THE EFFECT OF VISUAL SCANNING EXERCISES INTEGRATED INTO TASK-SPECIFIC ACTIVITIES ON THE FUNCTIONAL ABILITY IN PATIENTS WITH VISUAL PERCEPTUAL DISORDERS POST STROKE

By

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STATEMENT

I Andoret van Wyk, declare that the dissertation which I hereby submit for the degree M PhysT at the University of Pretoria, is my own work and has not been previously submitted by me for a degree at another tertiary institution.

Where secondary material has been used, this has been carefully acknowledged and referenced in accordance with the university requirements. I am aware of university policies and implications regarding plagiarism.

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LANGUAGE EDITORS LETTER

wordsm;ths
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TO WHOM IT MAY CONCERN

Andoret van Wyk's MPHYST dissertation has been proofread by me. Changes were made to a hard-copy version of the dissertation and the student herself applied the changes to the version of the dissertation intended for submission to the University of Pretoria.

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ABSTRACT

Stroke is the first cause of disability and second most frequent cause of mortality after ischemic heart disease in adults worldwide. The influence of visual system impairment on the patient's functional ability and quality of life are still largely neglected in neurological rehabilitation. Therapists are seldom concerned with the visual status and ability of their patients. Members of the rehabilitation team rarely assess, monitor or treat impairment of visual efficiency processes and visual information processing dysfunction that may be observed in patients after a stroke. In the absence of specific intervention visual deficits stabilise and become permanent due to poor or almost absent spontaneous recovery of the visual system in stroke patients.

A matched-pair randomised controlled trial was conducted. Twenty-four (24) participants were screened based on their functional activity level as measured on the Stroke Activity Scale (SAS). When a participant's SAS score matched a previously allocated participant's score, that particular participant was placed in the opposite group from the existing matched participant. If the newly assessed participant's SAS did not match another participant's SAS, the participant was randomly allocated to either the experimental or the control group. The process was repeated until (24) patients had been allocated into two groups consisting of twelve (12) participants per group as they were admitted to Tshwane Rehabilitation Centre (TRC).

Group 1 (Experimental Group) received saccadic eye movement training with visual scanning exercises integrated with task-specific activities and Group 2 (Control Group) received task-specific activities for four (4) consecutive weeks. Participants'

functional progress on body impairment and functional activity level were assessed and documented on a weekly basis during the intervention period of four (4) weeks. In order to determine whether the integration of visual scanning through saccadic eye movement training had a permanent or long-term effect on the participants' functional ability and quality of life after rehabilitation had been terminated, functional progress on body impairment-, functional activity and participation levels as well as their perceived quality of life were assessed and documented eight (8), twelve (12), sixteen (16) and twenty (20) weeks after admission to the rehabilitation facility. A large number of participants were lost to follow-up following discharge from the TRC after the intervention period of four (4) weeks. As result of the small sample group at week eight (8), week twelve (12), week sixteen (16) and week twenty (20), these results were not discussed.

Results of the matched-pair randomised controlled trial indicated that the effect of saccadic eye movement training with visual scanning exercises integrated with task specific activities as an intervention for participants that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke resulted in significant improvement in impairment level. This improvement related to oculomotor visual performance, visual attention, depression as well as results on functional activity level with regard to the ability to independently complete ADL after four (4) weeks of rehabilitation.

It may therefore be concluded that saccadic eye movement training with visual scanning exercises integrated with task-specific activities as an intervention tend to

improve functional ability in participants that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke.

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ABBREVIATIONS

ADL	Activities of daily living
aekde1	The average number of errors made during the completion of the King-Devick Subtest 1
aekde2	The average number of errors made during the completion of the King-Devick Subtest 2
aekde3	The average number of errors made during the completion of the King-Devick Subtest 3
AHA / ASA	American Heart Association and American Stroke Association
ANCOVA	Analysis of Covariance
AHCPR	United Sates Agency for Health Care Policy and Research
BADL	Basic activities of daily living
BDI	Beck Depression Inventory
BI	Barthel Index
BIT	Behavioural Inattention Test
CNS	Central Nervous System
CVI	Cerebral vascular incident
EST	Explorative saccade training
FARS	Functional Autonomy Rating Scale
FIM	Functional Independence Measurement
fMRI	Functional Magnetic Resonance Imaging
FT	Flicker-stimulation training
HADS	Hospital Anxiety and Depression Scale
HADSA	Anxiety subscale
HADSD	Depression subscale
HIV	Human Immunodeficiency Virus
HRP	High-resolution perimetry

HVFDs	Homonymous visual field defects
IADL	Instrumental activities of daily living
ICC	Intraclass correlation coefficients
ICF	International Classification of Functioning, Disability and Health
kde1	King-Devick Subtest 1
kde2	King-Devick Subtest 2
kde3	King-Devick Subtest 3
MAACL	Multiple Affect Adjective Checklist
MADRS	Montgomery Asberg Depression Rating Scale
MAT	Modified Metropolitan Achievement Test
MMAS	Modified Motor Assessment Scale
MMS	Mini-Mental Status
MMSE	Mini-Mental State Examination
PPC	Posterior Parietal Cortex
RCT	Randomised controlled trial
SAS	Stroke Activity Scale
SC	Superior colliculus
SD	Standard Deviation
SIS	Stroke Impact Scale Version 3.0
starcorrect	Results of the correct number of stars “cancelled” during the completion of the Star Cancellation Test
startime	Results of the time taken to complete the Star Cancellation Test
TRC	Tshwane Rehabilitation Centre
TUG	Timed Up and Go Test
UP	University of Pretoria
UNS	Unilateral Neglect Syndrome
USI	Unilateral Spatial Inattention

USN	Unilateral Spatial Neglect
V1	Primary visual cortex
VCR	Vestibulocollic Reflex
VOR	Vestibulo-ocular Reflex
VRT	Vision Restoration Training
VS	Visual search
VSR	Vestibulospinal Reflex
TNR	Tonic Neck Reflex
WAIS	Wechsler Adult Intelligence Scale
WHO	World Health Organization
WRAT	Wide Range Reading Achievement Test

CHAPTER 1

INTRODUCTION AND PROBLEM IDENTIFICATION

1.1. Introduction

Stroke is the first cause of disability and second most frequent cause of mortality after ischemic heart disease in adults worldwide. An estimated 5.5 million subjects in the world die every year as a result of stroke, while two-thirds of patients who sustain a stroke in countries with developing market economies die as a result of the stroke (Salinas & Medina, 2007). Stroke causes a major public health challenge due to a high fatality rate and an increased number of stroke survivors dependent on the health care system, caregivers and their communities (Heller, Langhorne & James, 2000; Langhorne, Coupar & Pollock, 2009).

Long-term care, complete or partial working incapacity of patients post-stroke and the lack of community support contribute to enormous costs for patients, their families, caregivers, communities and the health care system. According to the United Nations, approximately 75% of the world's population lives in underdeveloped countries with 215 million people in Sub-Saharan African countries living below the threshold of the absolute poverty level (Salinas & Medina, 2007).

The life expectancy in countries with a developing market economy has increased from approximately 40 to 63 years over the last four decades. However, it is estimated that an inevitable increase in the incidence of chronic diseases such as stroke will continue to occur in these developing market economies. The prevalence of stroke in South Africa is estimated as 2.43 per 1000 population (WHO, 2004). The

available evidence strongly suggests that cerebrovascular disorders in Africa are rapidly becoming indistinguishable from those observed in developed countries (Salinas & Medina, 2007).

Moderate functional impairments are observed in 40% of people who have survived a stroke. Fifteen to thirty per cent of people who have survived a stroke present with severe disability following the stroke (Duncan et al, 2005). The increased prevalence of stroke in South Africa emphasises the importance of effective and evidence-based rehabilitation. The growing number of patients that survive a stroke, places an increased pressure on the limited number of rehabilitation therapists in both the public and the private sector in South Africa. It is therefore of utmost importance that the effectiveness and efficiency of rehabilitation of patients who sustain a stroke continuously be evaluated and, if necessary, be revised (Lannin & Herbert, 2003; Pollock, Baer, Pomeroy and Langhorne, 2007).

