The <u>ST</u>roke <u>RE</u>habilitation <u>A</u>ssessment of <u>M</u>ovement (STREAM): Validity and Responsiveness

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June, 1998

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Master of Science in Rehabilitation Science

0-612-50705-X

In dedication to my parents for their love and support

ABSTRACT

The main objectives of this prospective cohort study were to examine the construct and predictive validity of the STREAM, and estimating its responsiveness. Sixty three acute stroke patients were evaluated on the STREAM and other measures of impairment and disability during the first week post-stroke, four weeks later, and three months post-stroke. The results of the study showed that STREAM scores were associated with measures of impairment and disability, and could discriminate subjects based on Balance Scale and Barthel Index scores. Moreover, the STREAM during the first week post-stroke was found to be an independent predictor of discharge destination after the acute care hospital, and of gait speed and the Barthel Index at three months post stroke. In addition, the total and subscale STREAM scores were able to mirror changes in motor performance between each evaluation. The utility and measurement properties of STREAM warrant its use in clinical practice and research.

ABRÉGÉ

Les objectifs principaux de cette étude longitudinale sont de déterminer la validité prédictive, la validité de construit, et la sensibilité de l'évaluation STREAM. Soixante-trois sujets présentant un accident vasculaire cérébral (AVC), en phase aiguë, ont été évalués avec l'évaluation STREAM et d'autres outils mesurant des incapacités et handicaps au cours de la première semaine suivant l'AVC, après quatre semaines et après trois mois. Les résultats de l'étude ont démontré que l'évaluation STREAM est reliée à des instruments measurant des incapacités et handicaps. Cet outil peut répartir les sujets en trois catégories, à partir des tests mesurant l'équilibre et le niveau de fonctionnement dans des activités de la vie quotidienne (AVQ). Par ailleurs, les résultats ont permis de déterminer que, lorsqu'elle est administrée dans la première semaine, l'évaluation de STREAM, peut prédire le type de suivi après l'hospitalisation en soins aigus. A trois mois post AVC, l'évaluation STREAM peut également prédire la vitesse de marche et le niveau de fonctionnement dans des AVQ (tel que mesuré par l'Index Barthel). De plus, le résultat global et le résultat de chaque section de l'évaluation STREAM reflèctent les changements observés sur le plan moteur entre chacune des évaluations. Les propriétés psychométriques de l'évaluation STREAM en font un outil utile tant au niveau clinique que dans la recherche.

ACKNOWLEDGEMENTS

First and foremost I would like to thank my supervisor, Dr. Nancy Mayo, who has been a symbol of inspiration and a mentor over the past two years. Her assistance, guidance, and availability throughout all phases of this project are sincerely appreciated. Dr. Mayo's enthusiasm, patience and love of teaching provided a stimulating learning environment that always left me wanting to 'know more'.

I would also like to express my gratitude to my advisors Mrs. Lois Finch and Dr. Sharon Wood-Dauphinee. They committed both time and energy to proof-read my thesis and their editorial and professional input allowed me to write a theses of improved quality. Dr. Wood-Dauphinee's guidance and attention to detail helped refine my work and better my writing skills. Lois' love for the profession and guidance throughout my internship were both inspiring and encouraging to persevere.

I would also like to thank the many patients and their families who willingly gave of their time and let us into their homes at a difficult period of adjustment. Without their time and patience this project would not have been possible.

A sincere appreciation to Nancy Salbach and Johanne Higgins. Their support and assistance with starting the data collection process is greatly valued. Nancy's help throughout each stage of the masters program and encouragement have made the past two years much easier. I would also like to express my gratitude to Claudette Corrigan for coordinating this project- including patient recruitment, data collection and database preparation. Thanks to Carla Hutchison for her assistance with patient evaluations and her willingness to help at any time. Both of their support and enthusiastic spirits were encouraging and facilitated the process of completing this theses.

The assistance of Susan Scott, Adrian Levy, and Judy Soicher with the data analysis, and the research nurses Susan Anderson, Rosemary Hudson, Lisa Wadup and Angela

Andrianakis with patient recruitment is greatly appreciated. Thanks also to Nadine Larivière for her help with the English to French translation of the abstract for this thesis.

A special thanks to my husband. His patience, love, and support, and knowing that he is there for me has made this journey easier. I would like to thank my parents for their support and encouragement to always do my best, and my brothers for their support and concern always asking "When will you finish?". Last, but not least a sincere thankyou to the many friends and fellow graduate students for the interest that they showed and their words of encouragement. Without all these people this would not have been possible.

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PREFACE

Regulations for a Manuscript-Based Thesis
Faculty of Graduate Studies and Research,
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The Faculty of Graduate Studies and Research (FGSR) of McGill University requires that the first five paragraphs of the *Guidelines for Thesis Preparation* be reproduced in the Preface section of this thesis. This is necessary to inform the external examiner of the regulations regarding a manuscript-based thesis. The last two paragraphs regarding originality and co-authorship do not apply to this thesis.

"1. Candidates have the option of including, as part of the thesis, the text of one or more papers submitted, or to be submitted for publication, or the clearly-duplicated text (not the reprints) of one or more published papers. These texts must conform to the Thesis Preparation Guidelines with respect to font size, line spacing and margin sizes and must be bound together as an integral part of the thesis.

2. The thesis must be more than a collection of manuscripts. All components must be integrated into a cohesive unit with a logical progression from one chapter to the next. In order to ensure that the thesis has continuity. Connecting texts that provide logical bridges between the different papers are mandatory.

3. The thesis must conform to all other requirements of the "Guidelines for thesis preparation" in addition to the manuscripts. The thesis must include the following: a table of contents; an abstract in English and French; an introduction which clearly states the rationale and objectives of the research, a comprehensive review of the literature; a final conclusion and summary; and , rather than individual reference lists after each chapter or paper, one comprehensive bibliography or reference list, at the end of the thesis, after the final conclusion and summary.

4. As manuscripts for publication are frequently very concise documents, where appropriate, additional material must be provided (e.g. appendices) in sufficient detail to allow a clear and precise judgment to be made of the importance and originality of the research reported in the thesis.

5. In general, when co-authored papers are included in a thesis the candidate must have made a substantial contribution to all papers included in the thesis. In addition, the candidate is required to make an explicit statement in the thesis as to who contributed to such work and to what extent. This statement should appear in the single section entitled "Contributions of Authors" as a preface to the thesis. The supervisor must attest to the *accuracy of this statement at the doctoral oral defense. Since the task of the examiners is made more difficult in these cases, it is in the candidate's interest to clearly specify the responsibilities of all the authors of the co-authored papers."*

Organization of the Thesis

The two primary objectives of this study were related to the further psychometric testing of the Stroke Rehabilitation Assessment of Movement (STREAM), a relatively new measure of motor recovery. Each objective is addressed independently, in two separate manuscripts, which will later be submitted to scientific journals for publication. Additional connecting chapters have been incorporated into the present theses in order to keep in line with the regulations of the Faculty of Graduate studies and Research (FGSR).

The FGSR requires that the theses include a literature review and conclusion separate from that included in the manuscripts. It is for this reason that that there is unavoidable duplication of some material.

The first Chapter is a general introduction to motor recovery and the importance of its measurement in stroke. Chapter 2 is a literature review which is common to both manuscripts. In this chapter, the conceptual framework, used as a basis for the further testing of the STREAM, is described. The importance of measuring motor recovery, given the significant role it plays during the recovery from stroke, and its relation to other constructs, is also discussed. Finally, comparisons between the STREAM and other existing measures of motor recovery are made. This provides further justification for the continued testing of the STREAM.

Chapter 3 summarizes the rationale for further testing of the STREAM including the necessary measurement and practical characteristics of a scale, and outlines the two main objectives that were tested in the two manuscripts.

Chapter 4 compromises two sections. The first is a literature review which pertains to validity testing, the main focus of manuscript 1. The various concepts and methods related to scale validation are reviewed. The first manuscript is presented in the second section. The format of the manuscript, including the text, the figures, the tables, and the references are done according to the style of the journal entitled *"Stroke"*. The introduction, methods, data analysis, results, discussion, limitations of the study, and conclusions pertain to the validity testing of the STREAM and are described in detail.

Chapter 5 links the conclusions of the first manuscript with the primary objective of manuscript 2. The first section of Chapter 6 reviews the literature pertinent to the second manuscript, which focuses on estimating the responsiveness of the STREAM. The issues and methods related to testing the responsiveness of a measurement scale are reviewed, and the importance of having a measure that is responsive to motor recovery is also discussed. Manuscript 2, the second section of Chapter 6, and the text, figures, tables, and references are also formatted for the journal entitled *"Stroke"*. The different components of the manuscript, including the introduction, the methods, data analysis, results, discussion, limitations of the study, and conclusions, are written in relation to the testing of the responsiveness of the STREAM. In conclusion, Chapter 7 summarizes the findings and conclusions of both manuscripts. In addition, a general comparison is made between the STREAM and related measures in terms of measurement properties and utility. Finally, implications for future research are discussed.

Information which is not normally presented in a manuscript to be submitted for publication (e.g. detailed description of the instrumentation used),can be found in the Appendix. The table of contents contains a complete list of the appendices.

At the completion of this study, the STREAM, which exhibits the psychometric properties of a good measure and excellent clinical utility, is recommended for clinical use and continued testing of its performance in stroke patients.

CHAPTER 1
INTRODUCTION

In most industrialized populations, stroke, or cerebrovascular accident, is the third major cause of death in the elderly[1,2] and contributes significantly to hospital admissions and long-term disability.[3] Recent estimates indicate that stroke probably affects 50,000 persons each year in Canada.[4] In 1993 it was estimated that 208,000 Canadians were living with the sequelae of stroke[5], and in the U.S there were two and a half million disabled survivors of stroke.[6] Fifty to sixty percent of survivors will be disabled and seventy percent will have reduced capacity for work.[6] It is a disease which afflicts people of all ages, but is more prevalent in the elderly. Therefore, stroke is both a social and economic burden, and, as medical care prolongs life expectancy of the population and the number of elderly increase, there will be a rise in the number of people at risk of stroke.[2,3]

1.1 The Impact of Motor Dysfunction in Stroke

Three-fourths of individuals who have sustained a stroke will present with a moderate to severe decline of motor ability in the affected limbs.[5] Bonita and Beaglehole[8] who assessed the natural history of motor recovery for patients with stroke in Auckland, New Zealand, reported that 88% of the patients had motor deficits. These authors[8] also found that the recovery rate was related to the extent of motor deficit at the onset of the stroke. Scmidt et. al.,[9] after carrying out a seven year prospective study of stroke patients, found that the return of the ability for self-care and work depends principally on the recovery of the motor system. Thus the loss of motor function often leaves patients helpless to perform the simplest to the most complex tasks. This in turn frequently renders the individual dependent on a caregiver or institution to assist in the needs of daily living. In addition, the physical and financial stresses that are placed on the caregiver may lead to depression and diminished social and emotional health.[10] Therefore, the loss of motor function at the onset of stroke has far reaching implications which may result in social handicap and reduced quality of life.

Given the extensive physical, personal, and social consequences of motor impairment post-stroke, the treatment of motor dysfunction is a very important component of rehabilitative efforts. The principal contribution of physical therapists in the rehabilitation of stroke patients is to improve motor function and thereby maximize physical autonomy.[11] To monitor the effectiveness of physical therapy interventions, it is important to have a tool that accurately documents motor recovery. A good measure will help determine therapeutic goals as well as the level of intervention needed. Further, it will be useful in the clinical setting and in research to monitor motor recovery and its contribution to overall functional recovery.[12]

1.2 The Measurement of Motor Recovery

Physical therapy treatments are more specifically directed towards the facilitation of voluntary movement and basic mobility with the ultimate goal of maximizing functional independence. Therefore, in order to evaluate the impact of physiotherapy interventions, there must be a measure which precisely and accurately evaluates these attributes. A number of instruments intended to measure motor recovery have been developed,[13-20] but none are widely used in clinical practice. According to a 1991 survey, less than 5 % of physiotherapy departments routinely used the existing published instruments for motor evaluation following stroke.[21] Many reasons for this low level of use were related to the practical aspects of these instruments including administration time, the need for many pieces of equipment, and the complexity of the scoring scheme. In addition many therapists felt that the instruments did not comprehensively assess the characteristics of interest.

Given the limitations of many of the existing measures, a team of researchers and clinicians in 1988 set out to construct a more "user friendly" instrument called the <u>ST</u>roke <u>RE</u>habilitation <u>A</u>ssessment of <u>M</u>ovement (STREAM). Based on input from clinicians, the content and format of the instrument were designed so that the above barriers to routine clinical use would be avoided.[7] Other attributes considered essential during the development of the STREAM, were its appropriateness for use at all levels of stroke rehabilitation and for individuals with motor dysfunction ranging from mild to severe. It was intended that the STREAM would meet the standards of measurement rigor as well as the needs of physical therapists and, hence, be incorporated into routine clinical use. This will allow for the consistent and objective documentation of the course of motor recovery.

To date, work on the STREAM has shown that it has many advantages over existing measures of motor recovery in terms of its practical use and accurate estimate of *pure* motor recovery. Formal testing revealed that the STREAM is internally consistent, reliable, and shows promise of being a valid and responsive measure.[21] This study will continue work on the STREAM by assessing its construct and predictive validity, and its responsiveness.

CHAPTER 2
MOTOR RECOVERY

When studying motor recovery, it is important to clearly understand the concept and the theoretical framework that guides the testing of the instrument. The conceptualization of an instruments theoretical basis, as well as an understanding of the properties that a measure should have, are necessary when developing and testing an instrument.[22] The first part of this chapter describes the theoretical framework on which the STREAM is based. The importance of measuring motor recovery, given the significant role it plays during the recovery from stroke, and its relation to other constructs is also discussed. This knowledge provides a rationale for measuring motor recovery. The second part of this chapter will review the characteristics of existing measures of motor recovery and discuss some comparisons to the STREAM. This information provides further justification for the continued testing of the STREAM.

2.1 Theoretical Framework For Measuring Motor Recovery

Up to now there has not been one clear definition of motor function because it is influenced by many factors, and it is a difficult construct to measure. One way to think of motor function, is that it has different components, such as limb movements, postural stability (balance), and mobility. Moreover, as cited in many studies that are listed in Table 2.1, motor recovery is influenced by many factors such as age, size and site of lesion, motivation, pain, comorbid conditions, and cognitive level.[23] Although it is difficult to separate the influences of these various factors, motor recovery is manifested by the re-emergence of voluntary limb movement and the restoration of basic mobility. It is these attributes that the STREAM is intended to measure, and that can be easily assessed in the clinical setting.[7]

To understand the measurement of an abstract concept such as motor recovery, it is important to place it within a theoretical framework. The World Health Organization has created a theoretical framework and set standard definitions for the terms impairments, disability, and handicap.[2] This model helps guide health care professionals to target their treatments or assessments. Evaluation of *impairments* refers to identifying factors that cause the functional disability including sensory loss, loss of motor control, paresis, and perceptual deficits. *Disability* refers to whether or not an individual can carry out activities of daily living such as bathing, feeding, dressing, walking, shopping, and cooking. *Handicap* refers to a persons inability to fulfill their social roles such as those related to occupation or family activities.[24]

Impairments can be seen as the direct effect of a pathology and are the basic underlying cause of disability. Physical therapy interventions for stroke patients often involves the remediation of impairments with the expectation that decreasing impairment will reduce the eventual disability.[25]

The distinction between the recovery at the impairment and disability levels is critical.[26,27] As treatment is often directed towards the individual impairments, outcome measures that monitor change in these impairments, such as motor recovery, are needed. Many factors influence motor performance and, therefore, the ideal situation would be to have an instrument that measures individual impairments such as strength, paresis, and sensory deficits as well as the persons' ability to perform tasks that are influenced by these underlying impairments. In the absence of such a comprehensive instrument, a performance based measure of motor recovery will provide a link between impairments and disability.

Ideally, the intermediate outcome, the disability, is judged by the functional consequence of the impairment. As acute care for stroke shortens, the patient is often not on treatment long enough for the impact of the disability to be manifested. In these settings outcome measures targeting treatment strategies directed toward impairments are ideal. The STREAM was developed to evaluate treatment strategies that incorporates this level.

The STREAM is related hierarchically to other measures of impairments and disabilities in that it is intended to measure basic motor ability – one step beyond the level of primary impairments, and one step before functional mobility and ADL measures (disability).[7] In the Nagi disablement scheme this is referred to as "functional limitations". The National Center for Medical Rehabilitation Research defines functional limitations as: "*a restriction or lack of ability to perform an action in the manner or range consistent with the purpose of an organ or organ system*". Nagi has described functional limitations as the most direct way through which disease and impairments contribute to subsequent disability (Figure 2.1).[24] Therefore, the STREAM will hopefully be sensitive to changes in motor function, which is a main target of physical treatment, and a precursor to understanding disability.

Figure 2.1: Model From The National Center for Medical Rehabilitation Research:

Pathophysiology (interruption of normal physiological function e.g. cellular processes) → **Impairment** (e.g. sensory loss) → **Functional limitation** (e.g. basic mobility, transfers) → **Disability** (e.g. gait) → **Societal Limitation** (e.g. return to work)

2.2 The Significance of Measuring Motor Recovery as a Stroke Outcome

The ultimate goal of rehabilitation post-stroke is to reduce impairment, and prevent disability and handicap, in order to facilitate the reintegration of patients into society and ultimately improve patients quality of life. As mentioned in the first chapter, motor recovery is an important focus of rehabilitative treatment following stroke. Given that many interventions are directed towards the restoration of motor function, motor ability is an important outcome that must be incorporated into the evaluation of the effectiveness of rehabilitation efforts.

It is important in both clinical practice and research to be able to distinguish the level of pure motor recovery from functional performance. Measures of disability[28,29] include the compensatory components of improvement and are not pure measures of motor recovery . While functional measures are sometimes used to reflect motor recovery, these indices frequently include the interaction of cognitive ability and perceptual functioning.[25,26] For example, a patient who has regained voluntary movement of the lower extremity may still not be a functional walker because walking involves the integration of several components such as cognition and perception. Consequently, even though motor recovery has occurred it is not reflected through functional activity. The opposite may also be true, where a patient might make functional gains by compensating for the neurological deficit with the uninvolved side while the actual motor deficit remains unchanged. Therefore, the existence of an instrument that can effectively measure motor performance is important for understanding the process of motor recovery from stroke. In addition, this knowledge will help determine the efficacy of therapeutic interventions aimed at accelerating and enhancing the recovery of motor function.[12]

To understand the role that motor recovery plays in global recovery from stroke, it is important to examine its relationship with other related constructs. Despite the fact that various impairments post-stroke are distinctly different, it seems that their course of recuperation are very similar (Table 2.1a ,2.1b).[30-39] Both upper and lower extremity motor recovery are associated with other variables of improvement after stroke, and many studies have looked at these relationships (Table 2.1a). One investigation was conducted to explore the associations among outcome measures in a clinical study of stroke.[40] The investigators found significant correlations between measures of neurological status, stroke severity, motor performance, cognition and functional capacity. These correlations provide important evidence concerning the positive associations between motor, functional, and balancing ability.[12] Other studies have also found high correlations between upper extremity and lower extremity motor performance with balancing ability.[31,41] Poor lower extremity performance was associated with a greater number of abnormal findings in the organization of postural adjustments.[41] Strong relations have also been found in a number of studies between motor ability and functional performance.[12,26] These studies have shown that better motor performance was correlated with improved functional ability. As well, Richards et. al.[42,43] have found a positive correlation between the scores of motor performance of the lower extremity and gait velocity.

In sum, there is a known relationship between motor recovery and the restoration of balance, upper extremity function, functional mobility, functional ADL and gait speed. These relationships reflect the potential for a measure of motor function such as the STREAM for inferences related to the final disability, handicap and the quality of life of patients having sustained a stroke.

A number of clinical indices have been developed to measure motor function. These include the Fugl-Meyer Sensorimotor Assessment for stroke,[14] the Chedoke-McMaster Stroke Assessment,[19] the Motor Assessment Scale,[44] the Rivermead Stroke Assessment[45] and the Motor Capacity Assessment.[18] Many of these instruments, are presented by Daley,[7,21] and are summarized in Table 2.2. Despite the availability of instruments which aim to measure motor recovery, none have been found to be clinically useful. In addition, many of these instruments capture many constructs as opposed to pure motor recovery (Table 2.3) in the final score[7,21] and are based on older theories that have been questioned.[13,46-49] Therefore, there is a need for a tool which measures motor recovery that will be clinically accepted and consistently used among healthcare professionals, interested in the rehabilitation of individuals with stroke.

2.3 The STREAM: Advantages Over Other Measures of Motor Recovery

The STREAM is an outcome measure that was developed by a clinically based research team.[21] It was designed to monitor patients' motor function over time, and to evaluate the effectiveness of interventions. The items included in the original instrument were drawn from clinical experience and from existing published assessments. Movement patterns commonly used to assess motor performance of stroke patients were included. The scale was found to have acceptable clinical utility after it was used at one rehabilitation hospital for a number of years. A content verification survey was carried out to assess the broad acceptability of the original STREAM.[21] Despite generally positive feedback, the survey identified many possible refinements which could be made to improve the instrument (Table 2.4). Thus, to enhance content validity, further work on the content of STREAM was performed. Changes included adding more details relating to the quality of movement, as well as more mobility and lower level limb movement items. In addition, the original scoring (0: unable, 1: able to perform the test item) was modified to increase the response options in an effort to improve the sensitivity over time. A number of scoring dimensions were incorporated in the scoring scheme of the revised STREAM: active range or amplitude of voluntary movement possible, quality of movement, and the degree of assistance required (Appendix A1.0).

The final revised STREAM consists of thirty items divided among three subscales: ten items for voluntary motor ability of the upper extremity, ten items for voluntary motor ability of the lower extremity, and ten items for basic mobility. A three point ordinal scale is used for scoring voluntary movements of the limbs and a four point ordinal scale for basic mobility. The first formal evaluation of the revised STREAM was completed in 1994 by Daley et. al..[7,21] In this study the STREAM was found to have a high degree of inter-rater (Generalizability correlation coefficient (GCC)=.99) and intra-rater (GCC=.99) reliability, internal consistency, (coefficient alpha=.96) and demonstrated content validity. The instruction manual and scoring sheet for the STREAM can be found in Appendix A1.0.[21]

The STREAM has advantages over other measurements of motor recovery. One advantage is that the STREAM includes measures of voluntary movement and basic mobility. Some instruments assessing motor recovery evaluate these aspects of movement but also include many other domains such as pain, range of motion, sensation, and tone and, therefore, do not reflect pure motor recovery (Table 2.3). In addition, other tools that only assess voluntary movement and basic mobility such as the MAS and the Rivermead assessment have very few items within each subscale.[44,45] This makes these scales less sensitive to changes in voluntary movement and basic mobility. Other measures such as the Fugl-meyer,[14] the Lavigne,[17] and the Chedoke McMaster[19] are based on the sequential patterns of recovery.[50,51] However, many investigators have questioned the "synergy" approach since not all patients follow this rigid sequence of recovery, and this approach is not functionally oriented.[13,46-48] The movements in the STREAM are functional but at the same time simple. The STREAM requires very little equipment which reduces the effect of perceptual and cognitive functioning on the movement, and improves its utility and portability. In addition, the STREAM is easy to score and does not require any formal training for its administration.

Objective outcome measures play an important role in the health care system to evaluate treatment effectiveness and to justify the costs associated with these treatments.[52] As the restoration of motor function is a significant component of physical treatment post-stroke, the STREAM may be an ideal measure to incorporate into the process of the analysis of cost-effectiveness.

Table 2.1a: Relationship of Variables During Recovery Post-stroke

Study	Number of Subjects	Time Period	Outcome Measures & Variables Assessed	Results
Badke & Duncan, 1983	8-10 healthy subjects 7-9 hemiplegic subjects	?	F M[1] → motor performance Platform tests → postural adjustment	Patients with high level motor skills, as measured by the F M assessment scale, demonstrated postural adjustments more similar to those found in healthy subjects than did those patients with low-level motor skills.
Berg, 1992	60	12 weeks (acute)	Berg Balance →balance F M →motor performance B I[2] →self care & mobility	The Berg balance scale is positively correlated with the BI (0.8-0.94) & the F M (0.62-0.94)
Brandaster et. al., 1983	23	1.5-5.5 months post CVA	F M→Stage of motor recovery Minicomputer based locomotion analysis system→Gait variables Perceptual evaluation→ Perception	Walking speed & swing period symmetry related to stage of motor recovery with correlation coefficients of 0.8 & 0.69 respectively. Gait variables (stance period & double support) which were highly correlated with gait speed also showed a relationship with stage of motor recovery, but probably due to speed dependence.
Dettman et al, 1987	15 males after stroke	once/month for 11 weeks.	Interrupted light photography →walking ability Force platforms→ postural stability F M → motor performance B I → self care & mobility	A correlation was found between the BI & sections of the F M (0.74 for total motor control & 0.67 for total score) Significant relationship found between scores on the BI & F-M with measures of walking velocity and upright stability (0.76 & 0.66 respectively.)
Jorgensen et. al., 1995	1,197	onset up to 6 months	Scandinavian Neurological stroke scale →neurological deficits (e.g limb power) B I→Activities of daily living	The time course of both neurological and functional recovery were strongly related to initial stroke severity. On average neurological recovery was achieved two weeks earlier than functional recovery

[1] Fugl - Meyer
[2] Barthel Index

Table 2.1a: Relationship of Variables During Recovery Post-stroke (continued)

Study	Number of Subjects	Time Period	Outcome Measures & Variables Assessed	Results
Keenan et al, 1984	90	7 - 365 days post stroke over average period of 38.8 days	Ranchos Los Amigos stroke scale →Descriptive data & Cognitive status Physical Therapy → muscle function & control Evaluation form → Sensation & Balance Balance Reactions	Motor control & proprioception showed the strongest relation to equilibrium (0.78 & 0.74 respectively at discharge). Balance correlated strongly with ability to ambulate (r=0.79).
Olsen, 1990	75	onset to discharge	Medical Research Council system→ Paresis B I[1] → -Upper extremity function Ability to walk→ Lower extremity function	Arm and leg paresis are useful predictors of functional outcome. Severe extremity paresis predicts a bad outcome.
Richards et al, 1992	27	onset to 18 months	F M[2] → motor performance B I → self care & mobility Triax electrogorimeter → Gait movement & speed	Gait speed correlates with both the F-M & BI in the first 3 months post stroke.
Richards et al, 1995	18	6 weeks post stroke	F M leg subscore → motor performance B I ambulation subscore → mobility Berg Balance → balance Triax electrogorimeter → Gait analysis Photocells → Gait velocity	Correlations found between Gait velocity & BI ambulation score (0.58) FM-leg score (0.62) and Berg (r=0.60), respectively.
Wood-Dauphinee et. al., 1990	167	onset-5wks. Post	Neurological grading system for acute stroke→ neurological status F M→ motor performance Mcmaster measure→ severity of stroke BI→ ADL performance Level of rehabilitation scale→ behavior, cognitive, functional performance	Significant correlations between measures of neurological status, stroke severity, motor performance, cognition, & functional capacity. FM & BI highly correlated at admission and at follow up.

[1] Barthel Index
[2] Fugl Meyer

Table 2.1b: Patterns of Recovery Post Stroke

Study	Number of subjects	Time Period	outcome measure used	Constructs assessed	Recovery
Bonita & Beaglehole 1988	680	onset to six months	categories of mild, moderate, severe	severity of hemiparesis	88%, 71%, 62% presented with a motor deficit at onset, 1month, and 6months after onset, respectively. Return of motor function associated with stroke severity, but not with age or sex. Those with a mild motor deficit at onset were 10 times more likely to recover motor function than those with a severe stroke.
Duncan 1992	104	onset to 6 months	F M[1] B I[2]	motor recovery ADL function	Most dramatic recovery during first 30 days, regardless of initial stroke severity, but most patients experienced some recovery 30-90 days post stroke. Correlation between FM and BI 30,90,&180 days post stroke ranged from r=0.80-0.91.
Duncan, 1994	95	onset and 5,30,90,180 days after stroke.	F M	motor recovery	When stroke severity controlled, no difference in percent motor recovery between upper and lower extremities, most rapid recovery of both extremities within 30 days post stroke.
Gray et. al., 1990	157	onset to 28 days	normal ,flexor, extensor, or flaccid MRC motor scale Reflex normal, increased, reduced	Tone Limb power Reflexes	Predominant abnormality at admission was flaccidity Recovery to normal tone occurred mainly during initial 7 days. For subjects with flaccidity at onset, at 28 days 20% of patients had normal upper limb tone and 28 % normal lower limb tone. For subjects with increased tone at onset 23% and 33% had normal upper and lower limb tone respectively. Most significant recovery of power in first 48 hours for all groups but continues up to 28 days.
Lincoln et. al., 1989.	70	up to 13 weeks after onset to 9 months post stroke.	Rivermead motor function assessment ADL scale	Gross motor function ADL	Motor function was single most important determinant of physical function and independence in ADL at discharge, but less predictive nine months after stroke.

