIMT to usual care (0.53) (Wolf et al., 2006). Additionally, our primary outcome measure is very applicable to real life situations, as it evaluates a wide variety of daily activities that incorporate the full range of upper limb movement, motor control, and coordination while the majority of outcomes for trials (Wolf et al., 2006; Platz et al., 2005) use outcomes that primarily assess reach, grasp, and unimanual skills (e.g. FM, ARAT, WMFT).

The minimal detectable change (MDC) (i.e. change representing a real improvement) (Haley and Fragala-Pinkham, 2006) for the CAHAI has been calculated as 6 points. The GRASP group exceeded this MDC by eight points. Moreover there was a six point difference between the experimental and control groups. A change of one
point on a CAHAI item represents a corresponding increase of paretic upper limb use of approximately 25%. We found individuals in the GRASP group increased use of their paretic upper limb on CAHAI items by 33%, in contrast the control group increased by 15%.

A group difference of 4.7 points in favor of the GRASP protocol on the ARAT was observed. van der Lee et al. (2001) found that a group difference of three points on the ARAT is meaningful. Furthermore, the increase on the Motor Activity Log (MAL) was equivalent to the large randomized controlled trial of CIMT by Wolf and colleagues (Wolf et al., 2006). Individuals in the GRASP group achieved an average post intervention score of 3.3 on the MAL which indicates the ability to use the paretic upper limb at least 50% as much as before the stroke (Wolf et al., 2006). At baseline both groups scored in the category of “occasional use of the paretic upper limb in daily activities” on the MAL, however only the GRASP group progressed to “frequent use of the paretic upper limb in daily activities” following the intervention.

Our intervention techniques are consistent with those studies utilizing repetitive task oriented practice (Platz et al., 2005; Winstein et al., 2004), however our study is a homework based, self-administered protocol versus therapist driven and delivered. This method of treatment delivery was effective and participants adhered to the protocol with minimal time from the therapist. Despite being a self administered program, no participants suffered any serious adverse effects and reported high levels of satisfaction. Notably, we found that over 50% of participants’ families were involved in facilitating the completion of the GRASP protocol. Family members had a positive reaction to the GRASP protocol and felt they were able to contribute to the recovery of
their family member. Involving family in the rehabilitation process could be an important aspect of treatment delivery.

Inpatient trials that evaluated upper limb recovery using repetitive goal-oriented treatment found an additional 30-60 minutes of therapist time per day was required to improve upper limb performance (Platz et al., 2005; Winstein et al., 2004). Positive results from inpatient trials involving CIMT have been found, but require from 2-6 hours of supervised therapy (Boake et al., 2007; Dromerick et al., 2000). Additional hours of supervised therapy time cannot be delivered feasibly by the existing parameters of most inpatient rehabilitation centers. We present a time efficient, easy to implement and clinically effective model for upper limb recovery in the sub-acute stage post stroke.

In addition, the significant improvement gained by the GRASP group was retained at retention (five months post stroke); however, the retention results must be interpreted with caution. Although we accounted for missing data in the analysis, attrition of retention data reduced power to detect differences at this time which may represent a distortion bias. Our planned comparison was for the post intervention time frame and the retention data simply served to assess the feasibility of continuing the protocol in the community. Individuals in the GRASP group continued to complete the upper limb exercises during the retention period without any monitoring or reminders from study personnel. However, further studies need to investigate the long-term effects of the GRASP protocol.

Contamination between groups was minimized by eliminating contact between site assessors and coordinators and by providing reminders to participants to not reveal group allocation when on the unit. In addition, we attempted to contain contamination
between treating therapists and study participants by educating and monitoring the unit staff on participant anonymity. Feedback from clinicians in the rehabilitation unit (e.g., physicians, therapists) suggested that they did not change their practice during the trial.

3.4.1 Limitations

We cannot determine which component of the program, additional time during upper extremity activities or the specific home-work based treatment method, contributed to the success of our findings because we matched groups for therapist attention, but we did not include a control group with an equivalent increase (35 min/day) of one-on-one traditional therapy time. Such a comparison was less relevant to us as it is already known that additional one-on-one therapy time does improve stroke rehabilitation outcomes (Kwakkel et al., 2004). Given that our home-work based treatment consisted of typical exercises undertaken in rehabilitation, it is likely that the additional dedicated time practicing upper extremity activities contributed to the success of our program. Replication of this study with a larger sample size and a third group to evaluate an equivalent increase in one-on-one traditional therapy would be beneficial. Furthermore, as our study only extended to five months post-stroke, we were not able to determine effects which may or may not extend into the chronic phase of stroke.

3.5 Conclusion

In summary, the GRASP protocol was found to be a safe, time efficient, cost and treatment effective method to improve upper limb recovery in the sub-acute phase of stroke. These findings suggest that GRASP is an effective treatment method for stroke for inpatient settings. Further studies should be conducted to determine the long-term
effects of this protocol and its feasibility in additional settings (e.g. outpatient, community).
Table 3.1: Demographic and Clinical Characteristics of Sample at Baseline

<table>
<thead>
<tr>
<th>Variable</th>
<th>GRASP (N=53)</th>
<th>Control (N=50)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (n)</td>
<td>31M/22F</td>
<td>28M/22F</td>
</tr>
<tr>
<td>Age (mean ±SD), yrs</td>
<td>69.4 (11.7)</td>
<td>69.3 (15.3)</td>
</tr>
<tr>
<td>Side of Paresis (n)</td>
<td>35L/18R</td>
<td>30L/20R</td>
</tr>
<tr>
<td>Dominant Hand Affected (n)</td>
<td>16(30%)</td>
<td>18(36.7%)</td>
</tr>
<tr>
<td>Fugl-Meyer Arm Score, max=66 (mean ± SD)</td>
<td>39.5 (14.2)</td>
<td>40.0 (12.6)</td>
</tr>
<tr>
<td>Type of Stoke (n)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infarct</td>
<td>35</td>
<td>34</td>
</tr>
<tr>
<td>Hemorrhage</td>
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<td>11</td>
</tr>
<tr>
<td>Lacunar</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Location of Stroke (n)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cortical</td>
<td>31</td>
<td>25</td>
</tr>
<tr>
<td>Subcortical</td>
<td>22</td>
<td>25</td>
</tr>
<tr>
<td>Time post stroke to study start date (mean ±SD), days</td>
<td>20.5 (7.1)</td>
<td>20.8 (7.0)</td>
</tr>
<tr>
<td>Mini Mental Status Exam max=30 (mean ±SD)</td>
<td>26.7(3.3)</td>
<td>26.9 (2.6)</td>
</tr>
<tr>
<td>Star Cancellation Test max=56 (mean ±SD)</td>
<td>51.9(7.0)</td>
<td>51.6(5.9)</td>
</tr>
<tr>
<td>Chedoke Arm and Hand Activity Index, (mean ±SD), max=63</td>
<td>32.6(15.3)</td>
<td>32.7 (17.2)</td>
</tr>
<tr>
<td>Action Research Arm Test, (mean ±SD), max=57</td>
<td>31.1 (18.3)</td>
<td>31.0(20.0)</td>
</tr>
<tr>
<td>Motor Activity Log (mean ±SD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount of Use, max=5</td>
<td>2.0 (1.2)</td>
<td>1.9 (1.4)</td>
</tr>
<tr>
<td>Quality of Use, max=5</td>
<td>2.0 (1.1)</td>
<td>1.8 (1.3)</td>
</tr>
<tr>
<td>Grip Strength (mean ±SD), kg</td>
<td>9.0 (8.1)</td>
<td>8.8 (8.0)</td>
</tr>
<tr>
<td>Modified Ashworth Scale, (mean ±SD), max= 4</td>
<td>1.0(0.76)</td>
<td>1.1 (0.81)</td>
</tr>
<tr>
<td>SF-12 (mean ±SD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical Health Summary Score, max=50</td>
<td>38.0 (7.7)</td>
<td>34.5 (7.7)</td>
</tr>
<tr>
<td>Mental Health Summary Score, max=50</td>
<td>48.7 10.3)</td>
<td>49.7(10.6)</td>
</tr>
</tbody>
</table>
Table 3.2: Mean (range) of amount of therapy and study protocol received during intervention and retention period.

<table>
<thead>
<tr>
<th>Variable</th>
<th>GRASP group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time spent in therapy:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical Therapy</td>
<td>4.2h/wk (4.0-4.5h/wk)</td>
<td>4.2h/wk (4.0-4.5h/wk)</td>
</tr>
<tr>
<td>Occupational Therapy</td>
<td>3.4h/wk (3.0-4.0h/wk)</td>
<td>3.4h/wk (3.0-4.0h/wk)</td>
</tr>
<tr>
<td>Time spent with study coordinator</td>
<td>45 min/wk (0.5h-1.5h/wk)</td>
<td>45 min/wk (0.5h-1h/wk)</td>
</tr>
<tr>
<td>Time spent completing GRASP protocol:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intervention period</td>
<td>3h/wk (1h-7h/wk)</td>
<td></td>
</tr>
<tr>
<td>Retention period</td>
<td>4h/wk (1h-8h/wk)</td>
<td></td>
</tr>
<tr>
<td>Days spent completing GRASP protocol:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intervention period</td>
<td>4.8d/wk (1.3d-7d/wk)</td>
<td></td>
</tr>
<tr>
<td>Retention period</td>
<td>4.0d/wk (0.3-7d/wk)</td>
<td></td>
</tr>
<tr>
<td>Satisfaction survey, max=5</td>
<td>4.1 (4.0-4.5)</td>
<td>4.4 (4.0-5.0)</td>
</tr>
</tbody>
</table>
Table 3.3: ANCOVA results for the primary outcome measure, Chedoke Arm and Hand Activity Inventory at post intervention.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Baseline Score</th>
<th>Posttest Score (95% CI)</th>
<th>Change Score (95% CI)</th>
<th>ANCOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRASP</td>
<td>32.6</td>
<td>46.7 (44.9-48.8)</td>
<td>14.1 (11.8-16.2)</td>
<td>p&lt;0.001</td>
</tr>
<tr>
<td>Control</td>
<td>32.7</td>
<td>40.1 (38.9-42.8)</td>
<td>7.9 (5.0-10.3)</td>
<td></td>
</tr>
</tbody>
</table>
Table 3.4: MANOVA post hoc univariate results for the secondary outcome measures at post intervention.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>Baseline Score</th>
<th>Posttest Score (95% CI)</th>
<th>Change Score (95% CI)</th>
<th>ANCOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Action Research Arm Test</td>
<td>GRASP</td>
<td>31.1</td>
<td>42.8 (40.3-45.4)</td>
<td>11.7 (8.8-14.3)</td>
<td>p= 0.025</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>31.0</td>
<td>38.0 (35.9-41.0)</td>
<td>7.0 (4.0-10.4)</td>
<td></td>
</tr>
<tr>
<td>Grip Strength (kg)</td>
<td>GRASP</td>
<td>9.0</td>
<td>13.1 (11.9-14.1)</td>
<td>4.1 (2.5-5.2)</td>
<td>p= 0.027</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>8.8</td>
<td>10.8 (9.8-12.1)</td>
<td>2.0 (0.9-3.2)</td>
<td></td>
</tr>
<tr>
<td>Motor Activity Log amount of use scale</td>
<td>GRASP</td>
<td>2.0</td>
<td>3.3 (2.9-3.7)</td>
<td>1.3 (1.5-3.0)</td>
<td>p= 0.023</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>1.9</td>
<td>2.8 (2.4-3.2)</td>
<td>0.9 (0.83-2.7)</td>
<td></td>
</tr>
<tr>
<td>Motor Activity Log quality of movement scale</td>
<td>GRASP</td>
<td>2.0</td>
<td>3.2 (2.8-3.2)</td>
<td>1.2 (1.0-2.5)</td>
<td>p=0.007</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>1.8</td>
<td>2.7 (2.5-3.0)</td>
<td>0.9 (0.87-1.9)</td>
<td></td>
</tr>
</tbody>
</table>
Figure 3.1: Consort Diagram

Total stroke admissions across 4 sites = 542

Individuals excluded = 398
No upper limb deficits = 186
No upper limb movement = 66
Cognitive Deficits = 46
Receptive aphasia = 42
Fatigue = 35
Other = 23

Total individuals screened = 144

Total individuals refused = 41

Individuals randomized = 103

Individuals randomized to control group plus usual care = 50
Received allocated intervention = 44
Did not receive allocated intervention = 6

Individuals randomized to GRASP treatment plus usual care = 53
Received allocated intervention = 50
Did not receive allocated intervention = 3
Reference List


Chapter Four: The Effect of an Upper Limb Intervention on Depressive Symptoms during Inpatient Stroke Rehabilitation.3

4.1 Introduction

Depression early after stroke is common, with studies reporting a prevalence rate ranging between 23% and 72% in hospital settings (Hackett et al., 2005; Sackley et al., 2008; Robinson, 2003). Further, studies have found that post stroke depression increases the risk for stroke mortality (Morris et al., 1993; Everson et al., 1999). Yet a systematic review showed that post stroke depression is under diagnosed and under treated (Hackett et al., 2005). Several diverse predictors of post stroke depression have been found including female gender (Dafer et al., 2008; Weimar et al., 2002), lesion location (Singh et al., 2000; Berg et al., 2003), and functional outcome (Pohjasvaara et al., 2001; Whyte et al., 2004). Studies have found that stroke related depression has a negative impact on activities of daily living (Goodwin and Devanand, 2008; Van De Port et al., 2007) and health related quality of life (Pan et al., 2008; Lo et al., 2008). Consequently, depression may impede full participation in stroke rehabilitation.

Whether improved function post stroke has a positive impact on depression or whether depression has a negative impact on functional recovery is unclear. Studies have found that greater functional recovery during inpatient and community rehabilitation was related to improvement in ratings of post stroke depressive symptoms (Chemerinski et al., 2001; Saxena et al., 2007). Sims et al. (2009) studied the effect of a community-based strength-training program (RCT) for both the upper and lower limb

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3 A version of this chapter has been submitted for publication. Harris, J.E.; Eng, J.J.; Miller, W.C.; Dawson, A.S. The effect of an upper limb intervention on depressive symptoms during inpatient stroke rehabilitation.
on depression in chronic stroke. The results of this randomized controlled trial showed that the strength training group had significantly lower depression scores compared to the control group at the completion of a 10 week program. However, the study sample size (n=45) did not meet the stated number of participants needed (n=60) to detect group differences. Additionally, the control group did not receive any intervention and thus group differences detected on depression scores could be partially attributed to social contact (Blumenthal et al., 2007) and not physical gain. Nannetti et al. (2005) and Culley et al. (2005) studied the influence of post stroke depression on functional recovery during inpatient rehabilitation. Results indicated that depression had a negative impact on functional recovery as measured by the Barthel Index and the Functional Independence Measure. In a study of community dwelling individuals with stroke, Van de Port et al. (2006) showed that depression was a significant predictor in mobility deterioration at one year post stroke.

The results of these studies suggest that functional recovery and depression are inter-related, where improvement in one variable positively impacts the outcome of the other. Subsequently, rehabilitation can have a positive impact on post stroke depression by focusing on the development and maintenance of functional ability.

The ability to use the upper limb is instrumental in performing many activities of daily living (ADL) as well as participating in social activities. Upper limb dysfunction post stroke is prevalent with up to 70% of individuals incurring paresis in the initial stage of recovery (Nakayama et al., 1994). Although poor upper limb function and depression have been linked in a number of health conditions such as upper limb trauma and arthritis (Keogh et al., 2000), no studies have quantified the effect of upper limb function
on depression in stroke. However, poor upper limb function has been associated with lower levels of health-related quality of life (Desrosiers et al., 2003; Clarke et al., 2002), subjective well-being (Wyller et al., 1998) and social participation (Shimoda and Robinson, 1998).

The purpose of this study was to determine 1) the effect of a novel inpatient upper limb treatment intervention (GRASP) on ratings of depressive symptoms compared to those in the control group and 2) the relationship between improved upper limb function and ratings of depressive symptoms in a group of inpatient stroke participants.

4.2 Methods

This prospective cohort was part of a multi-site randomized controlled trial that quantified the effect of a self-administered exercise program (GRASP) aimed at improving upper limb function in an inpatient setting (in press, Harris et al. 2009). In this study, 103 participants were recruited and randomized into the GRASP protocol (n=53) and the control group which consisted of a stroke education manual (n=50). Participants in the study received rehabilitation by the unit multidisciplinary team in addition to the experimental or control group protocols.

The GRASP protocol is a self-administered home-work based exercise program designed to improve paretic upper performance in ADL. Three exercise protocols (mild, moderate, and severe impairment) were developed into exercise books and kits. Exercises included strengthening of the arm and hand, range of motion, and gross and fine motor skills. Repetitive task oriented activities were designed to simulate partial or whole skill sets required in ADL (e.g. folding, buttoning, pouring, and lifting). In addition,
family members were encouraged to participate in the program by doing the exercises with the participant and offering support and encouragement. The GRASP protocol significantly improved upper limb function measured by the Chedoke Arm and Hand Activity Inventory (Barreca et al., 2006) and the Motor Activity Log (Uswatte et al., 2005) compared to the control group (in press, Harris et al., 2009).

Ethical approval was given by all health authorities involved and the university board of ethics. Participants were inpatients recruited from September 2006 to December 2007 from consecutive hospital admissions. The inclusion criteria were:

1. confirmed infarct or hemorrhage by a neurologist using either magnetic resonance (MRI) or computed axial tomography (CT scan),
2. presence of active scapular elevation (shoulder shrug) against gravity and palpable wrist extension (grade 1),
3. Fugl-Meyer Upper Limb Motor Impairment Scale (Folstein et al., 1975) score between 10 and 57.

The exclusion criteria were unstable cardiovascular status, significant upper limb musculo-skeletal or neurological condition other than stroke, a Mini Mental Status Exam (Folstein et al., 1975)<20, or receptive aphasia.

4.2.1 Measures

Several measures of participant characteristics (e.g. age, type of lesion) were recorded for descriptive and comparative purposes. Measurements were taken at baseline and after the four week intervention.