Functional disability can be minimised by the implementation of effective rehabilitation interventions early after stroke. Effective rehabilitation interventions initiated after the stroke can enhance the recovery process and result in improved functional outcomes in patients that suffer a stroke. Improved functional outcomes for patients who sustain a stroke also contribute to the patient's satisfaction, quality of life and community reintegration. Increased functional outcomes potentially reduce costly long-term expenditures (Duncan et al, 2005).

Since motor behaviour, perception and cognition are essential to basic activities of daily living (BADLs) such as transfers, toileting and dressing as well as instrumental

activities of daily living (IADLs) such as cooking, shopping and cleaning, the regaining of motor-, perceptual and cognitive function are essential for an individual's recovery of functional independence and return to daily living in the home and community environments post-stroke (Shumway-Cook & Woollacott, 2007). IADLs require higher-level neurophysiological organisation than is required for BADLs and are central to achieve independent living (Duncan et al, 2005).

Many stroke patients suffer from visual efficiency processing deficits; visual information processing system impairments and associated visual field defects (Jobke, Kasten, & Sabel, 2009). Some studies suggest that as many as 30% or more of all stroke survivors have some form of visual impairment (Das & Huxlin, 2010). Visual impairment in stroke patients may present with various ocular and visual impairments including gaze palsies, eye movement disorders and visual field defects as a result of damage to the primary visual cortex (V1) or its immediate afferents (Jones & Shinton, 2006; Das & Huxlin, 2010). Post-stroke patients with visual system impairment specifically impaired saccadic eye movements will experience decreased oculomotor visual performance resulting in slower saccadic eye movements, decreased control and coordination of eye movements resulting in the disruption of visual scanning and attention.

Visual and ocular impairments that result in reduced visual perception, cognition, executive function and motor behaviour caused by stroke lead to substantial functional disability during daily life activities and, thus, functional outcome. These patients may be impaired in many day-to-day activities such as safe mobilisation, navigating in complex environments, reading and driving (Schulmann, Godfrey &

Fisher, 1987; Pierce & Buxbaum, 2002; Leigh, & Kennard, 2004; Bowen & Lincoln, 2007; Chaiken, 2007; Shumway-Cook & Woollacot, 2007; Spering & Gegenfurtner, 2008; Nelles et al, 2009; Schuett et al, 2009; Das & Huxlin, 2010; Martin & Huxlin, 2010).

Impairments of oculomotor control, saccadic eye movements, smooth pursuit eye movements, convergent fusion, accommodation, unilateral homonymous hemianopia and homonymous visual field disorders are strikingly common in stroke patients but are rarely assessed and treated (Kerkhoff, 2000; Gilhotra et al, 2002; Linden et al, 2005; Jones & Shinton, 2006; Bouwmeester, Heutnik & Lucas, 2007; Nelles et al, 2009; Schuett et al, 2009; Das & Huxlin, 2010). Therapists are seldom concerned with participants' visual status and therefore rarely assess, monitor or direct patients' visual activity during therapy. In the absence of specific intervention, visual deficits stabilise and become permanent due to poor or almost absent spontaneous recovery of the visual system in stroke patients (Kerkhoff, 2000; Gilhotra et al, 2002; Linden et al, 2005; Jones & Shinton, 2006; Bouwmeester et al, 2007; Schuett et al, 2009; Das & Huxlin, 2010).

1.2. Limitations in the literature

A lack of evidence on the integration of visual scanning exercises through saccadic eye movement training as part of, and integrated with, physiotherapy has been identified in the literature regardless of the important role vision plays in movement and, ultimately, the functional ability of the patient.

From the literature reviewed that assessed the re-training of the visual system on patients' post-stroke's functional ability, perceptual processing and cognition post-stroke, it may be summarised that: (a) decreased visual efficiency processes, specifically impaired saccadic eye movements give rise to slower oculomotor speed, decreased control and coordination of eye movements resulting in disruption of visual scanning and attention; and (b) interventions that incorporate saccadic eye movement training with visual scanning techniques post-stroke improve the visual system with an associated improvement in perceptual processing, cognitive function and motor behaviour (Weinberg et al, 1977; Weinberg et al, 1979; Weinberg et al, 1982; Carter et al, 1983; Young et al, 1983; Webster et al, 1984; Gordon et al, 1985; Ball et al, 1988; Gur et al, 1992; Kerkhoff et al, 1992; Pizzamiglio et al, 1992; Wagenaar et al, 1992; Kerkhoff et al, 1994; Ladavas et al, 1994; Antonucci et al, 1995; Fanthome et al, 1995; Zihl et al, 1995; Paolucci et al, 1996; Kalra et al, 1997; Wiart et al, 1997; Niemeier et al, 1998; De Sèze et al, 2001; Nelles et al, 2001; Bailey et al, 2002; Brunila et al, 2002; Ciuffreda, 2002; Pierce & Buxbaum, 2002; Cappa et al, 2003; Pambakian et al, 2004; Pizzamiglio et al, 2004; Sabel et al, 2004; Bolognini et al, 2005; Cicerone et al, 2005; Rawstron et al, 2005; Bouwmeester et al, 2007; Mueller et al, 2007; Nelles et al, 2009; Roth et al, 2009).

Limitations highlighted in the review of studies that assessed the effects of visual therapy in patients who suffered a stroke were, first, the effect of intervention that addressed ocular and visual impairments were mainly assessed using paper-and-pencil tasks during visual-perceptual assessment. However, the reviewed studies did not provide an indication of change in an individual's ability to function in the complex everyday activities that are relevant to their life (Weinberg et al, 1977;

Weinberg et al, 1979; Weinberg et al, 1982; Carter et al, 1983; Young et al ,1983; Webster et al, 1984; Gordon et al, 1985; Ball et al, 1988; Gur et al, 1992; Kerkhoff et al, 1992; Pizzamiglio et al, 1992; Wagenaar et al, 1992; Ladavas et al, 1994; Fanthome et al, 1995; Zihl et al, 1995; Bailey et al, 2002; Brunila et al, 2002; Ciuffreda, 2002; Pierce & Buxbaum, 2002; Cappa et al, 2003; Cicerone, 2005; Rawstron et al, 2005; Reinhard, 2005; Goh, 2007; Jobke et al, 2009; Nelles et al, 2009).

Second, few researchers have evaluated the long-term effects of interventions that addressed ocular and visual impairments in patients post-stroke (Webster et al, 1984; Gordon et al, 1985; Ball et al, 1988; Kerkhoff et al, 1994; Niemeier, 1998; Bolognini et al, 2005).

Third, only a few studies have assessed the effects of re-training of the visual system on the individual's subjective well-being and quality of life (Kerkhoff et al, 1994; Nelles et al, 2001; Pambakian et al, 2004; Sabel et al, 2004; Bolognini et al, 2005; Reinhard et al, 2005; Goh, 2007; Mueller et al, 2007; Jobke et al, 2009).

From the limitations identified in the review of literature, it is concluded that outcome measures used in the research setting to evaluate the outcome of an intervention that incorporates saccadic eye movement training with visual scanning exercises should include assessment of the patient on body impairment level, functional activity- and participation levels. Also, assessment of the outcome of the intervention which aims to improve ocular and visual impairments post-stroke with associated improvements in cognitive function, perceptual processing, motor function and perceived quality of life should include assessment of body impairment level, functional activity- and participation levels. Visual scanning training through saccadic

eye movement exercises integrated into increasingly complex visual-perceptual and visual-motor tasks needs be assessed with a matched-pair randomised controlled trial (Chan, Chan & Au). Through a matched-pair randomised controlled trial the extent to which visual scanning training transfers to functional ability and quality of life in patients with visual impairments following stroke can be assessed.

1.3. Practical experience of the researcher

In practice the researcher has discovered that the integration of visual scanning exercises through saccadic eye movement training during task-specific activities as part of the treatment of unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke results in an improvement in functional ability, earlier discharge from the rehabilitation setting and good functional carry-over of acquired skills to “real life situations”. This observation and the lack of the integration of saccadic eye movement training with visual scanning exercises during task-specific activities urged the researcher to investigate the effect of visual scanning exercises integrated with task-specific activities as part of physical rehabilitation in patients who have sustained a stroke and who suffer from unilateral spatial inattention, visual-spatial disorders or visual-constructive disorders.