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[1] Fugl - Meyer

[2] Barthel Index

Table 2.1b: Patterns of Recovery Post Stroke (continued)

Study	Number of subjects	Time Period	outcome measure used	Constructs assessed	Recovery
Mayo, 1991	93	admission - discharge	Developed a Dichotomous scale None, mild, moderate to severe scale Dependent versus independent	Depression Perception, cognition, comprehension, and expression Sitting, walking, stairs	At admission 45, 75, & 75 patients could not sit, walk or negotiate stairs independently, respectively. The median time to achieve independence was 11 days for sitting, and 14 days for walking & stairs 73,66, & 68 days, respectively from onset. Age, perceptual impairment, depression, and comprehension influenced recovery time. Recovery still continued 4-5 months after acute onset.
Newman, 1972	39	up to 14 days post onset to 20 weeks Post stroke	Scales developed at Manitoba Rehabilitation Hospital: 3 point neurological scale 2point scale Koh's blocks Functional scale	Upper and lower limb movements, Speech sensory & mental function Transfers, wheelchair, walking, stairs, dressing, toilette	80% of neurological recovery was achieved from 3-7 weeks, longest time being 14 weeks. Motor recovery of lower extremity accounted for just under half the total number of points on the recovery score. Functional recovery closely follows neurological recovery
Partridge et al., 1987	368	onset to 8 weeks	Scale developed by two panels of therapists	Gross body movements, arm movements	Results suggest that recovery occurs in a predictable pattern. Recovery of feeding, dressing, transferring, sitting balance, standing, and walking is more rapid during the first 2 weeks post stroke.
Wade, 1985	99	first three months post stroke.	Norwick Park Assessment Schedule and the "Motricity Index" List of Activities	motor function function	Recovery is the most rapid in the first two weeks but continues slowly throughout 90 days for all functions. There is never any obvious plateau in recovery.

Table 2.2: Overview of Characteristics of Stroke Motor Assessments

Scale	Content Domains	Conceptual Framework	Scoring	Administration Time	PSYCHOMETRIC PROPERTIES: Reliability: Inter-rater	Intra-rater	Internal Consistency	Validity: Content	Criterion	Construct	Responsiveness to Clinical Change
Fugl-Meyer Sensorimotor Assessment *Fugl-Meyer et al, 1975*	Limb movement Balance Sensation ROM	based on synergies	3 point ordinal 113 items	30-50 minutes	••	•	—	•	••	••	•
Motor Assessment for Stroke (MAS) *Carr et al, 1985*	Motor performance Tone	functional, task-oriented; motor control theory	7 point ordinal 9 items	15-20 minutes	••	•	—	—	•	—	—
Chedoke-McMaster Stroke Assessment *Gowland et al, 1992*	Impairment: shoulder pain, postural control, limb movement Disability: mobility & walking	based on WHO's ICIDH; & on synergies	7 point ordinal 20 items; (6 impairment; 14 disability)	30-50 minutes	•	•	—	•	•	• (disability inventory only)	•

Key: —: not assessed, • assessed , •• assessed in more than one study & acceptable levels established (cont...)

5 Taken from Daley, 1994.

Table 2.2 (continued): Overview of Characteristics of Stroke Motor Assessments

Scale	Content Domains	Conceptual Framework	Scoring	Administration Time	PSYCHOMETRIC PROPERTIES: Reliability: Inter-rater	Reliability: Intra-rater	Reliability: Internal Consistency	Validity: Content	Validity: Criterion	Validity: Construct	Responsiveness to Clinical Change
Evaluation of the Hemiplegic patient; Bobath approach *Guarna et al,* 1988	Active movement, Tone, Reflexes, Postural reactions, Sensorium, Pain	based on Bobath's stages of recovery	4 point ordinal 6 components for each limb	30-50 minutes	•	•	—	—	• (w/e subscale only)	•	—
Lavigne Motor Recovery Assessment *Lavigne, 1975*	Movement of u/e, l/e, hand & face Balance, gait & sensation	based on synergies	5 point ordinal for movement (95 items); balance & sensation (38 items) dichotomous; gait (39 items) 3 point ordinal	30-50 minutes	•	—	•	—	—	•	—
Rivermead Assessment of Motor Function *Lincoln & Leadbitter 1979*	Movement of u/e, l/e, & trunk; Mobility	not specified	2 point ordinal (Guttman) 38 items	15-30 minutes	•	•	—	—	—	—	—
Physical Assessment for Stroke Patients *Ashburn et al, 1982*	Limb movement Mobility	not specified (synergies implied in graded movements)	3 point ordinal for limb movements (27 items) 4 point ordinal for mobility (18 items)	30-50 minutes	•	—	—	—	—	—	—

Key: —: not assessed, * assessed , ** assessed in more than one study & acceptable levels established

Taken from Daley, 1994

Table 2.3: Specific Domains assessed In Measures Of Motor Recovery

Passive ROM	Sensation	Pain	Tone	Reflexes	Balance	Postural reactions	Limb Movement (Voluntary)	Basic Mobility	Function
Fugl-Meyer Sanford et. al., 1993	✓	✓		✓	✓		✓ ▲▲▲		
Motor Assessment Scale Carr et. al., 1985			✓		✓		✓		✓
Chedoke McMaster Stroke Assessment Carr et. al., 1985		✓					✓ ▲		✓
Evaluation of the hemiplegic patient: Bobath approach Guarrna et. al.t	✓	✓	✓	✓		✓	✓ ▲▲▲		
Lavigne Lavigne, 1974	✓				✓		✓ ▲▲		✓
Rivermead Asssessment Lincoln & Leadbitter, 1979							✓ ▲	✓ ▲▲	✓
Phyical Assessment for Stroke Patients Ashburn et. al., 1982	✓						✓ ▲▲		✓
Sodring Motor Evaluation Sodring et. al., 1995					✓	✓	✓ ▲▲	✓ ▲	✓ ▲
Stroke Rehabilitation Assessment of Movement							✓ ▲▲▲	✓ ▲▲	

✓ : is assessed; ▲: < 10 items; ▲▲: 10-15 items; ▲▲▲: > 15 items

Table 2.4: Development of the STREAM.

Characteristics	Description
Conceptual Framework	•Developed to measure basic motor ability, one step beyond primary impairments and one step before functional mobility. •Movements range from very basic to gradually more difficult. Movements closely related to functional movements.
Item selection	•Chosen based on internal consistency analysis, face validity of experts, and relationship to other items. •Very high and low level items chosen to avoid floor and ceiling effects.
Scoring	•Scoring is both quantitative (amplitude of movement, level of independence) and qualitative. •Simple, unambiguous, and objective •Categories chosen make scoring quick and reliable.
Administration	•Instruction manual has been developed to standardize the testing procedure. •Does not require any special equipment or formal training. •Takes only 15-20 minutes to administer.
Psychometric Properties	•Reliability-Interrater, Intrarater, and internal consistency have been tested with excellent results across the full scoring range. Factors that enhance reliability of STREAM: simple scoring, and standardized instructions. •Validity- Support for Content validity through consensus panels and item reduction phases. Criterion validity not yet tested. Construct and Criterion predictive validity to be tested in present study. •Responsiveness - Not formally tested but considered during the selection of items. The scoring scale (total=100) was chosen to allow for meaningful clinical change to be detected. To be tested in present study.

CHAPTER 3
RATIONALE AND OBJECTIVES

Restoration of motor function is an integral component of the recovery from stroke. A tool with good measurement properties is needed to describe the restoration of motor deficits, to assist in identifying intervention strategies, and to assess effectiveness of interventions. A measure of motor recovery that meets the multiple needs of clinical practice and research will contribute valuable knowledge about post-stroke recovery.

During the development and testing of an instrument there are some basic considerations involved in judging what makes a good measure.[53-55] Apart from demonstrating acceptable measurement properties including reliability, validity, and responsiveness of the scale for identifying clinical change, a scale intended to be used in the clinical setting must be feasible for that milieu. This relates to the time needed to administer the test, the equipment needed, the portability, the ease of scoring, including how easy it is to interpret the scores, and the training required for the raters. The desired result is to have a tool that is quantitative, objective, and comprehensive, yet precise and attractive for use clinically. This will encourage the routine and objective documentation of motor recovery.

For many of the existing motor assessment scales, the ability of the tool to detect changes in motor function was not considered during the development of the instrument. Responsiveness to clinical change is imperative for a tool that is intended to be used to monitor motor recovery in stroke. This criteria would not be required, however, for a tool designed for classification purposes only. The Fugl Meyer[40] and the Chedoke Mcmaster[56] have been assessed for responsiveness (Table 2.2), but only to a limited extent. Both have been found to have ceiiing effects and have not yet been tested for responsiveness in low level stroke patients.[21] Although the responsiveness of the STREAM has not been formally tested, this important feature was considered during item selection and the development of the scoring scheme.[21]

Another consideration is whether the tool can be used to monitor recovery in an individual, a group of people, or in a population. It would not be cost-effective to use a measure that takes a long time to administer by highly trained professionals, such as the Fugl-Meyer, to monitor motor recovery in a population of stroke patients. This type of measure may be acceptable for a group of people, for example in a specific rehabilitation center, but even then some therapists may find that it requires too much time to incorporate into their regular clinical assessment. The STREAM will be capable of monitoring motor recovery at the level of an individual, group, and population since it does not require a long time to administer. The MAS and the Rivermead have comparable administration times, however, they incorporate hierarchic (i.e. activity more difficult with each increase in the score) scoring systems which have been questioned since they might underestimate the patients true ability.[44,45] Finally, the time needed to administer the instrument will significantly influence the willingness of therapists to use the tool in routine clinical practice. This relates to a common complaint made by physical therapists that lack of time is a substantial barrier to the use of standardized outcome measures.[57]

To date, the STREAM has shown many desirable characteristics of an outcome measure as compared to other measures of motor recovery. It has excellent clinical utility, is internally consistent, reliable, and shows promise of being a valid and responsive measure. The STREAM has already been used in a few studies to evaluate motor recovery. One clinical trial used the original STREAM to compare the level of motor recovery between two groups receiving a different treatment regimen aimed at retraining gait.[58] The STREAM was able to detect a significant difference in motor recovery between these two groups.

In summary, the existing measures of motor recovery have not demonstrated the necessary requirements. In comparison to other measures, the STREAM shows greater promise of being a practical responsive measure of motor recovery. It is portable, easy to score, easy to administer, and takes only 10-15 minutes to complete. The STREAM may play a unique and important role by facilitating routine objective assessment of motor function, which will allow physical therapists to monitor motor recovery in stroke patients and continuously assess the effectiveness of the interventions they provide. Content validity and reliability of the STREAM have been supported. However, to date the construct validity, predictive validity, and responsiveness of the STREAM have not been formally tested. Examining its validity will help to understand how it relates to other measures of disability and impairment. Formal testing of the STREAM's responsiveness is needed to delineate its potential to monitor changes in motor recovery following stroke. Therefore, the overall objective for this study is to generate evidence supporting the validity of the STREAM and to assess its responsiveness.

The Specific Objectives are:

1. To determine the degree of association between the STREAM and measures of upper extremity function, balance, gait speed, functional mobility, and functional ADL scores (construct validity).

2. To determine if the STREAM can differentiate among groups of stroke patients on the basis of performance on measures of balance, and independence in ADL (construct validity).

3. To assess the ability of the STREAM to predict 1) the recovery of the level of independence in functional ADL 2) gait speed and 3) discharge destination (criterion predictive validity).

4. To estimate the responsiveness of the STREAM to motor recovery in the first three months after first time stroke (responsiveness).

CHAPTER 4
VALIDITY

4.1 Literature Review

In the first two chapters it was highlighted that, to date, the STREAM has proven to be a reliable and clinically feasible measure. Moreover, content validity was deemed adequate following the extensive steps taken in the development of the measure. In order to understand which inferences can be made based on scores from the STREAM, further validity must be formally tested.

Validity refers to the extent to which an instrument adequately measures the construct that was intended. By validating a scale we determine the amount of confidence we can place on inferences we make about individuals based on the scores from that scale.[54] There are three main types of validity: content validity, criterion validity (concurrent and predictive validity), and construct validity. Construct and criterion predictive validity are the main foci of the present study.

Predictive validity is a future-oriented prediction based on an assessment made today. If a test is predictively valid of a certain characteristic or performance, then we can say that people who do well on the test have a higher probability of later achievement.[59] For example, if a measure of motor recovery is predictive of a future functional ability, the measure that assesses motor recovery would be administered now, and that which assesses functional ability would be administered at a later date. Predictive validity is an important property for health status assessments because many decisions in clinical practice are based on prognostic assumptions. Being able to predict the natural course of a patients' disorder and the effect that a particular treatment will have on the disorder is one of the major challenges for therapists today.[60,61] For use in the clinical setting, objective methods are needed to prioritize and direct the rehabilitation management of stroke patients. In the bigger scheme, the use of objective measures will help identify the variables that affect long-term outcome[62-70] which is a first step toward making more informed decisions regarding patient care.

Construct validity refers to whether or not a particular measure relates to other measures consistent with theoretically derived hypotheses concerning the constructs (concepts) that are being measured.[71] The more abstract the construct the more difficult it is to validate measures purported to assess it.[72] Estimating the construct validity of an abstract concept, such as motor performance requires creative development of different hypotheses related to beliefs about how the construct should behave. Construct validity differs from other types of validity methodologically, however, *conceptually,* it is not different from other types of validity.[72]

Different empirical methods have been suggested for testing construct validity. One involves setting hypotheses about the relationships between the construct measured by the instrument and other constructs external to the assessment tool. The direction and magnitude of this relationship is then empirically tested.[71] Construct validity consists of convergent validity where the relation between two instruments that measure related constructs is tested, and divergent validity where the relationship between two measures that are not expected to be associated is tested.[54] Also, hypotheses can be made about known differences between two groups based on a specific characteristic (e.g. subjects with impaired balance versus those with normal balance) and then the construct validity of the tool is tested by examining the scores on the given tool and seeing if they can discriminate between the two groups (i.e. one group scores higher or lower on the new instrument). This is called the *Known groups technique.*[72]

There is no single study which can prove construct validity. Many studies should be conducted to learn more about the construct by making new predictions and then testing them.[54] As many ways as possible should be used in testing construct validity of a measure, for this will enhance confidence in its adequacy. If the tool behaves in the way that we would expect it to in relation to other variables, based on theory and previous studies, then we can be more confident that the instrument is a true measure of the construct, namely motor recovery .

The relationship of the STREAM with other measures of impairment and disability has not yet been studied. How the STREAM performs over time and its relation with measures of balance, upper and lower extremity function, and the level of independence in activities of daily living (ADL) will provide information about the ability of the STREAM to measure motor recovery. These interrelationships will also help interpret what the final scores on the STREAM mean and what future implications there may be in terms of functional independence and reintegration into the community.

4.2 Validity of The STroke REhabilitation Assessment of Movement (STREAM)

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Manuscript prepared for submission to the journal entitled *Stroke*

Running Title: Validity of The STroke REhabilitation Assessment of Movement (STREAM)

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Introduction

With the changes that are occurring in the health care system today therapists are challenged to justify treatment interventions with the use of objective standardized outcome measures. Clinicians want measures that can be easily incorporated into the assessment procedure and that are feasible, in terms of the time needed to administer the instrument, the amount of equipment needed, and the portability of the tool. In stroke rehabilitation, the major focus of physical treatment is the restoration of motor function so that patients can reach the highest level of functional independence possible. Therefore, a tool which assesses motor recovery is an essential component of the evaluation of recovery following stroke.

A relatively new measure, developed to assess motor recovery in stroke patients has been described, and is called the Stroke Rehabilitation Assessment of Movement (STREAM).[1] The STREAM was conceptualized to be an outcome measure to monitor the reemergence of voluntary movement and basic mobility in stroke patients. The development of the content of the STREAM and the testing of its intra-rater and inter-rater reliability have been discussed in previous articles.[1,2] The STREAM has been found to have good clinical utility, a high degree of interrater and intrarater reliability, and content validity. The construct validity, predictive validity, and responsiveness of the STREAM have not yet been formally tested. The purpose of this study was to examine the construct and predictive validity of the STREAM. The responsiveness of the STREAM will be discussed in a future article.

Validity refers to the extent to which an instrument adequately measures the characteristics that were intended.[3] To support the validity of an instrument that assesses motor recovery in stroke patients, it is important to determine how it performs in relation to other measures related to the recovery from stroke. These interrelationships can be examined by considering the theory that underlies the instrument, which for the STREAM, is its conceptual framework based on the World Health Organization's (WHO) classification of impairments, disability, and handicap.[4] The results of previous studies that have examined the associations between these variables also provide information as to how we would expect the measure to behave. Brandstater et al.[5] investigated 28 stroke patients and found that walking speed correlated ($r=0.88$) with motor recovery. Balance function has also been examined in terms of its relationship with motor recovery, and has been found to be highly correlated.[6,7] Strong associations have likewise been reported between motor ability and functional performance in a number of studies.[8,9]

There are several types of validity. The types that were tested in this study are construct validity, including convergent and divergent validity, and predictive validity. Convergent validity involves seeing how closely the new scale is related to other variables that make sense. Divergent validity is the opposite, where the association between the new scale and constructs that we do not expect to be related to the new scale are examined.[3] Predictive validity, one type of criterion validity, refers to a future-oriented prediction based on a measure made today.[10]

Therefore, to test the validity of the STREAM, its relationships with other variables during the first three months post-stroke are examined in this study. Recovery from stroke is the most rapid in the first few weeks following stroke, but continues up to three months.[11,12] Therefore, the acute period post-stroke is an ideal time to assess the predictive validity of the STREAM, since most subjects are expected to show improvement by three months. In addition, it allows the validity of the STREAM to be examined at different stages of recovery. The general objective for this study was to generate evidence to support the construct validity of the STREAM including convergent and divergent validity, and predictive validity. There were three main objectives:

1. To determine the degree of association between the STREAM and measures of upper extremity function, balance, gait speed, functional mobility, and functional ADL scores.

2. To determine if the STREAM can differentiate among groups of stroke patients on the basis of performance on measures of balance, and independence in ADL.

3. To assess the ability of the STREAM to predict the recovery of 1) the level of independence in functional ADL, 2) gait speed, and 3) discharge destination.

Methods

Study Design

This study was part of a larger study, designed to examine the recovery of upper and lower extremity function post-stroke. The methods, as well as the profile of recovery post-stroke have been reported by Salbach[13] for the lower extremity and Higgins[14] for the upper extremity. The overall design was a longitudinal cohort study. An inception cohort of acute stroke patients with residual physical deficits was followed over a three month period. Patients were assessed during the first week post-stroke, four weeks later, and then at three months post-stroke. At each evaluation, patients were assessed on measures of impairment and disability, which are described in the measurement section below (Appendix A2.0). This design permitted testing the validity of the STREAM.

Subjects

Patients admitted to any one of five Montreal large urban acute care, university teaching centers, with a first-time stroke were identified. A first-time stroke was defined as by the WHO's criteria of "rapidly developing clinical signs of focal (or global) disturbance of cerebral function lasting more than 24 hours or leading to death with no apparent cause other than that of vascular origin".[4] Having a 'first time stroke' was defined as having no documented evidence of a previous non - reversible ischemic deficit.

Patients were considered eligible if they had no apparent cognitive impairment (based on a score of fourteen or greater on the brief version of the Mini Mental State Examination (MMSE),[15]Appendix A2.1), and if they demonstrated stroke-related physical deficits of the upper and/or lower extremities as evidenced by scores less than age and gender based norms on the Nine-Hole Peg Test,[16] and greater than 10 seconds on the Timed 'Up & Go' (TUG).[17] Patients were excluded if they had completely recovered from the stroke, if they had severe language deficits or if they presented with comorbid conditions like disabling arthritis, Parkinsons disease, amputation, or severe cardiovascular disease. Ethical approval for this study was obtained from all participating hospitals, and each subject was required to sign a consent form before being enrolled in the study.

Measurement

Once consent was obtained, information related to the occurrence of the stroke, the patients medical history, and sociodemographics was recorded directly from the medical records. The screening measures (MMSE, Nine-Hole Peg Test, TUG) were administered (Appendix A2.1) to ensure that subjects met the inclusion criteria and to obtain baseline data. In addition, patients were classified according to severity using the Canadian Neurological Scale (CNS)[18] supplemented by information from the medical chart when the CNS was incomplete. The following instruments were administered at each assessment.

The STREAM[1,2] includes a total of 30 items divided among three main subscales: 10 items for voluntary motor ability of the upper extremity (UE), 10 items for voluntary motor ability of the lower extremity (LE), and 10 items for basic mobility. A three point ordinal scale is used for scoring voluntary movement of the limbs and a four point ordinal scale for basic mobility. An extra category for basic mobility has been added to allow for independence with the help of an aid. The scoring also includes letters a, b, and c to assess the quality of movement. A copy of the STREAM and its scoring scheme can be found in Appendix A1.0.

The *Barthel Index* is a valid and reliable self- proxy questionnaire which measures three categories of function: self-care, continence of bowel and bladder, and mobility.[19] It is composed of 10 items and has a maximum score of 100.[20] Granger et. al.[20] found that patients who scored between 5 to 40 were less likely to return home than those who scored in the range of 41 to 60. Individuals who scored between 60 to 100 had a shorter length of stay.

The *Balance Scale*[21,22] is a measure that consists of 14 task-oriented items which are scored on a scale from 0 to 4 (i.e. a 5 point scale). It has been tested and found to have excellent reliability, and supporting evidence for validity in stroke patients. The Balance Scale scores have been divided into three groups which roughly correspond to ambulatory status: *"poor"*, 0-20; *"fair"*, 21-40; *"good"*, 41-56.[23]

Gait speed was timed over a 5 meter distance. The starting mark was placed 2 meters before the test section, and the stopping mark was placed 2 meters after the test section to allow for acceleration and deceleration. This method of measuring gait speed has been found to have excellent reliability. A study conducted by Salbach[13] who compared comfortable and maximum gait speed for 5 meter and 10 meter distances has indicated that 5 meter comfortable walking speed is the most sensitive measure. Therefore, the 5 meter walking distance at a comfortable pace was chosen for this study.

The ***TUG*** is a practical and valid test of functional mobility. The patient is seated in a chair with armrests, and the time taken to stand up, walk forward 3 meters, and return to the seated position is measured. This test has been shown to have excellent inter-rater and intra-rater reliability in elderly subjects including those with stroke. Normal values for elderly individuals has been documented to be 7 to10 seconds.[17]

The ***Box and Block*** test[24] measures unilateral gross manual dexterity, and is a valid and reliable measure of upper extremity function. This test involves the patient moving, one by one, as many blocks as possible from one compartment of a box to another of equal size, within 60 seconds.

Albert's test is a standardized measure of perceptual neglect that has been validated in stroke patients. The test involves asking the patient to draw a line across all of the 40 lines distributed evenly on a sheet of paper. One sided neglect is indicated if more than 70 percent of the lines are left uncrossed on the same side as the patient's motor deficit.[25,26]

Data Analysis

Construct validity

To test the construct validity of the STREAM, validity coefficients were derived by correlating scores from the total STREAM and each of its subscales with scores from the Box and Block Test,[24] the Balance Scale,[21] gait speed,[13] the Timed 'Up and Go',[17] and the Barthel Index.[19] The Pearson correlation coefficient was used. Both convergent, which assesses the degree to which two measures that are related correlate with each other, and divergent validity coefficients, which assesses the extent to which two unrelated measures do not correlate with each other, were examined. To further assess the association between the STREAM and each measure mentioned above, multiple linear regression was used. Other sociodemographic and stroke-related attributes (Table 4.1) which could account for the variability in the STREAM were also included in the model. Because of the large number of sociodemographic and stroke-related variables, each group was first modeled separately and only the significant variables were included in the final model.

The 'known groups' technique was also used to examine the construct validity of the STREAM. Subjects were classified into known groups subdivided based on scores on the Balance Scale and the Barthel Index. Three methods of classification were used (i) classifications based on cut off points discussed in the literature as described in the Measurement section[20,23] (ii) above and below 95% of the total score (iii) above and below the median of the sample scores on the Balance Scale or the Barthel Index. Method (ii) and (iii) were also included because the distribution of scores by the second and third evaluations were such that there were fewer subjects in the *"poor"* group, and a large number of subjects had reached 95% of the total score or higher for the Balance Scale and the Barthel Index. This resulted in reduced power to detect a significant difference, whereas method (ii) and (iii) allowed for a more even partition of subjects between the two groups. Therefore, these two methods of classification were also included in the analysis. Tests of significance were performed cross-sectionally on STREAM scores between the derived groups using analysis of variance (ANOVA) for the three group comparisons, and t-tests for two group comparisons. Significance was tested at an alpha level of 0.05 (two-tailed). When the groups were created (first method of classification), linear regression was performed to determine if there was a linear trend between the three groups. All analyses for construct validity were completed on data obtained at entry to the study, four weeks later, and three months post-stroke.

Predictive Validity

To assess the ability of the STREAM to predict discharge destination immediately after leaving the acute care hospital simple logistic regression was used. Discharge destination was coded as a dichotomous variable: "home", or "not home". Exponentiating the parameter estimates from logistic regression gives the odds ratio. Odds is the ratio of the probability of occurrence of an event to that of nonoccurrence.[27] The odds ratio approximates the risk ratio when the outcome is rare.[28] When discharge destination was dichotomized approximately 50% of the sample went home, and therefore, the magnitude of the odds ratio is not reflective of the magnitude of the risk ratio. For this study the odd ratios from the logistic regression are calculated and presented. This analysis was repeated for the Barthel Index since previous studies have supported this measure, and other measures of function, as important predictors of discharge destination.[29,30] Therefore, the results of the logistic regression for the Barthel Index were used as a comparison for the STREAM.

To test the ability of the STREAM to predict functional ADL and gait speed three months post-stroke, multiple linear regression was used. Four models were derived, two using gait speed at three months as the outcome, and two using the Barthel Index. For each outcome, one model was assessed with the STREAM alone, and one with the STREAM adjusted for initial gait speed or initial Barthel Index scores. In all models, variables which may be potential confounders such as age, gender, type and side of lesion, level of cognition, and perceptual neglect were also included, and are listed in Table 4.1. Again, because of the large number of potential confounders, the two groups of variables were first modeled separately, and only the significant variables ($p \leq 0.05$) were retained.

For all multiple linear regression analyses, correlation matrices were first generated for the independent variables and each outcome variable to screen for potential problems with collinearity. To verify the assumptions of normality, homoscedasticity, and linearity, residual and partial regression plots were generated and analyzed. Regression diagnostics were performed to identify potential problems with collinearity and outliers. For all analysis the Statistical Analysis System was used (SAS, Windows version 6.12).

Treatment of Missing Data

One patient who had achieved maximum scores on all measures at the first evaluation except the Balance Scale, withdrew from the study before the second evaluation. The patient reported that she had fully recovered. Thus, it was assumed that the patient would have performed just as well or slightly better at the second and third assessments. For these two evaluations, the missing follow-up scores for the STREAM, the Box and Block, the Barthel Index, the TUG, and gait speed, were given the same scores as in evaluation one. A perfect score was given on the Balance Scale, for both the second and third evaluations. Six patients, who no longer wished to participate, had withdrawn from the study before the third evaluation. For these individuals, the average score of all other individuals who had similar initial scores and change scores between the first and second evaluation, were imputed for all measures of impairment and disability.

Assuming that the patient is able to attempt the TUG, its scores can increase infinitely as the level of disability increases. At each evaluation there were a number of patients who were not able to perform this test: 17 at the first evaluation, 7 at the second, and 2 at the third evaluation. Whether or not the patient could perform this test provides important information about recovery. Therefore, to handle the missing values, two new variables were formed. The first variable, called *"ability TUG"* which had two values: 0, for those who were not able to perform the TUG, and 1, for those who were able to perform it. To examine the effect of time taken to perform the TUG on STREAM scores, a variable called *"time*ability TUG"* was formed. It was calculated as the interaction between the ability to perform the TUG and the value of the individual TUG scores subtracted from the mean of the original TUG scores (centralized). Therefore, the two variables included in the analysis were the *"ability TUG"* and the *"time*ability TUG"*.

Out of the 63 subjects, 13 were not evaluated on the Balance Scale because they were not able to perform this test at the initial evaluation. Values were imputed for these individuals by giving a score of zero at the initial evaluation if they were unable to do the test, and since the Balance Scale was found to be highly correlated with gait speed ,the mean Balance Scale values of the sub-group with a similar range of gait speed scores as the subjects with missing data were substituted for the second and third evaluations.

Of the 64 subjects, 7 were not evaluated on the Box and Block test because these patients reported that they had completely recovered their upper extremity function. They, therefore, were assigned age and gender based norms for all three evaluations.

Results

In total, 357 patients were admitted with a first-time stroke to the five acute-care hospitals during the period of recruitment of the study. Of these, 170 patients met the inclusion criteria and were eligible, 78 were approached, and 67 consented to participate. The remaining patients could not be recruited because they were already participating in other research projects or they were unavailable to the investigators at the time of the first evaluation. Of the 67 consenting patients, complete data were obtained on 63 subjects. Table 4.2 summarizes the clinical and demographic characteristics of the final participants and non-participants for this study.

When the group of participants were compared to the group of non-participants, the study sample did not differ significantly with respect to age, gender, or side of lesion. They did differ significantly (0.046) in terms of the type of stroke, with the non-participants having more ischemic strokes. In addition, in the group of non-participants there were a significantly higher number of subjects that suffered a 'mild' stroke as compared to the study sample ($p = 0.007$). This is logical, since patients with a mild stroke tend to be sent home sooner from the hospital and, therefore, were unavailable to participate.

The first evaluation was performed an average of 8 days (SD=3) post-stroke. There was a mean of 29 days between the first and second evaluation (SD=5) and 85 days (SD=17) between the second and last evaluation.

The mean and median scores for all measures of impairment and disability are presented in Table 4.3. The mean scores improved from the first evaluation through to the last evaluation at three months, except for the unaffected upper extremity for the Box and Block test. The median scores for the STREAM, the Barthel Index, and the Balance Scale, were much higher than the mean scores, indicating that the distribution of scores was skewed to the left. Initially, the mean total and subscale scores on the STREAM were greater than 73% of the total score. At five weeks and at three months, these scores on the STREAM were greater than 84% and 87% of the total score, respectively.