The Center for Epidemiological Studies Depression rating Scale (CES-D) (Radloff, 1977) is a self-report 20-item scale developed to identify depressive symptoms
in the general population. The participant is asked to rate each item according to how he/she felt in the past week. The participant identifies the frequency of the feeling that is reflected in each item, such as “I felt fearful” or “I had crying spells,” using a four point scale. The scale ranges from ‘none of the time’ to ‘all of the time.’ Scores range from 0-60 with a suggested cutoff score of ≥16 for depressive symptoms (Radloff, 1977). Higher scores indicate higher frequencies of depressive symptoms. Satisfactory reliability and validity of this scale has been found for individuals with stroke (Shinar et al., 1986; Parikh et al., 1988; Pickard et al., 2006). In addition, the CES-D has been used frequently in stroke outcome studies to measure depressive symptoms (Sackley et al., 2008; Van De Port et al., 2007; Whyte et al., 2004).

The Chedoke Arm and Hand Activity Inventory (CAHAI) (Barreca et al., 2006) was used to evaluate the performance of the paretic arm in the completion of ADLs. The assessor encourages the client to use both hands to complete each task. The CAHAI consists of 13 tasks of daily living (e.g., pouring, buttoning, zipping). Scoring is done on a 7-point ordinal scale (1 = total assistance, 7 = complete independence). Scoring is based on the percentage of contribution to each task by the paretic arm/hand. Satisfactory psychometric properties of this measure have been found to be satisfactory (Barreca et al., 2005; 2006)

The Motor Activity Log short version (MAL) (Uswatte et al., 2005) was used to measure each participant's perception of how much and how well he or she uses the paretic arm during ADLs. It is a semi structured interview that consists of 14 ADL items (e.g., brushing teeth, buttoning a shirt, eating). Scoring is completed using two scales, the Amount of Use and Quality of Use scale. For this study we only used the Amount of
Use scale. The MAL has been shown to have good reliability and validity (Uswatte et al., 2005) in persons with stroke.

Isometric strength of the paretic hand was tested using a hand grip dynamometer. The average of three trials was used to determine the final recorded score. Reliability and validity has been well established for hand held dynamometry in the stroke population (Bohannon et al., 1997; Bertrand et al., 2007).

4.2.2 Analysis

Descriptive statistics were calculated using t-test for continuous variables and chi-squared for categorical data. Intention-to-treat analysis was performed for all measures at post intervention testing. Any missing values at post intervention and retention were imputed using last-value-observed-carried-forward. Group differences for the primary variable, CES-D, were determined using analysis of variance (ANOVA) for baseline and change score evaluations. Analysis of covariance (ANCOVA) was used to determine group differences on post intervention CES-D score. The baseline score on the CES-D was the covariate.

Scatter plots and correlation analysis were examined to determine the relationship between CES-D post intervention score and the change scores of grip strength, Chedoke Arm and Hand Activity Index, and the Motor Activity Log (amount of use scale). Bivariate correlations were generated using Pearson and Spearman correlation coefficients. Change scores were used because we were interested in determining how improvement in upper limb function related to ratings of depressive symptoms during inpatient stroke rehabilitation. A p-value of ≤0.05 was considered significant. SPSS statistical software 15.5 for Windows was used for all analyses.
4.3 Results

The demographic and clinical characteristics of the participants are shown in Table 4.1. Participants (N=103) were an average age of 69.4 years with 57.3% being male. The scores on the Fugl-Meyer Motor Impairment Scale (upper limb) ranged from 12 to 57 with a mean of 39.5 (SD=13.4), indicating varying degrees of upper limb motor severity. In addition, participants (N=103) scored a mean of 16.2 (SD=9.1) on the CES-D at baseline, however, at post intervention (4 weeks after baseline), the mean score on the CES-D was 11.7 (SD=9.9).

4.3.1 Analysis of Variance

Table 4.2 displays the analysis of variance results. There were no group differences for baseline CES-D scores. The GRASP group reported significantly lower post intervention CES-D scores compared to those in the control group (p<0.001). The participants in the GRASP group reported significantly higher change scores on the CES-D compared to the control group (p<0.001).

Since a group difference on post intervention scores was found, we did the following post hoc analysis. The cut-off score for indicating significant depressive symptoms on the CES-D is ≥16 (Radloff, 1977). We divided each group (GRASP and control) into two categories ‘depressed (≥16)’ and ‘not depressed (<16)’ at baseline and at post intervention. At baseline, 27/50 participants (55.1%) in the control and 25/53 (47.2%) in the GRASP group were classified as ‘depressed’ which was not a significant group difference (chi²=0.64, p=0.436). At post intervention, 25/50 (51%) in the control and 15/53 (28.3%) in the GRASP group were classified as ‘depressed’ which was a significant group difference (chi²=17.39, p<0.001).
4.3.2 Correlational Analysis

Correlations among the variables from the GRASP group are displayed in Table 4.3. Among the variables, significant but low correlations were found. The GRASP group change scores on grip strength, Chedoke Arm and Hand Activity Inventory, and Motor Activity Log produced significant correlations with post intervention CES-D ($r^2 = -0.26$ to $-0.31$, $p<0.05$-$p<0.01$). Only the change score from the Motor Activity Log of the control group produced a significant correlation with post intervention CES-D ($r^2 = -0.22$, $p<0.05$). These results indicate that those with greater improvement in upper limb function reported less depressive symptoms.

4.4 Discussion

This study has showed that improved upper limb ability can have a positive influence on depressive symptoms in an inpatient stroke population. These findings are congruent with previous studies which have investigated the association between motor impairment and post stroke depression (Nannetti et al., 2005; Sims et al., 2009; Van Port et al., 2006). In addition, our findings suggest those with greater improvement in upper limb ability report less depressive symptoms.

The prevalence of reported depressive symptoms at baseline (50.5%) is comparable to other inpatient studies (Sackley et al., 2008; Ng et al., 1995; Robinson, 2003). Additionally, our percentage of individuals (30%) reporting significant depressive symptoms ($\geq 16$ on the CES-D) at post intervention is similar to other studies evaluating stroke outcome in the sub-acute stage of recovery (28% to 47.7%) (Chemerinski et al., 2001; Culley et al., 1995; Sackley et al., 2008). However, these rates are higher than those reported for a comparable older adult population (5.7-26%) (Preville et al., 2008;
Chachamovick et al., 2008). The higher rates of depressive symptoms suggest that those individuals with stroke are a more vulnerable group than older adults without stroke.

For person with stroke, recovery can be a complex process of adapting to physical deficits, decreased autonomy, and limitations in functional ability. Further, not being able to accomplish everyday activities that were once easy can cause frustration and feelings of helplessness (Robinson et al., 2003). Individuals may in turn feel less motivated to actively engage in rehabilitation. Severity of disability has been found to be a predictor of post stroke depression (Burvill et al., 1997; Ng et al., 1995; Ramasubbu et al., 1998). The relationship between disability and depression in persons with stroke lends support to the notion that post stroke depression is a response to the physical deficits caused by the stroke (Sato et al., 1999). We found that those individuals with more improvement in upper limb ability reported less depressive symptoms compared to those who had less improvement in upper limb ability. Our results maintain the idea that severity of deficits has a negative impact on post stroke depression.

A lack of activity during the day may create a sense of apathy, especially if the person is unable to engage in usual occupations. One study showed that individuals with stroke were only involved in therapy for 5.3% of the day, with the remainder of time spent inactive and alone (Bernhardt et al., 2007). We designed a self-administered homework based exercise program to increase the amount of time spent in rehabilitation activities and with family members. Studies have indicated the value of social and family involvement in stroke rehabilitation as a mediator of well-being
(DiMatteo, 2004; Damush et al., 2007). This may be a factor in our findings, since 55% of the GRASP group had family involved in their program. Support may contribute to recovery by increasing confidence, motivation, satisfaction with hospital stay, and in turn decreasing stress and depression. Though we collected data on family involvement for those individuals in the GRASP group, we did not for the control group. Therefore, it is only speculation that family involvement may play a role in lessening post stroke activities.

Activities in rehabilitation require participation of the individual but not necessarily initiation. In qualitative studies involving persons with stroke, researchers found that individuals voiced the need to be proactive in their rehabilitation (Dixon et al., 2007; Wiles et al., 2002). In addition, they reported increased hope for recovery in those individual who were able to become actively involved in planning and implementing their rehabilitation. By designing a self-administered exercise program, we were able to foster a sense of control and autonomy over an aspect of their rehabilitation. Consequently, this may have increased motivation to participate in recovery, resulting in an optimistic outlook on life and feelings of empowerment. This is congruent with studies that have examined the effect of positive emotional states and self-determination on depressive symptoms (Prince et al., 1997; Ostir et al., 2008).

Our study focused on the effect of an exercise based upper limb program as exercise has been shown to have positive effects on depression and depressive symptoms (Blumenthal et al., 2007; Dunn et al., 2005; Singh et al., 2000). In a systematic review by Lawlor and Hopker (2001), various pathways were suggested regarding the influence of physical activity on depression, including distraction from negative thoughts, improved self esteem, and self efficacy. In addition, exercise in
animals and humans have lead to increased levels of neurotrophic factors and neurogenesis, which is thought to impact depressive symptoms (Duman, 2005; Dimeo et al., 2001). The GRASP group achieved an addition 35 minutes of exercise per day over the four week program. It may be that the improved functional ability found from exercise interventions has a mediating effect on depressive symptoms such as fatigue, apathy, and motivation.

4.4.1. Limitations

We did not record the use of anti-depressant medication however; studies have found that exercise intervention for older adults with depression was as effective in remitting depression as antidepressant medication (Blumenthal et al., 2007; Babyak et al., 2000). It is important to note that we did not assess depression as diagnosed using the DSM-IV; instead we recorded frequency of depressive symptoms. A large multi-site observation study reported that 80.17% of the stroke population assessed for depression was classified as exhibiting depressive symptoms and not meeting the classification of major depression (Paolucci et al., 2006). We did not include persons with receptive aphasia. It may be those with aphasia demonstrate greater depressive symptoms based on their inability to communicate. In addition, individuals with aphasia seem to have worst functional outcome than those without (Barker-Collo and Feigin, 2006). Our sample size calculation was based on our primary objective of the intervention trial which was to improve upper limb function and not on our secondary objective to explore the benefits of upper limb exercise on depressive symptoms. As such we may not have achieved sufficient power to find group differences. However, researchers of a similar randomized exercise trial with individuals with stroke found they
required a sample size of 60 to find clinically meaningful group differences on the CES-D (Sims et al., 2009); our sample size was 103.

4.5 Conclusion

Improved upper limb ability had a positive effect on post stroke depressive symptoms. It appears that depressive symptoms and functional recovery are associated. Given the detrimental effects of post stroke depression, efforts to improve depressive symptoms such as upper limb rehabilitation, should be a focus. Further, clinicians need to be aware of the importance of depression on engagement in treatment for persons entering rehabilitation. Interventions that promote self-determination, control, and family involvement may be instrumental in lessening depressive symptoms.
Table 4.1: Demographic and Clinical Characteristics of Participants at Baseline

<table>
<thead>
<tr>
<th>Variable</th>
<th>GRASP (N=53)</th>
<th>Control (N=50)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (n)</td>
<td>31M/22F</td>
<td>28M/22F</td>
</tr>
<tr>
<td>Age (mean ±SD), yrs</td>
<td>69.4 (11.7)</td>
<td>69.3 (15.3)</td>
</tr>
<tr>
<td>Side of Paresis (n)</td>
<td>35L/18R</td>
<td>30L/20R</td>
</tr>
<tr>
<td>Fugl-Meyer Arm Score, max=66 (mean ± SD)</td>
<td>39.5 (14.2)</td>
<td>40.0 (12.6)</td>
</tr>
<tr>
<td>Type of Stoke (n)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infarct</td>
<td>35</td>
<td>34</td>
</tr>
<tr>
<td>Hemorrhage</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td>Lacunar</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Location of Stroke (n)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cortical</td>
<td>31</td>
<td>25</td>
</tr>
<tr>
<td>Subcortical</td>
<td>22</td>
<td>25</td>
</tr>
<tr>
<td>Time post stroke, days (mean ±SD)</td>
<td>20.5 (7.1)</td>
<td>20.8 (7.0)</td>
</tr>
<tr>
<td>Mini Mental Status Exam max=30 (mean ±SD)</td>
<td>26.7 (3.3)</td>
<td>26.9 (2.6)</td>
</tr>
<tr>
<td>Chedoke Arm and Hand Activity Index, (mean ±SD), max=63</td>
<td>32.6 (15.3)</td>
<td>32.7 (17.2)</td>
</tr>
<tr>
<td>Motor Activity Log (mean ±SD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount of Use, max=5</td>
<td>2.0 (1.2)</td>
<td>1.9 (1.4)</td>
</tr>
<tr>
<td>Grip Strength (mean ±SD), kg</td>
<td>9.0 (8.1)</td>
<td>8.8 (8.0)</td>
</tr>
</tbody>
</table>
Table 4.2: ANOVA: Group differences between GRASP (n=53) compared to Control (n=50) on baseline, post intervention and change scores on the CES-D*.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean (SD)</th>
<th>95% Confidence Interval</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline CES-D</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GRASP</td>
<td>15.13 (7.4)</td>
<td>12.64 to 17.63</td>
<td>P=0.23</td>
</tr>
<tr>
<td>Control</td>
<td>17.29 (10.7)</td>
<td>14.70 to 19.98</td>
<td></td>
</tr>
<tr>
<td>Post CES-D†</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GRASP</td>
<td>8.79 (6.46)</td>
<td>8.12 to 10.83</td>
<td>P&lt;0.001</td>
</tr>
<tr>
<td>Control</td>
<td>16.21 (9.28)</td>
<td>13.62 to 16.49</td>
<td></td>
</tr>
<tr>
<td>Change CES-D</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GRASP</td>
<td>6.34 (6.03)</td>
<td>4.81 to 7.87</td>
<td>P&lt;0.001</td>
</tr>
<tr>
<td>Control</td>
<td>1.51 (5.12)</td>
<td>-0.08 to 3.10</td>
<td></td>
</tr>
</tbody>
</table>

*CES-D = Center for Epidemiological Studies Depression Rating Scale
† ANCOVA
Table 4.3: Correlations between change scores on measures of upper limb function and post intervention CES-D

<table>
<thead>
<tr>
<th>Variable</th>
<th>CES-D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Δ Grip strength</td>
<td></td>
</tr>
<tr>
<td>GRASP Control</td>
<td>-0.246**</td>
</tr>
<tr>
<td>Control</td>
<td>-0.167</td>
</tr>
<tr>
<td>Δ Chedoke Arm and Hand Activity Inventory</td>
<td></td>
</tr>
<tr>
<td>GRASP Control</td>
<td>-0.226*</td>
</tr>
<tr>
<td>Control</td>
<td>-0.129</td>
</tr>
<tr>
<td>Δ Motor Activity Log (amount)</td>
<td></td>
</tr>
<tr>
<td>GRASP Control</td>
<td>-0.311**</td>
</tr>
<tr>
<td>Control</td>
<td>-0.22*</td>
</tr>
</tbody>
</table>

Δ=change score, *p<0.05, **p<0.01
Reference List


Chapter Five: Social Support in Treatment is a Predictive Factor of Improved Arm Function in Individuals with Sub-acute Stroke.\textsuperscript{4}

5.1 Introduction

Upper limb dysfunction post stroke is prevalent with up to 70\% of individuals incurring paresis in the initial stage of recovery (Nakayama et al., 1994). Use of the upper limb is vital to the completion of many activities of daily living as well as socialization and health related quality of life (Clarke et al., 2002; Desrosiers et al., 2003). Additionally, stroke survivors state that upper limb recovery is an important but neglected aspect of rehabilitation (Barker and Brauer, 2005). The ability to predict upper limb recovery is important to many aspects of rehabilitation. Treatment can then be focused on those aspects that promote upper limb function.

Several outcome variables have shown to be predictive of upper limb function scores. One of the more prevalent factors associated with poor arm function is initial upper limb motor scores. Upper limb motor scores taken two weeks post stroke have accounted for between 50 and 54\% of the variance of discharge score (approximately 6 weeks post stroke) on the Functional Independence Measure (Kwakkel et al., 2003; Meldrum et al., 2004) as well as contributing to significant predictor models of upper limb function (Desrosiers et al., 2003; Feys et al., 2000). In addition, impairments such as weakness, decreased range of motion, and loss of sensation are associated with decreased scores in upper limb function and ADL measures (Harris et al., 2007; Wagner et al., 2006; Hashimoto et al., 2007; Smania et al., 2007; Tyson et al., 2008; Wagner et al., 2006).

\textsuperscript{4} A version of this chapter has been submitted for publication. Harris, J.E.; Eng, J.J.; Miller, W.C.; Dawson, A.S. Social Support in Treatment is a Predictive Factor of Improved Arm Function in Individuals with Sub-acute Stroke.
Many of the most significant predictors of upper limb recovery post stroke cannot be altered (e.g. initial scores and impairment level); this is problematic for clinicians whose goal is to provide interventions designed to remediate stroke related disability. Recently, the role of family members in stroke rehabilitation is gaining recognition as a method for clinicians to increase treatment time and as a potential factor in improved functional outcome (Galvin et al., 2008; Maeshima et al., 2001, 2003). These studies reported that a high percentage (75%) of family members was interested in participating in rehabilitation. The clinical trials by Maeshima et al. (2001, 2003) reported improved lower limb strength, mobility, and activities of daily living in the group where family members participated in the treatment program. Additionally, a positive relationship between family support, exercise adherence and recovery from stroke has been found (DiMatteo, 2004; Molloy et al., 2008).

We have previously reported that a four week inpatient upper limb exercise program (GRASP), significantly improves upper limb function in individuals with sub-acute stroke (Harris et al., 2009). An important aspect of this program was the encouragement of family members or friends, when possible, to be involved in the exercise program. However, it is not known whether the involvement of family members and or friends contributed to the improvements in upper limb function. It would be important to understand potential factors that can be influenced by clinicians or patients (i.e. modifiable determinants) which lead to improvement in upper limb function.

The purpose of this secondary analysis was to identify modifiable factors contributing to the improvement of upper limb function following the GRASP trial. We hypothesized that baseline grip strength, baseline motor impairment, and family or
friend involvement in the program would be predictive of upper limb function in sub-acute stroke. For the purpose of continuity family/friend involvement will be referred to as social support for the remainder of the study.