Limitations experienced in both literature and clinical practice are that rehabilitation approaches used in the treatment of the motor system, perception and cognition focus only on the facilitation of recovery of the different subsystems as a single entity and not as an integrated holistic approach where the visual, perceptual, cognitive and gross motor activities are integrated in normal movement and functional activities.

Rehabilitation interventions aiming to optimise functional recovery in stroke patients therefore need to incorporate the restoration of sensory / perceptual, motor and cognitive impairments, in order to increase functioning on both activity and participation levels. There is a need for evidence that saccadic eye movement training during task-specific activities results in better outcome on body impairment level, functional activity and participation level in the treatment of patients who experience unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke.

1.4. Problem statement

A lack of evidence on the integration of visual scanning exercises as part of, and integrated with, physiotherapy has been identified in the literature regardless of the important role vision plays in movement and ultimately the functional ability of the patient. Schulmann et al (1987) recommend that visuomotor training should be encouraged amongst the post-stroke population to enhance postural strategies in patients with postural control impairment secondary to stroke. Patients with decreased postural control may be trained to use re-fixation saccadic eye movements to enable them to obtain a stable visual field for peripheral vision. Peripheral vision is utilised to provide the spatial orientation for postural control.

The aim of visuomotor therapy is to address the oculomotor system – specifically the oculomotor control impairments, which entail saccadic eye movements, smooth pursuit eye movements, accommodation and convergence disorders and their mutual interactions. The goal of treatment is not to address these impairments in isolation, but to integrate oculomotor control with the sensomotor system to facilitate efficient

and coordinated behaviour within a context of appropriate spatial sense under a variety of external and internal conditions and environments (Ciuffreda, 2002).

There is a need for evidence that saccadic eye movement training during task-specific activities results in improved outcome on body impairment level, functional activity and participation level in the treatment of patients with visual-perceptual disorders following a stroke. In order to determine whether the integration of visual scanning through saccadic eye movement training has a more permanent or long-term effect on patients' postural control, functional ability and quality of life, it would be important to perform assessment of the effect thereof on a longitudinal basis.

1.5. Significance of the research

If the evidence from the study shows that saccadic eye movement training with visual scanning exercises integrated with task specific activities as an intervention has a significant effect on cognitive functioning, oculomotor visual performance, functional ability and quality of life in participants that present with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke, the evidence will contribute to an evidence-based holistic understanding of treatment strategies in the field of stroke rehabilitation. The evidence will further contribute to an understanding of the role of vision in postural control and rehabilitation of patients who have sustained a stroke (Teasell et al, 2011).

1.6. Research questions

(1) What is the effect of saccadic eye movement training with visual scanning exercises integrated with task-specific activities versus patients who have only received the task-specific treatment approach on:

- **Oculomotor visual performance;**
- **Functional ability;**
- **Perceptual processing and cognitive functioning; and**

in patients who have sustained a stroke and present with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders, after four (4) weeks of rehabilitation, as well as eight (8), twelve (12), sixteen (16) and twenty (20) weeks after rehabilitation has been terminated?

(2) What is the effect of saccadic eye movement training with visual scanning exercises integrated with task-specific activities versus patients who have only received the task-specific treatment approach on **quality of life** in patients who have sustained a stroke and present with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders eight (8), twelve (12), sixteen (16) and twenty (20) weeks after rehabilitation has been terminated?

1.7. Aims of the study

The aims of this study were to determine:

(1) The effect of task-specific activities as an intervention approach versus the effect of visual scanning exercises integrated with task-specific activities as an intervention approach on participants that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke's:

- Oculomotor visual performance;
- Functional ability; and
- Perceptual processing and cognitive functioning;

on a weekly basis during the intervention period of four (4) weeks as well as eight (8), twelve (12), sixteen (16) and twenty (20) weeks after rehabilitation has been terminated.

(2) The effect of task-specific activities as an intervention approach versus the effect of visual scanning exercises integrated with task-specific activities as an intervention approach on participants that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke' quality of life eight (8), twelve (12), sixteen (16) and twenty (20) weeks after rehabilitation has been terminated.

1.8. Objectives of the study

The objectives of this study were to determine:

(1) The effect of visual scanning exercises integrated with task-specific activities received by participants in Group 1 versus participants in Group 2 that received task-specific activities alone on participants' that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke's **oculomotor function** measured with the **King-Devick Test ©** on a weekly basis during the intervention period of four (4) weeks as well as eight (8), twelve (12), sixteen (16) and twenty (20) weeks after rehabilitation has been terminated.

(2) The effect of visual scanning exercises integrated with task-specific activities received by participants in Group 1 versus participants in Group 2 that received task-specific activities alone on participants that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke's **functional ability** measured with the **Stroke Activity Scale, Barthel Index** and **Timed Up and Go Test** on a weekly basis during the intervention period of four (4) weeks as well as eight (8), twelve (12), sixteen (16) and twenty (20) weeks after rehabilitation has been terminated.

(3) The effect of visual scanning exercises integrated with task-specific activities received by participants in Group 1 versus participants in Group 2 that received task-specific activities alone on participants that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke's **perceptual processing** and **cognitive functioning** measured with the **Star Cancellation Test** and **Mini-Mental State Examination** on a weekly basis during

the intervention period of four (4) weeks as well as eight (8), twelve (12), sixteen (16) and twenty (20) weeks after rehabilitation has been terminated.

(4) The effect of visual scanning exercises integrated with task-specific activities received by participants in Group 1 versus participants in Group 2 that received task-specific activities alone on participants that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke's **quality of life** measured with the **Stroke Impact Scale Version 3.0** and the **Walking ability questionnaire** eight (8), twelve (12), sixteen (16) and twenty (20) weeks after rehabilitation has been terminated.

1.9. Ethical approval

Ethical approval to conduct this study was granted by the Ethics Committee of the Faculty of Health Sciences at UP (S33/2009) (Addendum 1). Permission to conduct this study in the Physiotherapy Department at the TRC in Pretoria, Gauteng, South Africa was granted by the Acting Chief Executive Officer of TRC (Addendum 2).

1.10. Course of the study

In Chapter 1 the need for this study, aims and objectives of the study are discussed.

In Chapter 2 the role of the visual system in optimising postural control in participants who have suffered a stroke is identified and explained. The chapter also reviews the visual therapy interventions used to address disorders of the visual system and recovery in the post-stroke population.

In Chapter 3 a detailed account is given on how the research was performed. This account includes the research setting, the recruitment of patients, the matching and allocation of participants, the research process and the assessment procedure of participants from Group 1 that received visual scanning exercises integrated with task-specific activities received by participants versus participants from Group 2 that received task-specific activities alone.

In Chapter 4 the results of the research methodology are presented in tables and graphs. A detailed account of the analysis of the data and a discussion of the results gathered during the matched-pair randomised controlled trial are presented in Chapter 4. The demographical data of all the participants who participated in this clinical trial as well as the results of the outcome measures obtained at the pre-determined times are identified and described in Chapter 4.

In Chapter 5 the results of the trial are discussed in the context of the relevant literature. The conclusion of the effect of saccadic eye movement training with visual scanning exercises integrated with task-specific activities on participants that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke's functional outcome after four (4) weeks of rehabilitation are discussed. The limitations of the study and suggestions for further studies are also discussed in Chapter 5.

CHAPTER 2

LITERATURE REVIEW

2.1. Introduction

In Chapter 2 the existing research evidence and limitations in the evidence on the influence of impairment of the visual system has on the patient's functional ability are discussed. The published interventions used to address disorders of the visual system in the stroke population to improve impairments of oculomotor control, saccadic eye movements, smooth pursuit eye movements, convergent fusion, accommodation, unilateral homonymous hemianopia and homonymous visual field disorders are reviewed.