Construct Validity of the STREAM

The first method used to evaluate the construct validity of the STREAM was to examine correlations, which are presented in Table 4.4. The correlations between the total score of the STREAM and all measures of impairment and disability were moderate to high, ranging from r =0.57 to r =0.80 for all three evaluations, except with the "*time*ability TUG*", which became important at the final evaluation. All clinical measures were significantly correlated (p=0.0001) with the total score on the STREAM except for the unaffected upper extremity of the Box and Block (p<0.25) and the "*time*ability TUG*" for the initial (p<0.1) and five week evaluations (p<0.5).

The only stroke-related variable (Table 4.1) that was significantly correlated (p=0.0001) with the total and subscale STREAM scores at all three evaluations was severity of the stroke, with correlations ranging from moderate to high (r =0.66-0.77).

The results of the multiple linear regression analyses done cross-sectionally at each point in time (Table 4.5), also showed strong associations between the STREAM and the other measures of impairment and disability. Every regression analysis involved modeling the total STREAM scores as a function of each measure of impairment and disability, first alone and then adjusted for age and severity, the only other variables that were consistently associated with the STREAM. The parameter estimates were significant, and the association with total STREAM scores remained strong even after adjustment for age and severity. The amount of variability that each clinical measure explains in the STREAM was also significant (p=0.0001), with the total variability explained ranging from 54%-82%.

The 'known groups'[3] technique was also used to examine evidence for the construct validity of the STREAM. Subjects were grouped according to their performance on the

Balance Scale, and the Barthel Index. Table 4.6. shows the three different methods of classification of subjects on the Balance Scale. For each grouping, the mean STREAM scores increase as the performance on the Balance Scale improves. Subjects were first classified into three groups: "*good*", "*fair*", and "*poor*" based on Balance Scale scores.[23] Simple linear regression showed a significant linear trend ($p=0.0001$) across the three groups: mean STREAM scores were higher for subjects classified as "*good*" compared to "*fair*", and for those classified as "*fair*" compared to "*poor*". For the initial evaluation the means for the three groups were significantly different from each other ($p<0.05$). At five weeks all means were significantly different from each other ($p<0.05$) except between the "*fair*" and "*poor*" group ($p>0.05$). The sample sizes for these two groups at five weeks were much smaller and, therefore, the power to detect a significant difference was also reduced.[31] At three months there were no patients classified as "*poor*", and a significant difference was found between the "*fair*" and "*good*" group ($p=0.0001$). Subjects were also classified above and below 95% of the total score, and above and below the median of Balance scores. For both methods of classification, there was a significant difference ($p=0.0001$) in mean STREAM scores between the two groups.

A similar pattern was found for the Barthel Index. Please see Table 4.7.

The Ability of The STREAM to Predict Discharge Destination

The average time between onset of stroke and discharge from the acute care hospital was 12 days (SD=6). Thirty one subjects were discharged home, 30 to rehabilitation, one subject to another acute care hospital, and one was discharged to long-term care. The odd ratios from simple logistic regression were used to identify cut off points on the STREAM that would differentiate between whether a patient would be discharged home or to another medical institution (Table 4.8a). Ranges of scores that had similar odd ratios were grouped together. It was found that three different intervals of total STREAM scores significantly differentiated the odds of being discharged home after the acute care hospital: 0-70, 70-90, and above 90. The odd ratios and the percent of individuals in each group who were discharged home is presented in Table 4.8a. The number of individuals discharged home increases as the value of the interval scores on the STREAM increases. Eighty percent of those who scored above 90 on the STREAM were discharged home. For individuals who attained a score between 70-90, their odds of going home are five times higher then for those who scored below 70 on the STREAM. The odds of being discharged home are 24 times higher for subjects who score above 90 on the STREAM as compared to those who score below 70. When the analysis was repeated with adjustment for age, the results were similar and the odd ratios for the STREAM still remained significant. The cut off points for the Barthel Index were obtained in the same way as for the STREAM (Table 4.8b). The percentage of patients who were discharged home in each group was similar to that seen for the STREAM interval scores. The analysis for the Barthel Index also yielded significantly high odds ratios. Once again, the results were similar after adjusting the Barthel Index for age.

The Ability of the STREAM to Predict Independence in Functional ADL and Gait Speed

The first method of assessing the relationship between initial STREAM scores and gait speed and the Barthel Index at three months, was to calculate the means of these latter two measures in the three intervals of STREAM scores, as estimated from the previous logistic regression. Gait speed and the Barthel Index mean scores increased as the STREAM cut-off points increased. Simple linear regression showed a significant (p=0.0001) linear trend in mean scores between the three groups, for both the Barthel Index and gait speed (Table 4.9).

The ability of the STREAM during the first week post-stroke to predict gait speed and Barthel Index scores at three months was assessed. The STREAM was first unadjusted and then adjusted for initial gait speed or initial Barthel Index scores (Table 4.9). The unadjusted parameter estimates were significant (p=0.0001), and the STREAM, during the first week post-stroke, was found to be an independent predictor of the Barthel Index and gait speed at three months. The parameter estimates indicated that an initial 10 point increase on the STREAM resulted in a 3 point increase on the Barthel Index, and a 0.08 meters/second increase in gait speed at three months. When the STREAM was adjusted for initial gait speed the STREAM still came out as a significant predictor of gait speed at three months, with a ten point increase in the STREAM resulting in a 0.05 meters/second increase in gait speed. When the STREAM was adjusted for initial Barthel Index scores the STREAM no longer emerged as a significant predictor of the Barthel Index at three months.

Discussion

Acute stroke patients with motor and functional deficits are expected to improve,[11,32] and thus provide an ideal population in which to assess the performance of the STREAM. This study provided information about how the STREAM performs in a cohort of 63 stroke subjects, during the first three months post-stroke. The correlations of the STREAM with measures of balance, upper extremity function, functional independence in ADL, functional mobility, and gait speed were all in the hypothesized direction, moderately to highly strong, and statistically significant. In addition, the mean STREAM scores distinguished between different levels of balance ability and independence in functional ADL, and also differentiated stroke patients according to whether they were discharged home or not. There is also evidence that the STREAM during the first week post-stroke is an independent predictor of gait speed and independence in functional ADL at three months.

The results provided evidence to support the construct validity of the STREAM. The STREAM scores of subjects were strongly associated (Table 4.4) with the Box and Block, the Barthel Index, the TUG, and gait speed for all three evaluations. Based on evidence from the literature,[6,7,33,34] we had hypothesized that the measures of balance, upper extremity function, the level of independence in ADL, and mobility should be positively related to the STREAM since a certain amount of motor recovery is required for postural stability and the performance of functional activities. The use of multiple linear analyses allowed us to further examine the relationship between the STREAM and other measures of impairment and disability, while considering the influence of various sociodemographic and stroke-related characteristics. The only characteristics that were found to be significant correlates of the STREAM were age and severity. When the other measures of impairment and disability were adjusted for these variables the association between the STREAM and the Box and Block, the Balance Scale, the Barthel Index, the TUG, and gait speed remained highly significant. Also, the variability of total STREAM scores explained by each variable was high, but never 100% (Table 4.5.). This reflects that the STREAM is related to other scales of impairment and disability, but is still assessing a different component of recovery that is not captured by the other measures.

The associations between the STREAM subscales and these measures were also examined, and provided evidence for the convergent and divergent validity of the STREAM. As expected, for all three evaluations, the correlations between the UE subscale and the affected upper extremity score on the Box and Block (0.76-0.79), was higher then for the lower extremity and basic mobility subscales (0.53-0.70). Motor recovery of the lower extremity is needed to improve performance in mobility tasks.[6,35] It was, thus, expected at each evaluation point that the LE subscale of the STREAM would be more highly correlated with the Balance Scale, since 93% of tasks are performed in standing, the TUG, and gait speed as compared to the UE subscale. This was confirmed for the initial evaluation, where the correlations of the TUG and gait speed with the UE subscale were 0.69 (*ability*), 0.20 (*time*ability*), and 0.56 respectively, and with the LE subscale were 0.75 (*ability*) 0.23 (*time*ability)*, and 0.74 respectively. However, for the five week and three month evaluations the correlations between the mobility measures and the UE and LE subscales were still moderate but similar. This may be in view of the fact that the items on the LE subscale consist of simple limb movements, such as extending the knee in sitting, which are important for functional activities such as walking. However, the quality and quantity of the movement is different when the patient performs it alone as opposed to when it is incorporated into the functional activity and, therefore, as the patient becomes more functional the isolated movements are not as highly related to the mobility measures. Initially, the return of function may be more closely associated to neurological recovery and the restoration of voluntary movement, but as the patient recovers and the impact of the disability begins to manifest itself, other factors such as compensation, cognitive ability, and motivation begin to play a role in achieving independence and improving functional performance.[8,36] Therefore, at first the variability of motor recovery of the lower extremity is more closely related to the recovery of functional performance as reflected by the disability measures, but over time this relationship decreases because other explanatory variables which also influence functional activity begin to play a role. In contrast, the mobility subscale of the STREAM contains items which reflect basic functional abilities, such as transferring from sitting to standing, and most tasks are performed in standing. Therefore, it was hypothesized that it would be more highly related to the mobility measures, as compared to the LE and UE subscales of the STREAM. This hypothesis was confirmed, as the mobility scale was highly correlated with the TUG, gait speed, and the Balance Scale for all three evaluations.

Interesting associations were found between the total and subscale STREAM scores and the TUG. The correlation between the STREAM and the *ability TUG* decreased over time, whereas the correlation with the *time*ability TUG* increased over time. In this study, the variability in the *ability TUG* decreased throughout the three months, since by the third evaluation only two subjects were unable to perform the TUG. This may explain the decreased correlation of *ability TUG* with the STREAM over time. The Timed 'Up & Go' is a test of functional mobility, and a decrease in the amount of time needed to perform this test indicates improved functional mobility. In contrast, whether or not a subject could perform the TUG (i.e. *ability TUG*) is a more global and less sensitive indication of functional capacity. When motor recovery initially occurs patients may not yet be able to incorporate this recovery into functional activity. Over time, as patients learn to integrate neurological recovery with learning and compensatory strategies, the effects of the neurological recovery are reflected through functional activity. Therefore, this may be a possible explanation why motor recovery as measured by the STREAM becomes more highly related to the *time*ability TUG* as functional performance improves.

The mean STREAM scores of stroke subjects, grouped according to their performance on the Balance Scale and the Barthel Index, demonstrated a gradient effect with those classified as good having the higher scores, and those classified as poor, the lower. The same results were found with two other classification strategies. This provides further evidence for the construct validity of the STREAM as motor recovery often parallels the return of postural stability and functional recovery.[6-9,12,33-35,37-41]

The ability to predict discharge destination when stroke patients are admitted to the acute care hospital is very important. This allows the multidisciplinary team to immediately make the necessary arrangements in order to avoid having patients stay in acute care longer then is medically needed. Extending the period of acute-care hospitalization, unnecessarily, is not only costly but may be detrimental for persons with stroke because of deconditioning, social isolation, and the fostering of dependent relationships.[42] The STREAM scores during the first week post-stroke were able to predict the odds of being discharged home immediately after the acute care hospital. Some studies have identified functional ability as measured by the Barthel Index as an important predictor of discharge destination,[29,30] and, therefore, the Barthel Index was used as a comparative predictor to the STREAM. The results for the STREAM were comparable to those for the Barthel Index. Even though the odds for the Barthel Index were larger then the odds obtained for the STREAM, in both cases the odds were high and significant. The data also showed that the cutoff point on the STREAM between patients that are discharged home and those that are not is 60, and for the Barhel Index it is 55. Many studies have examined the use of functional scales, such as the Functional Independence Measure (FIM) or the Barthel Index, to predict the discharge destination of stroke patients.[43] Although these scales are often valid and reliable measures of disability, they may not represent the focus of immediate acute care therapy interventions.[44]

Whether or not the patient will be able to function independently in daily self-care activities is of concern to patients, family, and professionals. In other studies motor function has been demonstrated to predict ADL function.[45-51] Accordingly, such a predictive ability should be expected for a new measure of motor recovery. The mean Barthel Index scores at three months showed a significant linear trend between the three different intervals of STREAM scores estimated through logistic regression (Table 4.9). Therefore, the STREAM has prognostic value in terms of the level of functional independence in ADL.

The regression analysis showed that the initial total STREAM was a significant independent predictor of the Barthel Index at three months. However, when the STREAM was adjusted for the initial Barthel Index scores, the association between initial STREAM scores and the Barthel Index at three months was significantly reduced, and initial Barthel Index scores were found to be the best predictor. This coincides with the literature in that admission function is commonly found to be the best predictor of discharge function on the same measure.[52] Functional potential, however, can parallel motor recovery, and in the acute setting, a better understanding of the relationship between early motor impairment and subsequent functional ability has several clinical and experimental implications. Assessing the level of motor impairment helps group patients according to the severity of stroke, which facilitates the identification of specific therapies that will be most sensitive to different levels of motor impairment. In research, the ability to distinguish the level of motor recovery between subjects helps minimize the confounding effects of differences in motor status between groups.[44] For example, in clinical trials patients can be stratified according to their level of motor performance. In addition, successive evaluation of motor recovery is useful in understanding the process of recovery of independence in functional ADL.[8] Finally, with continuous assessment of motor impairment, functional improvements from neurologic recovery may be distinguished from those caused by compensatory learning, and cognitive changes.[44]

In this study, mean gait speed at three months also reflected a significant linear trend between the three groups classified based on STREAM scores and the STREAM was found to be an independent predictor of gait speed at three months (Table 4.6). Often, in the acute setting, the use of higher level functional measures such as gait speed is not yet appropriate for severe stroke patients. In this setting, the STREAM as a clinical measure would play an important role in predicting the level of gait speed performance. Being able to predict an important component of walking ability such as gait speed will assist in choosing appropriate treatment interventions and with discharge planning.

Various methods were used to provide evidence to support the validity of the STREAM. Each method provided a different means of examining the performance of the STREAM in relation to other measures of impairment and disability. The results of this study support the validity of the STREAM, and with the ongoing testing of the psychometric properties of the STREAM, clinicians and researchers will have a new tool capable of assessing motor recovery in stroke patients.

Limitations of the Study

There were significant differences found between the study sample and the non-participants in terms of the type and severity of stroke. An instrument is only valid for individuals similar to those on which the scale was tested. Therefore, the results can only be generalized to patients who have the same characteristics as those who participated in the present study.

The cut off points for the STREAM which were estimated from observing the odds ratio in the logistic regression analysis are only rough estimates. Further use of the STREAM in the clinical setting and evaluation of its performance in other stroke cohorts, are needed to more accurately assess the ranges of scores that best discriminate between different groups of stroke patients.

When testing the ability of the STREAM to predict discharge destination, the outcome was dichotomized as "home" versus "not home", since most patients either went home or to rehabilitation. Testing the STREAM in a sample of stroke patients where discharge destination is more variable would provide stronger information with regards to its ability to discriminate between patients for this very important outcome.

The sample size for this study was calculated based on a correlation greater or equal to 0.45, at 90 percent power, and a two-tailed alpha level of significance of 0.05. A larger sample size would have allowed smaller mean differences to be significant across the groups.

The first evaluation occurred an average of 8 days post-stroke. A significant amount of motor recovery can take place in the first ten days post-stroke, therefore, some patients may have experienced a certain amount of recovery before the first evaluation. Not having captured this early recovery may have reduced the variability in STREAM scores, and underestimated its ability to predict the level of independence in functional ADL and gait speed.

In addition, the methods used to handle the missing data were only estimates of the true level of recovery. It is possible that some of the results were overestimated or underestimated, however, during the data analysis, care was taken to ensure that the imputed values did not cause large influences on the distribution of scores.

The primary limitations of this study are related to the ongoing process of instrument validation in the absence of a gold standard. Estimating the validity of an instrument involves judgments about which variables relate to the construct, and what degree of correlation is needed to support the validity of the instrument. Collectively, the various strategies used in this study to assess the validity of the STREAM are convincing of its ability to assess motor recovery following stroke.

Conclusion

This study provides supporting evidence that the STREAM is a valid measure of motor recovery. It relates to other measures of impairment and disability in a manner that is expected based on theory and previous studies. The STREAM is able to predict important outcomes of stroke including discharge home, functional independence in ADL, and gait speed. The STREAM is a simple tool to use which can be easily incorporated into the routine acute stroke assessment. This will allow the consistent objective documentation of motor recovery, and assist rehabilitation specialists in the decision making process and planning patient care. The validation of a scale is an ongoing process, and wider clinical use and future studies will aid in further understanding the properties of the STREAM.

Acknowledgments

The authors wish to thank the research nurses Susan Anderson, Angela Andrianakis, Rosemary Hudson, and Lisa Wadup for patient recruitment, and Claudette Corrigan for her assistance in running the study. The assistance of Adrian Levy, Susan Scott, and Judy Soicher in the analysis are also gratefully acknowledged.

Tables

Table 4.1: Measurement of Variables for Validity

Independent Variable/ Measure	Measurement Scale	Scoring/Coding
Measures of Impairment and Disability		
Box & Block Test	continuous	number of blocks
The Timed 'up & Go'	continuous	seconds
Gait Speed (5m, comfortable pace)	continuous	meters/second
Balance Scale	quasi-continuous	/56
Barthel Index	quasi-continuous	/100
Sociodemographic Variables		
Gender	binary	0=male, 1=female
Presence of caregiver	binary	0=yes, 1=no
Age	continuous	years
Comorbidity	continuous	number of comorbid conditions
Stroke- Related Variables		
Cognition	pseudo-continuous	/22
Perceptual Neglect (Albert's Test)	binary	0 = yes, 1= no
Side of Stroke	binary	0=right, 1=left
Type of stroke	binary	0=ischemic, 1=hemorrhagic
Limbs affected	ordinal	0=UE, 1=LE, 2=UE & LE
Hospital of admission	categorical	5 hospitals coded 0 to 4
Severity of stroke (CNS)*	ordinal	0=severe, 1=moderate, 2=mild
Time between stroke and evaluation	continuous	days

Abbreviations: UE, LE indicates upper/lower extremity, respectively; CNS. Canadian Neurological Scale.
*Stroke severity was based on CNS scores: mild ≥11, moderate 9 ≤ CNS < 11, severe stroke CNS <9.

Table 4.2: Demographic and Clinical Characteristics of Study Participants and Eligible Non-participants

Characteristic	Eligible Subjects		p-value
	Participants (n=63)	Non-participants (n=120)	
Age in years,mean(SD)	67 (14)	70(13)	0.561
Range	25-95	34-100	
Gender, No. (%)			
Male	39 (62)	67(55)	0.363
Female	24 (38)	55(45)	
Side of lesion, No.(%)			
Right	31(49)	46(54)	0.623
Left	30 (48)	38(45)	
Bilateral	2(3)	1(1)	
Missing	0	37(30)	
Type of stroke, No. (%)			
Ischemic	59 (94)	66(83)	0.046
Hemorrhagic	4 (6)	14(18)	
Missing	0	21(17)	
Severity of stroke, No.(%)			
Mild	12(19)	44(36)	0.007
Moderate	33(52)	38(31)	
Severe	18(29)	18(15)	
Missing	0	22(18)	

Table 4.3: Performance of Study Subjects on Measures of Impairment and Disability at Three Points in Time (n=63)

Measure	Initial			5 weeks			3 months		
	Mean	(SD)	Median	Mean	(SD)	Median	Mean	(SD)	Median
STREAM									
Total	74..65	26.71	86.1	86.37	19.96	94.4	89.42	17.54	96.7
UE subscale	73.21	33.28	90	84.92	26.20	100	87.79	23.57	100
LE subscale	75.09	28.88	85	86.04	22.29	95	89.89	18.74	100
Mobility subscale	73.99	25.92	83.3	88.15	16.39	96.7	90.57	14.68	96.7
Box and Block									
affected UE	24.77	21.04	27	36.48	22.79	43	41.25	71.70	45.5
unaffected UE	48.64	13.84	47	55.98	11.81	55.5	55.93	12.66	57.5
Barthel Index	72.22	27.89	85	86.11	20.43	100	91.98	14.04	100
Balance Scale	33.51	21.21	40.5	43.62	15.88	52	47.70	10.04	52
TUG (s)	20.83	16.52	21.6	12.31	5.27	12.7	11.67	4.04	11.3
Gait Speed (m/s)	0.55	0.38	0.58	0.82	0.43	0.90	0.85	0.36	0.93

Abbreviations: SD, Standard Deviation; UE, upper extremity; LE, lower extremity; TUG, Timed 'Up & Go'; s, seconds; m/s, metres/second.

Table 4.4: Pearson Correlations of the Total and Subscale STREAM Scores with Other Measures of Impairment and Disability at Three Points in Time*(n=63)

Measure	Initial				5 weeks				3 Months			
	Total	**UE**	**LE**	**Mobility**	**Total**	**UE**	**LE**	**Mobility**	**Total**	**UE**	**LE**	**Mobility**
Box and Block *affected UE*	0.73	0.78	0.53	0.66	0.77	0.79	0.64	0.69	0.78	0.76	0.70	0.66
unaffected UE	0.44	0.33	0.40	0.55	0.37	0.36	0.29	0.40	0.36	0.31	0.30	0.40
Barthel Index	0.78	0.67	0.71	0.84	0.71	0.66	0.59	0.75	0.75	0.67	0.63	0.82
Balance Scale	0.75	0.57	0.73	0.88	0.68	0.61	0.58	0.71	0.65	0.53	0.55	0.78
TUG *ability*	0.80	0.69	0.75	0.85	0.64	0.60	0.59	0.57	0.57	0.49	0.51	0.62
*time*ability*	-0.25	-0.20	-0.23	-0.26	-0.38	-0.33	-0.27	-0.50	-0.66	-0.59	-0.60	-0.66
Gait Speed	0.74	0.56	0.74	0.83	0.62	0.53	0.55	0.65	0.73	0.64	0.65	0.76

Abbreviations: UE, upper extremity; LE, lower extremity; TUG, Timed 'Up & Go'.
*All correlations significant at the p=0.0001 except for *time * ability TUG* at the initial ($p \leq 0.1$) and 5 week ($p < 0.05$) evaluations and the unaffected arm of the Box and Block at all three evaluations ($p < 0.025$).

Table 4.5: Results of the Multiple Linear Regression Analyses Demonstrating the Relationships Between the STREAM and Measures of Impairment and Disability

Measure	Evaluation (n=63)	Unadjusted ß* † (se)	R^{2}**	Adjusted for age and severity ß (se)	R^2
Barthel Index	*Initial*	0.8 (0.1)	0.61	0.5 (0.1)	0.74
	5 weeks	0.7 (0.1)	0.51	0.6 (0.1)	0.66
	3 months	0.9 (0.1)	0.57	0.8 (0.1)	0.63
Box & Block (affected)	*Initial*	0.8 (0.01)	0.56	0.5 (0.1)	0.67
	5 weeks	0.7 (0.1)	0.60	0.5 (0.01)	0.65
	3 months	0.6 (0.1)	0.60	0.5 (0.09)	0.62
Box & Block (unaffected)	*Initial*	0.9 (0.2)	0.22	0.4 (0.2)	0.63
	5 weeks	0.6 (0.2)	0.14	0.6 (0.2)	0.54
	3 months	0.5 (0.2)	0.13	0.3 (0.3)	0.42
Balance Scale	*Initial*	0.1 (0.1)	0.57	0.6 (0.1)	0.72
	5 weeks	0.9 (0.1)	0.46	0.7 (0.1)	0.64
	3 months	1.1 (0.2)	0.43	0.9 (0.2)	0.55
Gait Speed@ meters/second	*Initial*	5 (0.6)	0.55	3.5 (6.2)	0.73
	5 weeks	2.9 (4.7)	0.38	2.7 (4.4)	0.67
	3 months	3.6 (4.3)	0.53	3.2 (5.2)	0.63
Ability TUG‡ (Yes/No)	*Initial*	47.8 (4.2)	0.70	34.8 (5.1)	0.77
	5 weeks	40.2 (5.5)	0.55	34.2 (5.0)	0.71
	3 months	56.8 (6.2)	0.77	53.3 (5.8)	0.82
Time*Ability TUG	*Initial*	-0.5 (0.1)	0.70	-0.3 (0.1)	0.77
	5 weeks	-0.5 (0.1)	0.55	-0.5 (0.1)	0.71
	3 months	-0.9 (0.1)	0.77	-0.8 (0.1)	0.82

Abbreviation: n, number of subjects.
* ß is the parameter estimate; se is the standard error. ß/se = t-test.
** R^2 is the amount of variability of the total STREAM scores explained by each measure.
† All parameter estimates are significant even after adjustment for age and severity. p=0.0001 except for the unaffected Box and Block (p<0.01) at 5 weeks and 3 months.
‡ Ability and Time*Ability TUG were always modeled together.
@ The parameter estimates are divided by 10 indicating the effect of 0.1 meters/second.

Table 4.6: Relationship Between Mean STREAM Scores and Different Balance Scale Score Classifications

	Classification of Balance scores.	Initial Mean (SD) n	5 weeks Mean (SD) n	3 months Mean (SD) n
(i)*	Good@	91.3 (16.1) 30	93.5 (10.3) 45	94.7 (9.6) 49
	Fair	77.9 (8.8) 15	71.5 (22.7) 10	70.1 (25.6) 14
	Poor	44.3 (27.6) 18	64.5 (32.0) 8	----- ----- 0
(ii)**	> 95% total score	92.8 (10.1) 12	97.5 (3.0) 23	98.9 (1.8) 24
	< 95% total score	70.4 (27.6) 51	79.1 (22.7) 40	83.6 (20.2) 39
(iii)**	> median score	91.22 (8.7) 31	97.0 (4.6) 28	97.4 (6.4) 28
	< median score	58.62 (28.6) 32	77.9 (23.3) 35	83.1 (20.9) 35

@ Good = 41-56, Fair = 21-40, Poor = 0-20.
* $p < 0.05$ except between fair and poor group at 5 weeks ($p > 0.05$). Significance test performed using ANOVA
** $p = 0.0001$. Significance test performed using t-test

Table 4.7: Relationship of Mean STREAM Scores With Different Barthel Index Score Classifications

	Classification of Balance scores.	Initial Mean (SD) n	5 weeks Mean (SD) n	3 months Mean (SD) n
(i)*	Good@	88.14 (13.9) 42	91.7 (12.7) 52	91.6 (14.2) 59
	Fair	59.5 (21.0) 8	62.8 (29.8) 7	60.8 (38.4) 3
	Poor	40.4 (26.6) 13	58.7 (30.2) 4	47.8 (na) 1
(ii)**	> 95% total score	93.6 (7.4) 22	96.7 (4.8) 36	96.6 (6.7)
	< 95% total score	64.5 (27.8) 41	72.6 (24) 27	72.9 (23.2) 19
(ii)**	> median score	91.1 (8.9) 27	96.7 (4.8) 32	97.6 (5.6) 38
	< median score	61.7 (28.3) 36	75.8 (23.9) 31	76.1 (21.9) 25

@ Good = 61-100, Fair = 41-60, Poor = 0-40.
* $p<0.05$ except between the fair and poor means at 5 weeks and all mean comparisons at 3 months ($p<0.05$). Significance test performed using ANOVA
** $p=0.0001$. Significance test performed using t-test

Table 4.8a: Odd Ratios Obtained by Logistic Regression to Assess the Ability of the STREAM to Predict Discharge Destination

STREAM Category	n went home (%)	Odd Ratios (95% CI)	Odd Ratios Adjusted for Age (95% CI)
0-70 (n=21)	3 (14%)	Reference point	Reference point
70-90 (n=17)	8 (47%)	5* (1.1, 24.8)	6(1.2, 26.9)
90-100 (n=25)	20 (80%)	24** (5, 115)	23(4.7, 109)

Abbreviations: n, number of subjects; CI, confidence interval.
* $p<0.05$
** $p=0.0001$

Table 4.8b. Odd Ratios Obtained by Logistic Regression to Assess the Ability of the Barthel Index to Predict Discharge Destination

STREAM Category	n went home (%)	Odd Ratios (95% CI)	Odd Ratios Adjusted for Age (95% CI)
0-70 (n=21)	2 (9%)	Reference point	Reference point
70-90 (n=20)	10 (50%)	10* (1.6, 55)	10 (1.8, 60)
90-100 (n=22)	19 (86%)	60 ** (8.5, 427)	70 (9.8, 495)

Abbreviations: n, number of subjects; CI, confidence interval.
* $p<0.001$
** $p=0.0001$

Table 4.9. The Ability of the Total STREAM to Predict Gait Speed and the Barthel Index at Three Months, and its Relationship with Their Mean Scores.

STREAM Classification	Gait Speed% mean+ (SD)	Barthel Index mean+ (SD)
0-70	0.57 (0.36)	81.2 (17.6)
70-90	0.91 (0.28)-	95.3 (11.1)
90-100	1.06 (0.23)	98.8 (3.3)
β^{*} unadjusted (SE)	0.08 (0.001)θ	3.3 (0.05)
β^{**} adjusted (SE)	0.05 (0.002)∝	0.09 (0.08)

% Measured in meters/second.
+ Mean scores at three months post-stroke. Overall significance test between means results in p=0.0001.
* Parameter Estimate of the total STREAM multiplied by 10. t-test =ß/SE.
** Adjusted for initial Gait Speed or initial Barthel Index scores.
θ Also adjusted for age and cognition.
∝ Also adjusted for age.

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CHAPTER 5

INTEGRATION OF MANUSCRIPT 1 AND 2

5.1 Primary Research Objectives of Manuscript 1 and 2

Manuscript 1: To determine the construct validity of the STREAM including convergent and divergent validity, and predictive validity.