5.3 Methods

This prospective cohort was part of a multi-site randomized controlled trial that quantified the effect of a self-administered upper limb exercise program (GRASP) aimed at improving upper limb recovery in an inpatient setting (Harris et al. 2009). In this study, 103 participants were recruited and randomized into the GRASP protocol (n=53) and the control group which consisted of a stroke education manual (n=50). The GRASP protocol consisted of an exercise booklet and kit tailored according to motor impairment level. The booklet included range of motion, strengthening, activities of daily living, and fine motor activities. The GRASP protocol is a self-administered homework based program but supervised by a study coordinator. Activities were to be completed for 60 minutes a day, six days per week for four weeks. The participants were encouraged to include their family/friends in the GRASP protocol. Details of this study have been published elsewhere (Harris et al., 2009). For this study 50 participants randomized into the GRASP protocol will be used for the analysis as three participants withdrew and data for family involvement was not available.

Ethical approval was given by all health authorities involved and the university board of ethics. Participants were inpatients recruited from September 2006 to December 2007 from consecutive hospital admissions. The inclusion criteria were:

1. confirmed infarct or hemorrhage by a neurologist using either magnetic resonance (MRI) or computed axial tomography (CT scan),
2. presence of active scapular elevation (shoulder shrug) against gravity and palpable wrist extension (grade 1),
3. Fugl-Meyer Upper Limb Motor Impairment Scale (Fugl-Meyer et al., 1975) score between 10 and 57.

The exclusion criteria were unstable cardiovascular status, significant upper limb musculo-skeletal or neurological condition other than stroke, a Mini Mental Status Exam (Folstein et al., 1975)<20, or receptive aphasia.

5.2.1 Measures

Several measures of participant characteristics (e.g. age, type of lesion) were recorded for descriptive and comparative purposes. Measurements were taken at baseline and after the four week intervention. The four week inpatient upper limb exercise program (GRASP, n=53), significantly improved upper limb function measured by the Chedoke Arm and Hand Activity Inventory (Barreca et al., 2004) and the Motor Activity Log (Taub et al., 1993) compared to the control group (educational, n=50). Three individuals did not complete the GRASP protocol; therefore the analysis for this study used the remaining 50 participants of the GRASP group. For this secondary analysis, we examined the GRASP group post-intervention Chedoke Arm and Hand Activity Inventory and the Motor Activity Log scores as the dependent variables and entered in demographic, baseline and social support scores as the independent variables in the model.
5.2.2 Dependent Variables

The Chedoke Arm and Hand Activity Inventory-9 (CAHAI) (Barreca et al., 2006) evaluates the performance of the paretic upper limb in the completion of activities of daily living (ADL). Tasks involve use of both arms (e.g., doing up buttons, putting toothpaste on a tooth brush) as the majority of ADL tasks require bilateral arm use. Scoring is based on the percentage of contribution to each task by the paretic upper limb with higher scores meaning greater use. Strong measurement properties have been established for this measure in stroke (Barreca et al., 2005, 2006). We used the post intervention score (after the four week intervention) as the dependent variable in model 1. The Motor Activity Log-14 (MAL) (Taub et al., 1993) measures the participant’s perception of how much (Amount of Use) and how well (Quality of Movement) they use their paretic upper limb during activities of daily living (ADL). Uswatte and colleagues (2005) established satisfactory measurement properties of the MAL in individuals with stroke. We used the post intervention score on the subscale ‘Amount of use’ as the dependent variable in model 2.

5.2.3 Independent Variables

The independent variables included demographic, baseline measurements, a measure of rehabilitation intensity, and social support in the GRASP intervention. Demographics variables included: age in years, gender, mini-mental status exam, and side of lesion. Baseline impairment measurements included the Fugl-Meyer Upper limb Motor Impairment Scale and grip strength. We measured intensity of rehabilitation in total minutes of exercise completed during the four week GRASP intervention. A log sheet was provided to each participant to record the total number of minutes completed
per day. Family involvement was recorded by each of the four site coordinator involved in the GRASP study. Social support was defined as verbal encouragement, actively participating in activities with the participant and helping to organize equipment. If a family member or friend was involved a minimum of twice per week in the GRASP intervention, social support was coded as 'yes', if less than twice per week, it was coded as 'no'.

5.2.4 Analysis

Descriptive statistics, independent sample t-test, and chi-square tests were used to analyze characteristics of the sample. Visual inspection of box plots, histograms, and skewness values were used to determine variable normality and homoscedasticity.

Correlation analysis was used as the initial step required in determining the variables appropriate for inclusion in the regression analysis. Bivariate correlations were generated using Person product moment correlations for nominal data, Spearman correlation coefficient for ordinal data, and point biserial correlation was used for dichotomous variables. Entrance into the regression models required a significance of $p \leq 0.10$ in the correlation matrix between the independent and dependent variables. Scatter plots of independent against dependent variables were inspected to determine linearity and to ensure that outlier and influential data points did not compromise the results.

Multiple regression analysis was used to determine which variables best predicted post intervention scores on the Chedoke Arm and Hand Activity Inventory (model 1) and the Motor Activity Log (amount of use scale, model 2). A total of two hierarchical regression models were constructed. Order of entry of the independent
variables was determined by three factors: 1) factors found to be predictive of upper limb function in previous studies, 2) factors that are modifiable and 3) strength of correlation coefficient with the dependent variable (i.e. \( r^2 \geq 0.20 \)).

To ensure that the assumptions of multiple regression was met, scatter plots of residuals against the model data were inspected, as were tolerance values and the variance inflation factor for possible problems with outliers, influential data points, and multicollinearity (Cohen et al., 2007). 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 models were set at 0.05 and removal at 0.10. A value of \( p \leq 0.05 \) was considered significant in all calculations. SPSS statistical software, version 15, was used for all analyses.

5.3 Results

5.3.1 Participant Characteristics

Data from fifty participants was collected; 29 had social support, 21 had no support. Participant characteristics and baseline measurement scores are listed in Table 5.1. There was no significant difference between participant or outcome scores at baseline.

There was a significant difference between groups for time spent completing the GRASP program. Those with support spent a mean of 15 hours over the four week intervention compared to 10 hours for those participants without support (\( p < 0.01 \)). Additional group differences were found in favor of those participants with support on post intervention outcome scores (Table 5.2).
5.3.2 Predictive Models

Significant correlations were found between the independent variable and dependent variables (Table 5.3).

Table 5.4 shows the results of the independent variables entered into the Chedoke Arm and Hand Activity Inventory and the Motor Activity Log models. The order in which the predictor variables are presented in Table 5.4 is the order they were entered into the model. For both models the largest predictor was the Fugl-Meyer score which accounted for 16% of the variance in the Chedoke Arm and Hand Activity Inventory and 18.3% of the Motor Activity Log score. For the model predicting post intervention score on the Chedoke Arm and Hand Activity Model, baseline grip strength, rehabilitation intensity and social support all contributed significantly to the model. In this model, support accounted for 9.6% of the model variance. For the model predicting post intervention score on the Motor Activity Log, rehabilitation intensity accounted for 14.7% of the model variance and support contributed an additional 15.7%.

5.4 Discussion

This is the first study to examine if upper limb function can be predicted through regression analysis using modifiable factors among individuals with sub-acute stroke. The identification of modifiable factors of improvement in upper limb function has practical value in rehabilitation settings. This study shows that factors that are amendable to therapy can make a positive impact on the movement and use of the paretic upper limb post stroke. The main determinants were baseline Fugl-Meyer score, grip strength, rehabilitation intensity, and social support in treatment.
Our study sample consisted of individuals that at baseline included those with minimal hand function (e.g. gross grasp but no release), were able to move limb within movement synergies, but with little to no coordinated bilateral upper limb movement. This resembles other studies that have explored upper limb recovery in an inpatient population (Kwakkel et al., 2007; Suzuki et al., 2006; Canning et al., 2004; Dromerick et al., 2006). In the past, studies have used stroke and baseline characteristics to predict upper limb disability (Hashimoto et al., 2007; Smania et al., 2007; Suzuki et al., 2006; Canning et al., 2004; Tyson et al., 2008) and found they are the strongest predictors of recovery. We also found that baseline Fugl-Meyer score (taken approximately 3 weeks post stroke) was the largest contributor to the upper limb models.

Age, sex, side of stroke, and cognitive status (MMSE) were not predictive of the outcome measures used in the regression models. Findings to support the predictive nature of these variables in upper limb recovery are conflicting. Recently, Fritz and colleagues (2006) investigated sample and stroke characteristics as predictors of outcomes used in Constraint-induced movement therapy and found age was a significant factor. Conversely, Kwakkel and Kollen (2007) did not find significance for age, sex, or stroke characteristics as predictors of upper limb recovery. This suggests that a large group of individuals, regardless of personal or stroke characteristics can benefit from upper limb interventions. Though a significant correlation was found between the MMSE and the dependent variables, it was not a significant predictor in the regression models. A possible explanation could be the small range (21-30) found in our study population. More specific measures of cognition may reveal the predictive aspect of cognition on upper limb function.
Baseline grip strength of the paretic hand was found to be a significant predictor for paretic upper limb performance in daily activities (Chedoke arm and hand activity index) and for the use of the paretic upper limb outside of therapy during activities of daily living. This finding illustrates the relationship between muscle weakness and poor performance on measures of upper limb function and further demonstrates the importance of hand function post stroke. Insufficient grip strength could diminish the use of the paretic hand in performing activities of daily living, supporting our findings of the importance of paretic grip strength. The results of this study and other studies (Mercier et al., 2004; Sunderland et al., 1989; Harris et al., 2007) suggest that the remediation of paretic grip strength may be important for the recovery of activities of daily living. In addition, grip strength has been shown to be a predictor of disability (Bourdeau et al., 2008) and mortality (Rantanen et al., 2000) in older adults.

Time spent completing the GRASP protocol was a significant predictor of the Chedoke arm and hand activity inventory and the Motor activity log. Our findings indicate that the more time spent doing the prescribed activities in the GRASP protocol, the better the function at post intervention. Systematic reviews have shown that increase in therapy time has a positive effect on upper limb recovery and on measures of activity of daily living (Kwakkel et al., 2004; Van Peppen et al., 2004). Our study showed that an additional 15 hours of upper limb therapy produced significant group differences on measures of upper limb function; this is in accordance to Kwakkel and colleagues (2004) who suggested an additional 16 hours was required for improvements in lower limb outcomes. However, additional time that utilizes one on one treatment principles is not always feasible in either an inpatient or outpatient
setting. Adding supplementary upper limb activities by employing alternate means such as homework or involving family members may be required.

Social support in the GRASP protocol was a significant predictor in the models of upper limb recovery, accounting for up to 15.7% of the variance. This reveals the important contribution that support can make to rehabilitation goals and the possible link between support and recovery. The impact of support not only on paretic upper limb performance (Chedoke Arm and Hand Activity Inventory) but on use of the upper limb outside of therapy time is critical. The ultimate goal of rehabilitation is for patients to not only use their paretic limb during therapy but to transfer these skills to every day activity. Any variable that can impact this objective would be highly relevant to clinicians.

Studies have indicated the value of social and family support during and after stroke (Doble et al., 2008; Damush et al., 2007; Lynch et al., 2008; Simon et al., 2008). Support may contribute to upper limb recovery by increasing confidence, motivation, satisfaction with hospital stay, and decreasing stress and depression. Involving family in rehabilitation may help patients participate in rehabilitation activities during their hospital stay; thus increasing the probability of improvements in upper limb function and use. Furthermore, family members and or friends may feel they are contributing to the recovery of their loved ones and this may help to maintain healthy relationships during this time (Lynch et al., 2008; Simon et al., 2008).

5.4.1 Limitations

The independent contribution of exercise intensity and social support on the models of upper limb function is not clear as we did not account for an interaction effect. Those individuals that received family support did spend significantly more time
completing the GRASP protocol. However, when these variables were entered into the regression model, they independently contributed a significant amount of variance. We used self-report to measure exercise intensity and social support. This type of measurement is subject to recall bias. We attempted to control for this issue by having the site coordinator review weekly the log sheets and the involvement of family members with each participant. In addition we coded support as a dichotomous variable (0 and 1) which was arbitrary and does not account for varying degrees of involvement. We cannot define the specific aspects of social support family given or the quality of the support. We defined social support to include both passive and active aspects (e.g. encourage and participation in activities) but there may be other aspect of involvement we did not capture, for example the quality of the involvement.

5.5 Conclusion

This study found that an increase in treatment intensity and the involvement of family members and friends in upper limb treatment post stroke is predictive of improved upper limb function. Importantly, we identified variables that are amenable to rehabilitation and therefore, of practical importance to clinicians. Further studies need to identify whether social support in rehabilitation can be implemented in other environments such as outpatient and community settings.
Table 5.1: Descriptive characteristics of sample at baseline (approximately 3 weeks post stroke onset)

<table>
<thead>
<tr>
<th>Variables</th>
<th>No Social Support (n=21)</th>
<th>Social Support (n=29)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (M/F), n</td>
<td>12/7</td>
<td>16/14</td>
</tr>
<tr>
<td>Age (mean ±std)</td>
<td>65.5 (14.5)</td>
<td>71.8 (9.6)</td>
</tr>
<tr>
<td>Time since stroke (days), (mean ±std)</td>
<td>20.2 (2.3)</td>
<td>20.5 (2.0)</td>
</tr>
<tr>
<td>Side of Paresis (R/L), n</td>
<td>7/12</td>
<td>7/23</td>
</tr>
<tr>
<td>Mini Mental Status Exam (mean ±std)</td>
<td>26.0 (4.4)</td>
<td>27.0 (2.2)</td>
</tr>
<tr>
<td>Modified Ashworth Scale/4, (mean ±std)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elbow</td>
<td>1.0 (0.83)</td>
<td>0.92 (0.68)</td>
</tr>
<tr>
<td>Fugl-Meyer/66, (mean ±std)</td>
<td>38.4 (15.6)</td>
<td>39.5 (13.9)</td>
</tr>
<tr>
<td>Grip (kg), (mean ±std)</td>
<td>7.9 (7.2)</td>
<td>9.5 (8.7)</td>
</tr>
<tr>
<td>Chedoke Arm and Hand Activity Inventory/63, (mean ±std)</td>
<td>31.7 (14.5)</td>
<td>33.0 (16.3)</td>
</tr>
<tr>
<td>Motor Activity Log/5, (mean ±std)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount of Use</td>
<td>1.7 (1.3)</td>
<td>2.2 (1.1)</td>
</tr>
<tr>
<td>Variable</td>
<td>Mean(±std)</td>
<td>95% CI</td>
</tr>
<tr>
<td>----------</td>
<td>------------</td>
<td>------------</td>
</tr>
<tr>
<td>Grip</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Support</td>
<td>14.0 (8.9)</td>
<td>12.98-15.03</td>
</tr>
<tr>
<td>No support</td>
<td>12.0 (9.5)</td>
<td>11.15-12.86</td>
</tr>
<tr>
<td>CAHAI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Support</td>
<td>50.85 (13.09)</td>
<td>47.54-52.56</td>
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<tr>
<td>No support</td>
<td>47.15 (14.85)</td>
<td>44.72-49.29</td>
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<tr>
<td>MAL</td>
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<td></td>
</tr>
<tr>
<td>Support</td>
<td>3.71 (1.09)</td>
<td>3.35-3.91</td>
</tr>
<tr>
<td>No support</td>
<td>2.89 (0.99)</td>
<td>2.79-3.42</td>
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</table>
Table 5.3: Correlation of independent and dependent variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Chedoke Arm and Hand Activity Inventory</th>
<th>Motor Activity Log – amount scale</th>
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</thead>
<tbody>
<tr>
<td>Mini Mental Status Exam</td>
<td>0.280*</td>
<td>0.275*</td>
</tr>
<tr>
<td>Fugl-Meyer</td>
<td>0.712**</td>
<td>0.461**</td>
</tr>
<tr>
<td>Grip strength</td>
<td>0.648**</td>
<td>0.450**</td>
</tr>
<tr>
<td>Social Support Intensity</td>
<td>0.290*</td>
<td>0.310**</td>
</tr>
<tr>
<td>Intensity</td>
<td>0.358**</td>
<td>0.380**</td>
</tr>
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*p<0.05, **p<0.001
Table 5.4: Multiple regression models of post intervention scores on the Chedoke Arm and Hand Activity Inventory and the Motor Activity Log.

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Predictors*</th>
<th>R² change</th>
<th>Standardized Beta weight (error)</th>
<th>P value of R² change</th>
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</thead>
<tbody>
<tr>
<td>Model 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chedoke Arm</td>
<td>Fugl-Meyer</td>
<td>0.507</td>
<td>0.133(0.094)</td>
<td>0.001</td>
</tr>
<tr>
<td>and Hand Activity</td>
<td>Grip strength</td>
<td>0.187</td>
<td>-0.451(0.164)</td>
<td>0.043</td>
</tr>
<tr>
<td>Inventory</td>
<td>Intensity</td>
<td>0.351</td>
<td>0.101(0.003)</td>
<td>0.016</td>
</tr>
<tr>
<td></td>
<td>Support</td>
<td>0.411</td>
<td>0.361(2.131)</td>
<td>0.049</td>
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<tr>
<td></td>
<td>Support</td>
<td>0.507</td>
<td></td>
<td>0.016</td>
</tr>
<tr>
<td>Model 2</td>
<td></td>
<td>0.597</td>
<td>0.343(0.014)</td>
<td>0.017</td>
</tr>
<tr>
<td>Motor Activity</td>
<td>Fugl-Meyer</td>
<td>0.272</td>
<td>0.170(0.024)</td>
<td>0.051</td>
</tr>
<tr>
<td>Log</td>
<td>Grip strength</td>
<td>0.293</td>
<td>-0.307(0.001)</td>
<td>0.034</td>
</tr>
<tr>
<td></td>
<td>Intensity</td>
<td>0.440</td>
<td>0.281(0.311)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Support</td>
<td>0.597</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*listed by order of entry into regression model
Reference List


Chapter Six: Discussion and Future Direction

6.1 Overview

This thesis explored several questions related to upper limb function in adults with stroke in the sub-acute stage of recovery. In the meta-analysis, I examined the treatment effectiveness of upper limb strength training on upper limb strength and function, as well as ADL. Then, in a multi-site randomized controlled trial, I examined the effect of a self-administered graded repetitive supplementary upper limb exercise program (GRASP) on 1) upper limb function, 2) upper limb use, and 3) depressive symptoms. I also examined the determinants of improved upper limb function and use among individuals in the sub-acute stage of stroke recovery. Next I will draw research conclusions, and provide a summary of clinical implications and future research direction.