Patients with visuomotor deficits, visual-perceptual and cognitive impairments following a stroke may present with the following impairments during functional activities (Chaikin, 2007):

1) Avoidance of near (close-up) tasks;
2) Neglecting one side of the body or space during the performance of an activity;
3) Losing the place when reading;
4) Bumping into walls or objects during walking or when maneuvering in a wheelchair;
5) Difficulty with activities of daily living due to poor eye-hand coordination – knocking objects over or missing objects during reaching;
6) Appearing to misjudge distance;

7) "Under reaching" or over reaching for objects;
8) Closing or covering one eye during conversations and/or activities due to blurred vision or double-vision;
9) Squinting;
10) Seeming to look past the observer and having difficulty maintaining eye contact; and
11) Decreased attention during conversations and/or activities (patient day dreams)

Patients with visuomotor deficits, visual-perceptual and cognitive impairments following a stroke may suffer from the following ocular and visual impairments (Chaikin, 2007):

1) Blurred vision;
2) Having difficulty "seeing" with or without glasses;
3) Double-vision;
4) Letters jumping around on the page during reading;
5) Experiencing eye strain or headaches;
6) Portions of the page being missing when reading;
7) Portions of objects not being observed;
8) Not seeing people or objects approaching suddenly from one side; and
9) Having difficulty concentrating on tasks

Visual and ocular impairments that result in reduced visuomotor deficits, visual-perceptual and cognitive impairments caused by stroke lead to substantial impaired

functional ability during activities of daily living in and around the house, in the work environment, community and recreational environment. The therapy interventions used to address disorders of the visual system that includes impairments of oculomotor control, saccadic eye movements, smooth pursuit eye movements, convergent fusion, accommodation, unilateral homonymous hemianopia and homonymous visual field disorders should be evaluated. The result of training of the visual system on patients' functional ability, perceptual processing and cognition following a stroke should also be reviewed.

2.2. Literature search strategy

A search for relevant literature using multiple databases was used to identify all potential literature on therapy interventions used to address disorders of the visual-perceptual system, cognitive processing and the possible influence of impairment of the visual system on the patient's functional ability.

The literature search excluded animal trials and was restricted to articles in the English language only. The search strategy included articles published from 1970 – 2011 and included (1) randomised controlled trials (RCTs); (2) case studies; (3) Cochrane reviews prepared and maintained by The Cochrane Collaboration and published in *The Cochrane Library*; (4) clinical observational studies; (5) quasi-experimental studies; (6) systematic literature reviews; and (7) retrospective case reviews.

Various Internet search engines were also used to obtain relevant literature for this clinical trial. These included:

- Google Scholar
- Electronic library of University of Pretoria:
    - Science Direct
    - Pubmed
    - PEDro
    - Cochrane
    - Cinhal

- Websites: http://www.ebrsr.com/ = Evidence-based of Stroke Rehabilitation

  http://who.com/ = World Health Organization

  http://wcpt.com/ = World Confederation for Physical Therapy

- Keywords that were used are:
    - Stroke
    - Postural control
    - Physical therapy
    - Rehabilitation approaches for stroke patients
    - Motor control
    - Physiotherapy
    - Motor learning
    - Cognition
    - Perception
    - Sensorimotor integration
    - Visual scanning
    - Eye movements
    - Saccades / Saccadic eye movements
    - Activities of daily living
    - Neurovisual rehabilitation
    - Task-orientated activities
    - Visual learning
    - Executive function

- Bibliographies of articles selected were also reviewed for relevant additional literature.

2.2.1. Assessment of the quality of selected literature

In the case of RCTs the quality of the research was evaluated according to the PEDro scale for RCTs: http://www.pedro.fhs.usyd.edu.au/scale. Formulation of conclusions according to the levels of evidence was based on the Eastern Ontario / Queen's Evidence Based Report. The report is based on the levels of evidence used by the United States Agency for Health Care Policy and Research (AHCPR) Guidelines for Stroke Rehabilitation (Teasell, 2011).

2.3. Functional activity and the visual system post-stroke

Visual efficiency processes that mainly consist of saccadic eye movements, visual fixation and smooth pursuit eye movements are controlled by a complex neural system. Smooth pursuit eye movements are used to maintain the eyes on a target, where saccadic eye movements are necessary to visually scan the surrounding environment to provide an individual with information on spatial relation and temporal-spatial relationships that includes: (a) the identification of objects' position in space; (b) the determination of the objects' movement; (c) the position of one's body in space; (d) the relation of one body part to another and (e) the motion of one's own body (Gorman, 2007; Shumway-Cook & Woollacot, 2007). Impairment to control gaze or to shift gaze appropriately to scan the environment will limit the visual system's input into postural-orientation processing and as a result affect postural

stability and ultimately result in the inability to execute goal-directed activities (Das & Huxlin, 2010).

Many patients suffer from ocular and visual impairments following either a haemorrhagic or ischaemic stroke (Jobke, Kasten & Bernhard, 2009; Roth et al, 2009). Visual system impairments observed in patients who have suffered is summarised in Table.2.1.

Table 2.1. Visual system impairments post-stroke (Maddock et al, 1981; Schulmann et al, 1987; Zoltan, 1996; Kerkhoff, 2000; Leigh & Kennard, 2004; Chaikin, 2007; Shumway-Cook & Woollacott, 2007; Spering & Gegenfurtner, 2008; Schuett et al, 2009)

Visual impairment	Definition and Explanation
Accommodation	The ability of the eye to vary its refractive power to produce a focused image on the retina for different object distances (Maddock et al, 1981).
Unilateral homonymous hemianopia/Homonymous visual field defects (HVFDs)	Loss of vision in both monocular hemifields contralateral to the side of the stroke (Schuett et al, 2009). Unilateral homonymous hemianopia is the most frequent visual disorder following damage to the V1 or its postchiasmal afferents. Damage to the V1 occurs in patients as result of a stroke in the territory of the posterior cerebral artery infarction affecting the postchiasmatic visual pathway (Leigh & Kennard, 2004; Pambakian et al, 2004; Bolognini et al, 2005; Bouwmeester, Heutink & Lucas 2007; Schuett, Kentridge, Zihl & Heywood, 2009; Das & Huxlin, 2010).

Visual impairment	Definition and Explanation
	Twenty to thirty per cent (20 – 30%) of patients with stroke presents with homonymous visual field disorders, resulting in poor rehabilitation progress and therefore decreased functional ability (Das & Huxlin, 2010).
Unilateral spatial inattention and hemianopia	The inability to perceive stimuli on one side of the body resulting in neglect of one side of the body and extrapersonal space on that side (Shumway-Cook & Woollacot, 2007).
Binocular vision/convergent fusion disorder	To direct the eyes to a target nearer than the present fixation point (Kerkhoff, 2000). Thirty per cent (30%) of patients with stroke show reduced convergent fusion resulting in poor rehabilitation progress and therefore decreased functional ability (Das & Huxlin, 2010).
Eye movement disorder: Conjugate eye deviation/Saccadic eye movement impairment	The inability to shift eyes rapidly from object to object, therefore not allowing quick localisation of movements observed in the periphery (Chaikin, 2007).
Eye movement disorder: Smooth pursuit disorder	Impairment in the tracking (following) of a moving visual object of interest when the head is stationary (Schulmann et al, 1987; Zoltan, 1996; Spering & Gegenfurtner, 2008).
Visual spatial perception disorder	Impairment in the perception of vertical and horizontal orientation. Impairment in the perception of the length, size and position discrimination of objects (Kerkhoff, 2000).

Visual and ocular impairments displayed in Table 2.1 may result in (1) small saccadic eye movements; (2) decreased speed of saccadic eye movements towards the impaired visual field; (3) a narrow scope of saccadic eye movements with visual

scanning in the visual field; and (4) slower speed, poor control and decreased coordination of saccadic eye movements, visual fixation and smooth pursuit eye movements. Dysfunction of saccadic eye movements, visual fixation and smooth pursuit eye movements result in the following impairments on body impairment level:

- Difficulty in localisation of other objects in relation to the individual itself (extrapersonal perception);
- Difficulty in localisation of the individual in relation to other objects (intrapersonal perception);
- Inability to maximise peripheral vision by not being able to provide a stable visual field;
- Inability to bring near objects into clear focus automatically and without strain;
- Difficulty to keep an image of a moving object stationary on the fovea while the static background (the peripheral visual field) appears to move;
- Increased visual exploration time, target omissions and unsystematic oculomotor scanning patterns;
- Inability to examine the details of the extrapersonal visual environment of an individual, resulting in a visual-spatial dysfunction;
- Impaired visual orientation and visual search in two-dimensional (2D) and three-dimensional (3D) spaces;
- Impaired orientation during self-motion of a person; and
- The inability to track and maintain the image of a moving object on the fovea of the eye.