Manuscript 2: To estimate the responsiveness of the STREAM during the first three months post-stroke.

5.2 Integration of Manuscript 1 and 2

The majority of stroke patients are left with some level of motor deficit following stroke which limits their ability to function independently in activities of daily living and mobility. Given the extensive physical, personal, and social consequences of motor impairment post-stroke, the treatment of motor dysfunction is a very important component of rehabilitative efforts and a good measure is needed to evaluate this outcome.

Exhibiting the appropriate psychometric properties is the fundamental criteria for any good measure. Following the examination of reliability and content validity,[7,21] it was important to ensure that the STREAM was a valid measure of motor recovery through examining its performance in relation to other measures of impairment and disability. In the first manuscript, the different methods of testing provided supporting evidence for the validity of the STREAM. The correlations of the STREAM with measures of balance, upper extremity function, functional independence in ADL, functional mobility, and gait speed were in the hypothesized direction, moderately to highly strong, and statistically significant. In addition, the mean STREAM scores distinguished between different levels of balance ability and independence in functional ADL, and also differentiated stroke patients according to whether they were discharged home or not. There is also evidence that the STREAM, during the first week post-stroke, is an independent predictor of gait speed and independence in functional ADL at three months.

The suitability of the STREAM as an outcome measure of motor recovery, requires that it also demonstrates the ability to detect small changes in patient status with repeated administrations, and be able to discern a beneficial effect of treatment. The usefulness of an instrument to measure change over time requires that it be reliable and valid, but these properties alone are not adequate to support the responsiveness of the measure.[73] The ability to detect change also depends on the number of response categories in the scoring scheme, and the number and type of items within the scale or within the individual subscales.[74] Thus, once there was supporting evidence that the STREAM is a valid measure of motor recovery, it was important to test its ability to monitor changes in motor performance. This would allow clinicians and researchers to monitor the effectiveness of rehabilitation interventions aimed at restoring motor function. Therefore, the ability of the STREAM to reflect change in patient status was tested through to the first three months following stroke.

CHAPTER 6

RESPONSIVENESS

6.1 Literature Review

In order for clinicians to evaluate the outcome of motor recovery over time and to document patient response to treatment, they need instruments that can detect clinically important change in patient status. As outcome measures are used more often in the clinical setting, we need useful ways to estimate and communicate whether particular changes in health status are clinically relevant.[76] The ability to detect clinical change, even if it is small in magnitude, provides motivation to patients, helps therapists during treatment planning, and has implications for resource allocation. In research, when a measure is sensitive to minimal change, fewer subjects are needed.[40,73]

Responsiveness is the term used to describe the ability of a tool to detect clinically important change in a given construct, and is also known as the sensitivity of the instrument. During the creation of a measure, items must be chosen based on clinical relevance and potential responsiveness to change. By including items that effectively detect changes, and having a range of response options, the measures ability to detect finer gradations of change is enhanced.[75] A tool that aims to evaluate the outcome of motor function should be responsive to changes in motor recovery, and as such will allow for monitoring interventions in clinical practice and in research.

Table 6.1: Estimators of Responsiveness

Estimator	Calculation	Reference
Effect Size	Mean Δ/ $SD_{initial}$	Kazis et al.., 1989[76]
Standardized Response Mean	Mean Δ/ SD_{change}	Liang et. al., 1990[78]
Paired t-test	Mean $\Delta/SD/(^{*}n)^{1/2}$	Liang et. al., 1985[81]
Relative Efficiency	t-statistic$_{test1}$/t-statistic$_{test2}$	Deyo et al., 1991[80]
Sensitivity and Specificity	Sensitivity =P(trueΔ/Δoccurred) Specificity = P(no Δ/no Δ occurred)	Deyo et. al.1984[82]
Receiver Operating Characteristic Curves	area under curve = P(correctly identifying the improved patient from randomly selected pairs of improved and unimproved patients)	Deyo et al., 1986[83]
Intraclass Correlation Coefficient	$\sigma^2_{change}/\sigma^2_{change}+\sigma^2_{error}$	Streiner et. al., 1995[54]

Abbreviations: SD, standard deviation; n: number of subjects;Δ, change; P, probability of.

Many empirical methods for assessing responsiveness have been developed and are listed in Table 6.1. One method uses change scores to calculate an Effect Size Index, which was first suggested by Cohen, and this index is a unitless measure.[77] Many variations of the Effect Size Index have been advocated. Kazis et. al.[76] calculated Effect Size (ES) as the ratio of the average change score from pre- to post-treatment to the standard deviation of the pre-treatment score. Liang et al.[78] suggested the use of the standard deviation of subjects' change scores as the denominator for calculating the ES index and this is called the Standardized Response Mean (SRM). The larger the ES or the SRM the more responsive is the tool.[74,76] ES is often preferred to the SRM for comparisons between studies since the standard deviation of pre-treatment scores is more commonly reported in the literature than the standard deviation of change scores.[74] The advantage of the SRM is that it accounts for the heterogeneity of responses in patients, either undergoing treatment or during the natural recovery from disease. Guyatt et. al.[73] suggested the use of the Index of Responsiveness. For this index the numerator is the "minimal clinically significant difference" and the denominator is the standard deviation of change scores in stable subjects. The Index of Responsiveness only considers the amount of clinically meaningful change relative to the variability in a stable control group, and therefore, is likely to underestimate the variability of scores.[79] Cohen's guidelines for interpreting ESs are as follows: 0.2 or less is small, 0.5 is moderate, and 0.8 or more is large.

The paired t-statistic has also been used to estimate responsiveness.[80] Liang et. al.[81] developed a method called Relative Efficiency which uses t-statistics to reflect a scale's relative responsiveness as compared to another measure's t-statistic. Relative efficiency more or less than 1.0 indicates that one scale is better or worse at measuring change than a comparison scale.[81]

Another method involves looking at a clinical scale as a diagnostic test and then calculating the sensitivity and specificity to identify true score changes.[82] This method determines the probability that either true improvement or true deterioration in the attribute of interest occurred by comparing test scores with performance on an external criterion. The Receiver Operating Characteristic curve is one method which is an extension of the idea of diagnostic testing. The area under these curves is proportional to a scales ability to distinguish between patients who change and those who do not.[83,84] It is also possible to examine the within person change following an intervention of known efficacy or after a period during which change is expected according to the natural history of the illness. For both methods the external criterion chosen should be considered a gold standard for the attribute being measured.[83,84]

A version of the intraclass correlation coefficient for measuring responsiveness has been proposed by Streiner et. al.[54] Variability due to systematic and/or random error is accounted for in the denominator. This coefficient is interpreted as the proportion of the variance in the change score due to true change and ranges in value from 0 to 1.0.

To date, there has not been any consensus as to which method is best for assessing responsiveness,[100] however, some methods have specific applications under certain circumstances.[74] In addition, a tool is only responsive for what it purports to measure and for the specific application for which it was tested.[100] For all indices of responsiveness, the basic goal in improving the ability of the instrument to detect change is to reduce the amount of measurement "noise" (e.g. variation in a control group, variation between subjects), and improve the ability to capture the treatment effect, or improvement in patient status due to the natural recovery process of the disease which is the "signal".[74] For this paper ES and the SRM were chosen to assess the responsiveness of the STREAM.

Determining what constitutes a clinically important change is not based on statistical calculations alone, and individual judgment must also play a role when the final results are interpreted.[74] Whether a given change is important will depend on factors such as the patients baseline health status, expectations and goals, and the need to carry out certain activities.[74]

Most stroke patients recover during the first three months post stroke.[5,8] The present study examines the changes in motor recovery during this time period. The methods used for assessing the responsiveness of the STREAM will address whether the STREAM and its subscales can detect changes in the status of acute stroke patients over the three month follow-up period. This is necessary if the STREAM is to be used as an evaluative outcome measure to assess the impact of various physiotherapy interventions on the restoration of motor function.

6.2 Responsiveness of the STroke REhabilitation Assessment of Movement (STREAM)

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Manuscript prepared for submission to the journal entitled *Stroke*

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Introduction

Responsiveness is the ability of a measure to detect clinically important change in a given characteristic, even if that change is small.[1] Tools that are responsive to changes in patient status are needed for the evaluation of the efficacy of rehabilitation programs. Therapists need instruments that will allow them to document patient response to treatment. The restoration of motor function is a major focus of rehabilitative efforts and, therefore, necessitates having an instrument that is responsive to changes in motor recovery.

The Stroke Rehabilitation Assessment of Movement (STREAM) is a relatively new measure which evaluates motor recovery in stroke patients. The development and content of the STREAM have been described in a previous paper.[2] There is evidence supporting its internal consistency, and reliability and it has excellent clinical utility. In a previous paper, the results provided support for the construct and predictive validity of the STREAM.[3] The STREAM requires only 10-15 minutes to administer and the assessment does not require any special equipment. It was developed to be used as an evaluative measure. Therefore, the responsiveness of the individual items was considered during item selection. The items are scored out of three for the voluntary movement items and out of four for the basic mobility items. The total score of the scale ranges from 0 to 100, which allows ample opportunity for meaningful clinical changes to be noted.[4] When compared to other tools of motor recovery the STREAM has been found to have many advantages over these measures.[4]

Several empirical methods for the estimation of responsiveness have been developed, and the strengths and weaknesses of each have been reviewed extensively in the literature.[5-10] No one statistical method for the evaluation of responsiveness has become a standard.[9,11] For this study two variants of Effect Size (ES) were chosen to assess this psychometric property. ES is the mean change in score divided by the standard deviation of the baseline score and it is a unitless measure.[8] However, a major criticism of the ES is that it does not account for the variability of patient change over time. The Standardized Response Mean (SRM) is similar to ES except that it compares the magnitude of change to the standard deviation of change and, therefore, accounts for the variability of change scores. The SRM was selected for the comparison of the responsiveness of the STREAM to other measures of stroke outcome.

While the STREAM has demonstrated good psychometric performance for validity and reliability, to date, the responsiveness has not been formally tested. Thus, the main purpose of this study was to estimate the responsiveness of the STREAM. A secondary objective was to compare the responsiveness of the STREAM to that of other measures of stroke outcome.

Methods

Study Design

The methods for this study have been described previously in the first manuscript as well as by Salbach[12] and Higgins.[13] A prospective cohort study that targeted stroke survivors with residual physical deficits was carried out. Patients were assessed on a battery of tests during the first week post-stroke, four weeks later, and three months post-stroke. Since most stroke patients undergo marked improvement in motor and functional status during the first few months following stroke,[14] this time frame was chosen for the study. The battery of tests included the STREAM, [2,4] the Box and Block, [15] the Barthel Index,[16] the Balance Scale, [17,18] the Timed 'Up and Go'(TUG),[19] and gait speed.[12]

Subjects

Patients admitted to one of five Montreal large urban acute care, university teaching centers, with a first-time stroke were identified by a research nurse specifically assigned to each location. A first-time stroke was defined by the World Health Organization's (WHO) criteria of "rapidly developing clinical signs of focal (or global) disturbance of cerebral function lasting more than 24 hours or leading to death with no apparent cause other than that of vascular origin".[20] Having a 'first time stroke' was defined as having no documented evidence of previous non - reversible ischemic deficit.

Patients were considered eligible if they had no apparent cognitive impairment (based on a score of fourteen or greater on the brief version of the Mini Mental State Examination[21] (MMSE) Appendix A2.0), and if they demonstrated stroke-related physical deficits of the upper and/or lower extremities as evidenced by scores less than age and gender based norms on the Nine-Hole Peg Test,[22] and greater than 10 seconds on the TUG.[19] Patients were excluded if they had completely recovered from the stroke, if they had severe language deficits, or if they presented with comorbid conditions like disabling arthritis, Parkinsons disease, amputation, or severe cardiovascular disease. Ethical approval for this study was obtained from all participating hospitals, and each subject was required to sign a consent form before taking part in the study.

Measurement

Once a patient consented to participate, information related to the occurrence of the stroke, the patient's medical history, and sociodemographics were recorded directly from the medical records. Screening measures were administered to ensure that subjects met the inclusion criteria and to obtain baseline data. The instruments which were administered at each assessment have been extensively reviewed in a previous paper related to the validity of the STREAM.[3] Briefly, *the STREAM*[2,4] includes a total of 30 items divided among three main subscales: 10 items for voluntary motor ability of the upper extremity (UE), 10 items for voluntary motor ability of the lower extremity (LE), and 10 items for basic mobility. A copy of the STREAM and its scoring scheme can be found in Appendix A1.0. *The Barthel Index*[16] is a valid and reliable self- proxy questionnaire which measures three categories of function: self-care, continence of bowel and bladder, and mobility. It is composed of 10 items and has a maximum score of 100.[23] *The Balance Scale*[17,18,24] is a measure that consists of 14 task-oriented items which are scored on a scale from 0 to 4 (i.e. a 5 point scale). It has been tested and found to have excellent reliability, supporting evidence for validity, and is responsive when used with stroke patients. *Gait speed* was measured over a 5 meter distance, with a 2 meter distance given for acceleration and deceleration, and with the patient walking at a comfortable pace. This method of measuring gait speed has been found to have good reliability, and to be more responsive than over a 10 meter distance.[12]

The TUG[19] is a reliable and valid test of functional mobility. Normal values for elderly individuals has been documented to be 7 to10 seconds.[19] *The Box and Block test*[15] measures unilateral gross manual dexterity, and is a valid and reliable measure of upper extremity function. *The Canadian Neurological Scale (CNS)* is a valid and reliable measure which was developed to monitor neurological status in acute stroke patients.[25] Based on this measure patients were classified as having suffered a 'mild' (CNS ≥11), 'moderate' (9 ≤ CNS < 11), or 'severe' stroke (CNS <9). Data obtained from notes in the medical charts were used to compare participants and non-participants.

Data Analysis

Responsiveness of the STREAM

The responsiveness of the STREAM and each of its subscales was estimated by calculating ESs and SRMs. These calculations were repeated between STREAM scores obtained during the first week post-stroke and five weeks post-stroke, five weeks post-stroke and three months post-stroke, as well as the mean change over the entire three months. Responsiveness was also examined in each sub-group of subjects, 'mild', 'moderate', and 'severe' as classified by scores on the CNS.[25]

Responsiveness of the STREAM Compared to Other Measures of Impairment and Disability

To compare the responsiveness of the STREAM to other measures of stroke outcome the SRM of each measure was computed. Comparisons were made with the entire sample as well as within each sub-group, 'mild', 'moderate', and 'severe'.[25] The ceiling effects of each instrument were estimated by calculating the percentage of individuals who had attained the maximum score for each measure.

Treatment of Missing Data

The methods used to replace the missing data have been discussed in detail in a previous paper.[3] Values were imputed for one patient who had withdrawn from the study before the second evaluation, and for six subjects who had withdrawn before completing the third evaluation.

The scores on the TUG can increase infinitely as the level of disability increases. Two different methods were used for imputing missing scores at the first evaluation (n=17), the second evaluation (n=7) and the third evaluation (n=2): (i) missing scores were imputed with twice the maximum score of the entire study sample at each evaluation, (ii) subjects with missing data were dropped from the analysis (n=17).

Out of the 63 subjects 13 were not evaluated on the Balance Scale because they were not able to perform this test at the initial evaluation. Values were imputed for these individuals by giving a score of zero at the initial evaluation if they were unable to do the test, and since the Balance Scale was found to be highly correlated with gait speed ,the mean Balance Scale value of the sub-group with a similar range of gait speed scores as the subjects with missing data were substituted for the second and third evaluations. The SRM for the Balance Scale was calculated (i) without these imputed values (n=50), (ii) and with the imputed values (n=63).

Out of the 63 subjects 7 were not evaluated on the Box and Block test because these patients reported that they had completely recovered their upper extremity function. Therefore, since these patients' Box and Block scores were not expected to change over time, they were not included in the calculations for the responsiveness of the Box and Block.

Results

Study Sample

In total 357 patients were admitted with a first-time stroke to the five acute-care hospitals during the period of recruitment for this study. Of these, 170 patients met the inclusion criteria and were eligible for the study, 78 were approached, and 67 consented to participate. The remaining patients could not be approached because they were already participating in other research projects or they were unavailable to the investigators at the time of the first evaluation. Of the 67 consenting patients, complete data were obtained on 63 subjects. Participants and non-participants were comparable except for severity and type of stroke with non-participants having a greater number of people with hemorrhagic and 'mild' strokes.

Responsiveness of the STREAM

The first evaluation was performed an average of 8 days (Standard deviation (SD)=3) post-stroke. There was an average of 29 days between the first and second evaluation (SD=5) and 85 days (SD=17) between the first and last evaluation.

The first approach to estimating the responsiveness of the STREAM was to consider the descriptive data. Table 6.2 lists mean scores, and the SD for the total STREAM and each subscale. The variability of the UE subscale is consistently higher as compared to the other subscales and the total score. The table demonstrates that, in each case to a greater or lesser extent, the mean scores improve systematically over time. Most of the change occurs during the first five weeks. Similar changes in mean scores were found in the three subgroups: 'mild', 'moderate', and 'severe' (data not provided). However, those who were classified as 'severe' showed the greatest improvement in mean scores over the three months, followed by those who were classified as 'moderate', and those who were classified as 'mild' showed the least change between each evaluation and over the entire three months.

The ESs and the SRMs calculated for the STREAM and each subscale are presented in table 6.3. The ES for the total STREAM and for each subscale over the three month period were moderate and those for the first five weeks were slightly lower. At both times the basic mobility subscale had the largest ES as compared to the other subscales and the total score, with an ES of 0.64 over the three months and 0.55 during the first five weeks. The ES for the total score and each subscale were much lower for the five week to three month period ranging from 0.11 to 0.17. These findings are in line with the mean changes that can be seen in Table 6.2.

SRMs are also shown in Table 6.3. Over the three month period SRMs were large for the total and all subscales of the STREAM except for the UE subscale which had a moderate SRM of 0.72. For the first five weeks the SRMs were large for the total (0.94) and the mobility (0.81) subscale and moderate for the UE (0.72) and LE (0.62) subscales of the STREAM. As with the results from the calculations of ES, the SRMs from five weeks to three months were much lower ranging from 0.22-0.32.

The SRMs were also examined for the three severity groups. At all time periods and for all severity groups the total score on the STREAM had a higher SRM then any of the individual subscales, except for the 'mild' group at five weeks (Table 6.4). However, each subscale did have a moderate to high SRM for all severity groups, over the entire three months. During the first five weeks and over the entire three months the total score and each subscale score were most responsive in the 'severe' group as compared to the other two groups. As for the entire study sample, the STREAM was least responsive between five weeks post-stroke and three months post-stroke for all severity groups. This difference was most apparent in those who were classified as 'mild', except for the mobility subscale. At this time period the 'mild' group actually showed a decline on the UE subscale with an ES and SRM of -0.43 and -0.20, respectively.

Responsiveness of the STREAM Compared to Other Measures of Impairment and Disability

Table 6.5 shows the performance of subjects on other stroke-related impairment and disability measures at the first, second and third evaluations. On average, subjects demonstrated a significant improvement on all measures by the second evaluation, and a slight improvement between the second and third evaluations. The variability in scores decreased for all measures between the first and second evaluation except for that of the Box and Block test for the affected upper extremity and gait speed for which the variability increased slightly. Between the second and third evaluation, the variability in scores decreased for all measures except for the Box and Block test where the variability increased by a large amount for the affected upper extremity and slightly for the unaffected upper extremity. To compare the extent of change between all study measures, the responsiveness of each measure was estimated using the SRM (Table 6.6). Table 6.6 also shows the confidence intervals for the SRMs, calculated using a jackknife procedure as prepared by Liang et. al.[7] Over the entire three months, the three most responsive measures were gait speed (1.15), the Barthel Index (1.03) and the total score on the STREAM (0.96). Although the SRM of the STREAM is lower than that of the Barthel Index during this time period, the upper bound of the confidence interval is higher than that of the Barthel Index. The least responsive measure was the Box and Block test for the affected upper extremity (0.24). Over the first five weeks the most responsive measures were the Box and Block for the affected upper extremity (1.3), followed by gait speed (1.05) and the Balance Scale (1.0), the Barthel Index (0.98) and the total score on the STREAM (0.94). The least responsive was the LE subscale (0.62) of the STREAM. SRMs were much lower between five weeks and three months for all measures ranging from -0.007 to 0.42. The two most responsive measures were the Barthel Index (0.42) and the TUG (-0.37) and the two least responsive were gait speed (0.17) and the Box and Block test for the unaffected upper extremity (-0.007).

Table 6.6 shows the effect of imputing scores on the estimates of responsiveness for patients unable to perform the TUG and for the Balance Scale. The TUG SRM changed very little when TUG scores for those unable to perform the test were imputed with twice the maximum score of the entire study sample, or when missing TUG scores were dropped from the analysis during the first five weeks and over the three months. However, between five weeks and three months the TUG SRM was much lower when missing values were dropped from the analysis. For the Balance Scale, missing values were imputed by giving a score of zero at the initial evaluation, and missing data were substituted for the second and third evaluations with the mean Balance value of the sub-group with a similar range of gait speed scores. When the imputed values were included, the SRM was higher during the first five weeks and lower for five weeks to three months and over the entire three months as compared to when the missing Balance values were dropped from the analysis

Ceiling effects of each stroke outcome measure was examined by evaluating the percentage of patients who reached the maximum score at each evaluation (Table 6.7). For the first evaluation the measures with the largest percent of patients demonstrating a ceiling effect, ranked from high to low, were the UE subscale of the STREAM, the Balance Scale and the LE subscale of the STREAM. The measures with the least percent of patients demonstrating a ceiling effect in increasing order were gait speed, the Box and Block test (unaffected UE), and the total score on the STREAM. For the second evaluation the measures with the largest percent of patients demonstrating a ceiling effect were the UE subscale of the STREAM, the Barthel Index, and the LE subscale. The three measures with the smallest percent of patients demonstrating a ceiling effect, ranked from low to high, are the Box and Block test (affected UE), gait speed, and the total score on the STREAM. At three months post-stroke, the measures with the highest percent of patients demonstrating a ceiling effect from the largest to the lowest were the Barthel Index, the UE subscale, and the LE subscale; measures with the lowest percent of patients ranked from low to high were the Box and Block, gait speed, and the Balance Scale.

Figure 6.1 presents the responsiveness of all measures of stroke outcome, throughout the entire three months, in subjects who had a 'mild', 'moderate', or 'severe' stroke. In the 'severe' group the three most responsive measures ranked from high to low were the Barthel Index, the TUG, and the STREAM. The least responsive measures were gait speed and the Box and Block. In the 'moderate' group, the most responsive measures ranked from high to low were gait speed, the STREAM, and the Barthel Index. The least responsive measures were the TUG and the Box and Block test. In the 'mild' group, the most responsive measures ranked from high to low were the Box and Block test followed by gait speed, and the STREAM. The least responsive measures in decreasing order (high to low) were the Balance Scale followed by the Barthel Index and the TUG which were equally responsive. The relationship between the SRMs of the measures of impairment and disability in each severity group between the first evaluation and five weeks, and between five weeks and three months were similar to the results described above for the entire three months (Appendix A6.2).

Discussion

Clinicians and researchers need tools that will allow them to monitor patient status over time and assess the effectiveness of treatment interventions. These tools should be sensitive to important clinical change and we must be able to interpret the final scores on these measures in order to make decisions about treatment planning and effectiveness.

Evidence for the responsiveness of the STREAM has been provided in this paper. The STREAM and each of its subscales were able to show improvement in mean scores over time, as expected according to the natural recovery process of stroke. Further support for the responsiveness of the STREAM was achieved through calculations of ES and SRMs. Both of these estimates of responsiveness were much higher during the first five weeks post-stroke as compared to the time period between five weeks and three months following the independent event. This is in accordance with what is documented about the clinical recovery of stroke. The greatest amount of recovery occurs during the first six weeks. It then starts to decrease and is mostly complete by three months post-stroke.[14]

Variations in responsiveness were also found between the subscales of the STREAM. During the first five weeks, the total score on the STREAM had a larger SRM as compared to any of the individual subscales. The basic mobility subscale proved to be the most responsive as compared to the other two subscales for the initial five weeks. A possible reason, is that the UE and LE subscale of the STREAM consist of items that reflect voluntary movement through simple limb movements, whereas the mobility subscale consists of basic functional activities (e.g. sit to stand). It is expected that there are limitations in the ability to recover motor skills because of residual neural lesions, but it is possible to improve in functional tasks by compensating for deficits.[24] However, despite these differences all subscales were responsive during the first five weeks post-stroke and over the entire three months, with their SRMs ranging from moderate to high.

The ES indices have also supported the responsiveness of the STREAM in all three groups of severity: 'mild', 'moderate', and 'severe'. It was found that the STREAM was most responsive throughout the three months and during the first five weeks for the individuals who were classified as 'severe' as compared to those who were classified as 'mild' and 'moderate'. These results can be explained by considering the level of function that would be expected from each severity group. The items on the STREAM are mostly simple limb and mobility tasks. Therefore, those who have had a 'severe' stroke would be expected to show more change in the items included in the STREAM. Those that have had a 'moderate' or 'mild' stroke, although there is often room for further motor recovery of the limbs, tend to be more functional and would probably show more change in higher level tasks. As was found for the entire study sample, for all three severity groups the SRM was large over the entire three months and during the first five weeks, and much lower between five weeks and three months post-stroke. Again this is line with what is known about the natural recovery process of stroke, where the greatest amount of recovery occurs during the first six weeks.

For the majority of motor assessment scales that have been developed in the past, little emphasis has been placed on developing an evaluative tool that can be used to monitor changes in motor recovery.[26-28] To the authors knowledge the only two other measures whose responsiveness have been formally tested are the Fugl-Meyer,[24,29] and the Chedoke-McMaster Scale.[30,31] In the study by Wood-Dauphinee and colleagues, the Fugl-Meyer was found to be much less responsive compared to the Barthel Index and the Balance Scale at all three time periods: entry to 6 weeks, 6 to 12 weeks, and entry to 12 weeks. The Barthel Index demonstrated a larger ES for detecting a treatment effect than other measures of neurological status, stroke severity, and the Fugl-Meyer in patients with acute stroke.[29] For these patients the Barthel Index has been reported as being a "gold standard" for responsiveness against which new instruments may be evaluated.[24] In this study, the SRM of the STREAM was only slightly lower then the Barthel Index or the Balance Scale during the first five weeks, and remained slightly lower compared to the Barthel Index over the entire three months, but was slightly higher than the Balance Scale during this time period.

Also, the SRM for the combined arm and leg subscale of the Fugl Meyer has been documented over the acute period post-stroke. Between entry and 6 weeks the SRM was 0.76, 6 to 12 weeks it was 0.38 and entry to 12 weeks it was 0.87. The STREAM was more responsive (0.94 and 0.95, respectively) for the initial and final time periods, but was approximately the same for the time period 6 to 12 weeks (0.31).

For the Chedoke McMaster Scale only the responsiveness of the disability inventory has been tested. The purpose of this scale is that the impairment inventory is to be used to classify or stratify patients when planning and selecting interventions and evaluating their effectiveness. On the other hand, the purpose of the disability inventory is to measure clinically important change in functional status.[30] Therefore, the Chedoke McMaster Scale might not be responsive to changes in motor recovery of the limbs. Many rehabilitation treatments are directed towards restoring the voluntary movements of the upper and lower extremities, especially in the acute stages post-stroke, where the patient has not been on treatment long enough for the impact of the disability to be manifested. It is in these settings where a tool, such as the STREAM, that is sensitive to changes in voluntary movements of the limbs is needed.

Over the entire three months when comparing all the stroke outcome measures, the STREAM emerged as one of the three most responsive measures. During this time period gait speed and the Barthel Index were the most responsive. During the first five weeks, the Box and Block test (affected upper extremity), gait speed, the Balance Scale, and the Barthel Index were found to be more responsive then the STREAM. During these time periods the STREAM may be less responsive then the other measures because of residual neurological deficits. The amount of motor recovery that is expected to occur may be limited, but it is possible to become independent in daily functional tasks or walking by compensating for deficits. In addition, impairments are less likely to be influenced by treatment than disability.[24,32] However, the responsiveness of the STREAM is comparable and in most cases only slightly lower then some of these more functional scales. Also, the STREAM contains a mobility subscale whose items reflect motor recovery through simple functional tasks. When treatment interventions are directed towards the restoration of voluntary movement with the purpose of maximizing or facilitating motor recovery, the STREAM would be an appropriate measure to use to monitor the progress in patient status.

When the SRMs of all the measures were examined in each severity group (Figure 6.1) it was found that, throughout the entire three months, the quasi-continuous scales such as the Balance Scale, the Barthel Index, and the STREAM were more responsive in the group that was classified as 'severe'. In the 'mild' group gait speed and the Box and Block test, which are measured on true continuous scales were found to be more responsive then the other measures. This pattern was slightly different between the initial evaluation and five weeks, and five weeks to three months, however, once again, gait speed and the Box and Block test were the least responsive in the 'severe' group and more responsive in the 'mild' group. This is in accordance with the results of Richards et. al.[33], who found that, in the group of patients who had not attained a high level of performance and walked slowly, the Balance Scale, and to a lesser extent the Barthel Index and the Fugl-Meyer, were more discriminative than gait speed as to the amount of physical assistance needed to ambulate. In comparison, for subjects achieving fifty percent of normal gait speed values, these clinical scales became less discriminative and plateaued whereas gait speed continued to improve six weeks and three months following stroke.[33] In the present study, however, many of the clinical measures continued to be responsive up to three months following stroke in the 'moderate' and 'mild' groups. The STREAM was the most responsive measure in the 'moderate' and 'mild' groups, following gait speed, between the initial evaluation and three months post-stroke. Therefore, although the STREAM is more responsive in those who have a 'severe' stroke, it can still continue to reflect changes in motor recovery in higher functioning patients.