6.2 Adding Strength Training to Upper Limb Treatment May be Advantageous

The findings from chapter two confirmed our hypothesis for upper limb strength training; upper limb strength training improves grip strength and upper limb function without adding adverse outcomes but does not improve performance in ADL. Given that upper limb function did improve with strength training, it is suggested that strengthening exercises be incorporated into inpatient treatment sessions. Why upper limb strengthening does not appear to improve ADL is unclear. In the study that found improvement in ADL (Langhammer et al, 2007), the treatment intervention was comprehensive, intensive (exertion measured), and included a variety of difference methods to improve strength which included weights.
(eccentric and concentric exercises) and function based activities (balls, household items, arm cycling). Other studies may not have provided adequate intensity or task specific activities to promote ADL improvement. Often studies do not explain the type or intensity of the strength training activities. These findings led me to include strength training involving eccentric and concentric exercises, grading of intensity, and task based activities to the GRASP protocol.

Future research in the area of upper limb strengthening should focus on type and intensity of strengthening exercise. Further, incorporating strengthening into functional tasks should be explored (e.g. wrist weights while performing ADL). Research involving individuals at different stages of stroke recovery may require unique strengthening protocols that are specific to the stage of recovery, severity of motor ability, and treatment setting.

**6.3 Self-administered Homework Based Exercise programs for the Upper Limb is a Safe and Effective Treatment Delivery System.**

The multi-site randomized controlled trial was the first study to evaluate an inpatient homework based program for the upper limb in individuals with stroke. The GRASP protocol showed significant improvement in two important domains: 1) paretic upper limb function and 2) use in ADL outside of therapy time, confirming our Chapter four hypothesis. Our hypothesis for Chapter five, the GRASP protocol would reduce reports of depressive symptoms, was also confirmed. We were able to identify modifiable factors as predictors of improved upper limb function among individuals with sub-acute stroke, confirming the Chapter six hypotheses.
The GRASP protocol can be used with large percentage of individuals admitted with stroke (up to 40%) and with various degrees of motor severity (severe to mild). No adverse effects were reported during this 15 month trial, indicating the GRASP protocol is a safe method of treatment delivery. Site coordinators spent on average 45 minutes per week monitoring the GRASP group. This equals less than 10 minutes a day, an amount therapists stated is manageable in conjunction with daily client case load. Participant satisfaction and compliance with the program was high. Additionally, the cost of the equipment in each kit was relatively inexpensive (approximately $25), with the wrist weight accounting for the majority of this cost.

One of the unique aspects of the GRASP protocol is self-administration of the exercises. This type of treatment delivery system has been studied extensively in out-patient and community settings and found to be effective. Our findings expand the application of this treatment method to those in a hospital setting. It may be that self-administered exercises were not previously implemented in an in-patient setting because of the risk factors associated with stroke acuity such as fluctuating tone, shoulder capsule integrity, and sensory deficits. Our findings do not support this concern; however, each participant was assessed by the site coordinator, who was a therapist, for upper limb joint stability and sensory deficits. Subsequently, protocol adjustments were made to accommodate these deficits. It is recommended that future studies incorporate a thorough assessment of upper limb integrity prior to prescribing a self-administered program.

The GRASP protocol was based on evidence reported in Chapter One and results from the meta-analysis in Chapter Two. Upper limb treatment programs that
include repetitive practice, and graded, goal oriented activities (e.g. CIMT) improve upper limb function and use compared to facilitative approaches (e.g. Neurodevelopmental). The meta-analysis showed that strength training can improve upper limb function. From the information in Chapter One and Two, we developed a comprehensive upper limb program that included range of motion, intensive strengthening, unimanual and bimanual activities, and fine and gross motor skills. All activities were repetitive and goal oriented. The compilation of these components may have contributed to the significant improvement found. However, I cannot discount that participants also increased the amount of time spent completing upper limb activities during the four week program (35min/day). The findings from Chapter Five demonstrated that those who spent more time doing the GRASP protocol had greater upper limb function and use. Many of the studies evaluating treatment programs for the upper limb were additive not equivalency studies. This suggests that dosage is a factor in improved upper limb function and warrants further exploration.

Social involvement with the GRASP intervention proved to be a predictor of improved upper limb function and use. This aspect of the program could account for the increased amount of time participants spent doing the activities. Social support may have motivated individuals to participate in GRASP by increasing time spent with family members, decreasing time spent inactive, and providing encouragement for gains. It may have created an avenue for them to discuss the rehabilitation process fostering hope for recovery. Support may have played an important part in our findings from Chapter five of reports of less depressive symptoms in the GRASP
group. Studies have demonstrated the positive impact family support has on adherence to medical treatment and recovery from illness (DiMatteo, 2004). Additionally, spousal support was found to be a predictor of post stroke depression (Burvill et al., 1997).

Our findings support the implementation of the GRASP protocol with individuals in the sub-acute stage of stroke recovery. Future research using the GRASP protocol is suggested to evaluate its feasibility and effectiveness in different treatment settings (e.g. out-patient and community) and with individuals with other conditions (e.g. joint replacement and Parkinson’s disease). Further, tailoring the protocol in more detail to those with specific motor and or sensory deficits would be beneficial. In addition, including a measure of ADL would help to determine carry-over of gains to everyday activities.

Studying the benefits of family involvement and social support in rehabilitation is new. Individuals spend considerable time in hospital alone (Bernhardt et al., 2004) but when asked family members want to be involved in rehabilitation (Maeshima et al., 2003). Asking family to participate in rehabilitation is a viable manner to improve outcome. It may be that because family is involved, individuals spend more time doing exercises. Future research on stroke rehabilitation should include family involvement/social support as an independent variable. To delineate the specific components, evaluation of family involvement should be quantified by type (e.g. encouragement, active participation), person (e.g. spouse, child), time spent involved, and satisfaction of participant and family member.
6.4 Strengths and Limitations

Our treatment deliver method is novel and innovative. This intervention trial was multi-site including four hospitals from both rural and urban areas in British Columbia, thus a representative sample. We were able to recruit using consecutive sampling and used a robust method of randomization (computer generate, independent management). Though we were not able to blind the participants, we were able to blind the assessors which contribute to the robustness of our findings. A medium effect size (0.45) was found from our intervention trial which supports our recommendation for the implementation of this protocol. We also had a very low drop-out rate (9%) during the four week intervention.

We did not compare our treatment method to an alternative method (e.g. CIMT), thus limiting our ability to contribute all of the improvement found to the type of intervention. The retention evaluation was at three months and we had a high attrition rate. In addition, we did not have a long term evaluation (e.g. one year). Therefore, we are only able to generalize our findings to the four week period and further evaluation is required to investigate the long-term effect. The exclusion of individuals with receptive aphasia and cognitive impairment limits the applicability of GRASP to individuals with these deficits post stroke. Tailoring GRASP to those individuals with cognitive deficits is worthy of investigation. Additionally, the exclusion of individuals with aphasia produced a bias toward those with right hemisphere lesions. This may also have limited the inclusion of those with apraxia.

Though we did have a comprehensive assessment package, we did not include sensory or ADL outcomes. It is recommended that outcome measures for
these areas be incorporated in any further investigation of the GRASP protocol. As well, our evaluation of family involvement was dichotomous and did not qualify or quantify this factor. Thus we can comment on involvement is beneficial but not what type of duration of involvement is required to promote improved outcome.

6.5 **Impact on the Rehabilitation of Individuals With Stroke**

Stay in hospital post stroke has shortened, yet the expectation of the health care system and the client for recovery is the same. Innovative treatment delivery methods are required. This project has contributed significantly to the potential of dramatic change in how inpatient rehabilitation is administered. Therapists want to be able to assign a practical, effective, and safe program to their clients to increase time in rehabilitation activities and produce positive outcomes. The GRASP protocol has the potential to impact all aspects of stroke rehabilitation, including lower limb function, speech and language ability, and cognitive and perceptual skills. The possibility to extrapolate this form of treatment to out-patient and community settings is exciting. The next logical step for research is to test the protocol for 1) treatment for people who are on waitlists for rehabilitation, 2) use in community based rehabilitation including community support works, community centers, and families and 3) group treatment. Our innovative treatment method has great potential for driving new research in stroke rehabilitation and in other neurological and orthopedic conditions.
Reference List


Appendix One: Ethics Approval for the Intervention Trial From the University of British Columbia
Certificate of Full Board Approval
Clinical Research Ethics Board Official Notification

PRINCIPAL INVESTIGATOR: Eng. J.J.
DEPARTMENT: Rehabilitation Sciences
NUMBER: C05-0680

INSTITUTION(S) WHERE RESEARCH WILL BE CARRIED OUT:
Providence Health Care, Vancouver Coastal Health Authority

CO-INVESTIGATORS:
Dawson, Drew; Harris, Jocelyn, Rehabilitation Sciences; Hung, Chi hya; Miller, William, Rehabilitation Sciences

SPONSORING AGENCIES:
Canadian Institutes of Health Research

TITLE:
Effect of a Supplementary Exercise Program for Upper Extremity Function in Stroke Rehabilitation

APPROVAL DATE: 21 February 2006
TERM (YEARS): 1
DOCUMENTS INCLUDED IN THIS APPROVAL:
Protocol version 1 dated 02 December 2005; Subject Consent Form version 2 dated 10 February 2006; Letter of Initial Contact version 1 dated 02 December 2005; Questionnaires and Tests

CERTIFICATION:
In respect of clinical trials:
1. The membership of this Research Ethics Board complies with the membership requirements for Research Ethics Boards defined in Division 5 of the Food and Drug Regulations.
2. The Research Ethics Board carries out its functions in a manner consistent with Good Clinical Practices.
3. This Research Ethics Board has reviewed and approved the clinical trial protocol and informed consent form for the trial which is to be conducted by the qualified investigator named above at the specified clinical trial site. This approval and the views of this Research Ethics Board have been documented in writing.

The documentation included for the above-named project has been reviewed by the UBC C Reb, and the research study, as presented in the documentation, was found to be acceptable on ethical grounds for research involving human subjects and was approved by the UBC C Reb.

The C Reb approval for this study expires one year from the approval date.
Appendix Two: Participant Consent Form
Subject Information and Informed Consent Form

The effect of additional programs for upper extremity function in stroke rehabilitation

Principal Investigator: Dr. Janice Eng, PhD PT/OT
Co-Investigator: Dr. William Miller, PhD, OT
Co-investigator: Dr. Drew Dawson

Contact number for study information and questions: 604-714-4108

Introduction:
We are investigating the effects of arm treatment programs on arm function of individuals who have had a stroke. You have been invited to participate in this study because you are having difficulty using the arm that was affected by the stroke.

Your Participation is Voluntary:
Your participation is voluntary, it is up to you to decide whether or not to take part in this study. This consent form will tell you about the study, why the research is being done, what will happen to you during the study and the possible benefits and risks. If you wish to participate, you will be asked to sign this form. If you decide to take part in this study, you are still free to withdraw at any time and without giving any reason.
If you do not wish to participate you will not lose the benefit of any medical care to which you are entitled or are presently receiving.

Background and purpose:
Monitoring of arm progress and increased arm exercise time following a stroke can improve arm function. The purpose of this study is to compare two arm programs to see if they improve arm function. The programs are provided in addition to your usual arm care. One program is a standardized progress evaluation and the other is progress evaluation and an additional hour of arm practice.

Who can participate in this study?
- Have been admitted to a hospital unit for stroke treatment
- 19 years or older
- Are experiencing difficulty using your arm
- Able to understand and follow instructions
Who should not participate in this study?
- If you have the following condition you are ineligible to participate in the study.
- Have uncontrolled high blood pressure or unstable cardio-vascular condition
- Injuries to muscles, bones, ligaments, tendons, or joints of the arm
- Unable to verbally speak or understand the investigators when asked questions

What the Study Involves:
The study will take place at the hospital where you are doing your rehabilitation. One hundred and twenty persons with stroke will be recruited for this study.

Arm Function Tests:
All subjects will complete an evaluation with a therapist which measures how you use your affected arm in activities (e.g. buttoning a shirt, pouring water into a cup, opening a jar) and muscle strength of both arms. In addition, a questionnaire about your well-being will be done. The evaluation will take about 90 minutes.

Determining which group you will participate in:
Your involvement in the study depends on the group which you are assigned to by chance (like the flip of a coin). You have an equal chance to be in the 'progress evaluation program' or 'progress evaluation and additional exercise program'. Once you have been assigned to a group please do not tell the person testing your arm or other people in the study which group you are in.

Description of study programs:
You will receive the usual care provided by the rehabilitation centre that you are attending. In addition, you will receive one of the following programs:

Progress evaluation and education program:
In the hospital you will be attending your usual sessions with either physiotherapy, occupational therapy or both. In addition, your progress will be monitored by an occupational therapist who will measure your arm ability using standardized measures when you are admitted and discharged from the rehabilitation centre and 3 months after you are discharged. You will also be given information about your stroke, arm recovery after stroke, ways you can decrease your chances of pain, joint stiffness, and decreased arm movement. The therapist will provide you with information about techniques to help increase the communication between your brain and your arm and give you homework so you can practice these techniques. The therapists will review that homework with you and answer questions. This program will last for 4 weeks.

Progress evaluation and additional arm exercise group:
In the hospital you will be attending your usual sessions with either physiotherapy, occupational therapy or both. In addition, your progress will be monitored by an occupational therapist who will measure your arm ability when you are admitted and discharged from the rehabilitation centre and 3 months after you are discharged.
Lastly, you will do an extra 60 minutes of arm exercises. The 60 minutes will consist of two 30 minute sessions spread out during the day.

During these sessions you will do range of motion exercises, strengthening, gripping, reaching, bilateral exercises (using both hands), and daily activities (buttons, zippers, folding clothes).

The program will be designed with you by a therapist and will be monitored on a weekly basis. At the beginning you will do the program with a therapist but eventually you will do the program either by yourself or with the help of a family member.

**Time Commitment for the Study:**
Progress evaluation program: 3 testing session at 90 minutes per session = 4.5 hours.
Progress evaluation and additional exercise program: 3 testing session at 90 minutes per session plus approximately 30 hours of additional exercise during your hospital stay = 34.5 hours.

**Risks:**
There is a chance you may feel tired or have some muscle soreness from the measurement or exercise sessions. This is usually gone in a few days.

**Benefits:**
Both groups have the potential to improve arm movement and independence in daily activities. The progress evaluation will provide additional information to clinicians so they can better prescribe your arm treatment. The additional arm exercise may improve arm strength and coordination.

**New Information Available that may Affect Your Decision to Participate:**
If there is new information that may affect your willingness to be in the study, you will be advised of this information.

**If You Withdraw Your Consent to Participate:**
Your participation in this research is entirely voluntary. If you decide to enter the study and withdraw, there will be no penalty and your medical care will not be affected.
The study investigators may decide to stop the study, or withdraw you from the study if they feel that it is in your best interest. If you choose to withdraw, all data collected about you will be retained for analysis. By law, this data cannot be destroyed.

**Alternatives to the Study Program:**
During the study you will be participating in usual care stroke rehabilitation.
If Something Goes Wrong:
In case of an emergency, please report to the medical staff on your unit. If something goes wrong, you do not waive your legal rights by signing the consent form.

After the Study is Complete:
Once the study is completed and the data are analyzed, you will be sent a report on your arm function.

Your Cost to Participate:
In order to defray the costs of transportation for the testing that will occur after discharge, you will receive an honorarium in the amount of $50.00. This will be paid at the end of your last test session, 3 months after discharge.

Confidentiality:
Your confidentiality will be respected. No information that shows your identity will be released or published without your specific consent. Research 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. No records that identify you by name or initial will be allowed to leave the Investigators’ offices.

Contact:
If you have any questions with respect to this study or during participation, you can contact Dr. Janice Eng or one of her associates at (604) 714-4108. 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 University of British Columbia Office of Research Services” at 604-822-8598.

Consent to Participate:
This is not a contract and I understand that I do not give up any legal rights by signing it. By signing the form I am indicating that:
- I have read and understood the subject information and consent form.
- I have had the opportunity to ask questions and have had satisfactory responses.
- I understand that all the information collected will be kept confidential and that the results will only be used for scientific objectives.
- I understand that my participation in this study is voluntary and I am free to refuse to participate or withdraw at any time without changing the quality of care that I receive.
- I understand I am not waiving any legal rights as a result of signing this consent form.
- I have read this form and I freely consent to participate in this study.
- I have been told that I will receive a dated and signed copy of this form.
<table>
<thead>
<tr>
<th>Printed Name of Subject</th>
<th>Subject Signature</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Printed Name of Witness</td>
<td>Witness Signature</td>
<td>Date</td>
</tr>
<tr>
<td>Printed Name of Principal Investigator/Designated Representative</td>
<td>Signature of Principal Investigator/Designated Representative</td>
<td>Date</td>
</tr>
</tbody>
</table>
Appendix Three: Site Coordinator Manual
WELCOME TO THE GRASP STUDY

I want to take this opportunity to thank you for your time and commitment to this project. In this binder you will find all you need to know about the GRASP study. We hope that the video tapes provide will also assist in your learning of the project protocols.

1. Introduction to the GRASP study
2. Initial contact protocol/forms/assessments – Tips Sheet
3. Randomization procedure
4. Protocol for Exercise Subjects
5. Protocol for Education Subjects
6. Exercise Manuals – Tips Sheet for Grading
7. Education Modules
8. Discharge Protocol/Forms
9. Literature
10. Miscellaneous Forms

The information is organized with colored tabs for easy access to each section.

Please note: At this time it is not recommended to show the GRASP study video or protocol binder to therapists working on the rehabilitation unit. It is important that usual care continue during this study and not be influenced by the project protocols. After the study has been completed we will be more than willing to share the information to all interested therapists.