The inability to perform smooth pursuit movements and visual fixation to track and maintain the image of a moving object on the fovea of the eye results in an impairment of central vision. Central vision dysfunction gives rise to impairment in the analysis of objects and result in functional deficits that include impairment of eye-hand coordination and difficulty with visually directed movement for fine motor tasks and gross movement.

Dysfunction of saccadic eye movements, visual fixation and smooth pursuit eye movements on body impairment level result in impairment of spatial orientation as result of an unstable visual field resulting in an impairment of depth perception and subsequent inaccuracy in judgement of distances. These visual and ocular impairments increase difficulty with peripersonal and intrapersonal ADL which includes (1) self-care and hygiene activities; (2) dressing, specifically closing fasteners and doing buttons; and (3) difficulty finding objects.

Impairment of saccadic eye movements results in body image impairment due to a lack of spatial orientation and attention to one half of the individual's intrapersonal space which may limit the performance of ADLs to one half of the body for example (1) eating food on one side of the plate; (2) dressing only one side of the body; (3) shaving one side of the face; (4) applying make-up to only half the face; (5) brushing teeth in only half the mouth; (6) missing kitchen utensils if they are located on the affected side; and (7) failure to recognise their affected extremities as their own and function as though they are absent.

Difficult and unsafe mobilisation due to the patient failing to see obstacles in their hemianopic field result in (1) increased risk of falls; (2) attempting to navigate through

a door oblivious to the fact that the affected arm may be caught on the doorknob or doorframe; (3) walking into objects present in the neglected side; (4) unsafe mobilisation over uneven surfaces and stairs; (5) unsafe mobilisation in the community; (6) when walking or driving a wheelchair veering towards the unaffected extrapersonal space rather than navigating in a straight line; and (7) unawareness of doorways and hallways in the affected extrapersonal space as well as turning in only one direction may result in these individuals losing their way and getting lost.

Absent visual scanning using saccadic eye movements on the affected side of the midline of the body defects give rise to (1) impaired reading due to impaired viewing of words toward the end of the lines, skipping individual words within a line and repetition of lines; (2) inability to change direction of fixation particularly at the end of a line; (3) losing the place on the total page; (4) slow reading speed, guessing errors and severely altered reading eye-movement pattern; (5) filling out only one half of a form; (6) reading only half the page; and (7) difficulty with letter identification resulting in deficits in reading. Difficulty with reading, writing and typing as result of impaired saccadic eye movements and visual fixation leads to difficulty in the workplace with relation to accuracy of work, management of workload and working speed. Patients may also have difficulty with computer-based tasks due to (1) poor concentration; (2) reduced sustained visual attention in near-work conditions; and (3) blurred vision as result of the dysfunction of saccadic eye movements, visual fixation and smooth pursuit eye movements on body impairment level.

Impairment of saccadic eye movements, visual fixation and smooth pursuit eye movements result in extensive functional impairments in the community and

recreational environment. Patients may have difficulty in recreational activities and hobbies such as (1) assembling a puzzle; (2) playing board games; and (3) using tools in building of models and woodwork.

Visual and ocular impairments on body impairment level influence functional activities on participation level in the sense that patients may experience difficulty in the identification and following of moving objects in the visual field periphery. The inability to perform saccadic eye movements, smooth pursuit movements and visual fixation may result in difficulty to (1) identify and follow moving vehicles, persons and moving objects in the extrapersonal visual surroundings; (2) difficulty with driving; and (3) difficulty in detecting vehicles or persons to avoid collisions.

For an extended period of time it was believed that visual impairments including visual efficiency processes and visual information-processing skills – such as visual field defects, oculomotor control, accommodation and convergence dysfunctions following stroke – were untreatable. The concept of plasticity of the brain and visual system has emerged in the neurosciences over the last two decades. It is now well recognised that the visual system shows modifiability and potential to recover from lesion-induced changes (Sabel & Kasten, 2000; Sabel et al, 2004; Mueller, Mast & Sabel, 2007).

A literature review on the effect of the re-training of the visual system post-stroke highlights recent developments in the re-training of the visual system and the resulting functional recovery in patients following a stroke (Das & Huxlin, 2010). A

summary of the results of previous studies that assessed the effect of re-training of the visual system on patients' functional ability post-stroke is displayed in Table 2.2.

Table 2.2. Results of previous studies that assessed the effect of re-training of the visual system on patients' functional ability post-stroke (Das & Huxlin, 2010; Teasell et al, 2011)

Articles published from 1970 – 2011	**Levels of evidence**
Ten (10) studies presented evidence for the effect of re-training of the visual system on patients' functional ability post-stroke. <u>These studies included:</u> Seven (7) randomised controlled trials One (1) case study One (1) open non-randomised clinical trial One (1) clinical observational study	Strong evidence (Level 1a) consisting of seven randomised clinical trials of fair quality (3 studies), good quality (1 study) and of excellent quality (3 studies) concludes that treatment incorporating visual scanning techniques through saccadic eye movement training improves the visual system post-stroke with associated improvements in function.
Forty (40) studies presented evidence for both short-term and long-term effect of treatment incorporating saccadic eye movement training with visual scanning exercises with associated improvements in oculomotor strategies and visual efficiency processes, cognitive function, visual-perceptual processes, independence in ADL, mobility and ambulation. <u>These studies included</u>: Eighteen (18) randomised controlled trials Two (2) quasi experimental studies Eleven (11) case studies Six (6) literature reviews One (1) open randomised clinical trial One (1) retrospective case review One (1) clinical observational study	Strong evidence (Level 1a) consisting of sixteen (16) randomised clinical trials of fair quality (5 studies), good quality (9 studies) and of excellent quality (2 studies) concluded that treatment incorporating visual scanning techniques through saccadic eye movement training improves the visual function post-stroke and is associated with improvements in oculomotor strategies, visual efficiency processes and function.

Articles published from 1970 – 2011	Levels of evidence
The improvement of motor impairment and restoration of motor function should focus on high-intensity, repetitive task-specific practice with feedback on performance (Pollock et al., 2007 & Langhorne et al., 2009).	The systematic review, however, did not include any studies that utilised and incorporated saccadic eye movement training with visual scanning exercises integrated into physiotherapy.

In RCTs performed between 1970 and 2011 (Table 2.2.) the conclusion can be made that: (1) No studies used or incorporated saccadic eye movement training with visual scanning exercises integrated into physiotherapy.

(2) **Visuomotor training** should be encouraged to enhance postural strategies of patients with postural control impairment secondary to stroke. Patients with decreased postural control may be trained to scan their peripheral visual field using re-fixation **saccadic eye movements** which aim to provide a stable visual field for peripheral vision. Peripheral vision is used to provide spatial orientation for postural control during the performance of functional tasks in everyday life (Schulmann et al, 1987).

(3) Treatment utilising and incorporating saccadic eye movement training with visual scanning exercises improves **oculomotor strategies and visual efficiency processes** in patients post-stroke.

(4) Visual scanning exercises that incorporate saccadic eye movement training improves ocular and visual impairments resulting in **associated improvements in functional ability**.

(5) Saccadic eye movement training with visual scanning exercises integrated with task-specific activities does not improve ocular and visual impairments in isolation, but integrate oculomotor control with the:

- Motor system to facilitate eye-hand coordination;
- Extremities to improve eye-hand and eye-foot coordination; and
- Overall body and other sensory modalities to produce efficient and coordinated behaviour within a context of appropriate spatial sense under a variety of external and internal conditions and environments (Ciuffreda, 2002).

Based on literature reviewed in Table 2.2. it can be concluded that intensive saccadic eye movement training can re-train and strengthen a patient's oculomotor strategies and visual efficiency processes. Improved oculomotor strategies optimise the visual system of patients post-stroke and further improve their ability to use vision in everyday life which results in improved functional ability in terms of independence during activities of daily living in and around the house, in the work environment, community and recreational environment.