When comparing the ceiling effects of the stroke measures it was found that at each evaluation the UE and LE subscales were one of the three measures with the highest ceiling effects. As mentioned above, these subscales consist of simple limb movements whereas the basic mobility subscale of the STREAM, and the other more functional measures consist of higher level functional tasks. Fewer subjects would be expected to attain the maximum score on these measures in the acute period. In addition, there were individuals included in the study sample who had deficits only of the upper extremity or only the lower extremity. These subjects would be expected to score high on one subscale or the other. The total score on the STREAM, however, was among the three measures with the lowest ceiling effects for the first two evaluations but not the third evaluation. This is consistent with what is known about the recovery process following stroke. During the acute period, when the impact of the disability has not yet manifested itself, fewer individuals would be expected to reach the maximum score on the STREAM. However, by six weeks following the stroke it has been reported that 80% of patients would have reached their highest level of motor recovery.[34] Nonetheless, at three months, less than 50 % of individuals had reached the maximum score on the total STREAM and less than 60% had reached the maximum score on the UE and LE subscales. The Barthel Index had the highest ceiling effect at three months post-stroke with 67 % of subjects reaching the maximum score. The ceiling effect of the Barthel Index has been previously documented as one of the limitations of this measure.[35,36]

The interpretation of the ES indices used in this study is the mean change found in a particular variable divided by the standard deviation of that variable (for the SRM it is the change in the standard deviation). For the STREAM, the SRM and the ES were calculated and yielded different values for the same time period. The relationship between the two is such that, "*when the correlation between baseline and follow-up scores is equal to 0.5, the ES is equal to the SRM. When this correlation is high the SRM is higher than the ES; when the correlation is low the ES is as much as 1.4 times higher than the SRM.*"[9] The SRM in this study tended to be higher than the ES (Table 6.3), suggesting that the correlation between baseline and follow-up scores was high.

In conclusion, the STREAM was able to detect change in motor function throughout the three months following stroke. During this time, most patients started in the acute care hospital and made the transition to a rehabilitation center and then home. Therefore, the

STREAM can be confidently used to assess change in motor recovery throughout this continuation of care. In addition, the change in mean scores for all measures were in accordance with what is known about the natural recovery process post-stroke.

Limitations of the Study

There were significant differences found between the study sample and the non-participants in terms of the type and severity of stroke. Also, the study sample was chosen during the acute period when the greatest amount of recovery is expected to occur. The STREAM was able to detect change over time and the estimates of responsiveness were moderate to high. However, the results cannot be generalized to patients who do not fit the description of the study sample and the results of the ES indices would be expected to be lower when the effect of a treatment intervention is being examined.[37]

Another limitation, is that in our study design there was no control group to estimate the amount of change that is expected to occur in a stable group of stroke subjects. The variability in scores that is expected to occur in stable subjects would have provided an assessment of background noise, and hence allowed us to obtain a more precise estimate of the responsiveness of the STREAM.

In addition, the average time to the first evaluation was 8 days. During this time a significant amount of recovery could have taken place. This may have resulted in an underestimation of the responsiveness of the stroke measures.

Conclusions

The STREAM has demonstrated that it is able to detect change in motor function up to three months following stroke. Although the STREAM is responsive among all groups of severity, it was most responsive in patients that had suffered a 'severe' stroke. The STREAM fills a gap left by other measures of motor recovery. It is easy and quick to administer and does not require any special equipment. Given the information known about the STREAM to date, the STREAM can play a big role in research, and clinicians can be confident that the STREAM mirrors moderate to large changes in voluntary movement and basic mobility for acute stroke patients.

ACKNOWLEDGEMENTS

The authors wish to thank the research nurses Susan Anderson, Angela Andrianakis, Rosemary Hudson, and Lisa Wadup for patient recruitment, and Claudette Corrigan for her assistance in running the study. The assistance of Adrian Levy, Susan Scott, and Judy Soicher in the analysis are also gratefully acknowledged.

Table 6.2: Performance on the STREAM and Each of its Subscales at each Evaluation (n=63)

	Initial		~5 weeks		3 months	
	Mean	**(SD)**	**Mean**	**(SD)**	**Mean**	**(SD)**
STREAM *Total*	74.7	26.7	86.4	20.0	89.4	17.5
UE subscale	73.2	33.3	84.9	26.2	87.8	23.6
LE subscale	75.1	28.9	86.0	22.3	89.9	18.7
Mobility subscale	74.0	25.9	88.2	16.4	90.6	14.7

Abbreviation: SD, Standard Deviation; n, number of subjects.

Table 6.3: ES and SRM Statistics for Assessing the Responsiveness of the STREAM and Each Subscale (n=63)

STREAM subscale	Initial - 5 weeks	5 weeks - 3 months	Initial - 3 months
Total			
ES	0.43	0.15	0.55
SRM	0.94	0.31	0.95
Upper extremity			
ES	0.35	0.11	0.44
SRM	0.72	0.22	0.72
Lower extremity			
ES	0.38	0.17	0.51
SRM	0.62	0.32	0.82
Mobility			
ES	0.55	0.15	0.64
SRM	0.81	0.22	0.85

Abbreviations: ES, Effect Size; SRM, Standardized Response Mean; n, number of subjects.

Table 6.4: Estimates of Responsiveness of the STREAM for Each Stroke Severity Group

	[illegible]			[illegible] months			Initial [illegible]		
	Mild n=12	Moderate n=33	Severe n=18	Mild n=12	Moderate n=33	Severe n=18	Mild n=12	Moderate n=33	Severe n=18
STREAM *Total*									
ES	0.65	0.76	1.04	0.04	0.43	0.26	0.68	0.98	1.32
SRM	0.89	1.15	1.54	0.04	0.40	0.40	1.09	1.0	1.77
UE subscale									
ES	0.66	0.49	0.92	-0.43	0.28	0.21	0.54	0.65	1.16
SRM	0.66	0.77	1.17	-0.20	0.29	0.31	0.71	0.66	1.26
LE subscale									
ES	0.34	0.46	0.69	0.09	0.38	0.21	0.39	0.66	0.90
SRM	0.42	0.49	1.12	0.07	0.37	0.35	0.58	0.69	1.68
Mobility subscale									
ES	0.34	0.70	1.11	0.20	0.15	0.29	0.49	0.76	1.37
SRM	0.39	0.83	1.21	0.18	0.16	0.33	0.62	0.82	1.42

Abbreviation: n, number of subjects; ES, Effect Size; SRM, Standardized Response Mean.

Table 6.5 Performance of Stroke Patients on Other Measures of Impairment and Disability (n=63)

Measure	Initial		5 weeks		3 months	
	Mean	(SD)	Mean	(SD)	Mean	(SD)
Box and Block*						
affected UE	24.77	21.04	36.48	22.79	41.25	71.70
unaffected UE	48.64	13.84	55.98	11.81	55.93	12.66
Barthel Index	72.22	27.89	86.11	20.43	91.98	14.04
Balance Scale						
(i)Missing values removed**	36.74	18.14	47	11.48	49.34	8.34
(ii)Missing values imputed	33.51	21.21	43.62	15.88	47.70	10.04
TUG						
(i) Missing values imputed	72.65	87.06	33.85	49.17	20.71	25.92
(ii) Missing values removed⁻	20.83	16.52	12.31	5.27	11.67	4.04
Gait Speed	0.55	0.38	0.82	0.43	0.85	0.36

Abbreviation: SD, Standard Deviation.
*n=56
**n=50
⁻n=46

Table 6.6 Standardized Response Means (95 %CI) for all Measures (n=63)

Measure	Initial - 5 weeks	5 weeks - 3 months	Initial - 3 months
STREAM			
Total score	0.94 (0.72,1.11)	0.32 (0.10,0.52)	0.96 (0.74,1.13)
UE score	0.72 (0.54,0.87)	0.22 (-0.05,0.48)	0.72 (0.55,0.87)
LE score	0.62 (0.36,0.80)	0.32 (0.08,0.55)	0.83 (0.57,1.02)
Mobility score	0.81 (0.59,0.97)	0.22 (-0.02,0.46)	0.85 (0.66,1.0)
Box and Block			
affected UE	1.3 (0.86,1.33)	0.20 (-1.93,1.15)	0.24 (-1.93,1.15)
unaffected UE	0.89 (0.54,1.04)	-0.007 (-0.27,0.24)	0.82 (0.48,0.98)
Barthel Index	0.97 (0.76,1.14)	0.42 (0.07,0.62)	0.91 (0.60,1.10)
Balance Scale			
(i)Missing values removed*	1.04 (0.64,1.05)	0.31 (0.03,0.51)	0.89 (0.54, 0.90)
(ii)Missing values imputed	0.95 (0.73,1.14)	0.47 (0.23,0.69)	0.94 (0.71,1.14)
TUG			
(i)Missing values imputed	-0.63 (-0.50,-0.75)	-0.37 (-0.24,-0.50)	-0.69 (-0.53,-0.84)
(ii)Missing values removed**	-0.68 (-0.20, -0.95)	-0.16 (-0.21,0.49)	-0.61 (-0.11,-0.89)
Gait Speed	1.05 (0.79,1.24)	0.17 (-0.13,0.43)	1.15 (0.80,1.43)

Abbreviations: CI, confidence interval; UE, upper extremity; LE, lower extremity; TUG, Timed 'Up & Go'.
*n=50
**n=56

Table 6.7: Percent of Patients Attaining Maximum Scores on the Measures

Measure	Max. Score	Evaluation 1	Evaluation 2	Evaluation 3
		No. (%) with Max. Score	No. (%) with Max. Score	No. (%) with Max. Score
STREAM				
Total score	100	5(8)	15(24)	21(33)
UE score	100	19(30)	32(51)	36(57)
LE score	100	17(27)	31(49)	37(58)
Mobility score	100	12(19)	20(32)	28(44)
Box and Block *affected UE*	*	4(7)	4(7)	4(7)
Barthel Index	100	17(27)	32(51)	38(60)
Balance Scale				
(i)Missing values removed#	56	4(8)	13(26)	15(30)
(ii)Missing values imputed	56	18(29)	16(25)	18(29)
TUG				
(i)missing values imputed	7-10 s	8(13)	18(29)	21(38)
(ii)missing values removed@	7-10 s	9(20)	20(44)	21(53)
Gait Speed	*	2(3)	13(21)	13(21)

Abbreviations: UE, upper extremity; LE, lower extremity; TUG, Timed 'Up & Go'.
* Based on age and gender norms.
# n=50
@ n=56

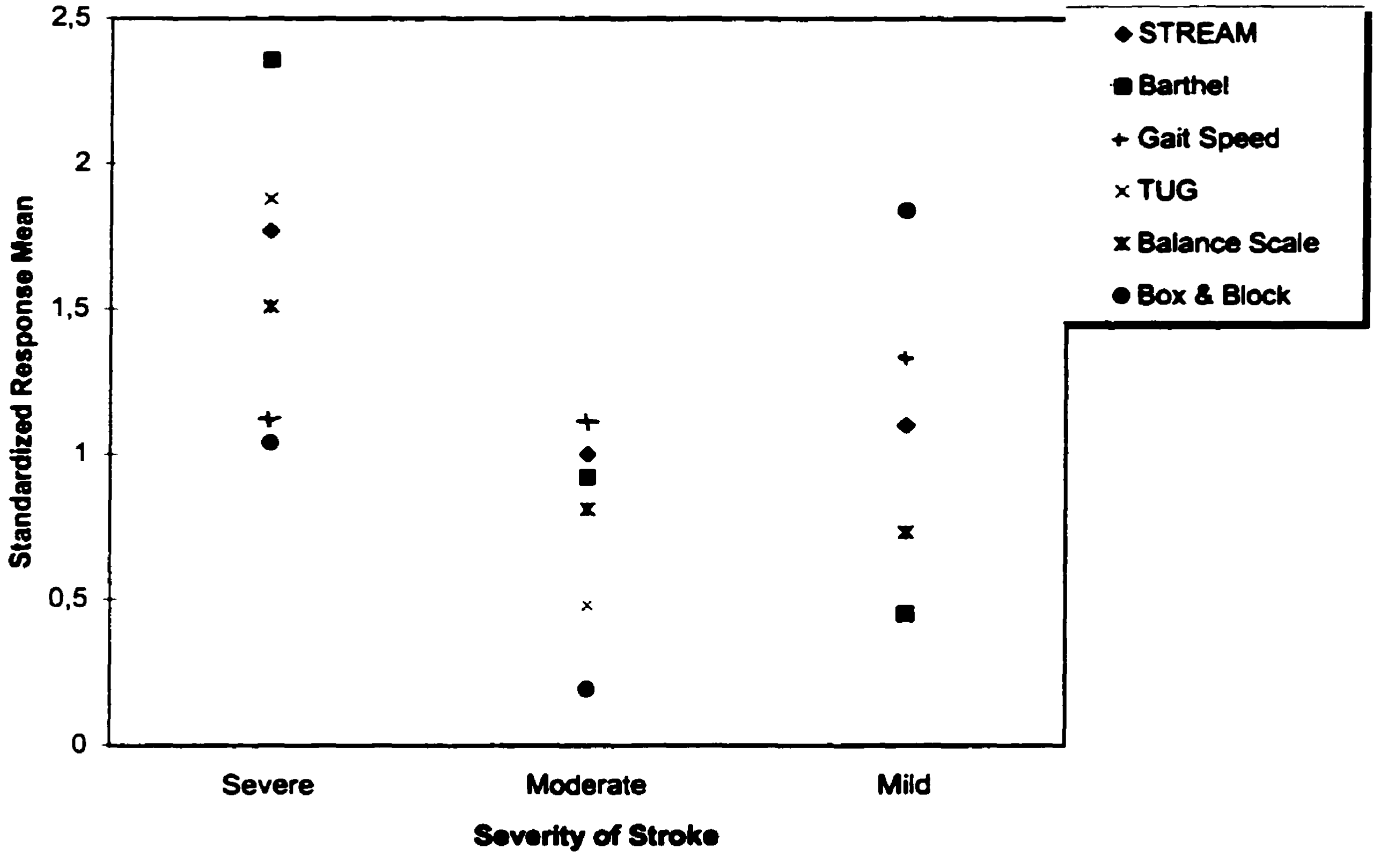

Figure 6.1: Responsiveness of Stroke Measures in all Severity Groups (Initial-3 months)

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CHAPTER 7

SUMMARY AND CONCLUSIONS

The return of motor function following stroke is important for performance of self-care activities, and mobility. A tool which exhibits the necessary psychometric properties and that is simple to use will provide clinicians with a means to routinely monitor their stroke patients progress on this key element. To date, none of the existing measures of motor recovery have met the needs of clinicians. This is reflected through the lack of routine clinical use of such assessments. The STREAM was developed in an attempt to fill this gap in the assessment of motor recovery of stroke patients. Daley et. al.[7] have reported positive results for the content validity and inter and intra-rater reliability of this outcome measure. The two primary objectives of the present study were to first generate evidence to support the construct and predictive validity of the STREAM, and second, to estimate its responsiveness. A secondary objective was to compare the responsiveness of the STREAM to other measures of stroke outcome.

This was a prospective cohort study of sixty three stroke patients assessed over a three month period immediately following a first-time stroke. Subjects were evaluated on measures of impairment and disability at three different times: during the first week, four weeks later, and three months post-stroke. The study sample consisted mainly of persons who sustained a moderate (52%) ischemic (94%) stroke. By three months, 57% of individuals had fully recovered voluntary movement of the upper extremity, 58% fully recovered voluntary movement of the lower extremity, and 44% were able to perform all basic mobility tasks on the STREAM.

Different methods were used to generate evidence to support the validity of the STREAM. Construct validity was demonstrated through the results of the correlation, multiple linear regression, and known groups analyses in relation to other measures of impairment and disability. A review of the literature and an understanding of the interrelationships between the different constructs related to recovery following stroke, provided us with a framework on which to base the anticipated performance of the STREAM. As expected, subjects who exhibited higher levels of motor recovery were able to function with a higher level of independence in ADL, had better functional ability of the upper extremity, had improved balance ability, were able to perform the TUG in a shorter time, and had a faster gait speed. The high positive correlations between the STREAM and the other measures of impairment and disability were seen at all three evaluations. Even when other potential confounding variables such as age, severity, and side and type of stroke, were considered, the relationships between the STREAM and these measures remained the same.

The subscales also performed as expected. For all evaluations, the UE subscale had a higher correlation with the Box and Block test, a measure of upper extremity function, compared to the LE and basic mobility subscales. For the first evaluation the LE subscale was more highly related to the TUG, gait speed, and the Balance Scale, compared to the UE subscale. By the second and third evaluations, the correlations between the mobility and balance measures, and the UE and LE subscale of the STREAM were about the same. The LE subscale consists of simple limb movements, such as extending the knee, and the quality and quantity of the movement is different when it is performed alone as opposed to when it is incorporated into functional activity. This may explain the decrease in the association between this subscale and the mobility measures over time. Furthermore, the recovery of the upper extremity has been found to parallel the recovery of the lower extremity and mobility.[26] The items on the mobility subscale of the STREAM consist of basic functional tasks, and most are performed in standing. Therefore, its higher correlation with gait speed, the TUG, and the Balance Scale compared to the UE or LE subscales was expected.

The 'known groups' technique for testing construct validity also provided support for this psychometric property. The mean STREAM scores of stroke subjects, grouped according to their performance on the Balance Scale and the Barthel Index, demonstrated a gradient effect with those classified as good having the higher scores, and those classified as poor, the lower. The same results were found with two other classification strategies. Therefore, the mean scores on the STREAM were able to discriminate between the known groups.

When the predictive validity of the STREAM was tested, it was found to forecast gait speed and the Barthel Index at three months, discharge destination immediately following the acute care hospital. In the acute setting there is a need for tools that are clinically practical and provide information that will assist healthcare professionals to predict the functional ability and discharge destination of stroke patients as soon as they are admitted to the acute care hospital. This will allow decisions about treatment and discharge planning to be made immediately. The STREAM is such a tool and can play an important role in the acute setting. In addition, it measures motor recovery, which is often a focus of early stroke treatment. Functional measures are expected to be better predictors of themselves,[70] and this was the case for gait speed and the Barthel Index. Although these two measures at three months were better predicted by initial values, there are many advantages to being able to use a measure of motor recovery in the acute stages of recovery. One of which is being able to group patients according to the severity of their stroke, which facilitates the identification of specific therapies that will be most sensitive to different levels of motor impairment. In addition, both gait speed and independence in activities of daily living require a certain degree of co-operation, and motivation on the part of the patient. As patients begin to regain their functional independence, the STREAM will assist in evaluating the level of pure motor recovery. This will help clinicians distinguish changes caused by neurological recovery from those caused by compensatory, learning, and cognitive changes.[63]

Clinicians and researchers need tools that will allow them to monitor patient status over time and assess the effectiveness of treatment interventions. These tools need to be sensitive to important clinical change and we must be able to interpret the final scores on these measures in order to make decisions about treatment planning and effectiveness. If the STREAM is to be used as an outcome measure it must be able to reflect significant clinical changes in patients. Evidence for the responsiveness of the STREAM has been provided in this study. The STREAM and each of its subscales were able to show improvement in mean scores over time, which is expected according to the natural recovery process of stroke during the first three months. Further support for the responsiveness of the total and subscale STREAM scores was achieved through calculations of ES and SRMs, which were moderate to high during the first five weeks and over the entire three months. The STREAM was also responsive in all three groups of severity: 'mild', 'moderate', *and* 'severe'. However, it was found that the STREAM was most responsive throughout the three months and during the first five weeks for the individuals who were classified as 'severe' as compared to those who were classified as 'mild' and 'moderate'. The items on the STREAM are mostly simple limb and mobility tasks. Therefore, for those who have suffered a 'severe' stroke they would be expected to show more change in these items. For those that have suffered a 'moderate' or 'mild' stroke, although there is often room for further motor recovery of the limbs, these patients tend to be more functional and would probably show more change in higher level tasks.

The basic mobility subscale proved to be the most responsive as compared to the other two subscales for the initial five weeks and over the entire three months. The mobility subscale consists of basic functional tasks and therefore allows more room for patients to improve through compensation and learning effects.

Over the entire three months when comparing all the stroke outcome measures, the STREAM was one of the three most responsive measures. During this time period, only gait speed and the Barthel Index were more responsive. Within the first five weeks, the Box and Block test (affected upper extremity), gait speed, the Balance Scale, and the Barthel Index were found to be more responsive than the STREAM. However, all of these instruments require the patient to participate fully in the evaluation, something which may be difficult because of medical interventions, and cognitive ability of the patient. When treatment interventions are directed towards the restoration of voluntary movement with the purpose of maximizing or facilitating motor recovery, the STREAM would be an appropriate measure to use to monitor the progress in patient status.

When all the clinical measures were compared in each group of severity, measures such as the STREAM, the Barthel Index, and the Balance Scale were found to be the most responsive in the 'severe' group even though these instruments are measured on only quasi-continuous scales (not all values are possible), a property which tends to increase variability. In the 'mild' group gait speed and the Box and Block test, which are measured on continuous scales were found to be more responsive than the other measures. However, in the present study many of the clinical measures continued to be responsive up to three months following stroke in the 'moderate' and 'mild' group. The STREAM was the most responsive measure in the 'moderate' and 'mild' groups, following gait speed, between the initial evaluation and three months post-stroke.

Although the STREAM is more responsive in those who have a 'severe' stroke, it can still continue to reflect changes in motor recovery in higher functioning patients.
At three months less than 50 % of individuals had reached the maximum score on the total STREAM, less than 60% had reached the maximum score on the UE and LE subscales, and only 40 % reached the maximum score on the basic mobility subscale. The Barthel Index had the highest ceiling effect at three months post-stroke with 67 % of subjects reaching the maximum score. The ceiling effect of the Barthel Index has been previously documented as one of the limitations of this measure.[85,22]

This study has provided evidence to support the validity of the STREAM, and the total and subscale STREAM scores were able to detect change in motor function throughout the first three months following stroke. Detailed comparisons between the STREAM and other measures of motor recovery were discussed in Chapter 2. The theoretical framework of most scales of motor recovery is based on the synergistic theory of recovery. Many therapists prefer to take a more functional approach to treating patients and, therefore, these measures do not fully meet the needs of clinicians. In addition, many of the other measures of motor recovery assess several domains, and the final score does not reflect the level of pure motor recovery. A larger barrier to the routine objective assessment of motor recovery has been that previous measures required several pieces of equipment, had a long administration time, and required the formal training of therapists. These issues were considered during the development of the STREAM, so that the final result would be an instrument that was clinically practical and comprehensive and meaningful. Furthermore, for many of the existing measures, their ability to detect clinical change was not considered during the development of the instrument. In comparison to other measures, the STREAM shows greater promise of being a practical responsive measure of motor recovery. To date, the STREAM has exhibited the necessary psychometric properties of a good measure. It is portable, simple to score, easy to administer, and takes only 10-15 minutes to complete. Table 7.1 provides a summary of its measurement properties.

A relatively new measure, called the Sodring Motor Evaluation[86,87] of Stroke Patients, has been developed for physiotherapists to evaluate motor function and activities in stroke patients. This measure was discovered near the end of completing this thesis, and comparing it to the STREAM provides a good summary of the advantages of the STREAM over some of the existing measures of motor recovery. The scale consists of 34 items which range from isolated arm and leg movements to more complex upper extremity activities, walking , and balance. The scoring is on a five point scale for arm and leg movements and walking, and a three point for activity and balance items. It has some similarities to the STREAM in that it incorporates some basic functional activities as in the mobility subscale of the STREAM, and the scoring evaluates quality of movement. However, some of the items on the Sodring scale can be considered higher level functional activities, for example *"cut meaty object"*. Such tasks do not reflect *pure* motor recovery, but also encompass the compensatory and learning effects that influence function. In addition the scoring appears to be more descriptive and less objective, especially for the arm and leg items. For example, it assesses whether the movement can be performed actively, out of a synergistic pattern, but does not refer to the amount of movement that is completed. Furthermore, it is questionable whether the scoring scheme would be reliable because it leaves room for individual interpretation. In addition the measure may require training of therapists or that an experienced clinician administer the instrument because of the complexity and nature of the scoring scale. To the authors knowledge the reliability and responsiveness of the scale have not been assessed. Support for the ability of the Sodring to predict survival and the Barthel Index and the Frenchay Activities Index has been reported. The construct validity through factor analysis, and concurrent validity of the arm and leg subscales through correlations with the Lavigne motor assessment scale have been tested, and this study reported positive results. However, the Lavigne assessment is not considered a "gold standard" measure of motor recovery and is not commonly used among therapists. The information available on the Sodring is not enough to ensure that it will be a clinically feasible instrument with the necessary measurement properties Therefore, to date, the STREAM still appears to be a more practical measure of motor recovery, and exhibits the necessary psychometric properties of a good measure.

Table 7.1: Summary of the Measurement Properties of the STREAM

Study	Psychometric Property	Results
	RELIABILITY	
Daley, 1994[21]	**Inter-rater** **Intra-rater** **Internal Consistency**	A high degree of inter-rater (Generalizability correlation coefficient (GCC)=0.99) and intra-rater (GCC=0.99) reliability, internal consistency, (coefficient alpha=0.96)
	VALIDITY	
Daley et. al, 1997[7]	**Content**	Formally developed using two consensus panels involving twenty physical therapists.
This study	**Construct**	Strong association with measures of impairment and disability.
This study	**Predictive**	Independent predictor of gait speed and Functional Independence in ADL at three months post-stroke.
This study	**RESPONSIVENESS**	The SRM and ES for the total and subscale scores are moderate to high over the 5 weeks post-stroke, 5weeks to 3 months, and over the entire 3 months post-stroke.

Abbreviations: ADL, activities of daily living; SRM, Standardized Response Mean; ES, Effect Size.

With wider use more information and evidence will accumulate as to how the STREAM performs in different groups of stroke patients, and in diverse care settings. The standards of measurement demonstrated by the STREAM also warrant its use in research. The use of the same instrument in research and clinical practice will facilitate the exchange of information and improve our understanding of motor recovery post-stroke. This will allow further understanding of the extent of motor dysfunction post-stroke and the best methods of treatment. Stroke incorporates such a wide range of symptoms and functional deficits that it is impractical to differentiate patients solely on diagnosis.[95] The STREAM, which is a performance-based measure, helps distinguish between different groups of stroke patients. In addition, motor function can improve over time whereas characteristics such as diagnosis and age cannot change.

In conclusion, the STREAM has continued to perform well relative to other measures. The results of this study have provided further information on its measurement properties. The current attributes of the STREAM are sufficient to recommend its use in daily clinical practice and research.

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APPENDICES

A1.0

Instructions and Scoring Manual For The <u>ST</u>roke <u>RE</u>habilitation <u>A</u>ssessment of <u>M</u>ovement (STREAM)

Glossary of Terms for Scoring

(use as a reference the first few times you are scoring the STREAM)

Movement through an appreciable range: implies movement of an observable amplitude that is *greater than* a *flicker* or a small, essentially *nonfunctional*, movement (ie. must be at least 10% of the normal amplitude of movement).

Part of the movement (Limb movements: 1a & b): includes any active movement observed (without hands on facilitation) that is greater than a flicker or slight movement (category 0) and less than the complete movement (categories 1c, or 2).

Part of the activity (Basic mobility: 1a & b): implies that a patient is able to actively participate in a basic mobility activity (ie. does not require major assistance), but is unable to complete the activity without partial assistance or stabilization.

Complete movement (1c, 2 & 3): refers to movement that is *comparable* to the *quantity* of movement observed on the unaffected side, or to the attainment of a basic mobility task (ie. must be at least 90% of the normal amplitude of movement).

Marked deviation (1a & 1c): the performance of the test activity does not follow a natural sequence of movement comparable to how an individual without motor impairment would perform it (ie. it is not within the expected range of so called "normal movement"). Thus, moderate or major deviations or irregularities of movement, including strong associated reactions, gross postural asymmetry, and tremor or dysmetria *interfering with function*, should result in downgrading (ie. scores of 1a or 1c).

Comparable to the unaffected side (1b, 2 & 3): the performance of the test movement or activity *closely resembles* the *quality* and/or *quantity* of movement observed on the unaffected side.

Grossly normal movement pattern (1b, 2 & 3): the performance of the test activity follows a natural sequence of movement comparable to how an individual without motor impairment would perform it (ie. it is within the expected range of so called "normal movement"). Thus, to get full marks the movement need not be perfectly executed, but must be approaching normal; minor deviations or irregularities of movement should not result in downgrading.

Aid: refers to any *external / adaptive device(s)* (walking aids, splints, etc.) that may be used by a patient to perform a movement. The use of hand(s) to push up to stand, and the use of handrail(s) in stair climbing are also graded as using an aid.

Able to *complete* the activity *independently* (category II: 1c, 2 & 3): implies that a patient is able to carry out the basic mobility task without any *hands-on*, or *physical* assistance from another person; verbal encouragement, cueing and close supervision however may be given.

General Instructions for Using the STREAM

1. The patient should be in his/her usual state of attention and health.

2. The patient should be dressed in clothing that does not restrict movement, and that allows the therapist to observe the movement clearly (eg. shorts and T-shirt). Comfortable walking shoes or the patients usual footwear should be worn when testing the activities performed in standing.

3. Instructions (*italics* on scoring form) should be given verbally, demonstrated and repeated to the patient as necessary. For the items testing voluntary movement of the limbs, ask the patient to perform the movement once with the unaffected side. This allows you to observe the patient's comprehension of the test item, and the available range and movement pattern on the patient's 'unaffected side'.