At no time should you need to photocopy any information. If you need more copies of forms or have any question, comments, concerns please contact me at:

Jocelyn Harris
604-737-6310 (GF Strong Lab)
Purpose of the GRASP study

The purpose of the GRASP study is to determine if a homework based upper limb exercise program is feasible in an inpatient setting.

The rationale for this study comes from recent literature that suggests that the upper limb requires an additional one hour of therapy per day for at least 4 weeks to improve upper limb performance in activities of daily living. Some of the treatment techniques in the GRASP study are based on recent studies that suggest that increased repetition, though not always functional, does produce beneficial results for upper limb performance.

The study is being conducted on 4 rehabilitation units: GF Strong Rehab Center, Holy Family Hospital, Kelowna General Hospital, and Victoria General Hospital. At each site is a coordinator who is responsible for the recruitment of subjects, teaching and monitoring the study programs, arranging appointments for the site assessor, and communicating with the study coordinator. At each site there is a site assessor whose responsibility it is to assess each subject in the study pre treatment start, post treatment, and 3 months from hospital discharge. The plan is for each site to enroll 50 subjects within one year of start date.

As the study coordinator I am responsible for making sure training is adequate and complete for both the site coordinators and assessors, fostering open communication with all parties involved, monitoring of site recruitment and implementation of study guidelines, and making sure adequate supplies are available when required.

You are an integral part of this study and your participation is key to its success.
Tips on How to Explain the Study

1. First off explain you are helping to conduct a research study about arm recovery after stroke, and would they be interested in hearing more.

2. One of the main things is to explain that there are two groups in the study; one being the arm exercise program and one being the education program. The important thing to communicate is that the subject could be in either group.

3. Explain the randomization process as being like the ‘flip of a coin,’ they have an equal chance of being in either group.

4. When explaining about the two different groups it is important that they do not know that the education group is the control group. Describe it as being a study onto itself. For example: “We have two treatment groups we are studying for this project, one involves education and the other exercises. The education study has various topics on stroke, arm recovery after stroke, bone health, and healthy lifestyle. The exercise study is focused on increasing the amount of exercise you do for your weaker arm and hand. For the exercise study you will be taught the exercises by me but then you will do them as homework for the rest of the week. I will check on you each week and see how you are doing. You have an equal chance of being in either group. Do you think you would like to be involved?”

5. They may start to ask more questions about the study and please go ahead and answer them. I think it is important to let them know if they choose to be involved that it is for 4 weeks, that there will be testing involved, and follow-up testing 3 months from discharge.

6. If they are interested, go over the Consent Form with them. Ask them if they have any questions, would they like to take the time to read it and sign it now, or would they like to read it later and you will pick it up the next day you are in?

7. Once the Consent Form is signed, it needs to be photocopied and the copied version given to them. At this time you will do the randomization and let them know what group they are in. Once you know the group assignment, you can set up the assessment appointment and your first treatment visit.
# Protocol Checklist

This checklist is to be done for each potential subject in the study, even if the subject is not eventually enrolled in the study. If the person looks eligible from chart review and or team meeting proceed to initial contact.

## Initial Contact

<table>
<thead>
<tr>
<th>Contacted between 72 hours and 14 days of admission to unit. If not contacted within the specified time please indicate the time from admission to rehab unit to first contact:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approach and explain project</td>
</tr>
<tr>
<td>Assess visible paretic wrist extension - it can be very slight (approx 5°) to qualify</td>
</tr>
<tr>
<td>Fugl-Meyer Motor Assessment Scale (need a score between 10-58)</td>
</tr>
<tr>
<td>Complete Screening Tests:</td>
</tr>
<tr>
<td>List of Chronic Diseases</td>
</tr>
<tr>
<td>Mini Mental Status Examination</td>
</tr>
<tr>
<td>Modified Ashworth Scale</td>
</tr>
<tr>
<td>Consent form given (subject has a maximum of 24 hours to review)</td>
</tr>
<tr>
<td>Consent form signed – bring two copies, they sign both and keep one</td>
</tr>
</tbody>
</table>

## Randomization

| Subject randomized - done on computer |
| Subject code and treatment group assignment will be given by computer |
| Did subject agree to participate in randomized group? If NO please provide the explanation: |
| If the subject is in the exercise group please given them the GRASP pamphlet. |
| Make appointment for testing. Inform site assessor of test subject name, code, and time of assessment by email. |
| Proceed to initial visit. Try to have the subject assessed within 48 hours of your initial visit (starting the treatment program). |

## Eligibility Criteria

| Age 19 and older |
| Treatment goal concerning upper limb recovery |
| Fugl-Meyer score between 10-58 |

## Exclusion Criteria

| Receptive aphasia |
| Other neurological conditions (indicated through the List of Chronic Conditions) |
| Mini Mental score of less than 20 (can make allowances for language barriers) |
Please find enclosed:

List of Chronic Diseases
Mini Mental Status Examination
Fugl-Meyer Motor Assessment Scale – Upper limb portion
Modified Ashworth Scale
Pain Analogue Scale
List of Chronic Conditions

From the Canadian Community Health Survey

I’d like to ask about certain chronic health conditions which you may have. We are interested in ‘long term conditions’ that have lasted or are expected to last 6 months or more and that have been diagnosed by a health professional.

Do you currently have: 

Please tick ✓

1. Arthritis
   - Rheumatoid arthritis
   - Osteoarthritis

2. Osteoporosis

3. Chronic obstructive pulmonary disease? (COPD) or any lung disease
   Specify:__________________

4. Heart disease?

5. Cancer?

6. Parkinson’s disease?

7. Multiple Sclerosis?

8. Huntington’s Disease

9. Amyotrophic Lateral Sclerosis (ALS)

Note: If the participant has any of the following, MS, ALS, PD, Huntington’s, or previous fixed contractures, they are not eligible for the study.
The Folstein Mini-Mental Status Examination (MMSE)

Score 1 for every correct answer:

1. What year is it?    
2. What season are we in?    
3. What month are we in?    
4. What is today’s date?    
5. What day of the week is it?    
6. What country are we in?    
7. What province are we in?    
8. What city are we in?    
9. What hospital are we in?    
10. What floor of the hospital are we on?    

Name three objects (“Ball,” “Car,” “Man”). Take a second to pronounce each word. Then ask the patient to repeat all 3 words. Take into account only correct answers given on the first try. Repeat these steps until the subject learns all the words.

11. Ball?    
12. Car?    
13. Man?    

Either “please spell the word WORLD and now spell it backwards” or “Please count from 100 subtracting 7 every time”

14. “D” or 93    
15. “L” or 86    
16. “R” or 79    
17. “O” or 72    
18. “W” or 65
What were the 3 words I asked you to remember earlier?

Show the subject a pen and ask: “Could you name this object?”
22. Pen.

Show the subject your watch and ask: “Could you name this object?”
23. Watch

Listen and repeat after me:
24. “No ifs, ands, or buts.”

Put a sheet of paper on the desk and show it while saying: “Listen carefully and do as I say.”
25. Take the sheet with your left/right (unaffected) hand.
26. Fold it in half.
27. Put in on the floor.

Show the patient the visual instruction page directing him/her to “CLOSE YOUR EYES” and say:
28. Do what is written on this page.

Give the subject a blank sheet and a pen and ask:
29. Write or say a complete sentence of your choice.

Give the patient the geometric design page and ask:
30. Could you please copy this drawing?

**Total Score: (/30)  ____**
# Fugl Meyer Upper Extremity Motor Assessment

<table>
<thead>
<tr>
<th>Test</th>
<th>Scoring Criteria</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reflexes</strong></td>
<td>Position: Biceps – extension  Triceps - flexion</td>
<td></td>
</tr>
<tr>
<td>Biceps</td>
<td>0 - no reflex</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 - reflex elicited</td>
<td></td>
</tr>
<tr>
<td>Triceps</td>
<td>Note: If the person has active elbow flexion/extension you can skip this test.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Score 2</td>
<td>2</td>
</tr>
<tr>
<td><strong>Flexor Synergy</strong></td>
<td><strong>Movement:</strong> Bring arm fully supinated to the ear of the affected side, the</td>
<td></td>
</tr>
<tr>
<td></td>
<td>elbow is fully flexed, the shoulder abducted to at least 90, externally</td>
<td></td>
</tr>
<tr>
<td></td>
<td>rotated, retracted and elevated.</td>
<td></td>
</tr>
<tr>
<td>Elevation</td>
<td>0 - cannot be performed</td>
<td>2</td>
</tr>
<tr>
<td>Retraction</td>
<td>1 – performed partly</td>
<td></td>
</tr>
<tr>
<td>Abduction (at least 90)</td>
<td>2 – performed faultlessly</td>
<td>2</td>
</tr>
<tr>
<td>External Rotation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elbow Flexion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forearm Supination</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Extensor Synergy</strong></td>
<td><strong>Movement:</strong> Adduct/internally rotate the shoulder, fully extend the elbow</td>
<td></td>
</tr>
<tr>
<td></td>
<td>towards the unaffected knee, forearm should be pronated.</td>
<td></td>
</tr>
<tr>
<td>Adduction/Intern. Rotation</td>
<td>0 - cannot be performed</td>
<td>2</td>
</tr>
<tr>
<td>Elbow Extension</td>
<td>1 - performed partly</td>
<td>2</td>
</tr>
<tr>
<td>Forearm Pronation</td>
<td>2 - performed faultlessly</td>
<td>2</td>
</tr>
<tr>
<td><strong>Mixing Synergies</strong></td>
<td>Hand to Lumbar spine</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0 - No specific action performed</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>1 - Hand passes anterior superior i liac spine</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 - Action is performed faultlessly</td>
<td></td>
</tr>
<tr>
<td>Shoulder Flexion to 90, elbow</td>
<td><strong>Movement:</strong> The elbow must be fully extended throughout the ROM, the forearm</td>
<td></td>
</tr>
<tr>
<td>at 0</td>
<td>in mid-position between pronation and supination.</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>0 - Arm immediately abducted or elbow flexes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 - Abduction or elbow flexion occurs late in motion</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 - Faultless motion</td>
<td></td>
</tr>
<tr>
<td>Pronation/Supination of forearm</td>
<td>0 - Incorrect position and/or no pronation/supination</td>
<td></td>
</tr>
<tr>
<td>with elbow at 90 and shoulder at</td>
<td>1 - Correct position with minimal pronation/supination</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>2 - Correct position and complete pronation and supination</td>
<td>2</td>
</tr>
<tr>
<td><strong>IV Out of Synergy</strong></td>
<td>Shoulder abduction to 90, elbow full extended to 0, forearm pronated</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0 - Initial elbow flexion or deviation from pronated forearm</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>1 - Motion performed partly or if during motion elbow is flexed or</td>
<td></td>
</tr>
<tr>
<td></td>
<td>forearm not kept in pronation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 - Faultless motion</td>
<td></td>
</tr>
<tr>
<td>Shoulder flexion from 90 - 180,</td>
<td>0 - Initial flexion of elbow or shoulder abduction</td>
<td></td>
</tr>
<tr>
<td>elbow at 0, and forearm in</td>
<td>1 - Elbow flexion or shoulder abduction</td>
<td>2</td>
</tr>
<tr>
<td>pronated</td>
<td>2 - Faultless motion</td>
<td></td>
</tr>
<tr>
<td>Pronation/Supination of</td>
<td><strong>Movement:</strong> The shoulder must be kept in a flexed position between 30-90 (not</td>
<td></td>
</tr>
<tr>
<td>forearm, elbow at 0, and</td>
<td>more than 90), elbow fully extended at 0</td>
<td></td>
</tr>
<tr>
<td>shoulder between 30 - 90 of</td>
<td>0 - Supination/Pronation not possible or elbow and shoulder</td>
<td></td>
</tr>
<tr>
<td>flexion</td>
<td>position cannot be attained</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 - Elbow and shoulder properly positioned, pron/supin limited</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 - Faultless motion</td>
<td>2</td>
</tr>
<tr>
<td><strong>V Normal Reflex Activity</strong></td>
<td><em><strong>Only evaluated if stage IV has a score of 6</strong></em></td>
<td></td>
</tr>
<tr>
<td>Biceps and/or finger flexors and</td>
<td>0 - at least 2 of the 3 reflexes are hyperactive</td>
<td>2</td>
</tr>
<tr>
<td>#</td>
<td>Description</td>
<td>Movement/Details</td>
</tr>
<tr>
<td>----</td>
<td>-----------------------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td><strong>V1 Wrist</strong></td>
<td><strong>Movement 1</strong>: Shoulder at 0, elbow at 90, forearm fully pronated, wrist at 15 of extension. If the person cannot actively attain elbow flexion to 90, you can place them in the required position. Once the position has been attained you exert some force to see if they can resist against it. 0 - Cannot extend wrist to required 15 1 – Extension is accomplished, but no resistance is taken 2 - Position can be maintained with some resistance</td>
</tr>
<tr>
<td></td>
<td>M1: Shoulder 0, elbow 90, wrist 15 extension, forearm pronated</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M2: Full wrist extension/flexion</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M3: Shoulder 30, elbow 0, wrist 15 extension, forearm pronated</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M4: Full wrist extension/flexion</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td><strong>Movement 2</strong>: Same position as above, but have the person move between full flexion/extension of the wrist. No resistance tested. 0 – volitional movement do not occur 1- cannot actively move through the range total range but can through partial 2 – full active range</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Movement 3</strong>: Shoulder at 30 of flexion, elbow at 0 extension, the forearm pronated. (If needed, you can support the person in this position). Wrist at 15 of extension. Resistance tested. 0 - Cannot extend wrist to required 15 1 – Extension is accomplished, but no resistance is taken 2 - Position can be maintained with some resistance</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Movement 4</strong>: Same position as above but have the person move between full flexion/extension of the wrist. No resistance tested. 0 – volitional movement do not occur 1- cannot actively move through the range total range but can through partial 2 – full active range</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Circumduction</td>
<td>0 - Cannot be performed 1 - Jerky or incomplete circumduction 2 - Complete motion with smoothness</td>
</tr>
<tr>
<td>3</td>
<td><strong>VII Hand</strong></td>
<td><strong>Finger mass flexion – make a fist</strong> 0 - No flexion occurs 1 - Some flexion, but not full motion 2 - Complete active flexion (compared with unaffected hand)</td>
</tr>
<tr>
<td></td>
<td><strong>Finger Mass Extension – extend the fist</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>MP joints fully extended, PIPs &amp; DIPs fully flexed. Test resistance by pulling against DIP and PIP joints</strong></td>
<td>0 - Required position cannot be performed 1 - Grasp is weak 2 - Grasp maintained against reasonable resistance</td>
</tr>
<tr>
<td></td>
<td><strong>M1: Adduct thumb with IP &amp; MP at 0</strong></td>
<td><strong>Movement 1</strong>: Fully adduct thumb with IP and MP at 0. Place a piece of paper between thumb and 2nd digit MCP for resistance</td>
</tr>
</tbody>
</table>
### M2: Thumb oppose to index finger -

**Movement 2**: Thumb opposed to index finger – place paper between thumb and index finger for resistance testing.

<table>
<thead>
<tr>
<th>Grasp can</th>
<th>0 - Function cannot be performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grasp tennis ball</td>
<td>1 - Paper (can, ball) can be held in place but not against a tug</td>
</tr>
<tr>
<td></td>
<td>2 - Paper (can, ball) is held against tug</td>
</tr>
</tbody>
</table>

### Co-ordination/Speed

**Movement for the next 3 items: Finger to Nose Test**

You will do this with the unaffected hand first to time them, then with the affected hand. Please demonstrate.

**Instruction**: Take the index finger of your stronger hand and place it about 12’ from your nose, then touch your nose with the index finder of your weaker hand. I want you to move your finger from your nose to your index finger, back and forth 5 times. Do this as fast as you can. You will do this with your eyes closed.

<table>
<thead>
<tr>
<th>Tremor - Finger to nose</th>
<th>0 - Marked tremor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 - Slight tremor</td>
</tr>
<tr>
<td></td>
<td>2 - No tremor</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dysmetria - Finger to nose</th>
<th>0 - Pronounced or unsystematic dysmetria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 - Slight or pronounced dysmetria</td>
</tr>
<tr>
<td></td>
<td>2 - No dysmetria</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Speed - Finger to nose</th>
<th>0 - More than 6 seconds longer than unaffected hand</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 - 2 - 5 seconds longer</td>
</tr>
<tr>
<td></td>
<td>2 - less than 2 seconds</td>
</tr>
</tbody>
</table>

### Total

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>66</strong></td>
</tr>
</tbody>
</table>
**FSS Questionnaire**

Please read each statement and circle a number from 1 to 7, depending on how appropriate you feel the statement applies to you over the past week.