2.4. Visual system, visual perception and cognition

Decreased oculomotor function, visual efficiency processes and saccadic eye movements result in reduced visual perception and cognition, which results in substantial functional disability during daily life activities (Kerkhoff, 2000; Nelles et al, 2009). The presence of decreased oculomotor function, visual efficiency processes and saccadic eye movements are, therefore, associated with visual perceptual dysfunction and decreased cognitive functioning.

Perceptual dysfunction is an important cause of long-term disability in patients who have suffered a stroke. Impairments of the perceptual system can adversely affect a patient's ability to safely and efficiently mobilise in and around the house as well as at

work and in the community. Perceptual impairments also affect the patient's ability to perform most tasks in the work environment, reading and enjoyment of many recreational activities. Perceptual impairments therefore severely affect a stroke survivor's overall quality of life (Martin & Huxlin, 2010).

2.4.1. Perceptual processing

Perception is the integration of multiple sensory input through the individual sensory systems and sensory strategies into meaningful information that is fundamental to the successful performance of functional tasks in a particular environment (Shumway-Cook & Woollacott, 2007). Unilateral spatial neglect (inattention) is a visual-perceptual disorder that entails the inability to perceive and integrate stimuli on one side of the body, resulting in the neglect of the intrapersonal or extrapersonal space of one side of the body. USN or hemi-inattention is characterised by a disturbance in spatial perception affecting the contralateral side of the body. This visual-perceptual deficit may occur in up to 50% of patients with stroke affecting the right cerebral hemispheres and up to 25% of left hemispheric stroke (Diserens et al, 2007).

Visual-perceptual dysfunction is caused by the impairment of central associative processing of primary visual input obtained through visual efficiency processes that mainly consist of saccadic eye movements, visual fixation and smooth pursuit eye movements. USN is the most disruptive impairment of visual scanning, with fewer eye movements observed to one side of body or extrapersonal space during the performance of an activity. With careful observation of a patient's activity the fovea of the eye does not appear to be directed to gather information from one side of the body or extrapersonal space. Visual scanning using saccadic eye movements occurs

on only one side of the midline within the unaffected side of the body. Spontaneous eye movements or head movement past the midline into the affected space is absent (Zoltan, 1996; Chaikin, 2007).

Visual-perceptual dysfunction, specifically unilateral spatial neglect (USN), is a major cause of disability and impairment in stroke patients that negatively influences functional recovery and is, therefore, associated with poor functional outcome (Fanthome et al, 1995; Kalra, 1997; Cassidy et al, 1998; Kerkhoff, 2000; Cherney, 2001; Bailey et al 2002; Cappa et al, 2003; Jones & Shinton, 2006; Luauté et al, 2006; Chaikin, 2007). Regardless of the side of the stroke (Kalra, 1997), visual-perceptual deficits are rarely observed in isolation. They **present in combination** with motor, language and **cognitive dysfunctions**. The presence of these impairments delays the progress of rehabilitation, as visual-perceptual disorders are highly associated with deficits in functional activities in the home-, work-, community- and recreational environment (Kerkhoff, 2000; Linden et al, 2005; Luauté et al, 2006).

2.4.2. Cognitive functioning

Impairment of cognitive function is a significant cause of disability following a stroke. Cognitive dysfunction may result in reduced efficiency, speed and persistence of functioning and decreased effectiveness in the performance of routine ADL. Individuals with cognitive impairment also fail to adapt to novel or problematic situations. Stroke patients with cognitive impairments present with extensive functional disability at discharge from acute hospital settings, increased length of stay in rehabilitation facilities, increased hospital resource use, and increased duration of therapy input (Kalra, 1997; Carter, 1983; Chaikin, 2007; Martin & Huxlin, 2010).

Visual scanning with saccadic eye movements allows individuals to examine the details of our extrapersonal visual environment to provide the visual sensory information that precedes motor actions (Land, 2009). During visual scanning the saccadic eye movements and visual fixation **are preceded by a shift of attention** to the goal of the next saccade (Leigh & Kennard, 2004). Efficient and effective visual scanning is therefore **dependent on cognitive factors**, which include planning, sequencing, visual-spatial attention, and spatial working memory to optimise saccadic eye movements and visual fixation (Leigh & Kennard, 2004).

Active visual scanning is **dependent upon the integration of visual attention and oculomotor control**. Therefore, an attentional deficit may impair a patient's ability to search and scan the extrapersonal visual space surrounding him. Impairment of visual scanning ability may contribute to cognitive dysfunction that negatively influences postural control and, as such, the level of functional independence post-stroke (Leigh & Kennard, 2004). Attention to a specific part of the visual field also benefits visual processing in that area of the visual field. Attention is distributed across the visual field to improve visual-information processing by means of improving the efficiency with which stimuli are detected and discriminated between (Poggel et al, 2004).

Patients who suffered a stroke are likely to exhibit multiple forms of cognitive impairment. It is therefore essential to continually evaluate the effectiveness of integrated therapy that addresses the complex interaction between cognitive impairments, functional disability, perceptual dysfunction and participatory impairments with the goal of reducing disability and improve functional ability in and around the house, in the work environment, community and recreational environment

(Cicerone et al 2000). Results of studies reviewed in the literature that assessed the effect of re-training of the visual system on patients' perceptual processing and cognitive function post-stroke are summarised in Table 2.3.

Table 2.3. Results of studies that assessed the effect of re-training of the visual system on patients' perceptual processing and cognitive function post-stroke (Das & Huxlin, 2010; Teasell et al, 2011)

Articles published from 1970 – 2011	**Levels of evidence**
Forty (40) studies presented evidence for both short-term and long-term effect of treatment incorporating saccadic eye movement training with visual scanning exercises with associated improvements in oculomotor strategies and visual efficiency processes, **cognitive function**, **visual-perceptual processes**, independence in ADL, mobility and ambulation. <u>These studies included:</u> Eighteen (18) randomised controlled trials Two (2) quasi experimental studies Eleven (11) case studies Six (6) literature reviews One (1) open randomised clinical trial One (1) retrospective case review One (1) clinical observational study	Strong evidence (Level 1a) consisting of sixteen (16) RCTs of fair quality (5 studies), good quality (9 studies) and of excellent quality (2 studies) concluded that treatment incorporating visual scanning techniques through saccadic eye movement training improves the visual function post-stroke and is associated with improvements in oculomotor strategies, visual efficiency processes and function.
Sixteen (16) studies presented evidence for both short-term and long-term (sustained) effect of treatment incorporating saccadic eye movement training with visual scanning exercises assessed by standardised cognitive outcome measures. The paper-and-pencil cognitive outcome measures	Strong evidence (Level 1a) consisting of ten (10) RCTs of fair quality (2 studies), good quality (7 studies) and of excellent quality (1 study) concludes that treatment incorporating visual scanning techniques through saccadic eye movement training improves the visual system post-stroke with associated

Articles published from 1970 – 2011	Levels of evidence
used in the studies provide an indication of changes in the underlying cognitive impairment (Bowen & Lincoln, 2007). These studies included: Ten (10) randomised controlled trials Two (2) quasi experimental studies (n = 77) and (n = 12) Two (2) case studies (n = 5) and (n = 13) Two (2) literature reviews	improvement in cognition.
In the InChanti study (2005) (n = 926) the association between performance on tests of cognitive processes (executive function) and performance on lower extremity tasks were researched. This cross-sectional study concluded that cognitive and executive function is **independently associated** with tasks of lower extremity function that require high attentional demand (Ble et al, 2005; Yogev et al, 2008).	
Similar findings were reported by Holtzer et al. (2006) (n = 186) where the researchers demonstrated associations between speed of cognitive processing, attention, memory, language, executive function, and gait speed.	
Associations between cognitive function, executive function and performance of balance and mobility were observed in stroke patients (n = 63) even after adjustment for age, quadriceps strength of the paretic side, and current physical activity level (Liu-Ambrose et al, 2007).	