4. If the patient's sitting balance is precarious, they may be seated on a chair with back support while testing items performed in sitting (items # 7-21).

5. Therapists may assist the patient to maintain standing while performing items # 23-25. Stabilization of the arm (items 1 & 2), and foot (item 5) is permitted where specified.

6. Therapists may assist the patient to achieve the starting positions specified. However, no hands-on *facilitation* of the limb movements should be given; if support or *partial* physical assistance (except as stated above in instructions 4 & 5) is required for performance of the mobility items, the patient is given a score of *1a or 1b*.

7. If necessary, the patient is permitted *three* attempts on each item and the best performance recorded.

8. The items should be tested in the order as presented.

9. Therapists should count at a rate such that 20 counts is equivalent to 20 seconds (eg. "one-1000, two-1000, three-1000....."; this should be timed and practiced several times prior to testing).

10. If the assessment is interrupted for any reason, it may be restarted from where it was left off if done so within a 24 hour period. If not, it should be redone from the beginning.

11. An item should be excluded (score X) if movement is limited by marked restriction of passive range or pain, and the following codes used to indicate the reason: **ROM, Pain, Other (reason).**

12. The following equipment should be available for use:
    - -sturdy stool (<u>or</u> treatment plinth <u>or</u> armless chair) of a height such that patient can sit comfortably on a firm support with feet resting on the floor or on a small foot stool, with the hips and knees at 90°
    - -support surface (firm, and large enough to permit rolling safely; raised approximately 1/2 meter off the ground); if using the patient's bed, it must be flat and encumbering bedding should be removed; alternatively, a large treatment plinth (raised mat) may be used
    - -pillow
    - -stairs with railings (departmental steps <u>or</u> full flight: standard height approximately 18 cm)

STREAM SCORING

I. VOLUNTARY MOVEMENT OF THE LIMBS (/2)

0 unable to perform the test movement through any appreciable range (includes flicker or slight movement)

1 a. able to perform only **part** of the movement, and with **marked deviation** from normal pattern

b. able to perform only **part** of the movement, but in a manner that is **comparable to the unaffected side**

c. able to complete the movement, but only with **marked deviation** from normal pattern

2 able to complete the movement in a manner that is **comparable to the unaffected side**

X activity not tested (specify why; ROM, Pain, Other (reason)*)*

II. BASIC MOBILITY (/3)

0 unable to perform the test activity through any appreciable range (ie. minimal active participation)

1 a. able to perform only **part** of the activity independently (requires partial assistance or stabilization to complete), with or without an aid, and with **marked deviation** from normal pattern

b. able to perform only **part** of the activity independently (requires partial assistance or stabilization to complete), with or without an aid, but with a grossly **normal** movement pattern

c. able to complete the activity independently, with or without an aid, but only with **marked** deviation from normal pattern

2 able to complete the activity independently with a grossly **normal** movement pattern, but **requires** an aid

3 able to complete the activity independently with a grossly **normal** movement pattern, **without** an aid

X activity not tested (specify why; ROM, Pain, Other (reason)*)*

AMPLITUDE OF ACTIVE MOVEMENT

		None	Partial	Complete
MOVEMENT QUALITY	Marked Deviation	0	1 a	1 c
	Grossly Normal	0	1 b	2 (3)

STroke REhabilitation Assessment of Movement (STREAM)

Assessment Dates (Y/M/D)

1.
2.
3.
4.

Patient's Name: ______________________________

Date of CVA: ____________ **Sex:** M F **Age:** ________

Side of Lesion: L R **Side of Hemiplegia:** L R

Comorbid Conditions: ______________________________

Type of aid(s) used: ______________________________

Physiotherapist(s): ______________________________

General Comments: ______________________________

____

____

____

STREAM SCORING

I. VOLUNTARY MOVEMENT OF THE LIMBS

0 unable to perform the test movement through any appreciable range (includes flicker or slight movement)
1 a. able to perform only part of the movement, and with marked deviation from normal pattern
 b. able to perform only part of the movement, but in a manner that is comparable to the unaffected side
 c. able to complete the movement, but only with marked deviation from normal pattern
2 able to complete the movement in a manner that is comparable to the unaffected side
X activity not tested (specify why; ROM, Pain, Other (reason)*)*

II. BASIC MOBILITY

0 unable to perform the test activity through any appreciable range (ie. minimal active participation)
1 a. able to perform only part of the activity independently (requires partial assistance or stabilization to complete), with or without an aid, and with marked deviation from normal pattern
 b. able to perform only part of the activity independently (requires partial assistance or stabilization to complete), with or without an aid, but with a grossly normal movement pattern
 c. able to complete the activity independently, with or without an aid, but only with marked deviation from normal pattern
2 able to complete the activity independently with a grossly normal movement pattern, but requires an aid
3 able to complete the activity independently with a grossly normal movement pattern, without an aid
X activity not tested (specify why; ROM, Pain, Other (reason)*)*

		AMPLITUDE OF ACTIVE MOVEMENT		
		None	Partial	Complete
MOVEMENT QUALITY	Marked Deviation	0	1 a	1 c
	Grossly Normal	0	1 b	2 (3)

STREAM SCORE

UPPER EXTREMITY Item	Score	LOWER EXTREMITY Item	Score	BASIC MOBILITY Item	Score
1		3		4	
2		15		5	
7		16		6	
8		17		21	
9		18		22	
10		19		26	
11		20		27	
12		23		28	
13		24		29	
14		25		30	

	UPPER EXTREMITY	LOWER EXTREMITY	BASIC MOBILITY
Subscale Total Score	(max 20)	(max 20)	(max 30)
*Subscale Score out of 100			

$$\text{STREAM Total Score} = \frac{\dfrac{\_\_\_\_}{100} + \dfrac{\_\_\_\_}{100} + \dfrac{\_\_\_\_}{100}}{3} = \boxed{}$$

(max 100)

Note: maximum score is based on the number of items scored. ie. for limb subscales, maximum score is 20 if all items are scored, 18 if only 9 items are scored, etc. Similarly, for mobility subscale, maximum score is 30, 27 if 9 items are scored, ...

*Subscale scores are transformed to a score out of 100 to correct for items not scored (due to pain, limited ROM, etc.). In addition, since the transformed subscale scores have the same denominator, equal weight is given to each of the subscales when the total STREAM score is obtained by summing the transformed subscale scores.

Example

STREAM SCORE

UPPER EXTREMITY Item	Score	LOWER EXTREMITY Item	Score	BASIC MOBILITY Item	Score
1	2	3	2	4	3
2	2	15	2	5	3
7	2	16	2	6	3
8	2	17	2	21	3
9	2	18	1c	22	3
10	X(Pain)	19	2	26	3
11	1c	20	1a	27	3
12	2	23	2	28	3
13	2	24	1b	29	2
14	1b	25	X(ROM)	30	2

	Upper Extremity	Lower Extremity	Basic Mobility
Subscale Total Score	16/18 (max 20)	15/18 (max 20)	28/30 (max 30)
*Subscale Score out of 100	89/100	83/100	93/100

$$\text{STREAM Total Score} = \frac{\frac{89}{100} + \frac{83}{100} + \frac{93}{100}}{3} = 88/100$$

(max 100)

4	3	2	1		SCORE
					SUPINE
				/2	1. PROTRACTS SCAPULA IN SUPINE *"Lift your shoulder blade so that your hand moves towards the ceiling"* Note: therapist stabilizes arm with shoulder 90° flexed and elbow extended.
				/2	2. EXTENDS ELBOW IN SUPINE (starting with elbow fully flexed) *"Lift your hand towards the ceiling, straightening your elbow as much as you can"* Note: therapist stabilizes arm with shoulder 90° flexed; strong associated shoulder extension and/or abduction = marked deviation (score 1a or 1c).
				/2	3. FLEXES HIP AND KNEE IN SUPINE (attains half crook lying) *"Bend your hip and knee so that your foot rests flat on the bed"*
				/3	4. ROLLS ONTO SIDE (starting from supine) *"Roll onto your side"* Note: may roll onto <u>either</u> side; pulling with arms to turn over = aid (score 2).
				/3	5. RAISES HIPS OFF BED IN CROOK LYING (BRIDGING) *"Lift your hips as high as you can"* Note: therapist may stabilize foot, but if knee pushes strongly into extension with bridging = marked deviation (score 1a or 1c): if requires aid (external or from therapist) to maintain knees in midline = aid (score 2).
				/3	6. MOVES FROM LYING SUPINE TO SITTING (with feet on the floor) *"Sit up and place your feet on the floor"* Note: may sit up to <u>either</u> side using any functional and safe method; longer than 20 seconds = marked deviation (score 1a or 1c); pulling up using bedrail or edge of plinth = aid (score 2).
					SITTING (feet supported; hands resting on pillow on lap for items 7-14)
				/2	7. SHRUGS SHOULDERS (SCAPULAR ELEVATION) *"Shrug your shoulders as high as you can"* Note: both shoulders are shrugged simultaneously.
				/2	8. RAISES HAND TO TOUCH TOP OF HEAD *"Raise your hand to touch the top of your head"*
				/2	9. PLACES HAND ON SACRUM *"Reach behind your back and as far across toward the other side as you can"*
				/2	10. RAISES ARM OVERHEAD TO FULLEST ELEVATION *"Reach your hand as high as you can towards the ceiling"*

SCORE

4	3	2	1		
				/2	11. SUPINATES <u>AND</u> PRONATES FOREARM (elbow flexed at 90°) *"Keeping your elbow bent and close to your side, turn your forearm over so that your palm faces up, then turn your forearm over so that your palm faces down"* Note: movement in one direction only = partial movement (score 1a or 1b).
				/2	12. CLOSES HAND FROM FULLY OPENED POSITION *"Make a fist, keeping your thumb on the outside"* Note: must extend wrist slightly (ie. wrist cocked) to obtain full marks.
				/2	13. OPENS HAND FROM FULLY CLOSED POSITION *"Now open your hand all the way"*
				/2	14. OPPOSES THUMB TO INDEX FINGER (tip to tip) *"Make a circle with your thumb and index finger"*
				/2	15. FLEXES HIP IN SITTING *"Lift your knee as high as you can"*
				/2	16. EXTENDS KNEE IN SITTING *"Straighten your knee by lifting your foot up"*
				/2	17. FLEXES KNEE IN SITTING *"Slide your foot back under you as far as you can"* Note: start with affected foot forward (heel in line with toes of other foot).
				/2	18. DORSIFLEXES ANKLE IN SITTING *"Keep your heel on the ground and lift your toes off the floor as far as you can"*
				/2	19. PLANTARFLEXES ANKLE IN SITTING *"Keep your toes on the ground and lift your heel off the floor as far as you can"*
				/2	20. EXTENDS KNEE <u>AND</u> DORSIFLEXES ANKLE IN SITTING *"Straighten your knee and bring your toes towards you"* Note: extension of knee without dorsiflexion of ankle = partial movement (score 1a or 1b).
				/3	21. RISES TO STANDING FROM SITTING *"Stand up; try to take equal weight on both legs"* Note: pushing up with hand(s) to stand = aid (score 2); asymmetry such as trunk lean, trendelenburg, hip retraction, or excessive flexion or extension of the affected knee = marked deviation (score 1a or 1c).

Appendix

SCORE					
4	3	2	1		
				/3	**STANDING** 22. MAINTAINS STANDING FOR 20 COUNTS *"Stand on the spot while I count to twenty"*
				/2	**STANDING** (holding onto a stable support to assist balance for items 23-25) 23. ABDUCTS AFFECTED HIP WITH KNEE EXTENDED *"Keep your knee straight and your hips level, and raise your leg to the side"*
				/2	24. FLEXES AFFECTED KNEE WITH HIP EXTENDED *"Keep your hip straight, bend your knee back and bring your heel towards your bottom"*
				/2	25. DORSIFLEXES AFFECTED ANKLE WITH KNEE EXTENDED *"Keep your heel on the ground and lift your toes off the floor as far as you can"*
				/3	**STANDING AND WALKING ACTIVITIES** 26. PLACES AFFECTED FOOT ONTO FIRST STEP (<u>or</u> stool 18 cm high) *"Lift your foot and place it onto the first step (or stool) in front of you"* Note: returning the foot to the ground is not scored; use of handrail = aid (score 2).
				/3	27. TAKES 3 STEPS <u>BACKWARDS</u> (one and a half gait cycles) *"Take three average sized steps backwards, placing one foot behind the other"*
				/3	28. TAKES 3 STEPS SIDEWAYS TO <u>AFFECTED</u> SIDE *"Take three average sized steps sideways towards your weak side"*
				/3	29. WALKS <u>10 METERS</u> INDOORS (on smooth, obstacle free surface) *"Walk in a straight line over to ... (a specified point 10 meters away)."* Note: orthotic = aid (score 2); longer than 20 seconds = marked deviation (score 1c).
				/3	30. WALKS <u>DOWN</u> 3 STAIRS <u>ALTERNATING FEET</u> *"Walk down three stairs; place only one foot at a time on each step if you can"* Note: handrail = aid (score 2); non-alternating feet = marked deviation (score 1a or 1c).

A2.0 Inclusion and Exclusion Criteria

Table A1: Operational Definition of Inclusion Criteria

Inclusion Criteria	Operational Definition
Stroke as defined by World Health Organization	Patient presents with a stroke as defined by the World Health Organization's (WHO) criteria of "rapidly developing clinical signs of focal (or global) disturbance of cerebral function lasting more than 24 hours or leading to death with no apparent cause other than that of vascular origin"(WHO, 1989).
First time stroke	Defined as having no documented evidence of previous non - reversible ischemic deficit.
Deficit of the Upper and/or Lower Extremity	The patient must respond no to: "Do you feel that you have completely recovered your walking ability and/or upper extremity functioning in comparison to your pre-stroke level of functioning". This will help eliminate fully recovered patients whose functioning ability was subnormal prior to the stroke.
Mental Competency	The patient must achieve a score of 14 or greater on the brief version of the Mini Mental State Examination (MMSE). 6

Table A2: Operational Definition of Exclusion Criteria

Exclusion Criteria	Operational definition
Disabling Comorbid Conditions	Patients who present with any medical condition which prevents participation in rehabilitation therapy such as, disabling arthritis, Parkinsons disease, amputation, or severe cardiovascular disease will be excluded from the study.
Complete recovery of function of Upper Extremity	Patient answers yes to the question : "Do you feel that you have completely recovered your walking ability and/or upper extremity functioning in comparison to your pre-stroke level of functioning".

A3.0 Measurement

A3.1 Screening Measures

A) The Canadian Neurological Scale.

B) The Brief Version of the Mini- Mental State Examination.

C) The Nine Hole Peg Test

D) The Timed 'Up and Go'.

E) Question of self perceived level of upper extremity function and walking ability

A) The Canadian Neurological Scale (CNS).

The CNS[88] is a simple clinical tool that was developed to evaluate the neurological status of acute stroke patients. The CNS is composed of two parts. The first tests mentation which is divided into three sections: level of consciousness, orientation, and speech. The second component tests motor function and consists of two subsections. Motor function is assessed for the face and proximal and distal arm and leg. The maximum score possible is 11.5. Internal consistency was estimated using Cronbach's alpha and was found to be 0.792. Inter-rater reliability was found to be 0.924 for the entire measure, and kappa statistics ranged from 0.535 to 1.00 for individual items. Concurrent validity was tested by correlating the initial CNS with the closest standard neurologic examination and Spearman rank correlations were used and found to range from 0.574 to 0.775. Predictive validity was tested and estimated for those with scores of 11 or more and those who scored 9 or less and the results showed that: 2.1% and 13.2% had died within 6 months, respectively; and 2.1% and 20.6% had a vascular event within 6 months, respectively. The results for independence after 6 months also indicated that high initial CNS scores tend to be associated with favorable outcomes. Discriminate validity was also assessed by comparing the Glascow coma scale to the CNS. It was found that the CNS correlates better with the standard neurologic examination. Convergent validity between the CNS and the standard neurologic examination was found to have a correlation 0.769. Responsiveness of the scale to change in neurologic status was assessed, and it was determined that a value of 1 or more provided the highest negative predictive value of 0.969, with a sensitivity of 0.933 and a specificity of 0.508.

B) The Brief Version of the Mini-Mental State Examination [89] (MMSE).

This measure concentrates on cognitive functioning, and includes 11 questions requiring only 10-15 minutes to administer. The MMSE is divided into two sections , the first covers orientation, memory, and attention and the maximum score is 21. The second section tests the ability to name, follow verbal and written commands, write a sentence spontaneously, and copy a complex polygon. For this section the maximum score is nine. The maximum total score is 30. Criterion validity testing showed that the MMSE is able to distinguish various diagnostic groups and the scores agreed with clinical opinion of the presence of cognitive difficulty. Scores below twenty were found in patients with psychosis or dementia. Concurrent validity testing resulted in a Pearson correlation of 0.776 between the MMSE and the verbal section of the Wechsler Adult Intelligence Scale (WAIS), and a Pearson correlation of 0.660 with the performance section of the WAIS. Intrarater and interrater reliability was found to be high with a pearson correlation of 0.887 and 0.827, respectively. Test retest reliability was assessed in a Clinically stable group of depressed and demented patients who were administered the MMSE twice over a 28 day period. No significant difference was found using the Wilcoxon T, and a product moment correlation of 0.98 was calculated.

C) Nine- Hole Peg Test.

The nine hole peg test[90] is a square board made of plywood with nine holes. The pegboard is centered in front of the subject with nine pegs placed in a container next to the board on the same side as the hand being tested. The subject is asked to pick up the pegs one at a time using the hand being tested only and put them into the holes in any order until all the holes are filled. Then the patient is asked to remove the pegs one at a time and return them to the container. They may stabilize the board with the other hand. The subject is timed with a digital stop watch. Reliability and validity testing on 26 occupational therapy students was conducted. Results revealed very high interrater reliability using Pearson correlation coefficient (right hand $r=0.69$, left hand $r=0.99$). Test retest reliability was moderate for the right hand ($r=0.43$) but high for the left hand ($r=0.69$). Concurrent validity of the nine hole peg test was assessed with the Purdue Pegboard as the parameter. For the right hand a significant inverse relationship was found ($r=-0.61$) as well as for the ($r=-0.53$) left hand using Pearson correlation (inverse relationship because low scores on the Purdue is better, whereas higher scores on the nine hole peg test is better). Normative data was also collected on 618 volunteers (310 males and 318 females) aged 20 to 94 years.

D) The Timed 'Up and Go'.[91]

This measure will be used to screen for functional mobility . The starting position is the patient seated in a chair with armrests, and the time taken to stand up, walk forward 3 meters, and return to the seated position is measured. Inter rater reliability was assessed through a videotaped session and resulted in a Kendall's coefficient W of 0.85 among physical therapists, and 0.69 among physicians. High test retest and inter rater reliability have been tested in elderly subjects and found to have a ICC of 0.99 for both. Concurrent validity testing yielded a poor correlation of 0.5 with laboratory measures , a moderate correlation of -0.75 with gait speed. Another group was tested , and resulted in poor correlations of -0.55 with gait speed and -0.51 with the Barthel Index and a moderate correlation with the Berg Balance Scale of -0.72. Normal values for elderly individuals has been documented to be 7-10 seconds.

E) Question of Self perceived level of upper extremity functioning and walking ability.

In the first evaluation patients will be asked the following questions.
Compared to your level of function prior to your stroke, do you feel that your walking ability has completely recovered?

Yes______ No______

Compared to your level of function prior to your stroke, do you feel that your arm and hand function has completely recovered?

Yes______ No______

Compare a votre niveau fonctionnel avant l'accident cerebro-vasculaire, pensez-vous que votre capacite a la marche a completement recuperee?

Oui______ Non______

Compare a votre niveau fonctionnel avant l'accident cerebro-vasculaire, pensez-vous que la fonction de votre bras et de votre main s'est completement recuperee?

Oui______ Non______

A3.2 Measures of Impairment and Disability

A) The Stroke Rehabilitation Assessment of Movement (STREAM).

B) Five Meter Comfortable Gait Speed.

C) The Timed 'Up and Go'.

D) The Box and Block Test.

E) The Balance Scale.

F) The Barthel Index.

A) The Stroke Rehabilitation Assessment of Movement (STREAM).

The STREAM is an outcome measure that assesses voluntary motor ability and basic mobility. It includes a total of 30 items divided among three main subscales: 10 items for voluntary motor ability of the upper extremity, 10 items for voluntary motor ability of the lower extremity, and 10 items for basic mobility. A three point ordinal scale is used for scoring voluntary movement of the limbs and a four point ordinal scale for basic mobility. An extra category for basic mobility has been added to allow for independence with the help of an aid. The STREAM was found to have acceptable clinical utility after it was piloted at the JRH for a number of years. The first formal evaluation of the STREAM was completed in 1994 by Daley [7] (as part requirement for the Masters Thesis). In this study the STREAM was found to have a high degree of inter -rater (Generalizability correlation coefficient (GCC) =.99) and intra - rater (GCC=.99) reliability, internal consistency (coefficient alpha=0.96). and demonstrates content validity (Test manual Appendix 8).[21]

B) Five Meter Comfortable Gait Speed.

Gait speed will be calculated by dividing the distance by the time taken to cover that distance. Preliminary data collection by Salbach[92] of comfortable and maximum gait speed for 5m and 10m distances have indicated that 5m comfortable walking speed is the most sensitive measure. Therefore, it is this measure of gait speed that will be used for this study. Tape will be used to mark the distances on the floor. Acceleration and deceleration distances, each of two meters will also be marked. Bright orange pylons will be placed at the starting point and finish point so that the patient will have a visual goal of where the test ends. The evaluator will begin timing when the first foot crosses the start line and stop timing when the first foot crosses the stop line. The evaluator will always walk beside the patient or follow behind to ensure safety and to obtain an accurate estimate of when to start and stop timing. A digital stopwatch will be used for timing.[92] Norms for gait speed for different ages and for both men and women have been documented.[93]

5 meter comfortable speed test:

I---2m---I------------5m------------I---2m---I

↑ start timing ↑ stop timing

C) Timed 'Up and Go' (see screening measures A3.1 D).

D) The Box and Block test.

The Box and Block test[94] measures unilateral gross manual dexterity. This test involves the patient moving, one by one, the maximum number of blocks from one compartment of a box to another of equal size, within 60 seconds. This instrument resulted in excellent test-retest reliability (over a one week period) and was tested in a sample of 35 able bodied elderly men and women (ICC=0.90 right hand; ICC= 0.89 left hand) as well as in a sample of 34 subjects who had one or more sensorimotor impairment in at least one upper limb (ICC=0.97 right hand; ICC=0.96 left hand). Construct validity was also assessed by correlating the Box and Block scores with a functional autonomy measure (Systeme de measure de l'autonomie fonctionelle - SMAF) and with another upper limb performance measure (the Action Research Armrest). Pearson correlations were higher with the former (0.80-0.82) than with the latter (0.42-0.54). Normative data has also been documented on a sample of 360 subjects, aged 60 years and over, who were stratified for age and sex . No significant difference was found between men and women, but a statistically significant difference was found between right hand scores and left hand scores.

E) The Balance Scale

This scale will be used to assess balance. This scale consists of items which are scored on a scale from 0 to 4 (i.e. a 5 point scale). Content validity was ascertained during the development of the instrument. The inter-rater reliability was tested on a group of elderly patients through videotaped assessments. The intraclass correlation coefficient (ICC) for the individual items ranged from 0.71 to 0.99, and for the total scores was 0.98. Intra-rater reliability testing resulted in a ICC of 0.71-0.99 for the individual items and a ICC of 0.99 for the total scores. Internal consistency using Cronbach's alpha was calculated to be 0.96.[95] Construct validity was established in stroke patients, and the product-moment correlation between the Berg and the Barthel index was 0.8 or higher, and with the Fugl Meyer was between 0.62 and 0.94. The Berg also discriminated between place of destination 12 weeks post stroke and between the use of mobility aids among elderly. For concurrent criterion validity, correlations between the Berg and laboratory measures of balance (with spontaneous measures $r=-0.55$; with pseudo random perturbation scores $r=-0.38$) were lower than with the Barthel mobility ($r=0.67$), the Timed 'Up and Go' ($r=-0.76$), and the Tinetti Balance Scale ($r=0.91$).[96] The Berg balance scores have been divided into three groups which roughly correspond to ambulatory status: poor 0-20; fair 21-40; good 41-56.[95]

F) The Barthel Index.

The Barthel Index is a self-proxy questionnaire which measures three categories of function: self-care, continence of bowel and bladder, and mobility.[97] The Barthel Index is a weighted function assessment scoring technique composed of 10 items and has a maximum score of 100.[98] The inter-rater reliability using the Pearson Product moment correlation was reported to range from 0.88-0.99 ($p<0.001$) for total scores.[57] The Barthel Index has been found to be related to the place of discharge and length of stay. Granger et. al.[98] found that patients who scored between 5-40 were less likely to return home, those who scored in the range of 41-60 were more likely to be discharged home, and those who scored between 60-100 had a shorter length of stay.

A3.3 Demographic Information.

PATIENT STATUS SHEET

Subject Number ____________ Hospital ____________ Room Number ____________

Sex M F Age __________ Name of patient____________________

Complete address (Street/apt. Number/city/province/postal code)____________________

____

Telephone numbers____

Date of stroke_________________ Date of emergency _______________

Date of admission______________ Date of discharge________________

Type of stroke 1. Ischemic R L CVA

2. Hemorrhagic Site of lesion_________________________

No. of comorbid conditions________ List:_____________________________

____

Ambulatory aid used prior to the stroke_________ No. of rehab sessions_____________

Destination 1. Home 2. Rehab 3. LTC 4. Transfer 5. Deceased

Name of institution________________ Caregiver Y N

Name______________________ Tel________________ Relationship______________

STUDY STATUS

Consent	Y	N	Date_________	Place________
Refusal	Y	N	Date_________	Place________
Assessment 1	Y	N	Date_________	Place________
Assessment 2	Y	N	Date_________	Place________
Assessment 3	Y	N	Date_________	Place________
Assessment 4	Y	N	Date_________	Place________
Assessment 5	Y	N	Date_________	Place________

Reason for not obtaining consent______________________

A4.0 FRENCH AND ENGLISH CONSENT FORMS

The consent forms refer to the combined study entitled "Physical Recovery From Stroke" consisting of three different projects by three M.Sc. students in Rehabilitation Science. The ethics committees of the five Montreal hospitals from which patients were recruited approved an English and a French version of the consent form written for this study. Only the consent forms for the Royal Victoria Hospital are presented.

ROYAL VICTORIA HOSPITAL
(English version)

PATIENT CONSENT FORM
Department of Medicine
ROYAL VICTORIA HOSPITAL
McGill University

Title of the Study: PHYSICAL RECOVERY FROM STROKE

Introduction: Researchers at the Royal Victoria Hospital and McGill University are conducting a study about the health and activity level of persons during the three month period following a stroke. This study will assess functional, manual and walking ability for persons who have had a stroke. We realize that you may be involved in other studies. Your participation in this study will not affect your participation in the other studies.

Procedures: We are asking if you would like to participate in this study. If you agree we will assess your ability to function after the stroke while you are still in the hospital. Once you have left the hospital we will assess you in your home or wherever else you may be staying after discharge. Each assessment usually takes about 60 to 75 minutes to complete, depending on the individual. This time includes rest periods. While you are in the hospital, the assessment may be broken up into 2 sessions of 35 minutes each so as to minimize fatigue.

The assessment of your function throughout the study will be performed by a trained health professional who will assess your balance, how well you move your arms and legs and how well you can do activities like walking, climbing stairs, washing and dressing. These tests will be done during the first week, the fifth week and three months after your stroke. If you are unable to walk initially after your stroke, we will wait until you are able to walk to perform the tests of walking ability. The walking tests will be repeated four weeks later and at the final assessment at three months. To summarize, three assessments will be done for people who can walk immediately after their stroke and a maximum of five assessments will be done for people who recover their walking ability later on.

In addition to these tests, we need to obtain some basic information about your medical history and your stroke from your medical chart.

Once you are discharged from the hospital, we will make appointments to visit you at your home or wherever you may be staying to continue the assessments as scheduled, at your convenience. During these visits, we will reassess you on the same tests that were done previously (balance, the movement of your arms and legs, walking and climbing stairs). These assessments will also be done by a trained health professional.

PATIENT CONSENT FORM
Department of Medicine
ROYAL VICTORIA HOSPITAL
McGill University

Title of the Study: PHYSICAL RECOVERY FROM STROKE

Participation and Confidentiality: Participation is voluntary. You may refuse to participate or withdraw from the study at any time without this having an effect on the care you receive while in the hospital or after. All of the information that we obtain from you will be kept strictly confidential. The data will be kept in a locked filing cabinet in the investigator's office. You will be assigned a study number and this will be the only identifying mark that will appear on your results. The results of the study will be published in scientific journals but your data will appear as numbers in statistical summaries.

Risks: We do not anticipate any risks or inconvenience to you if you participate in the study.

Benefits: The results of this study will help us better understand how stroke affects the physical function of an individual.

Contact Numbers: If you have any questions about the research, please contact the investigator, Dr. Nancy Mayo at (514)-842-1231 ext. 6925 or Claudette Corrigan at (514)-842-1231 ext. 6906.

By signing this consent form you acknowledge that the study has been explained to you and that you understand the contents of this consent form. You agree that you have had the opportunity to ask questions, that your questions have been answered to your satisfaction and you agree to participate in the study.

Declaration of the Participant: I understand what is involved in the study that I have been invited to join and I agree to participate in this study "Physical Recovery From Stroke ".

A copy of this consent form has been given to the participant named below.