A low value indicates that the statement is not very appropriate whereas a high value indicates agreement:

1: Strongly Disagree                      7: Strongly Agree

<table>
<thead>
<tr>
<th>During the past week, I have found that:</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. My motivation is lower when I am fatigued.</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>2. Exercise brings on my fatigue.</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>3. I am easily fatigued.</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>4. Fatigue interferes with my physical functioning.</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>5. Fatigue causes frequent problems for me.</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>6. My fatigue prevents sustained physical functioning.</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>7. Fatigue interferes with carrying out certain duties and responsibilities.</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>8. Fatigue is among my three most disabling symptoms.</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>9. Fatigue interferes with my work, family, or social life.</td>
<td>1 2 3 4 5 6 7</td>
</tr>
</tbody>
</table>
GRASP Study Survey

Please circle the program you were in: EDUCATION EXERCISE

1. Did you like the program?

   1  2  3  4  5
   Not at all  A little bit  Satisfactory  Good  Excellent

2. Did you find the program easy to follow?

   1  2  3  4  5
   Very difficult  A bit difficult  Satisfactory  Fairly easy  Very easy

3. Did you find the program helped you?

   1  2  3  4  5
   Not at all  A little bit  Satisfactory  Helpful  Very helpful

4. Would you recommend this program to others?

   Yes  No

5. Additional comments:

_________________________________________________________________
_________________________________________________________________
_________________________________________________________________
## Protocol for Exercise Group Visits

| First Visit  | 1. Explain the purpose of the study  
|             | 2. Explain the benefits of the study  
|             | 3. Explain what is expected of them  
|             | a) not to give the exercises to others  
|             | b) keep the equipment out of the way  
|             | c) exercises are to be done daily  
|             | d) do all exercises  
|             | e) exercise either for one 60 minute period or two 30 minute periods  
|             | f) importance of continuing regular therapy (OT/PT/SLP/Rec)  
|             | g) importance of writing down any questions, problems  
|             | 4. Show them the protocol binder (exercises, log sheet, and forms)  
|             | 5. Show them how to do each exercise  
|             | 6. Do each exercise with them  
|             | 7. Assign the appropriate grade of sets.  
|             | 8. Show them how to fill out the log sheet and pain analogue forms  
|             | 9. Let them know when you will see them again  
|             | Document on the sheet provided the level they are starting at.  
|             | 1. Explain the purpose of the study  
|             | 2. Explain the benefits of the study  
|             | 3. Explain what is expected of them  
|             | a) not to give the exercises to others  
|             | b) keep the equipment out of the way  
|             | c) exercises are to be done daily  
|             | d) do all exercises  
|             | e) exercise either for one 60 minute period or two 30 minute periods  
|             | f) importance of continuing regular therapy (OT/PT/SLP/Rec)  
|             | g) importance of writing down any questions, problems  
|             | 4. Show them the protocol binder (exercises, log sheet, and forms)  
|             | 5. Show them how to do each exercise  
|             | 6. Do each exercise with them  
|             | 7. Assign the appropriate grade of sets.  
|             | 8. Show them how to fill out the log sheet and pain analogue forms  
|             | 9. Let them know when you will see them again  
|           | 1. Observe 3 exercises (choose one from range of motion, one from strength, and one functional task)  
|           | 2. Check log sheets and pain analogue scale  
|           | 3. Make any adjustments to the exercises or grading.  
| Second Visit | 1. Have them demonstrate the protocol exercises to you (i.e. you observe their exercise session)  
|             | 2. Make any adjustments needed to exercises or grading  
|             | 3. Check to see if log sheets and pain analogue scale is done  
|             | 4. Let them know when you will see them again  
|         | This visit will occur the next day you are in for the study  
| Third visit | 1. Observe 3 exercises (you can pick any you want)  
|           | 2. Check log sheets and pain analogue scale  
|           | 3. Make any adjustments to exercises or grading.  
|         | Next time you are in  
| The first 3 visits would ideally occur within the first 10 days of enrollment | 
| Fourth visit | 1. Observe 3 exercises (choose one from range of motion, one from strength, and one functional task)  
|             | 2. Check log sheets and pain analogue scale  
|             | 3. Make any adjustments to the exercises or grading.  
|         | This visit will occur during the 3rd week  
| Fifth visit  | 1. Observe 3 exercises (choose one from range of motion, one from strength, and one functional task)  
|             | 2. Check log sheets and pain analogue scale  
|             | 3. Make any adjustments to the exercises or grading  
|         | This visit will occur during the 3rd week  
|           | 
|           |
| **Sixth visit**  
(about 15 minutes)  
This visit will occur during the 4th week | 1. Observe 3 exercises (choose one from range of motion, one from strength, and one functional task)  
2. Check log sheets and pain analogue scale  
3. Make any adjustments to the exercises or grading. |
| **Last visit**  
(about 30 minutes)  
This visit needs to happen before the person is discharged | 1. Explain that they can keep the equipment and binder  
2. Do not give them an upgraded protocol  
3. Explain the importance of continuing the exercises at home  
4. Discharge interview (see discharge checklist)  
5. Document on the sheet provided the level they ended the program at. |
Grading Protocol

To try and ensure that all grading of exercises is standardized please follow the guidelines outlined below.
Once you have assigned the appropriate exercise manual to the subject note the following:

1. Each manual has graded exercises within them. For example strengthening exercises start at 2 sets of 5 (Level 1) and then increase to 3 sets of 5 etc.
2. When you introduce the exercise manual to the subject (i.e. when you do the exercises with them on the first visit), assess them at the first grade. For example, if using Level 1 manual, the first grade is 2 sets of 5.
3. If they have no problem with that grade level, start them at the second grade level for their independent work. For example, if using Level 1 and the subject had no difficult with 2 sets of 5, you would have them start at 3 sets of 5.
4. There is room at each appropriate exercise for you to check off the box identifying the required sets of exercise repetition.
5. On your second visit (i.e. when you have them do all the exercises for you) if the subject is having no difficult with the grade (i.e. 3 sets of 5) then raise it to the next grade, 2 sets of 8.
6. Once the subject can do the final grade for the majority of the exercises (over 50%), the next Exercise Manual Level should be given.
7. If the subject is all ready on Manual 3, you can increase the sets and repetitions to 2 sets of 12, then 3 sets of 12. Stop at this level of grading.
Additional Tips for Modifying Exercises

1. Some individuals may need a pillow behind their back to maintain an upright position.
2. A pillow on their seat may help elevate them to an appropriate height for the target board exercises.
3. For those individuals with shoulder pain, you can decrease the repetitions and or encourage only partial range, and or encourage more rest breaks.
4. For those individuals with tone, you can decrease the repetitions, decrease the weight (only do anti-gravity), have them rotate between doing the exercise with their non-paretic and paretic arm, encourage more rest breaks, and stretching.
5. For those with high tone in the hand and wrist, you could modify the gripping exercises by using a ball instead of the gripper, using a gripper with less resistance, or even have them open and close their hand making a fist and focusing on extension.
6. For those individuals that are using major compensatory movements (i.e. shoulder hiking, shoulder abduction etc for reaching) you can have them do the exercises in front of a mirror to encourage proper movement.
7. If there are exercises in Manual 2 and or 3 that you feel your Level 1 or Level 2 subject can do please add it to their routine at the lowest set level (i.e. 2 sets of 5, then 3 sets of 5 etc).

Please note: The focus of this study is not to limit movement if the person is unable to do the movement properly. It is important that they are encouraged to keep moving their paretic arm as best they can. Improper movement should not be the cause of omitting an exercise.
## Protocol for Education Group

<table>
<thead>
<tr>
<th>First Visit</th>
<th>45 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Explain the purpose of the information</td>
<td></td>
</tr>
<tr>
<td>2. Explain the benefits of this information</td>
<td></td>
</tr>
<tr>
<td>3. Explain what is expected of them</td>
<td></td>
</tr>
<tr>
<td>a) to read the information</td>
<td></td>
</tr>
<tr>
<td>b) complete the homework given</td>
<td></td>
</tr>
<tr>
<td>c) importance of writing down any questions, comments</td>
<td></td>
</tr>
<tr>
<td>4. Show them the protocol binder (i.e. information sheets, question sheets to complete each week</td>
<td></td>
</tr>
<tr>
<td>5. Go over Module One</td>
<td></td>
</tr>
<tr>
<td>6. Give them the homework for that week.</td>
<td></td>
</tr>
<tr>
<td>7. Let them know when you will see them again</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Second Visit</th>
<th>(30 minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>This visit will occur in week 2</td>
<td></td>
</tr>
<tr>
<td>1. Go over the previous visits educational material - review</td>
<td></td>
</tr>
<tr>
<td>2. Go over homework</td>
<td></td>
</tr>
<tr>
<td>3. Go over Module Two</td>
<td></td>
</tr>
<tr>
<td>4. Assign next batch of homework</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Third visit</th>
<th>(30 minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>This visit will occur in week 3</td>
<td></td>
</tr>
<tr>
<td>1. Review last week’s educational material</td>
<td></td>
</tr>
<tr>
<td>2. Go over homework</td>
<td></td>
</tr>
<tr>
<td>3. Go over Module Three</td>
<td></td>
</tr>
<tr>
<td>4. Assign next batch of homework</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fourth visit</th>
<th>(30 minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>This visit will occur in week 4</td>
<td></td>
</tr>
<tr>
<td>1. Review last week’s educational material</td>
<td></td>
</tr>
<tr>
<td>2. Go over homework</td>
<td></td>
</tr>
<tr>
<td>3. Go over Module Four</td>
<td></td>
</tr>
<tr>
<td>4. Assign next batch of homework</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fifth visit</th>
<th>(30 minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Review last week’s educational material</td>
<td></td>
</tr>
<tr>
<td>2. Go over homework</td>
<td></td>
</tr>
<tr>
<td>3. Discharge interview</td>
<td></td>
</tr>
</tbody>
</table>
Appendix Four: Site Assessor Manual
Please find enclosed the following assessments:

- Edinburgh Handedness Inventory
- Star Cancellation Test
- Clinical Epidemiology Study - Depression Scale (CES-D)
- Grip Strength
- Chedoke Arm and Hand Activity Inventory (CAHAI)
- Action Research Arm Test (ARAT)
- Motor Activity Log (MAL)
- Medical Outcomes Survey Short Form (SF-12)
**Edinburgh Handedness Inventory**

Please indicate your preferences in the use of hands in the following activities by putting a + in the appropriate column. Where the preference is so strong that you would never try to use the other hand unless forced to, put ++. If in any case you are really indifferent put a + in both columns.

Some of the activities require both hands. In these cases the part of the task, or object, for which hand preference is wanted is indicated in brackets.

Please try to answer all the questions, and only leave a blank if you have no experience at all of the object or task.

<table>
<thead>
<tr>
<th></th>
<th>Left</th>
<th>Right</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Writing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Drawing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Throwing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Scissors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Toothbrush</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Knife (without fork)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Spoon</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Broom (upper hand)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Striking match (match)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Opening box (lid)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

i Which foot do you prefer to kick with?

ii Which eye do you use when using only one?
Star Cancellation Test

Instructions:
Please tell participant to cross out, with a black pen, all the small stars across the page.
Demonstrate by crossing out 2 of the center small stars.
Grip Strength Test: Jamar Dynamometer

**Instructions:**
The Jamar grip handle should be adjusted so that it is resting between the MCP and PIP joints of the participant. The individual should be able to flex their DIP joints around the handle. For women this position is usually set at notch 2 (starting from closest to the dial) and for men notch 3. Have the person sit in chair. With shoulder at 0°, elbow at 90°, wrist between 0°-30° dorsiflexion and 0°-15° ulnar deviation. Start with the non-paretic hand and rotate between the non-paretic and the paretic until you have assessed each 3x.

State the following before assessing grip strength:
“I want you to hold the handle like this (demonstrate) and squeeze as hard as you can for 3 seconds. Then I’m going to say ready, set, go. Ready. Set. Go. Squeeze. Relax.”

Record each score in **kgs** below. Make sure to zero the dial after each trial.

<table>
<thead>
<tr>
<th>NON-PARECTIC (R   L)</th>
<th>PARECTIC (R   L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trail 1________</td>
<td>Trial 1________</td>
</tr>
<tr>
<td>Trial 2________</td>
<td>Trial 2________</td>
</tr>
<tr>
<td>Trial 3________</td>
<td>Trial 3________</td>
</tr>
</tbody>
</table>

Mean________     Mean________
Action Research Arm Test:

Only assess the affected arm

Instructions: Subtests are ordered in such a way that if the person scores 3 on item one (the most difficult) the person is credited with having scored 3 on all items of the subtest. You don’t have to test the remaining subtest items.

If the person scores less than 3 on item one, then item two is administered. Item two is the easiest item in each of the subtests and if the person scores 0, then he/she is given a 0 for the remaining subtests. Move to the next subtest.

If the person scores less than 3 on item one and more than 0 on item two, all items in the subtest must be administered.

Scoring Scale:
3: Performs test normally
2: Completes test, but takes abnormally long time or has great difficulty
1: Performs test partially
0: Can perform no part of test

Test 1: Subtest Grasp: Lift objects listed onto shelf (37.5 cm high and placed a distance of 43cm from the subject)

Instructions: I want you to pick-up the object in front of you and lift it from the table onto the shelf in front of you.

1. Block 10cm  
   (if score = 3, total = 18  
   go to Grip test)  
   Left  
   Right
   _____  
   _____

2. Block 2.5cm  
   (if score = 0, rest = 0  
   go to Grip test)  
   _____  
   _____

3. Block 5cm
4. Block 7.5cm
5. Ball 7.5cm
6. Stone

194
### Test 2: Subtest Grip:

<table>
<thead>
<tr>
<th>Task</th>
<th>Left</th>
<th>Right</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pour water glass to glass</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>(if score = 3, total = 12 go to Pinch test)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Move the 2.25cm tube a distance of 43cm</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>(if score = 0, total is 0 go to Pinch test)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Move the 1cm tube as above</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>4. Put washer over a bolt</td>
<td>_____</td>
<td>_____</td>
</tr>
</tbody>
</table>

### Subtest 3: Pinch

**Instructions:** I want you to pick up the ball bearing or marble in the manner I tell you and lift it from the table onto the shelf in front of you.

<table>
<thead>
<tr>
<th>Task</th>
<th>Left</th>
<th>Right</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ball bearing of 6mm picked up between third finger and thumb</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>(if score = 3, total = 18 go to Gross movement test)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Marble picked up between first finger and thumb</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>(if score =0, rest = 0, go to Gross movement test)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Ball bearing 6mm picked up between second finger and thumb</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>4. Ball bearing of 6mm picked up between first finger and thumb</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>5. Marble picked up between third finger and thumb</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>6. Marble picked up between second finger and thumb</td>
<td>_____</td>
<td>_____</td>
</tr>
</tbody>
</table>
### Subtest 4: Gross Movement:

<table>
<thead>
<tr>
<th></th>
<th>Left</th>
<th>Right</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Place hand behind head (if score = 3, total = 9 if score = 0, total = 0)</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>2. Place hand on top of head</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>3. Touch mouth with hand</td>
<td>_____</td>
<td>_____</td>
</tr>
</tbody>
</table>

**Total score for ARAT**: _____/57
Motor Activity Log 14

Instructions:
Explain to the participant that this test looks at how much they use their affected arm in 14 daily activities. First ask the participant if they have used the affected arm to help accomplish the activity in question over the last week. If they did not use the affected arm for that activity because it was impossible (i.e. comb hair – but the person is bald), then the item is considered not applicable and dropped from the test. If they state they just did not use it but for no reason then they would score a ‘0’. After they have stated a score on the Amount of Use Scale, explain that they need to rate the quality of the movement of the affected arm during the activity in question.

If they did not do the activity in the past week, ask why and indicate on the form in the space provided.

1. Hold a book
   ____ Amount
   ____ Quality
   ____ Did not do in the past week. Explanation: _________________________________.

2. Use a towel to dry shelf
   ____ Amount
   ____ Quality
   ____ Did not do in the past week. Explanation _________________________________.

3. Pick up a glass
   ____ Amount
   ____ Quality
   ____ Did not do in the past week. Explanation _________________________________.

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4. Brush teeth
   ___ Amount
   ___ Quality
   ___ Did not do in the past week. Explanation ________________________________.

5. Shave/Put on Make-up
   ___ Amount
   ___ Quality
   ___ Did not do in the past week. Explanation ________________________________.

6. Open door with a key
   ___ Amount
   ___ Quality
   ___ Did not do in the past week. Explanation ________________________________.

7. Write/type
   ___ Amount
   ___ Quality
   ___ Did not do in the past week. Explanation ________________________________.

8. Steady self
   ___ Amount
   ___ Quality
   ___ Did not do in the past week. Explanation ________________________________.
9. Put arm through clothing
   ____ Amount
   ____ Quality
   ____ Did not do in the past week. Explanation ________________________________.

10. Carry object
    ____ Amount
    ____ Quality
    ____ Did not do in the past week. Explanation ________________________________.

11. Grasp fork/spoon
    ____ Amount
    ____ Quality
    ____ Did not do in the past week. Explanation ________________________________.

12. Comb hair
    ____ Amount
    ____ Quality
    ____ Did not do in the past week. Explanation ________________________________.

13. Pick up cup
    ____ Amount
    ____ Quality
    ____ Did not do in the past week. Explanation ________________________________.
14. Button clothes

____ Amount

____ Quality

____ Did not do in the past week. Explanation ________________________________.
Chedoke Arm and Hand Activity Inventory

**General Instructions for Administering the CAHAI**

The purpose of this measure is to evaluate the functional ability of the hemiplegic arm and hand to perform tasks that have been identified as important by stroke survivors. It is NOT designed to measure the client’s ability to complete the task using only their unaffected hand, but rather to encourage bilateral function.

Explain to your clients that some tasks are difficult and they should not get frustrated if unable to complete all the tasks. Encourage them to give their best effort using BOTH arms and hands. *The client may attempt each task twice.*

When attempting each task, always consider safety, especially for Stage I upper limb.

**Standard starting position**

**Posture:** seated in chair without armrests or in wheelchair with armrests removed, encourage erect posture, feet flat on the floor  
**Height of table:** at the level of the last costal rib  
**Distance from table:** client’s elbow comes to the table edge  
**Hands:** resting on the table

Variations from the standard starting position will be indicated at the top of the task page.
DESCRIPTION OF THE LEVELS OF FUNCTION FOR THE ACTIVITY SCALE

7 COMPLETE INDEPENDENCE - All of the tasks are performed safely, without modification, assistive devices or aids, and within reasonable time.

6 MODIFIED INDEPENDENCE - Activity requires any one or more of the following: an assistive device, more than reasonable time, or there are safety (risk) considerations.

5 SUPERVISION - The client requires no more help than standby, cueing or coaxing, without physical contact. A helper sets up needed items or applies orthoses.

4 MINIMAL ASSISTANCE - With physical contact the client requires no more than touching, and client expends 75% or more of the effort.

3 MODERATE ASSISTANCE - Weak limb manipulates and stabilizes during the task. The client requires more help than touching, or expends half (50%) or more (up to 74%) of the effort.

2 MAXIMAL ASSISTANCE - Weak limb stabilizes during task. The client expends less than 50% of the effort, but at least 25%.