The presence of visual and ocular impairments that includes decreased oculomotor function specifically decreased saccadic eye movements and visual fixation is associated with visual perceptual dysfunction and decreased cognitive functioning. In the literature summarised in Table 2.3. it is clear that impairment of visual-perceptual

processing and cognitive functioning result in impairments on body impairment level such as (1) decreased ability to learn; (2) inattention; (3) decreased arousal (decreased level of consciousness) and orientation (disorientation); (4) impaired memory; (5) impairment of problem-solving ability; (6) decreased self-awareness; (7) decreased planning; (8) decreased response inhibition and monitoring; (9) loss of mobility due to reduced motivation; and (10) decreased inner drive to move.

The effect of the decreased visual-perceptual processing and cognitive functioning on body impairment level as result of dysfunction of saccadic eye movements, visual fixation and smooth pursuit eye movements result in difficulty during performance of functional tasks in and around the house, workplace and recreational environment as described in paragraph 2.3.

Based on the results of RCTs performed between 1970 and 2011 (Table 2.3.) certain conclusions can be made. These are numbered 1 to 8 below.

(1) No studies used or incorporated saccadic eye movement training with visual scanning exercises integrated into physiotherapy in the treatment of perceptual processing and cognitive functioning in patients post-stroke.

(2) Treatment incorporating saccadic eye movement training with visual scanning exercises improves the visual system post-stroke **with associated improvements in perceptual processing and cognitive functioning**.

(3) The re-training of visual scanning, specifically saccadic eye movements, should be emphasised as part of the rehabilitation of patients post-stroke. Increased ability to perform visual scanning, specifically saccadic eye movements, should be incorporated in systematically increasingly complex visual-perceptual and visual-

motor tasks. Visual scanning, specifically saccadic eye movements, should be further emphasised and integrated during functional tasks such as gait and dressing. The influence of perceptual processing specifically USN and cognitive functioning on functional performance should be continuously monitored by objective and subjective testing.

(4) Clinicians need to evaluate cognitive function when assessing and treating impaired balance and mobility in community-dwelling adults after stroke. Cognitive impairment is a significant cause of disability following a stroke and result in reduced efficiency, speed and persistence of functioning in the performance of functional activities in and around the household, workplace and community.

(5) The association between cognition, balance and mobility in fall-prevention need to addressed in the rehabilitation of patients following a stroke.

(6) The consequences of spontaneous plasticity for perception appear to be relatively limited. Persistent loss of visual perceptual abilities, the impact on visual functions in everyday life and impaired quality of life **persist** in the long term in the majority of patients with visual system dysfunction following a stroke and where no intervention were provided.

(7) Many studies which attempted to retrain perceptual dysfunction by using visual scanning exercises with saccadic eye movements, observed a major unresolved issue – the functional significance of improvements in vision during the performance of activities of daily living.

(8) The effects of the research intervention were only assessed with paper-and-pencil tests and tasks. No assessment of the effects of the research intervention on functional ability was performed. Therefore, the functional effects of that particular intervention remain unknown and gives rise to the question; “How does the improved

performance on objective and subjective measures assessing visual function post-stroke translate to the ability to perform visually guided activities of daily living?

2.5. Anxiety and depression

In the literature published between 1970 and 2011 it is clear that the cognitive and physical consequences of stroke are influenced by the presence of depressive disorders in patients who suffered a stroke. Major depressive disorder is associated with a significantly greater degree of cognitive impairment following a stroke, although cognitive impairment does not result in post-stroke depression (Dam et al, 1989; Egelko et al, 1989; Burvill et al, 1995; Shimoda & Robinson, 1998; Talelli et al, 2004; Kalaria & Ballard, 2001; Jaillard et al, 2010).

An anxiety disorder following a stroke influences and slows down the course of recovery from the stroke by influencing the severity and course of depression; independence during the performance of activities of daily living and course of recovery in terms of social functioning at long-term follow-up (Astrom, 1996; Shimoda & Robinson, 1998). The presence of an anxiety disorder however does not affect cognitive impairment, which is influenced only by major depression. Cognitive impairment associated with depression is therefore not altered by a comorbid anxiety disorder. This suggests that depression and anxiety disorders are caused by different mechanisms of origin (Shimoda & Robinson, 1998).

The incidence of post-stroke depression (PSD) has been reported to be as large as 68%, with major depression reported in as many as 27% of stroke survivors

(Diserens et al, 2007). The presence of depression is significantly associated with the presence of cognitive impairment following stroke (Dam et al, 1989, Egelko et al, 1989; Burvill et al, 1995; Shimoda & Robinson, 1998; Talelli et al, 2004; Kalaria & Ballard, 2001; Jaillard et al, 2010). Murata et al (2000) concluded that major post-stroke depression leads to cognitive impairment, although cognitive impairment does not result in post-stroke depression.

2.6. Assessment of the effects of treatment on impairment, activity, and participation levels

The assessment of functional outcome is done using assessment tools that focus on the measurement of the functional outcome of the patient and quantifying the underlying impairments that constrain functional performance (Horak et al, 1997).

Assessment on functional activity level and treatment of motor disorders, language and speech are traditionally viewed as critically essential in the rehabilitation of patients who have sustained a stroke. However, the influence of visual-sensory and oculomotor disorders on the patient's functional outcome is still neglected in the rehabilitation of patients with neurological impairments (Kerkhoff, 2000; Ciuffreda et al, 2007). The neuroplasticity of the visual system provides the neurobiological substrate for a rationale and scientifically based visual rehabilitation strategy (Sabel & Kasten, 2000). The extent to which the positive effect of saccadic eye movement training with visual scanning exercises can transfer to other visually guided functional tasks and quality of life of patients with visual impairments following stroke should be assessed with a matched-pair randomised controlled trial (Sabel & Kasten, 2000; Chan, Chan & Au, 2006; Das & Huxlin, 2010; Martin & Huxlin, 2010).

2.7. Model of disablement used in this study

In this study the International Classification of Functioning, Disability and Health (ICF) (Ustun et al, 2003) was used as the model of disablement within which patients were assessed and treated. The ICF provides a conceptual distinction between the effects a stroke may have at different levels of body impairment, functional activity and participation levels (West, Bowen, Hesketh & Vail, 2009). The use of outcome measures assessing the effects of treatment on impairment, activity, and participation level is needed to determine the efficacy and also the direct relationship between saccadic eye movement training with visual scanning exercises on underlying impairments and the patient's functional ability on activity and participation levels.

2.7.1. Assessment of the effects of treatment on oculomotor function

An outcome measure were selected to assess the effect of visual scanning exercises integrated with task-specific activities received by participants from Group 1 versus participants from Group 2 that received task-specific activities alone on participants that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke's **oculomotor function** measured with the **King-Devick Test ©**. The use of the **King-Devick Test ©** to assess the effects and the direct relationship between saccadic eye movement training with visual scanning exercises on patients' **oculomotor function** (underlying impairment), functional activity and participation levels are summarised in Table 2.4.

Table 2.4. The use of the **King-Devick Test ©** to assess the effects and the direct relationship between saccadic eye movement training with visual scanning exercises on patients' **oculomotor function** (underlying impairment), functional activity and participation levels

OCULOMOTOR FUNCTION		
THE KING-DEVICK TEST © (Zoltan, 1996)	**Body impairment level**	**Functional activity level and participation level**
The assessment of: (1) Residual oculomotor functions in the clinical setting (Markowitz, 2006; Chaikin, 2007). (2) Eye movements during reading (Markowitz, 2006; Chaikin, 2007; Galetta et al, 2011). (3) Attention (Galetta et al, 2011). (4) Language (Galetta et al, 2011). (5) Other correlates of suboptimal brain function (Galetta et al, 2011).	Oculomotor function is crucial to the efficient processing of visual information (Zoltan, 1996). Impaired oculomotor function results in: (1) Slower speed of saccadic eye movements, visual fixation and smooth pursuit eye movements. (2) Decreased control of saccadic eye movements, visual fixation and smooth pursuit eye movements. (3) Decreased coordination of saccadic eye movements, visual fixation and smooth pursuit eye movements.	Impaired oculomotor function severely impairs a patient's ability to effectively scan his/her environment and in turn result in functional impairment (Zoltan, 1996). Impaired oculomotor function results in difficulty with: (1) Localisation of other objects in relation to the (2) individual itself (extrapersonal perception) (3) The localisation of the individual in relation to other objects (intrapersonal perception) (4) Fine motor tasks (5) Activities that require eye-hand coordination (6) Gross movement and ambulation tasks - Walking through an aisle (7) Hygiene and self-care activities (8) Dressing

OCULOMOTOR FUNCTION		
THE KING-DEVICK TEST © (Zoltan, 1996)	**Body impairment level**	**Functional activity level and participation level**
		(9) Reading (10) Typing (11) Driving (12) Sporting activities

The identification of limitations in functional performance such as inability to walk independently outside the house and climbing stairs does not provide information on the underlying impairments such as impaired oculormotor control and impaired eye movements that may be constraining functional performance (Martin & Huxlin, 2010). The King-Devick Test © is a useful tool for the assessment of residual oculomotor functions in participants post-stroke (Markowitz, 2006; Chaikin, 2007). The test is an indicator of oculomotor visual performance for eye movements during reading and assesses residual oculomotor functions in the clinical setting (Markowitz, 2006; Chaikin, 2007).