Signatures	**Print Name**	**Date**
Participant		
Witness		

Investigator
HÔPITAL ROYAL VICTORIA
(Version française)

FORMULAIRE DE CONSENTEMENT
POUR LE PATIENT
Service de médecine
HÔPITAL ROYAL VICTORIA
L'Université McGill

Titre de l'étude: **RÉCUPÉRATION DE LA MOTRICITÉ APRÈS UN ACCIDENT CÉRÉBRO-VASCULAIRE.**

Introduction: Les chercheurs de l'Hôpital Royal Victoria et de l'Université McGill ont entrepris une étude visant à évaluer la santé et le niveau d'activités des personnes atteintes d'un accident cérébro-vasculaire pendant les trois premiers mois suivant cet accident. Cette étude évaluera les capacités fonctionnelles, manuelles, ainsi que l'habileté à la marche chez les personnes ayant subit un accident cérébro-vasculaire. Nous sommes conscients que vous participez présentement à d'autres études. Toutefois, votre participation à cette étude n'affectera pas votre participation aux autres études.

Processus: Nous vous invitons à participer à cette étude. Si vous acceptez d'y participer, nous évaluerons vos capacités de fonctionnement après votre accident cérébro-vasculaire, pendant votre séjour hospitalier. Après votre départ du centre hospitalier, nous vous évaluerons chez-vous ou encore à tout autre endroit où vous allez habiter après avoir quitté l'hôpital. La durée d'une évaluation complète est habituellement de 60 à 75 minutes, dépendemment de l'individu. Cette période d'évaluation comprend des pauses. Pendant que vous êtes à l'hôpital, cette période d'évaluation peut être divisée en deux périodes de 35 minutes afin de minimiser la fatigue.

L'évaluation de votre fonctionnement tout au long de l'étude sera effectuée par un professionnel de la santé. Cette personne évaluera votre équilibre, le degré de mobilité de vos bras et vos jambes et la façon dont vous vous tirez d'activités telles que marcher, monter les escaliers, faire votre toilette et vous habiller. Ces tests seront effectués pendant la première et la cinquième semaine ainsi que trois mois après l'accident cérébro-vasculaire. Si vous n'êtes pas en mesure de marcher immédiatement après votre accident, nous attendrons que vous en ayez la capacité avant d'effectuer les évaluations de la marche. Ces évaluations de la marche seront effectuées quatre semaines plus tard ainsi qu'à l'évaluation finale à trois mois. En résumé, les personnes qui peuvent marcher immédiatement après l'accident seront evaluées trois fois et celles qui retrouvent l'habilité de marcher plus tard, seront évaluées un maximum de cinq fois.

En plus de ces évaluations, nous devons obtenir des renseignements de base à partir de votre dossier médical concernant vos antécédents médicaux et votre accident cérébro-vasculaire.

FORMULAIRE DE CONSENTEMENT
POUR LE PATIENT
Service de médecine
HÔPITAL ROYAL VICTORIA
L'Université McGill

Titre de l'étude: **RÉCUPÉRATION DE LA MOTRICITÉ APRÈS UN ACCIDENT CÉRÉBRO-VASCULAIRE.**

Une fois que vous aurez quitter l'hôpital, nous prendrons rendez-vous avec vous afin de poursuivre les évaluations à votre domicile ou à tout autre endroit où vous habiterez selon l'horaire mentionné ci-haut. Ces tests seront effectués à un moment qui vous conviendra. Les évaluations seront les mêmes que celles effectuées a l'hôpital (équilibre, degré de mobilité des bras et des jambes, marcher et monter des escaliers) et seront effectuées par un professionnel de la santé à votre domicile ou à tout autre endroit où vous aller demeurer une fois que vous aurez quitter l'hôpital.

Participation et confidentialité: La participation est volontaire. Vous pouvez refuser de participer ou vous retirer de l'étude n'importe quand, sans que votre décision ait un effet quelconque sur vos soins hospitaliers ou par la suite. Tous les renseignements que vous nous transmettrez seront strictement confidentiels. Les données seront entreposées dans un classeur fermé à clé dans le bureau du chercheur. Le numéro qui vous sera attribué sera la seule identification qui paraîtra sur les résultats de vos tests. Les résultats de l'étude seront publiés dans des publications scientifiques, mais vos données ne paraîtront que sous forme de tables statistiques.

Risques: Nous ne prévoyons pas que votre participation à l'étude présente un risque quelconque.

Bénéfices: Les résultats de cette étude nous aideront à mieux comprendre la façon dont un accident cérébro-vasculaire touche l'individu, la famille et les amis au fil des années.

Numéros ressources: Pour obtenir des renseignements supplémentaires sur l'étude, veuillez communiquer avec le chercheur principal Nancy Mayo PhD. au 842-1231, poste 6925 ou avec Claudette Corrigan au 842-1231, poste 6906.

En signant ce formulaire de consentement, vous reconnaissez que l'étude vous a été expliquée et que vous en comprenez le contenu. Vous confirmez également que vous avez eu l'occasion de poser des questions, qu'on y a répondu à votre satisfaction et que vous acceptez de participer à l'étude.

FORMULAIRE DE CONSENTEMENT
POUR LE PATIENT
Service de médecine
HÔPITAL ROYAL VICTORIA
L'Université McGill

Titre de l'étude: **LA RÉCUPÉRATION DE LA MOTRICITÉ APRÈS UN ACCIDENT CÉRÉBRO-VASCULAIRE**

Déclaration du participant:

Je comprends les détails de l'étude à laquelle on m'a invité(e) à participer et j'accepte de participer à cette étude sur "La Récupération de la Motricité Après un Accident Cérébro-Vasculaire". Je comprends également qu'en signant ce formulaire, je n'abandonne aucun de mes droits légaux.

Un exemplaire de ce formulaire de consentement a été remis au participant indiqué ci-dessous.

Signatures **Nom en majuscules** **Date**

____

____
Participant

____

____
Témoin

____

____
Chercheur

A5.0 Validity of The Stroke Rehabilitation of Movement (STREAM)

A5.1 Sample Size Calculation For The Validity Study

The sample size estimated for testing the validity of the STREAM was 50 individuals. For a correlation of 0.5 between two measures, for 90% power, and a two tailed alpha level of significance of 0.05, 38 subjects are required. The formula $n = v + p + 1$[99] was used to adjust for multiple variables, where:

n = the total number of subjects

v = the sample size for simple correlation

p = the number of additional variables included in the model

therefore,

n = 38+11+1

n = 50.

A5.2 Multiple Linear Regression Equations Derived For Each Subscale of The STREAM at all Three Evaluations

Table A3: Multiple Linear Regression Equations Derived for Each Subscale of the STREAM at all Three Evaluations

Outcome	Variables	Parameter Estimate	Standard Error	R^2	p value
Upper Extremity 1*	Box & Block	0.62	0.14	0.70	0.0001
	DTUG	17.22	7.23		0.02
	Severity	12.68	4.98		0.01
Lower Extremity 1	Gait Speed	23.45	8.82	0.66	0.004
	DTUG	26.59	7.88		0.004
	Severity	8.66	4.15		0.04
Mobility 1	Gait Speed	17.91	6.95	0.84	0.01
	Balance	0.35	0.16		0.03
	DTUG	17.21	6.03		0.006
	Severity	6.73	2.56		0.01
Upper Extremity 2*	Box & Block	0.73	0.09	0.72	0.0001
	DTUG	25.26	6.54		0.0003
	Age	0.34	0.13		0.01
Lower Extremity 2	Gait Speed	18.03	6.71	0.63	0.009
	DTUG	17.01	7.33		0.02
	Box & Block	0.33	0.1		0.001
	Age	0.61	0.14		0.0001
Mobility 2	DTUG	27.58	4.31	0.65	0.0001
	CDTUG	-0.59	0.10		0.0001
	AGE	0.24	0.1		0.02
	TYPE of CVA	-12.26	5.77		0.04
Upper Extremity 3*	Box & Block	0.47	0.1	0.72	0.0001
	DTUG	45.60	10.29		0.0001
	CDTUG	-0.69	0.17		0.0002
	Age	0..30	0.12		0.02
Lower Extremity 3	Box & Block	0.26	0.08	0.73	0.002
	DTUG	44.75	8.02		0.0001
	CDTUG	-0.73	0.13		0.0001
	Age	0.35	0.09		0.0004
Mobility 3	Balance	0.38	0.1	0.88	0.0005
	DTUG	45.16	4.21		0.0001
	CDTUG	-0.48	0.08		0.0001
	TYPE of CVA	-10.53	2.86		0.0005

* 1, 2, 3 represents the Initial, 5 week, and 3 month Evaluation respectively.

A5.3 Parameter Estimates and Standard Errors for The Predictive Validity of The STREAM

Table A4: Models Tested and Results of the Multiple Linear Regression Analysis for the Predictive Validity of the STREAM.

Outcome (Variables entered into the model)	Significant Variables	Parameter Estimate	Standard Error	R^2	p value
Barthel Index (STREAM + sociodemographics and stroke related variables)	STREAM	0.33	0.05	0.39	0.0001
Barthel Index (STREAM + initial Barthel index + socioiodemographics and stroke related variables)	Barthel $\text{Index}_{\text{initial}}$	0.35	0.05	0.49	0.0001
Gait Speed(STREAM + socio ad stroke related variables)	STREAM	0.008	0.001	0.6	0.0001
	Age	-0.009	0.002		0.0001
	MMSE	0.03	0.01		0.05
Gait Speed (STREAM + initial Gait Speed + sociodemographics and stroke related variables)	Gait $\text{Speed}_{\text{initial}}$	0.37	0.12	0.64	0.004
	STREAM	0.005	0.002		0.004
	Age	-0.007	0.002		0.003

Table A5: Parameter Estimates For the Logistic Regression Analysis Used to Assess the Ability of the STREAM to Predict Discharge Destination.

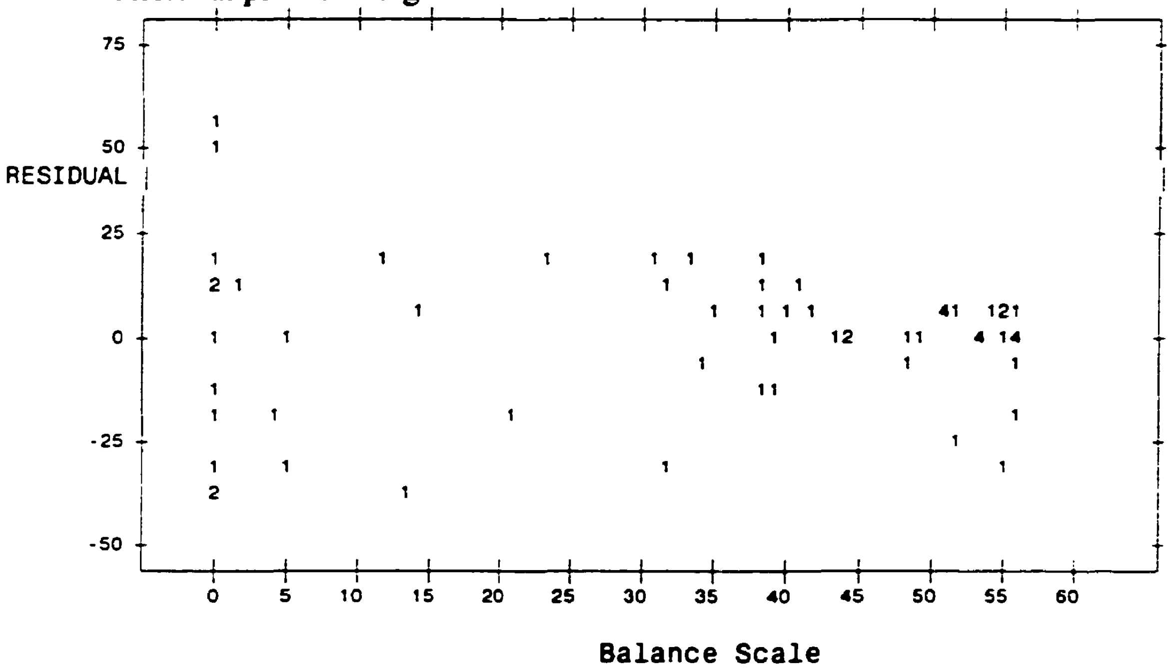
STREAM score interval	Parameter Estimate	Standard Error	p-value	Odds Ratio
0-70, Reference Point	n/a	n/a	n/a	n/a
70-90	1.67	0.79	0.03	5.33
90-100	3.18	0.80	0.0001	24

A5.4 Plots to Verify Assumptions of Multiple Linear Regression

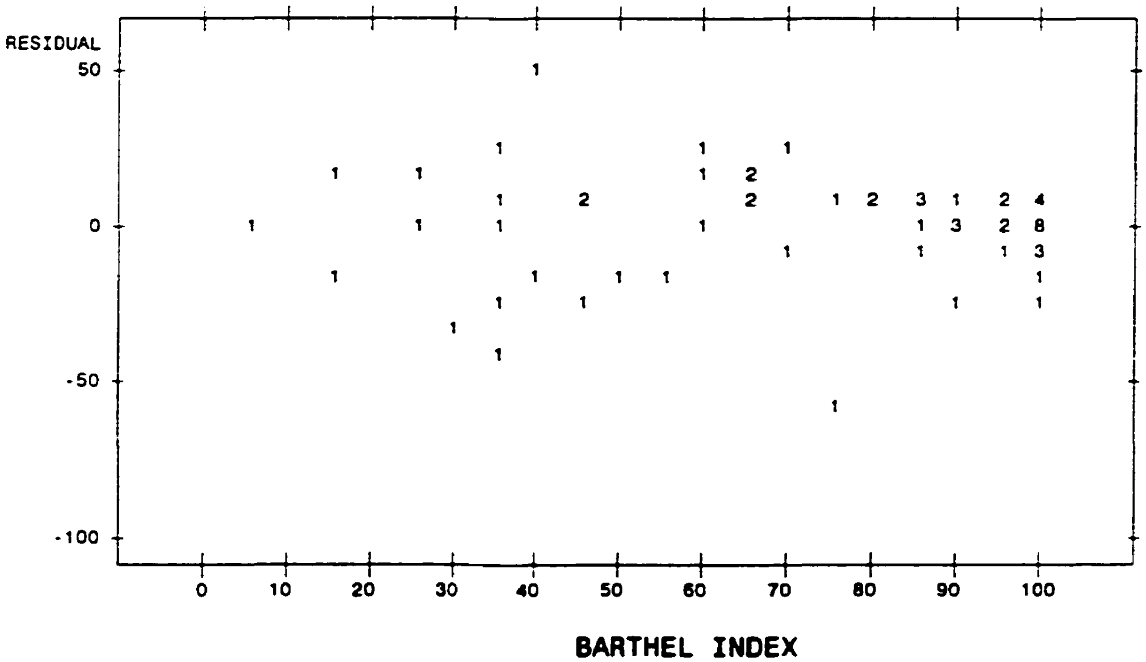
1= 1 obs., 2= 2 obs., etc.

Figure A1: Residual Plots For Each Measure of Impairment and Disability as an Independent predictor of the STREAM.

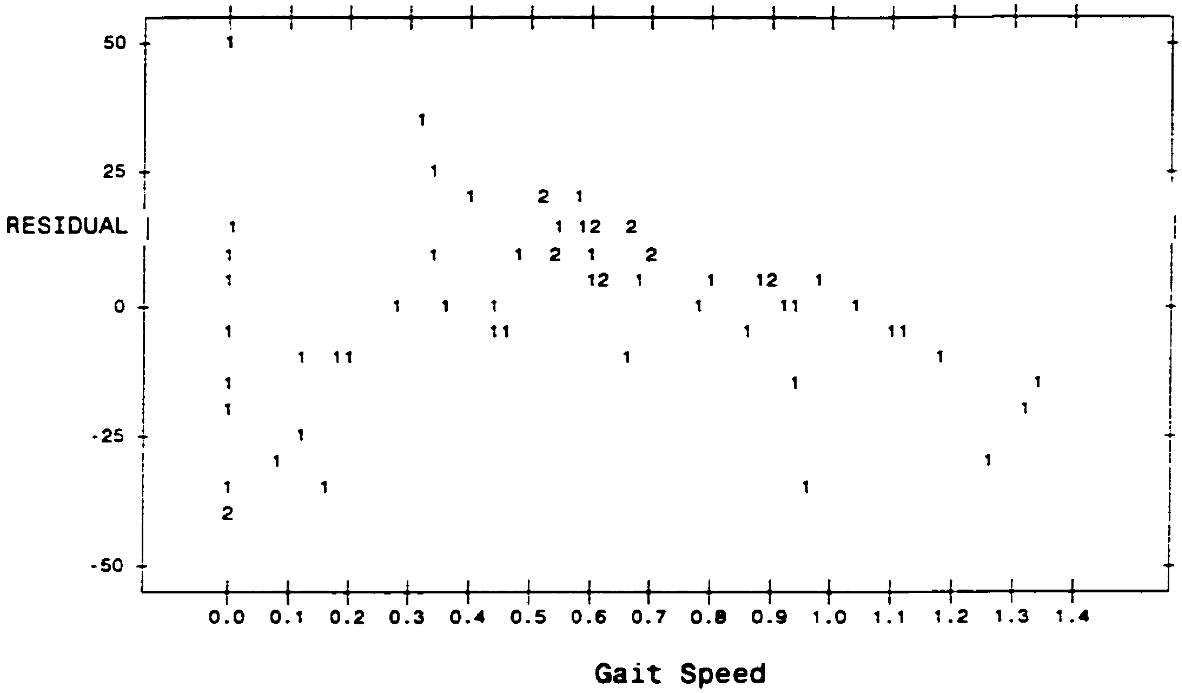
Residual plot for Berg



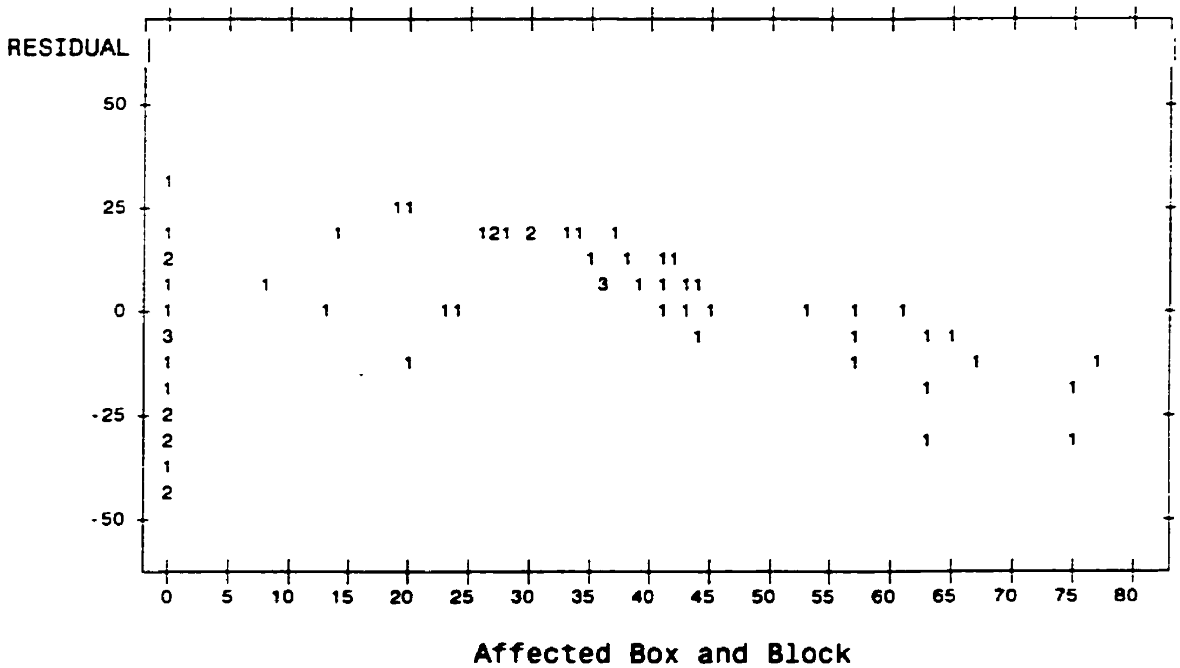
Residual Plot for the Barthel Index



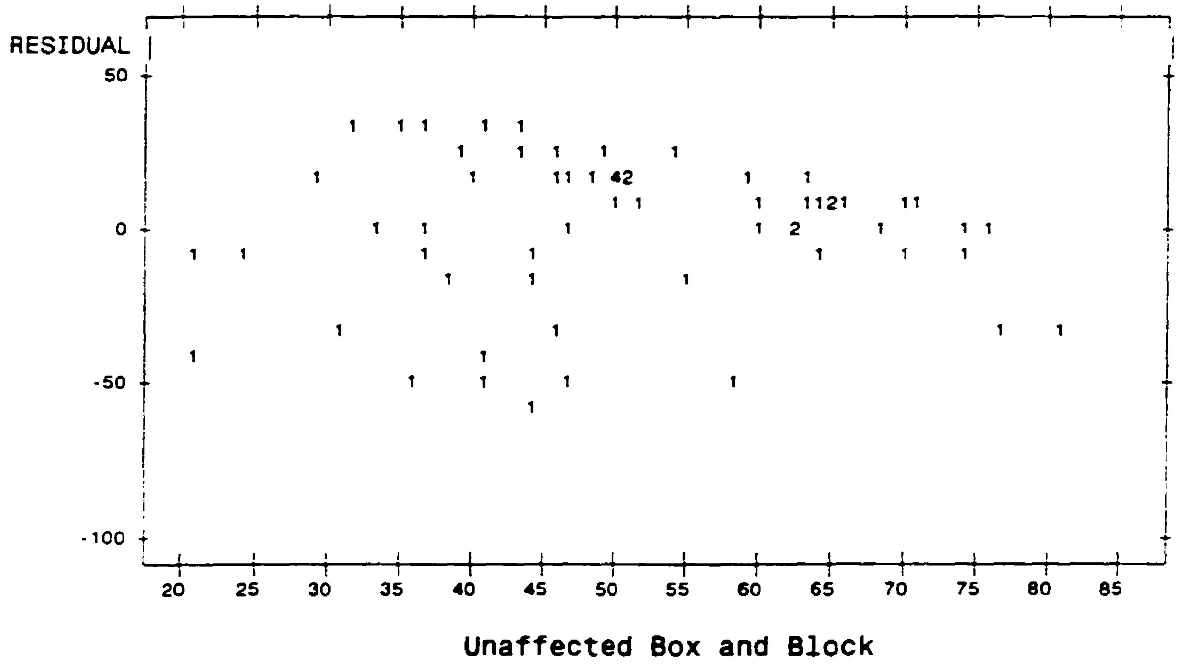
Residual Plot for Gait Speed



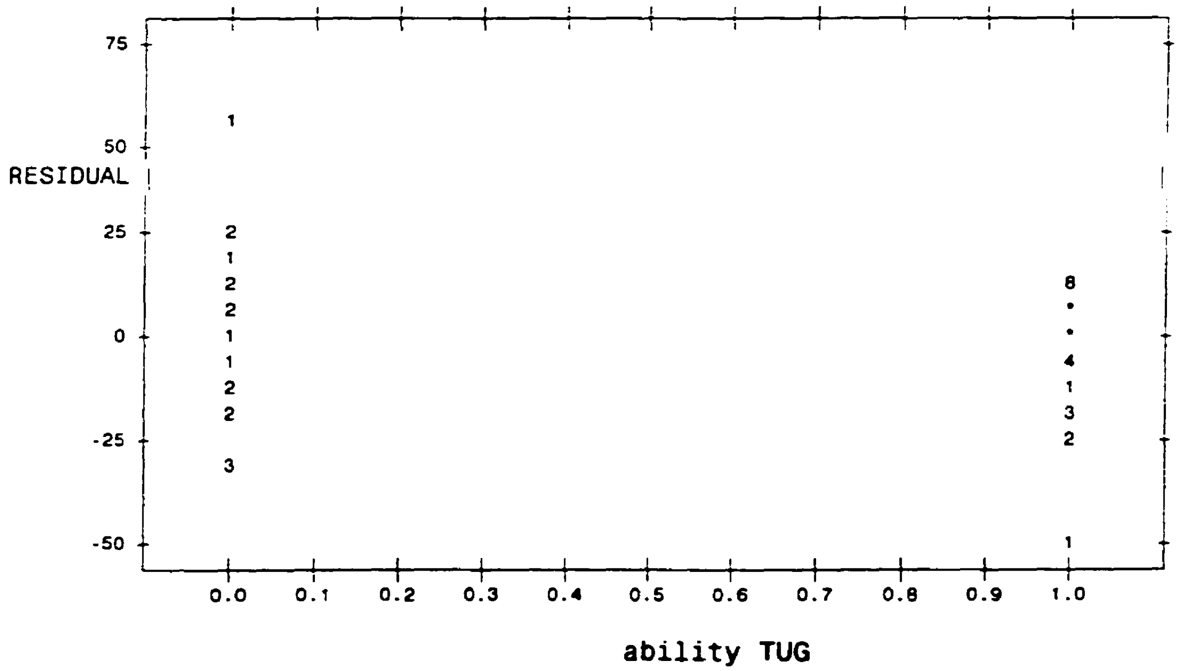
Residual Plot for the Box and Block (Affected)



Residual Plot for the Box and Block (Unaffected)



Residual Plot for ability TUG



Residual Plot for time*ability TUG

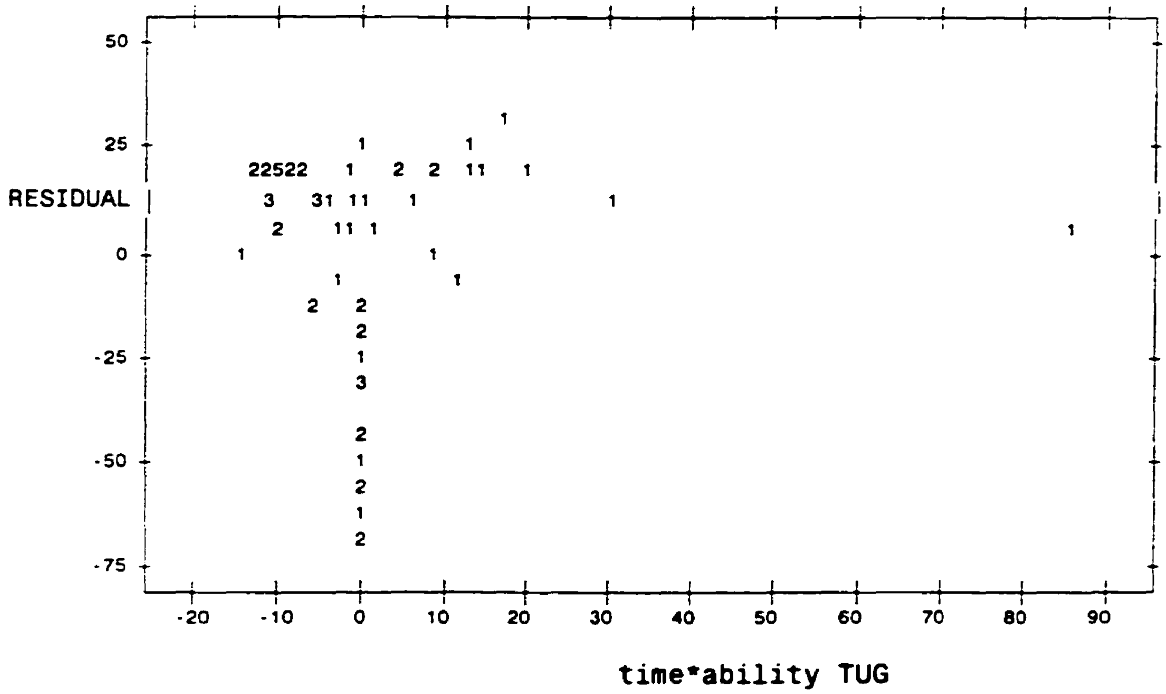
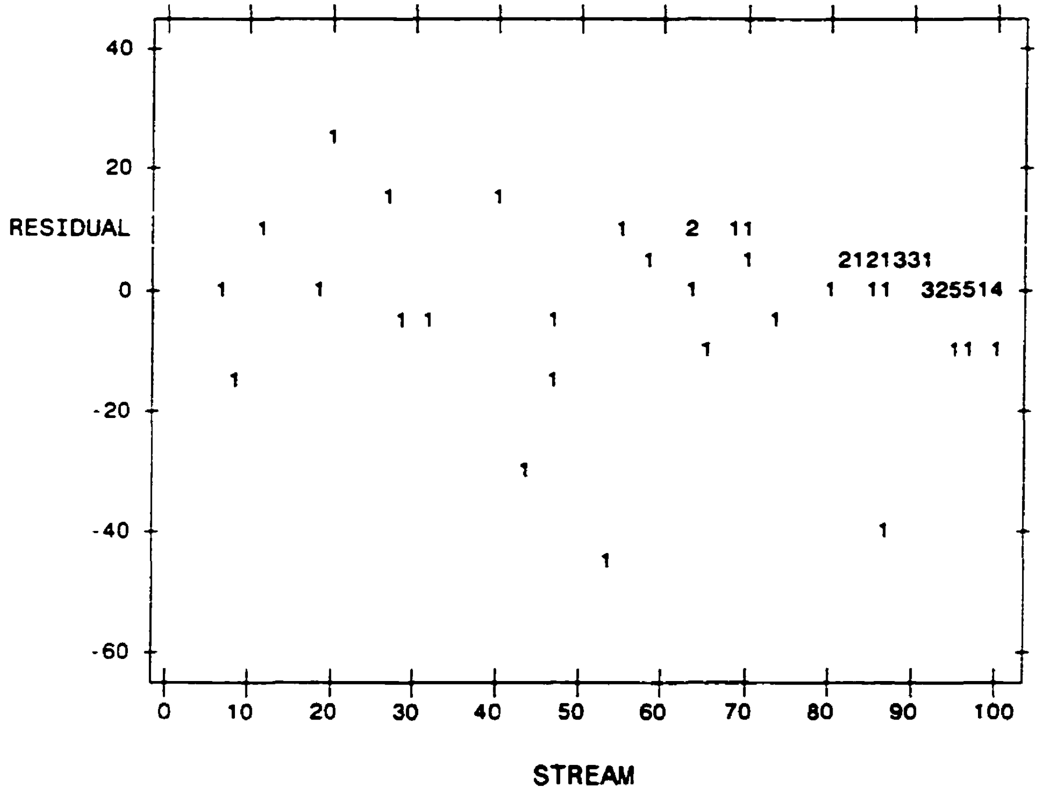
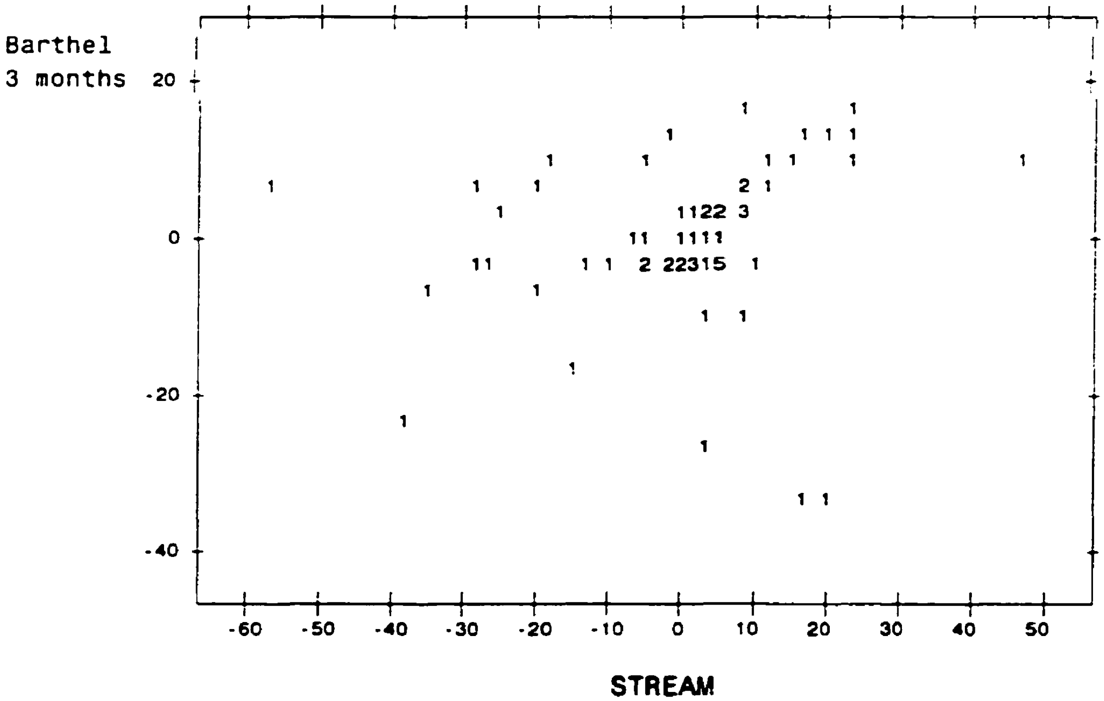