1 TOTAL ASSISTANCE - The client expends less than 25% of the effort.
Score 6 if more than reasonable time is required. (e.g. more than 3 times the normal time is required)
Score 6 if assistive devices (e.g. built up handles, dycem, cock-up/ dynamic splints) are used
Score 6 if there are safety concerns in doing upper limb tasks (e.g. impulsivity, balance, poor motor control)
Score 5 if you need to cue throughout the clients' second attempt of the task
Score 4 if client touches table very briefly
Score 3 if client continually uses table for support
Score 1 if client uses only one arm/hand
Score 1 if two people are required to assist in completing task
Score 1 if you feel it is unsafe to try the task.
# Chedoke Arm and Hand Activity Inventory: Score Form

## CAHAI-9 Version

## Activity Scale

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

## Affected Limb: Score

<table>
<thead>
<tr>
<th>Activity</th>
<th>Affected Limb</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Open jar of coffee</td>
<td>holds jar</td>
<td></td>
</tr>
<tr>
<td>2. Call 911</td>
<td>Holds receiver</td>
<td></td>
</tr>
<tr>
<td>3. Draw a line with a ruler</td>
<td>holds ruler</td>
<td></td>
</tr>
<tr>
<td>4. Pour a glass of water</td>
<td>holds glass</td>
<td></td>
</tr>
<tr>
<td>5. Wring out washcloth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Do up five buttons</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Dry back with towel</td>
<td>reaches for towel</td>
<td></td>
</tr>
<tr>
<td>8. Put toothpaste on toothbrush</td>
<td>holds toothpaste</td>
<td></td>
</tr>
<tr>
<td>9. Cut medium resistance putty</td>
<td>holds knife</td>
<td></td>
</tr>
</tbody>
</table>

**Total Score**

63
The Medical Outcomes Survey Short Form

Instructions:
The following questions will ask you about your health and how it affects your day to day activities. Please answer each question as best as you can.

1. In general, would you say your health is excellent, very good, good, fair, or poor?
   - Excellent
   - Very good
   - Good
   - Fair
   - Poor

2. The following items are about activities you might do during a typical day. Does your health now limit you in these activities? If so, how much?
   First, moderate activities such as moving a table, pushing a vacuum cleaner, bowling or playing golf. Does your health now limit you a lot, limit you a little, or not limit you at all.
   - Limited a lot
   - Limited a little
   - Not limited at all

3. Climbing several flights of stairs. Does your health now limit you a lot, limit you a little, or not limit you at all?
   - Limited a lot
   - Limited a little
   - Not limited at all

4. During the past 4 weeks, have you accomplished less than you would like as a result of your physical health?
   - No
   - Yes
5. During the past 4 weeks, were you limited in the kind of work or other regular activities you do as a result of your physical health?
   - No
   - Yes

6. During the past 4 weeks, have you accomplished less than you would like to as a result of any emotional problems, such as feeling depressed or anxious?
   - No
   - Yes

7. During the past 4 weeks, did you not do work or other regular activities as carefully as usual as a result of any emotional problems such as feeling depressed or anxious?
   - No
   - Yes

8. During the past 4 weeks, how much did pain interfere with your normal work, including both work outside the home and housework? Did it interfere not at all, slightly, moderately, quite a bit, or extremely?
   - Not at all
   - Slightly
   - Moderately
   - Quite a bit
   - Extremely

9. These questions are about how you feel and how things have been with you during the past 4 weeks. For each question, please give the one answer that comes closest to the way you have been feeling.

   How much time during the past 4 weeks have you felt calm and peaceful? All of the time, most of the time, a good bit of the time some of the time, a little of the time, or none of the time?
   - All of the time
   - Most of the time
   - A good bit of the time
   - Some of the time
   - A little of the time
   - None of the time
10. How much of the time during the past 4 weeks did you have a lot of energy? All of the time, most of the time, a good bit of the time, some of the time, a little of the time, or none of the time?
   - All of the time
   - Most of the time
   - A good bit of the time
   - Some of the time
   - A little of the time
   - None of the time

11. How much of the time during the past 4 weeks have you felt down? All of the time, most of the time, a good bit of the time, some of the time, a little of the time, or none of the time?
   - All of the time
   - Most of the time
   - A good bit of the time
   - Some of the time
   - A little of the time
   - None of the time

12. During the past 4 weeks, how much of the time has your physical health or emotional problems interfered with your social activities like visiting with friends, relatives etc? All of the time, most of the time, a good bit of the time, some of the time, a little of the time, or none of the time?
   - All of the time
   - Most of the time
   - A good bit of the time
   - Some of the time
   - A little of the time
   - None of the time
**Motor Activity Log 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 pre stroke).

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

5 – Used my weaker arm as much as before the stroke (same as pre stroke).
How Well Scale

0 – The weaker arm was not used at all.

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).
### CES-D

Below is a list of the ways you might have felt or behaved. Please tell us how often you have felt this way during the past week.

*Rarely or none of the time = less than 1 day
Some or a little = 1-2 days
Occasionally = 3-4 days
Most or all of the time*

<table>
<thead>
<tr>
<th></th>
<th>Rarely or not at all</th>
<th>Some or a little</th>
<th>Occasionally</th>
<th>Most or all the time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I was bothered by things that usually don’t bother me.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>I did not feel like eating; my appetite was poor.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>I felt that I could not shake off the blues even with help from my friends and family.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>I felt that I was just as good as other people.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>I had trouble keeping my mind on what I was doing.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>I felt depressed.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>I felt that everything I did was an effort.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>I felt hopeful about the future</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>I thought my life had been a failure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>I felt fearful</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>My sleep was restless.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>I was happy.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>I talked less than usual.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>I felt lonely.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>People were unfriendly.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>I enjoyed life.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>I had crying spells.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>I felt sad.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>I felt that people disliked me.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>I could not get “going.”</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Discharge Protocol

### Discharge Assessment

1. After you have completed the post assessment make an appointment for their 3 month follow-up assessment.
2. Fill out the 3 month follow-up test sheet and give it to them.
3. Tell them they will get a phone call 2 weeks prior to the appointment to remind them.
4. Let them know that they will be paid for their involvement in the study at the 3 month appointment.

**Note:** You have been given courier envelopes, self addressed, to mail the completed assessments every 2 months. You can coordinator mailing with the site coordinator if you wish.
Appendix Five: Equipment Required for GRASP
<table>
<thead>
<tr>
<th>Level One</th>
<th>Level Two</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wrist weight - 0.5-1lb</td>
<td>Wrist weight – 1-2lbs</td>
</tr>
<tr>
<td>Tennis ball</td>
<td>Tennis ball</td>
</tr>
<tr>
<td>Bean bag</td>
<td>Hand gripper – 10-15 lb resistance</td>
</tr>
<tr>
<td>Hand gripper – 5lb resistance</td>
<td>Theraputty – orange or green</td>
</tr>
<tr>
<td>Theraputty – yellow or orange</td>
<td>Knife and fork</td>
</tr>
<tr>
<td>Target board</td>
<td>Target board</td>
</tr>
<tr>
<td>Cup</td>
<td>2 cups</td>
</tr>
<tr>
<td>Towel</td>
<td>Towel</td>
</tr>
<tr>
<td></td>
<td>Own button up shirt</td>
</tr>
<tr>
<td></td>
<td>Large clothes pins - 10</td>
</tr>
<tr>
<td></td>
<td>Large Lego blocks - 10</td>
</tr>
<tr>
<td></td>
<td>Wooden blocks - 10</td>
</tr>
<tr>
<td></td>
<td>Popsicle sticks - 10</td>
</tr>
<tr>
<td></td>
<td>Paper clips - 10</td>
</tr>
<tr>
<td></td>
<td>Plastic jar with twist off lid</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Level Three</td>
<td></td>
</tr>
<tr>
<td>Wrist weight - 1lb-2lb</td>
<td></td>
</tr>
<tr>
<td>Tennis ball</td>
<td></td>
</tr>
<tr>
<td>Hand gripper – 10-15lb resistance</td>
<td></td>
</tr>
<tr>
<td>Theraputty – orange or green</td>
<td></td>
</tr>
<tr>
<td>Knife and fork</td>
<td></td>
</tr>
<tr>
<td>Target board</td>
<td></td>
</tr>
<tr>
<td>2 Cups</td>
<td></td>
</tr>
<tr>
<td>Towel</td>
<td></td>
</tr>
<tr>
<td>Own button shirt</td>
<td></td>
</tr>
<tr>
<td>Small clothes pins</td>
<td></td>
</tr>
<tr>
<td>Regular size Lego blocks</td>
<td></td>
</tr>
<tr>
<td>Wooden blocks (squares)</td>
<td></td>
</tr>
<tr>
<td>Popsicle sticks</td>
<td></td>
</tr>
<tr>
<td>Paper clips</td>
<td></td>
</tr>
<tr>
<td>Jar with twist off lid</td>
<td></td>
</tr>
<tr>
<td>Poker chips - 10</td>
<td></td>
</tr>
</tbody>
</table>

---

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Welcome to the Grasp study!

Thank you for volunteering your time for this program. The educational material provided in this manual has been designed specifically for people who have had a stroke.

Education is an important part of the Heart and Stroke Foundations’ best practice guidelines for stroke rehabilitation. There are a lot of benefits from educational material. Most of the information provided for you is about your weaker arm (the one affected by the stroke). Research has shown that education about arm recovery after stroke can:

- Improve your knowledge about how to move and position your arm properly
- Improve your ability to use your weaker arm in daily activities
- Improve the range of movement in your arm, and
- Decrease pain in your weaker arm

The study therapist (she or he is called the site coordinator) will explain the purpose of the educational material and the homework. Each week you will be given new information and asked to read it and answer questions about the information.
Remember this is a HOMEWORK based program so YOU are responsible for reading the material and answering the questions.

We are asking you to do about 20 minutes of reading and 10 minutes of homework each week.

We want to encourage your family to learn the material with you. Here are some ways they can be involved:

- read each weeks information together
- remind you to read and do the homework
- help you practice the suggestions, and
- help encourage and motivate!

We think you will enjoy this program and we welcome any questions or concerns.

Have fun!
Education Module One

Focus is on:
1. The brain and stroke,
2. The anatomy of your arm, and
3. Proper arm positioning
Section 1: Your brain and stroke

How does my brain work?

Your brain is made up of billions of nerve cells. It controls everything you think, feel, and do. The brain is divided into regions that control different body functions, like:
- Movement
- Speech
- Balance

**Left Side**
The *left side* of your brain controls the movement and senses on the right side of your body. It also controls your ability to:
- Read
- Talk
- Think
- Do arithmetic

**Right Side**
The *right side* of your brain controls the movement and senses on the left side of your body. It also controls your:
- Creativity
- Ability to enjoy music and art
- Ability to recognize people and objects
How does my brain get what it needs?

Your brain needs a constant supply of fuel in the form of oxygen and nutrients to work properly. The heart pumps blood, which contains oxygen and nutrients, to the brain through blood vessels called arteries.

Four main arteries carry blood through your neck to your brain. The main arteries branch out in a network of smaller and smaller arteries. Each artery supplies blood to specific areas of the brain. Some areas of the brain are supplied by more than one artery.

What is a stroke?

A stroke is a sudden loss of brain function. It can be caused by 2 things:

1. The rupture of blood vessels in the brain (aneurysm/hemorrhage).
2. The interruption of the flow of blood to the brain (embolism).
If an artery supplying blood to the brain bursts or becomes blocked and part of the brain supplied by that artery becomes permanently damaged, this is called a stroke.

The interruption of the blood flow or the rupture of blood vessels causes brain cells (neurons) in the affected area to die. The effects of a stroke depend upon where the brain was injured, as well as how much damage occurred.

Because the brain controls everything we say, do and think, a stroke can have a wide variety of effects. A stroke can affect your:

- Ability to move and coordinate movement
- Ability to feel: touch, temperature, pain and movement
- Ability to see or to interpret what you see
- Ability to think, to remember, understand, plan reason, or problem-solve
- Ability to communicate (speaking and understanding speech, as well as reading, writing and the ability to do mathematics)
- Personality
- Emotions
- Behavior
Section 2: Anatomy of your arm

A stroke can affect arm function for many individuals. For this reason, we have included some information about the bones and muscles in your arm in this section. Later, we will explain how a stroke can cause pain in your arm and give you some ideas on how to effectively deal with your pain.

Shoulder Anatomy

The shoulder complex is made up of three bones, which are connected by muscles, ligaments, and tendons. The shoulder joint is the most mobile joint in the body.

**Bones**

- *Humerus* (the large bone in the upper arm)
- *Scapula* (the shoulder blade)
- *Clavicle* (the shoulder blade)

**Ligaments**

Ligaments are like strong ropes that help connect bones and provide stability to joints.

The shoulder joint is surrounded by a large, loose "bag" called a capsule. The capsule has to be large and loose to allow for the many movements of the shoulder.

**Tendons** connect muscles to bone.

**Muscles**

There are about 15 muscles that help to move the shoulder. It is the muscles that move the shoulder and provide stability to the shoulder (help it remain still) when other parts of the arm and or body are moving. For example when you are lifting something, some muscles help your lift the bag while others keep the shoulder in close to your body so your shoulder won't get pulled downward.
Section 3: Proper arm positioning

Proper positioning of your weaker arm and hand after a stroke is very important. As you learned in the anatomy section, you have many bones, tendons, and muscles in your arm and hand. After a stroke these muscles etc may not be working as well as before your stroke. This can change the way your arm moves and looks. Your arm needs to be put in positions that will increase movement and decrease any pain you may have.

The therapists you are working with in the hospital will go over proper positioning of your arm when you are in bed and when sitting. The information we are providing to you is the same and you can take it home to practice proper positioning there.

Later in the manual you will learn more ways to increase movement of your arm and to prevent arm pain. Shoulder pain is common after a stroke. Proper positioning and handling of your shoulder can help decrease your chances of pain.

The three goals of proper positioning of your arm and hand after a stroke is:

1. To increase and or maintain arm movement,
2. To decrease swelling of the wrist and hand, and
3. To decrease arm pain

The next few pages will cover:

- Position in bed lying on your back
- Position in bed lying on your weaker side
- Position in bed lying on your stronger side
- Position in a chair/wheelchair
Positioning In a Chair or wheelchair

➤ Make sure your hand and arm are supported on the pillow or wheelchair tray.
➤ Try and maintain a position that keeps your arm away from your body.
➤ Always watch where your hand is – it should be on the pillow or wheelchair tray.

➤ At a table, place your arms on top of the table. This will help with range of motion and keep your arm where you can see it.

What not to do
Homework for Module One

Circle your answers

1. Do you have problems moving your arm and hand?  YES  NO

2. Do you think the problem with movement is because of the:
   a) brain
   b) bones
   c) muscles,
   d) all of them?

Discuss this further with your research coordinator.

3. What are some of the things you can do to increase the movement of your weaker arm?
   a) Going to daily therapy,
   b) Positioning your arm correctly,
   c) Not moving your arm,
   d) Only moving your arm when it does not hurt

4. What type of stroke did you have?
   a) Hemorrhage (bleeding)
   b) Ischemic (blockage)
   c) Thrombosis (reduced blood to area of the brain)

5. What area(s) of the brain did your stroke affect?
   a) movement
   b) sensation
   c) talking
   d) reading
   e) problem-solving
   f) other ____________________________
Education Module Two

Bone Health
Why is bone health important for people who have had a stroke?

Recent research has shown:

- fractures are the most significant problem after a stroke
- these fractures can be from a decrease in bone strength after a stroke
- the side of the body that was affected by the stroke has a greater decrease in bone strength than the side that was not affected,
- the decrease in bone strength is related to the non-use of the weaker arm and or leg
- both men and women are at risk for a decrease in bone strength after stroke
Stroke and Osteoporosis

- The incidence of osteoporosis is higher in those people who have a stroke compared to the rest of the population. This is because the bones of your affected side lose strength very quickly.
- Due to the physical effects of a stroke (e.g., muscle weakness, poor balance), people who have had a stroke fall more often than people who have not had a stroke.
- Because of weaker bones and higher likelihood of falling, people who have had a stroke are up to 4 times more likely than the rest of the population to sustain a hip fracture.

- But, osteoporosis can be prevented. People who have osteoporosis are able to increase their bone density by changing things like their diet and lifestyle.

- Therefore, early detection of bone loss is important for preventing fractures. This booklet is designed to help you assess your risk of osteoporosis so that you may take action.
Step 1: Understanding the Risk Factors for Osteoporosis

What is a ‘Risk Factor’?

- Something that increases your chances of developing a disease for either lifestyle or hereditary reasons. There are two kinds of risk factors:

1. **Lifestyle ‘Risk Factors’**
   - Things you choose to do and therefore it can be changed or modified.

   ➢ Examples of lifestyle ‘Risk Factors’ for osteoporosis:

   - Smoking
   - Eating a poor diet
   - Drinking too much coffee or alcohol
   - Living a sedentary lifestyle
   - Living a high stress lifestyle

2. **Hereditary ‘Risk Factors’**
   - Things you are born with and these things cannot be changed. What you can do is be aware of these risk factors and include healthy practices into your lifestyle.

   ➢ Examples of hereditary ‘Risk Factors’ for osteoporosis:

   - A family history of osteoporosis
   - Being Caucasian or Asian
   - Being a woman
   - Having an early natural menopause before age 45
Calcium Supplements – Do I need one?

How much calcium do I need daily?

- Women over the age of 50 or past menopause need 1 000 – 1200 mg of calcium daily. Do not exceed 2500 mg.
- Women with osteopenia (the beginning of osteoporosis) and osteoporosis need 1 500 mg of calcium daily.

Which Calcium Supplement is the best?

It depends on your needs. Ask your doctor what would be best for you.

Are there any side effects from Calcium?

Large amounts of calcium can cause bloating and constipation. You can decrease these side effects by increasing your fluid, dietary fiber, and physical activity.

Vitamin D: A key factor in good calcium absorption

Vitamin D increases calcium absorption by as much as 80%. You can get Vitamin D from exposure to sunlight. Just 15 minutes of summer sun will enhance Vitamin D production.

To make up for our lack of sunlight in the winter months, eat food such as milk, eggs, salmon, mackerel, swordfish, and fish oils (halibut and cod liver oils).

May people who take calcium supplements also take Vitamin D supplements. Ask your doctor about Vitamin D and calcium.

Exercise works with calcium to build stronger bones

We cannot tell the whole calcium story without mentioning the role of physical activity in maintaining health bones. Exercise has a beneficial effect on your bones because it helps form new bone.
Education Module Three

Nutrition and Healthy Eating
Homework for Module Three

1. A test to determine your nutritional health

2. A one day food log

You will find these two activities on the following pages.