Figure A2: Residual Plots for the Prediction of the Barthel Index

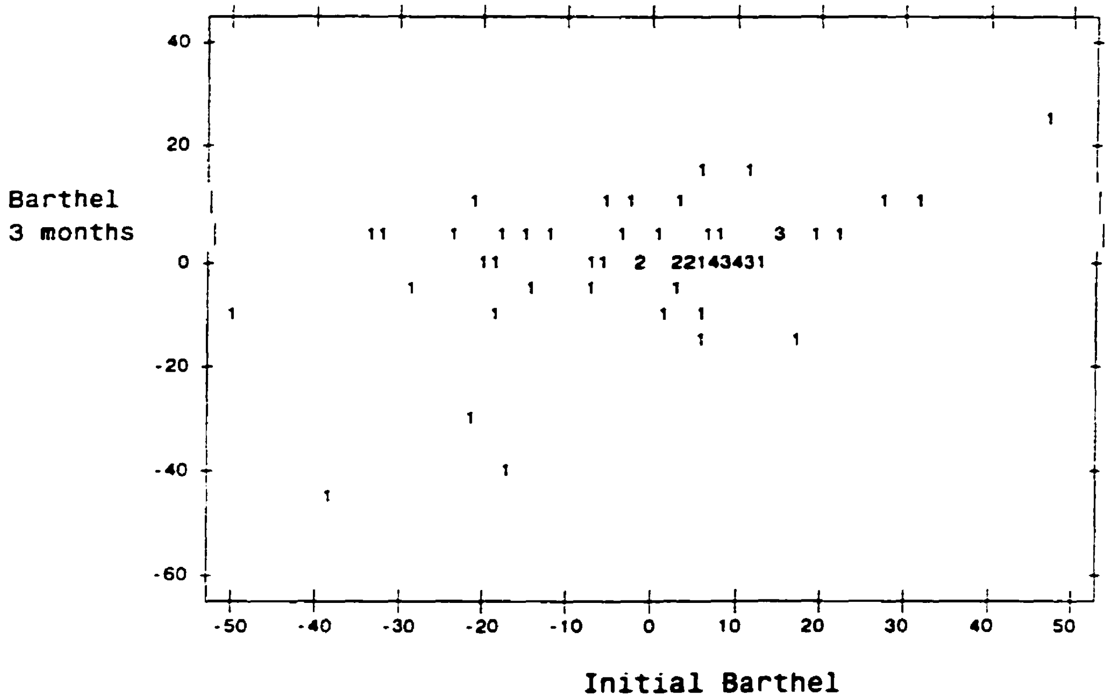
Residual Plot of STREAM



Partial Regression Residual Plot for Initial STREAM



Partial Regression Residual Plot



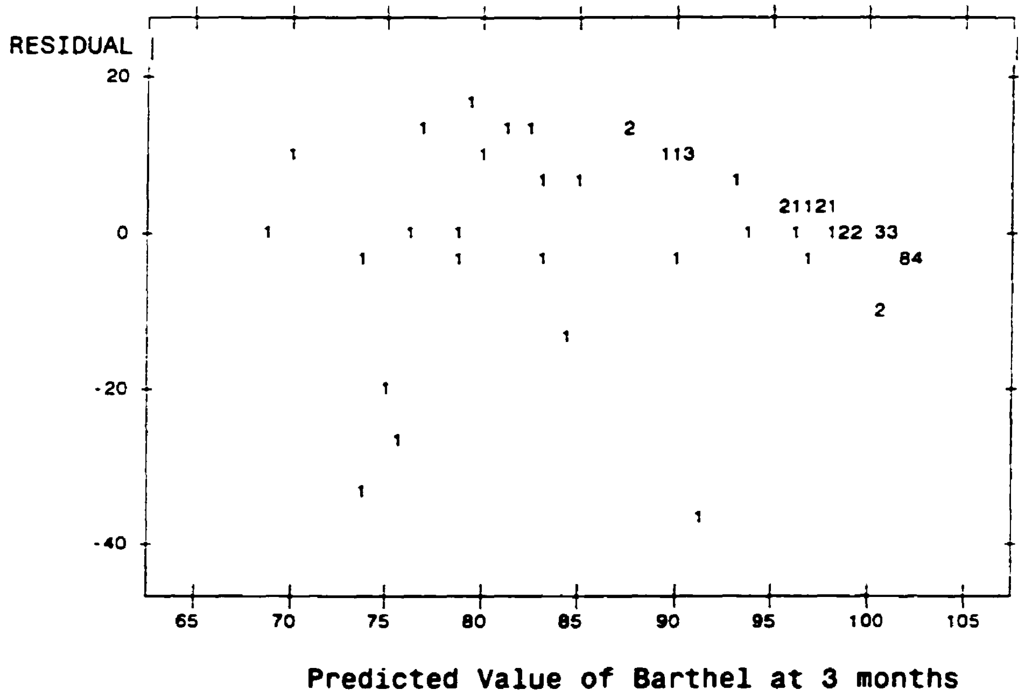
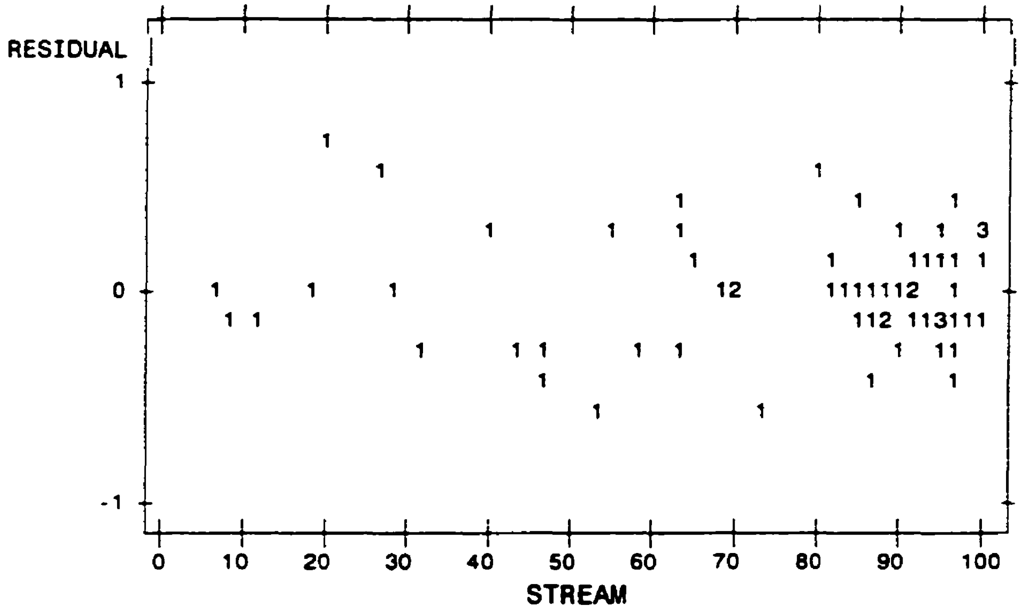
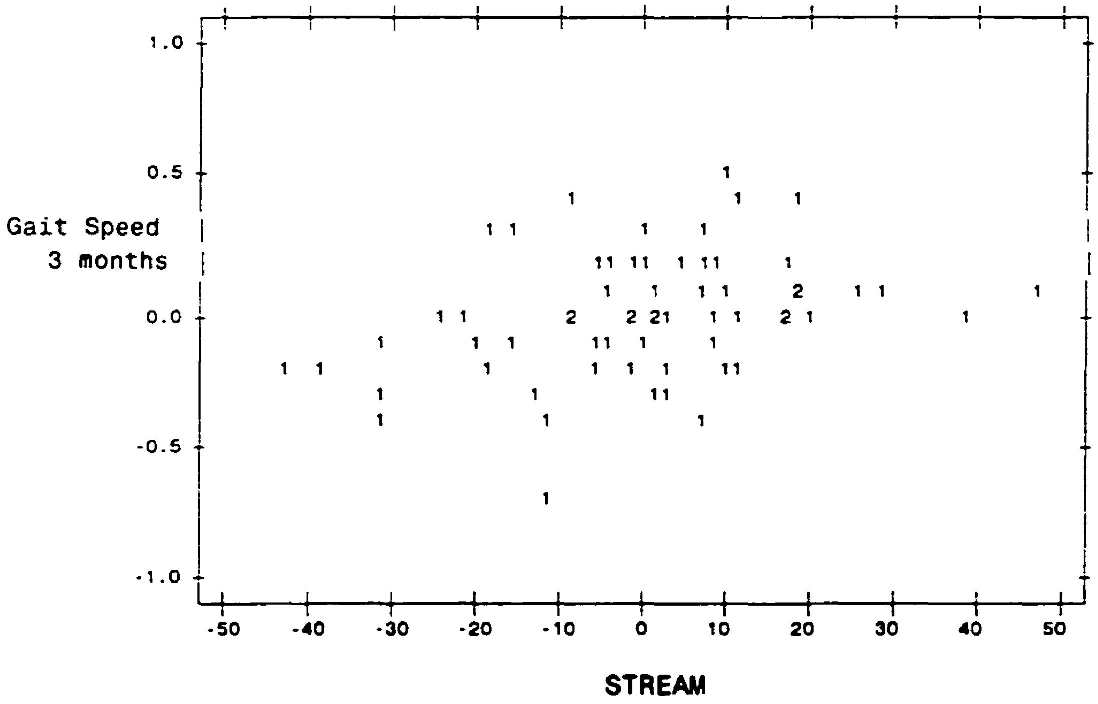


Figure A3:Residual Plots for the Prediction of Gait Speed.

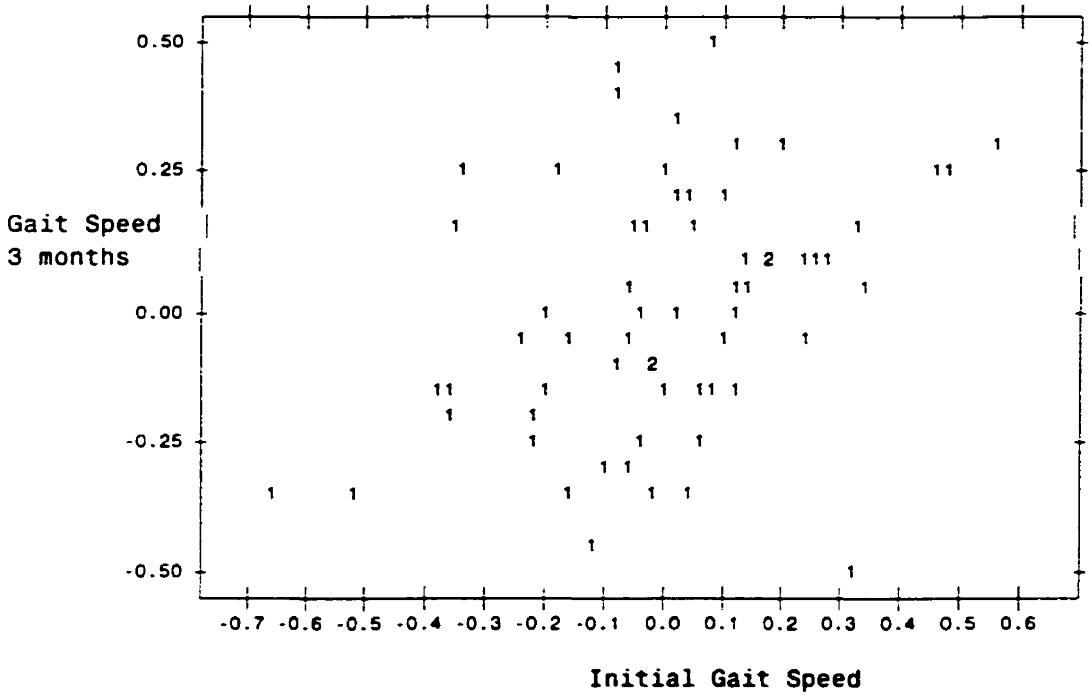
Residual Plot of the STREAM.

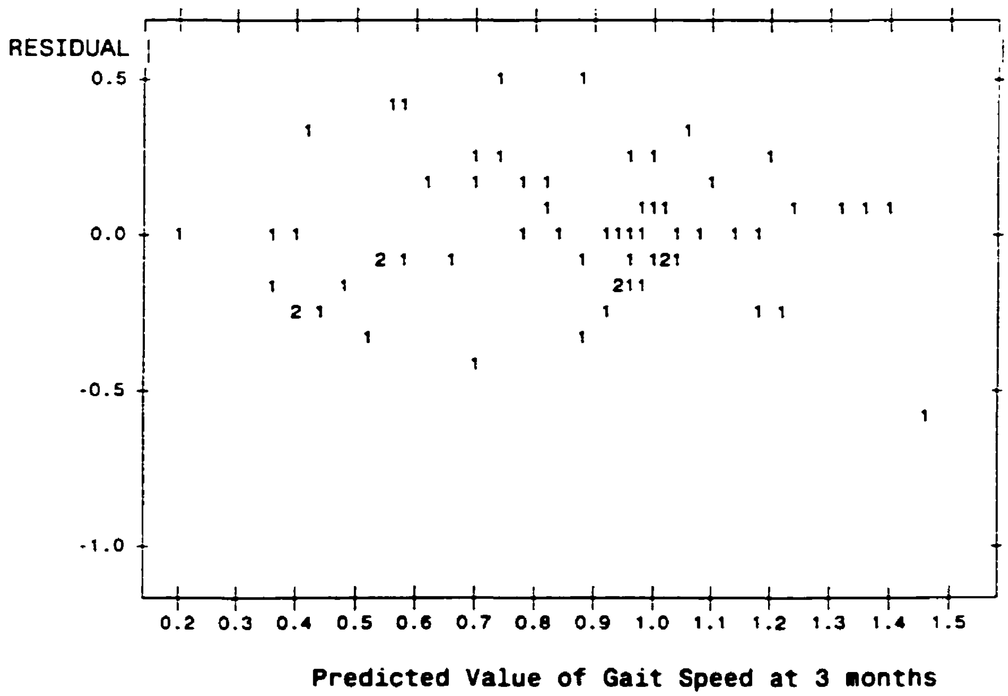


Partial Regression Residual Plot for Initial STREAM



Partial Regression Residual Plot for Initial Gait Speed





A6.0 Responsiveness of the STREAM

A6.1 Sample Size Calculation

Data obtained from a previous study by Salbach[92] was used to obtain an estimate of the standard deviation and mean difference in STREAM scores for a group of stroke patients. This data were collected for fifty subjects during the first week post-stroke (Time 1) and a month post-stroke (Time 2).

The formula for calculating sample size for related group study designs is the following:

$$n = \left[\left(z_{\alpha} - z_{\beta}\right)\sigma / \Delta\right]^2$$

where:

where:	n	= number of subjects needed
	z_{α}	= z-value for the risk of a Type I error (z_{α} = 1.96 for α=0.05, for a two-tailed test)
	z_{β}	= z-value for the risk of a Type II error (z_{β}= -1.96 for 95% power, two-tailed test)
	σ	= the standard deviation of the difference between the two means of STREAM scores at Time 1 and Time 2 (σ =13.026.[92])
	Δ	= $M_1 - M_2$: The mean difference between the average total STREAM scores at Time 2 minus the average total STREAM scores at Time 1 ($M_1 - M_2$ = 88.306-76.643=11.66, Salbach, 1997).
	n	= $[(1.96+1.96)13.026/11.66]^2$
	n	= 16 subjects

The mean difference obtained from the previous set of data was 11.66 and was used in the above calculation.[92] However, a reasonable estimate of a minimal clinically significant difference in STREAM scores could be as low as 8. The table below shows the range of mean differences in STREAM scores and the sample sizes needed based on the above equation. The largest sample size needed in the table is 41 subjects for a mean difference of 8. This was the smallest sample size that would be used to estimate responsiveness of the STREAM so that even a minimal clinically significant difference could be detected.

Table A6: Sample sizes for a range of mean differences in STREAM scores for the Responsiveness Study.

Mean Difference(Δ)	Sample size $n=[(1.96+1.96)13.026/\Delta]^2$
11.66	16
10	26
9	32
8	41

A6.2 Figures Related to the Responsiveness of the STREAM and Other Measures of Impairment and Disability

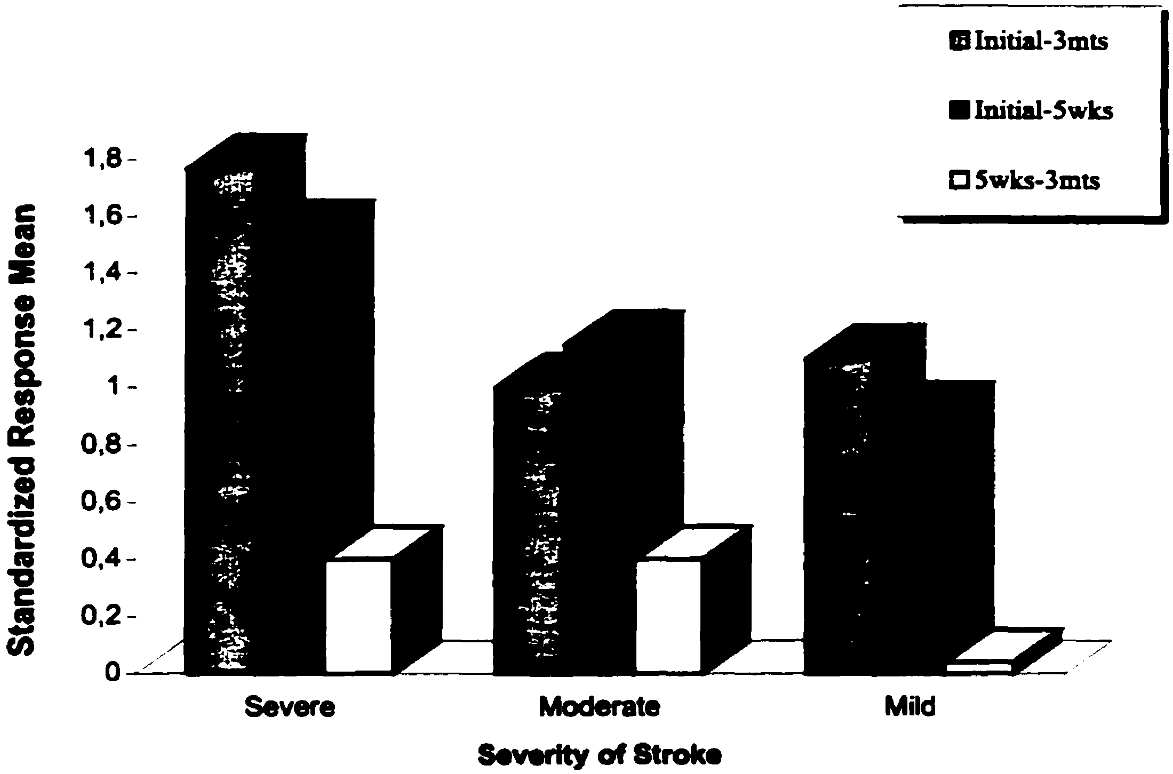


Figure A4: Responsiveness of The Total STREAM For Each Level of Stroke Severity

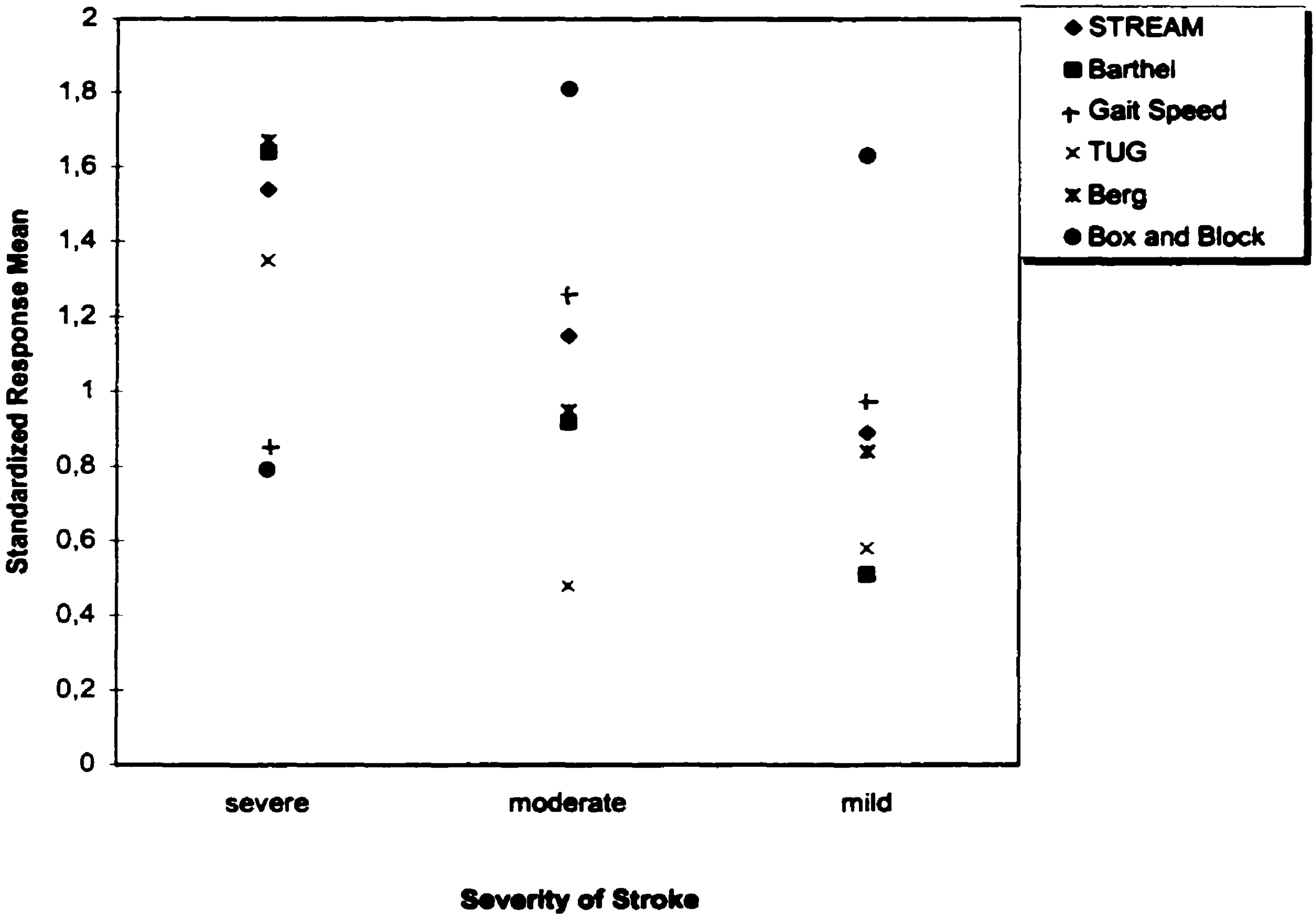


Figure A5 : Responsiveness of Stroke Measures in all Severity Groups (Initial-5weeks)

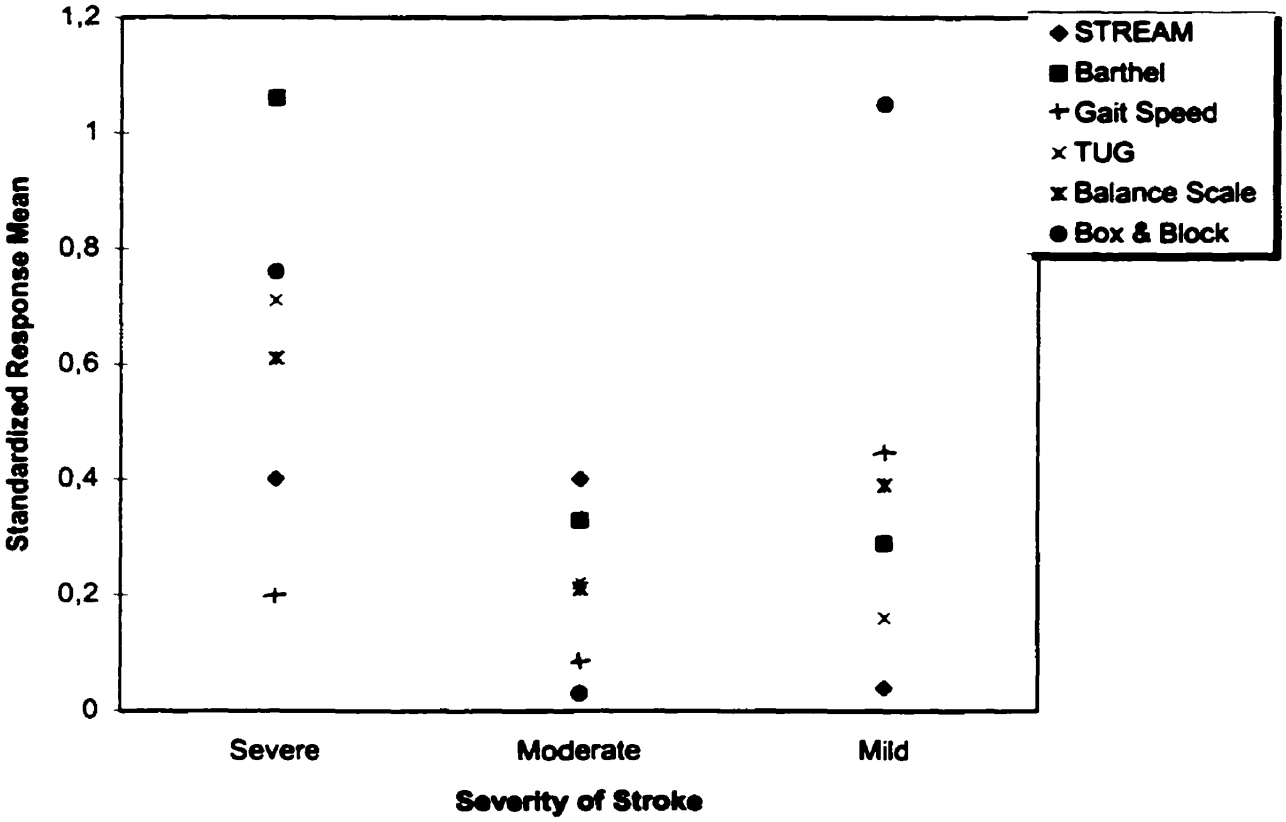


Figure A6: Responsiveness of Stroke Measures in all Severity Groups (5 weeks-3 months)