A recent study found that a diet high in fish oils, whole grains, fruit, vegetables, and low in cholesterol and fat reduced the risk of stroke and heart attack by 60%.
Education Module Four

Tips for a Healthy Lifestyle
After a stroke it can be hard to get back into your daily routine; after all things have changed. Here are some tips on how to get more out of your day and to enjoy what you are doing.

Take a moment to...

1. Set priorities

Decide, for you, what is...
- Urgent (must be done today)
- Important (must be done in the next few days)
- For later (must be done this week or month)
- Perhaps never (keep the big picture in mind)

But!

Make sure you are balancing your life and making time for all your activities – self-care, household duties, maintenance, family, friends, leisure, and exercise.

2. Plan

Plan ahead

- distribute heavy tasks over several days
- alternate light and heavy tasks
- alternate active and quiet tasks (e.g. vacuuming and paying bills)
Identify your energy boosters (activities or people that give you energy) and plan time for them each day. Identify what time of day you have the most energy and plan to do more strenuous things then.

Plan your week ahead of time; maybe Sunday night. If you find you have too many urgent tasks, and not enough balance, then re-think your priorities, share or pass some tasks on to others, and learn to say “NO” without feeling guilty.

3. Pace

What’s the rush?

Be realistic:

- Time yourself doing things. Get an idea of how long things take. You may find they take longer than you thought.
- Cut your “to do” list in half until you know your speed.
- Build in time to discuss and problem solve with others, and for unanticipated interruptions, mistakes, or distractions.
- It takes less time to do a job right the first time then to do it over again. Take the time needed to do a good job.

If you are anticipating a heavy day, build in time before and after for some rest and relaxation. Your mind and body cannot run at high speed all the time...prolonged stress leads to serious health problems. Listen to your body’s signals!

4. Position

Your environment and how you stand/sit (position) yourself can make a difference. You have already learned about the importance of proper positioning.

- Minimize noise, clutter, and use lights that are neither too bright nor too dim.
- Avoid awkward positions and practice proper lifting techniques (back straight, knees bend, elbows in).
- Make sure your work area is at the right height and your body is supported (like sitting in a chair to cut vegetables, or fix your bird feeder).
Identify your energy boosters (activities or people that give you energy) and plan time for them each day. Identify what time of day you have the most energy and plan to do more strenuous things then.

Plan your week ahead of time; maybe Sunday night. If you find you have too many urgent tasks, and not enough balance, then re-think your priorities, share or pass some tasks on to others, and learn to say "NO" without feeling guilty.

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- Avoid awkward positions and practice proper lifting techniques (back straight, knees bend, elbows in).
- Make sure your work area is at the right height and your body is supported (like sitting in a chair to cut vegetables, or fix your bird feeder).
Arrange items to close together

- For example, having a laundry basket on a chair near the ironing board containing items to be ironed, and a rack on the other side of the board for hanging clothing would provide a suitable sequence for energy conservation.

Avoid rushing

- Don’t waste your energy by panicking. Things that must get done will get done and more often, these things can wait.
- During times of stress, take time to relax. In other words, take a break! Play your favorite music, read, or call someone who makes you laugh. If you have pets, spend time with them.

Don’t be afraid to ask for help

- Don’t be afraid to ask for help so that you may accomplish some of the more difficult tasks that require too much energy. People are usually very happy and willing to help.
- We all need help from one another from time to time. Keep in mind that you are important to your friends and family and there is no inconvenience in helping a loved one.

Transporting items safely:

- Use a cart, wagon, or basket to gather work items
- Slide pots from the sink to stove, use a cart or table on wheels to transport items
- If you must carry an object, use both hands if you can and carry it close to your body

Use correct equipment

- Use tools that fit the job
- Use lightweight equipment (e.g., cookware, vacuum, iron, etc.)
- Use electrically powered equipment (e.g., mixer, electric can opener, battery-powered screwdriver, etc.)
Appendix Seven: Excerpts from Exercise Manual Level 2 (Fugl-Meyer 26-45)
GRASP

Graded Repetitive Arm Supplementary Program

Exercise manual

Level 2

This research project is funded by UBC and the Heart and Stroke Foundation
Welcome to the Grasp study!

Thank you for volunteering your time for this program. The exercises that you will do have been designed specifically for you.

There are lots of benefits to doing these exercises. Research has shown that adding 20 more hours of arm therapy during your hospital stay can:

- Strengthen your weaker arm
- Improve the range of motion of your weaker arm
- Improve your ability to use your weaker arm in daily activities
- Decrease pain in your weaker arm, and
- Improve life satisfaction

The study therapist (she or he is called the site coordinator) will help you learn the exercise program and check on your progress regularly. The study therapist will not be doing the exercises with you on a daily basis. Remember this is a HOMEWORK based program so YOU are responsible for doing your exercises daily. We hope that your family and friends will support and help you with your exercise program.
We are asking you to do 1 hour of prescribed exercises 7 days a week. You can divide the exercises up into 2 – 30 minute sessions if you want.

You are encouraged to continue these exercises once you are discharged from the hospital. You will be able to take home the equipment and the manual. We will be calling you to find out how you are doing at home.

We ask that you please check off the exercises that you complete each day on the Log Sheet in your exercise book.

Safety

Please tell your site coordinator as soon as possible if

- pain stops you from doing your exercises
- you feel so tired after doing your exercises that you cannot participant fully in your regular daily therapy,

Remember that this program has been designed especially for your arm ability. This means that you should NOT share your program or exercise kit with
other patients. Please understand that if you do share your program, you will be asked to return your exercise kit and will no longer be involved in the study.

We want to encourage your family to do the exercise program with you. Here are some ways they can be involved:

- some exercises can be done with a partner (these exercises are identified in this manual)
- help organize the exercise equipment for quick changes between exercises
- help put exercise equipment away after each exercise is done
- help keep track of the exercises on the daily Log Sheet
- and most of all help encourage and motivate!

We think you will enjoy this program and we welcome any questions or concerns.

Have fun! 😊
The Twist

- Make sure your back is touching the back of the chair for the whole exercise.
- Clasp your hands together and pull forward until you feel a stretch through your back.

- Turn your body to the left. Hold for a count of 3.
- Turn your body to the right. Hold for a count of 3.

- Repeat 5 times for each side.
Hand and Wrist Stretch

- Place your palms together.
- Push the left hand against the right.
- Hold for a count of 3.
- Push the right hand against the left.
- Hold for a count of 3.
- Repeat 5 times for each side.

• If you cannot put your hands together, make a fist with your weaker hand and place your stronger hand over.
Chair-ups

- Sit in a chair with both your hands on the arm rests.
- Using your arms NOT your legs, push your body upwards so that your bottom comes off the chair.
- Hold for a count of 3.
- Lower yourself for a count of 3.

- 3 sets of 5 repetitions
- 2 sets of 8 repetitions
- 3 sets of 8 repetitions

Put as much weight as can through your arms NOT YOUR LEGS when pushing up.
TIPS

The following exercises are for increasing arm strength. If you feel like your arm is tired or stiffing up (hard to move) try the following:

1. take a rest break of 30 seconds between exercises
2. rotate between doing the exercise on your weaker and stronger arm
3. do the exercise without the weight
Shoulder Exercises: Arm to the Front

- Place the weight around your weaker wrist or palm
- Raise your arm up as high as you can but no higher than your shoulder, for a count of 3.
- Lower your arm down for a count of 3.

- 3 sets of 5 repetitions
- 2 sets of 8 repetitions
- 3 sets of 8 repetitions
Wrist Exercises – Part 1

- Put the weight around the fingers and knuckles of your weaker hand.
- Put your forearm on the table palm facing down.
- Stabilize your weaker arm with your stronger hand.
- Lift your wrist as high as you can for a count of 3.
- Lower your wrist down for a count of 3.

- 3 sets of 5 repetitions
- 2 sets of 8 repetitions
- 3 sets of 8 repetitions
Grip Power

- Place your weaker arm on the table.
- Place the gripper in your palm between your knuckles and your thumb pad.
- Squeeze the gripper as hard as you can for a count of 3.
- Relax your hand for a count of 3.

- 3 sets of 5 repetitions
- 2 sets of 8 repetitions
- 3 sets of 8 repetitions
- 2 sets of 10 repetitions

Focus on opening your hand
Finger Power

- Place the putty on the table and roll into a thick rope.

- Take each finger of your weaker hand, starting with your thumb, and push into the putty.

- After you finish all 5 fingers, take a 30 second break. Then repeat two more times.
Cutting

- Take the putty and flatten it on the table.
- Take the knife and fork, as you would usually do, and cut the putty into 4 evenly shaped pieces.
- Re-shape into a pancake and

□ 1 set of 3 repetitions
□ _____________________
Waiter – Ball

- Place the ball in your weaker hand.
- Place the ball on the 1st dot. Leave the ball on the dot and place your weaker hand in your lap.
- Then reach with your weaker hand to pick up the ball and place the ball on the 2nd dot. Continue this pattern until you have placed the ball on each dot.
- Once you have finished the arc, start at dot 5 and retrace your steps.
- Repeat 3 times.
- Then, repeat as fast as you can 2 times!
Advanced Waiter

- Place the target board on the ground about 6” in front of your chair.
- Place the ball in your weaker hand.
- Hold on to the arm rest with your stronger hand and lean forward.
- Place the ball on dot 1 - now sit upright with back against chair.
- Lean forward and pick up the ball placing it on dot 2, sit up. Repeat this process for each dot.
- Repeat 3 times.

If at any time you feel dizzy STOP and rest for 1 minute. Try again but if you continue to feel dizzy go to next exercise.
Pouring

- Place two cups on the table, one half full of water.

- Hold the empty cup with your stronger hand, pick up the cup with water with your weaker hand.

- Pour the water into the empty cup. Pour back and forth 20 times.
Start the ball rolling with a partner

- Sit at each end of the long side of the table
- Roll or push the ball back and forth with your weaker hand
- Roll the ball between you so each person catches the ball 10 times
- Now do it as fast as you can 10 times.
Start the ball rolling
No partner

- Place your hands shoulder width apart.
- Roll or push the ball back and forth between your hands
- Continue until you have caught the ball with your weaker hand 20 times

If this is easy for you try rolling the ball faster or placing your hands further apart

If this is hard for you, use the bean bag instead of the ball.
Drop and Catch

- Place the ball in your stronger hand.

- Raise this arm as high as you can but not higher than your shoulder.

- Place your weaker hand on the table.

- Drop the ball and try and catch it with your weaker hand.

- Repeat 10 times

- Then switch and drop the ball with your weaker hand 10 times

If it is hard to use the ball, use the bean bag instead.
Laundry

- Use both hands for the following exercise.
- Take the towel provided and place it on the table
- Fold it in half and then in half again using your weaker hand as much as possible. Then unfold it.
- Fold and unfold the towel 3 times
Hanging up the Clothes

- Place a cup on the table.

- Using your weaker hand, take each clothes peg and clip it on the edge of the cup.

- Using your weaker hand, take each peg off the cup and place on the table.

  - 3 sets of 5 repetitions
  - 2 sets of 8 repetitions
  - 3 sets of 8 repetitions

If this is EASY, ask your coordinator for the smaller pegs.
Hanging up the Clothes

- Place a cup on the table.

- Using your weaker hand, take each clothes peg and clip it on the edge of the cup.

- Using your weaker hand, take each peg off the cup and place on the table.

- 3 sets of 5 repetitions
- 2 sets of 8 repetitions
- 3 sets of 8 repetitions

If this is EASY, ask your coordinator for the smaller pegs.
Jars

- Place the jar on the table.

- Hold the jar with your weaker hand and take off the lid with your stronger hand.

  □ 2 sets of 5 repetitions

- Now hold the jar with your stronger hand and take off the lid with your weaker hand.

  □ 3 sets of 5 repetitions
  □ 2 sets of 8 repetitions
  □ 3 sets of 8 repetitions
Drying Off

➢ Place the towel on the table. Fold in half length wise.

➢ Place a hand at each end of the towel and lift the towel over your head so it touches your neck.

➢ Move the towel back and forth across your neck. Like you are drying after a shower.

- 2 sets to the count of 10
- 3 sets to the count of 10
Arm Pain Scale

On the diagram below, please shade in the areas on your arm and hand where you feel pain. Put an X on the area that hurts the most.

Please rate your arm and hand pain by drawing a line that best describes your pain at its WORST in the past 24 hours.

No pain ___________________________ Extreme pain

Comments: ___________________________
Appendix Eight: Flow Chart of Site Recruitment
Figure 1: Flow chart of recruitment per site.
Appendix Nine: Randomization and Sample Size Calculation
Sample Size Calculation

\[ 2[(Z \alpha + Z \beta) \sigma / \Delta]^2 \]
\[ = 2[(1.96 + .84)10/6]^2 \]
\[ = 2[(2.8)(1.6)]^2 \]
\[ = 2(4.5)^2 \]
\[ = 40/\text{group} + 6 \text{ for 15\% drop out rate} \]
\[ \text{Total} = 46/\text{group} \]

- The standard deviation was taken from the article by Barreca et al 2005, and is from the change score of the study stroke population (N=39)

Limitations:
- The difference score of 6 was suggested as the minimal clinically important difference by Barreca et al 2005, however, it was devised based on individual change scores from pre-post testing and not from change scores based on group differences

Randomization:
- Randomization was done within each site not across site
- The subjects were stratified by Fugl-Myer Score
Appendix Ten: Meta-analysis Forest Plots Illustrating Fixed Effect Models for Main Outcomes
Choose your answer:

**Figure: Upper limb strength training on grip strength**

**Figure: Upper limb strength training on upper limb function**

**Figure: Upper limb strength training on activities of daily living.**
Appendix Eleven: Scatter Plots of Outcome Measures against covariate from Chapter Three.
Figure: Scatter plot of baseline Chedoke arm and hand activity inventory against post scores compared by group (red=control, green=GRASP).
Figure: Scatter plot of baseline Grip against post grip strength scores compared by group (red=control, green=GRASP).
Figure: Scatter plot of baseline Action Research Arm Test against post scores compared by group (red=control, green=GRASP).
Figure: Scatter plot of baseline Motor Activity Log – Amount against post scores compared by group (red=control, green=GRASP).
Appendix Twelve: Descriptive Characteristics of Subjects Displayed by Site
Table: Descriptive characteristics of outcome measures by site.

<table>
<thead>
<tr>
<th>Outcome Measure</th>
<th>GF Strong (n=11)</th>
<th>Holy Family Hospital (n=49)</th>
<th>Victoria General Hospital (n=37)</th>
<th>Kelowna General Hospital (n=10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fugl-Meyer Pre mean (±SD)</td>
<td>30.0(15.0)</td>
<td>41.1(10.6)</td>
<td>40.7(15.7)</td>
<td>39.9(14.1)</td>
</tr>
<tr>
<td>Grip Pre</td>
<td>5.3(6.8)</td>
<td>7.8(9.2)</td>
<td>11.4(8.2)</td>
<td>14.2(11.8)</td>
</tr>
<tr>
<td>Grip Post mean (± SD)</td>
<td>10.5(10.2)</td>
<td>11.4(8.2)</td>
<td>14.2(11.8)</td>
<td>12.8(10.3)</td>
</tr>
<tr>
<td>ARAT Pre</td>
<td>16.6(17.6)</td>
<td>34.2(16.8)</td>
<td>33.3(20.9)</td>
<td>24.2(18.1)</td>
</tr>
<tr>
<td>ARAT Post mean( ± SD)</td>
<td>28.2(19.7)</td>
<td>41.2(16.6)</td>
<td>43.3(16.0)</td>
<td>41.8(19.4)</td>
</tr>
<tr>
<td>CAHAI Pre</td>
<td>25.9(16.0)</td>
<td>33.7(14.6)</td>
<td>34.2(17.8)</td>
<td>29.5(18.4)</td>
</tr>
<tr>
<td>CAHAI Post mean (± SD)</td>
<td>38.6(19.8)</td>
<td>43.3(13.8)</td>
<td>46.2(15.2)</td>
<td>44.0 (18.3)</td>
</tr>
<tr>
<td>MAL(amt) Pre</td>
<td>(0.94(1.1)</td>
<td>2.3(1.2)</td>
<td>2.0(1.4)</td>
<td>1.3(0.85)</td>
</tr>
<tr>
<td>MAL(amt) Post mean (± SD)</td>
<td>2.1(1.2)</td>
<td>3.3(1.3)</td>
<td>3.2(1.5)</td>
<td>2.9(1.5)</td>
</tr>
</tbody>
</table>
Diagnosis of Major Depressive Disorder, Single Episode

A. The person experiences a single major depressive episode:

1. For a major depressive episode a person must have experienced at least five of the nine symptoms below for the same two weeks or more, for most of the time almost every day, and this is a change from his/her prior level of functioning. One of the symptoms must be either (a) depressed mood, or (b) loss of interest.
   a. Depressed mood. For children and adolescents, this may be irritable mood.
   b. A significantly reduced level of interest or pleasure in most or all activities.
   c. A considerable loss or gain of weight (e.g., 5% or more change of weight in a month when not dieting). This may also be an increase or decrease in appetite. For children, they may not gain an expected amount of weight.
   d. Difficulty falling or staying asleep (insomnia), or sleeping more than usual (hyper-somnia).
   e. Behavior that is agitated or slowed down. Others should be able to observe this.
   f. Feeling fatigued, or diminished energy.
   g. Thoughts of worthlessness or extreme guilt (not about being ill).
   h. Ability to think, concentrate, or make decisions is reduced.
   i. Frequent thoughts of death or suicide (with or without a specific plan), or attempt of suicide.

2. The persons' symptoms do not indicate a mixed episode.

3. The person's symptoms are a cause of great distress or difficulty in functioning at home, work, or other important areas.

4. The person's symptoms are not caused by substance use (e.g., alcohol, drugs, medication), or a medical disorder.

5. The person's symptoms are not due to normal grief or bereavement over the death of a loved one, they continue for more than two months, or they include great difficulty in functioning, frequent thoughts of worthlessness, thoughts of suicide, symptoms that are psychotic, or behavior that is slowed down (psychomotor retardation).

B. Another disorder does not better explain the major depressive episode.

C. The person has never had a manic, mixed, or a hypo-manic episode (unless an episode was due to a medical disorder or use of a substance).