The King-Devick Test © is based on the measurement of the speed with which the numbers was read aloud of three (3) subtests (reading aloud single digit numbers from three test cards – (Subtest 1, Subtest 2 and Subtest 3) and assesses impairment of eye movements, attention, language and other correlates of suboptimal brain function (Galetta et al, 2011). The level of difficulty increases as the participant progresses through the three (3) subtests in the sense that the King-Devick Subtest 2 requires larger saccadic eye movements and visual search strategies compared to King-Devick Subtest 1. The King-Devick Subtest 3 requires

larger saccadic eye movements and visual search strategies compared to King-Devick Subtest 2.

a. The King-Devick Subtest 1

The King-Devick Subtest 1 consists of randomly spaced numbers connected by horizontal lines. The patient is asked to call out numbers in the sequence that they are connected with the horizontal lines as fast as possible (Addendum 5). With the King-Devick Subtest 1 scores taken included (i) the time taken to complete the test (the time indicated the speed with which the test was completed); and (ii) the average errors made during the completion of the subtest.

b. The King-Devick Subtest 2

The King-Devick Subtest 2 consists of randomly spaced numbers without horizontal lines. The patient is asked to call out numbers in sequence (without connecting lines) from left to right as fast as possible. The King-Devick Subtest 2 increases with difficulty compared to King-Devick Subtest 1 in the sense that the King-Devick Subtest 2 requires larger saccadic eye movements and visual search strategies compared to King-Devick Subtest 1. The oculomotor strategies and visual efficiency processes, specifically the saccadic eye movements, required to complete the King-Devick Subtest 2 increased from King-Devick Subtest 1 to King-Devick Subtest 2 (Addendum 5). With the King-Devick Subtest 2 scores taken included (i) the time taken to complete the test (the time indicated the speed with which the test was completed); and (ii) the average errors made during the completion of the subtest.

c. The King-Devick Subtest 3

The King-Devick Subtest 3 consists of randomly spaced numbers, also without horizontal lines. The patient is asked to call out numbers in sequence from left to right as fast as possible. The King-Devick Subtest 3 is the most difficult subtest of the King-Devick Test © in the sense that the King-Devick Subtest 3 requires even larger saccadic eye movements and visual search strategies than to King-Devick Subtest 1 and King-Devick Subtest 2. With the King-Devick Subtest 3 scores taken included (i) the time taken to complete the test (the time indicated the speed with which the test was completed); and (ii) the average errors made during the completion of the subtest.

In each subtest scores taken included (i) the time taken to complete the test (the time indicated the speed with which the test was completed); and (ii) the average errors made during the completion of the subtests. Interpretation of the King-Devick Test © is displayed in Table 2.5.

Table 2.5. Interpretation of the King-Devick Test © – the King-Devick Subtest 1, Subtest 2 and Subtest 3

	Subtest 1	Subtest 2	Subtest 3
Time (seconds) taken to complete the subtest	14.86	16.87	18.73
Average Errors made in completion of the subtest	0.07	0.07	0.33

a. Validity and reliability of the King-Devick Test ©

The King-Devick Test © is used for the assessment of residual oculomotor function, impairment of eye movements, attention, language and is therefore an indicator of oculomotor visual performance for eye movements during reading in participants post-stroke (Markowitz, 2006; Chaikin, 2007). Although the test is quick, easy to score and can be administered by all members of the rehabilitation team, the researcher did not find any publication with regards to the test's reliability in the stroke population (Lieberman et al, 1983; Oride et al, 1986). The King-Devick Test © is used for children and adults (Zoltan, 1996; Galetta et al, 2011).

2.7.2. Assessment of the effects of treatment on functional ability

Outcome measure were selected to assess the effect of visual scanning exercises integrated with task-specific activities received by participants from Group 1 versus participants from Group 2 that received task-specific activities alone on participants that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke's **functional ability** measured with the **Barthel Index** and **Timed Up and Go Test** on a weekly basis during the intervention period of four (4) weeks as well as eight (8), twelve (12), sixteen (16) and twenty (20) weeks after rehabilitation has been terminated. The use of the **Barthel Index** and **Timed Up and Go Test** to assess the effects and the direct relationship between saccadic eye movement training with visual scanning exercises on patients' f**unctional ability** are summarised in Table 2.6.

Table 2.6. The use of the **Barthel Index** and **Timed Up and Go Test** to assess the effects and the direct relationship between saccadic eye movement training with visual scanning exercises on patients' **functional ability** functional activity- and participation levels.

FUNCTIONAL ABILITY		
OUTCOME MEASURES	**Functional activity level**	**Participation level**
Barthel Index	The assessment of: Feeding Bathing Grooming Dressing Bowel control Bladder control Toileting Chair transfer Ambulation Stair climbing	Difficulty to effectively and efficiently perform activities outside the house. Unsafe mobilisation over uneven surfaces and stairs. Unsafe mobilisation in the community. Poor or inaccurate estimation of physical limitations that may result in inappropriate evaluation of environmental hazards and may increase the risk of falling. Walking into objects. Difficulty in the workplace with relation to typing, reading and writing. Difficulty in recreational activities and hobbies. Difficulty in social interaction in the household, workplace and community.
Timed Up and Go Test	The ability to perform sequential motor tasks relative to walking and turning.	

(1) Barthel Index - Addendum 6

The Barthel Index assesses the performance of ten (10) common ADL regarding feeding, bathing, grooming, dressing, bowel control, bladder control, toileting, chair transfer, ambulation and stair climbing, as well as the patient's dependence (on assistance) to perform these activities (Mahoney & Barthel, 1965). The interpretation of the Barthel Index is displayed in Table 2.7.

Table 2.7. Interpretation of the Barthel Index (Shah et al, 1989)

Score	The Barthel Index
0 - 20	Total dependence
21 – 60	Severe dependence
61 – 90	Moderate dependence
91 – 99	Slight (minimal) dependence
100	Independent

a. Validity and reliability of the Barthel Index

The stroke-specific outcomes measure present with excellent validity, reliability and adequate responsiveness (Salter et al, 2006). The calculated inter-rater reliability using the intraclass correlation (ICC) = 0.94 and the internal consistency using Cronbach's alpha rangres between 0.89 – 0.92. The BI also closely correlated with the Berg Balance Scale and the Fugl-Meyer motor assessment in patients with stroke (Pearson's correlation coefficient r ≥ 0.78 (Hsueh et al, 2001).

(3) The Timed Up and Go Test – Addendum 7

The Timed Up and Go Test (TUG) assesses mobility, balance and locomotor performance. It also assesses the ability to perform sequential motor tasks relative to walking and turning (Salter et al, 2006). The TUG assesses mobility, balance and locomotor performance. It also assesses the ability to perform sequential motor tasks relative to walking and turning (Salter et al, 2006). The interpretation of the TUG is displayed in Table 2.8 to Table 2.10.

Table 2.8. Interpretation of the Timed Up and Go Test (Podsiadlo & Richardson, 1991; Shumway Cook et al, 2000)

Time	The Timed Up and Go Test (TUG)	
< 10 seconds	Completely independent	With or without walking aid for ambulation and transfers
< 20 seconds	Independent for main transfers	• With or without walking aid. • Independent for basic tub or shower transfers. • Able to climb most stairs and go outside the house alone
20 - 30 seconds	Dependent	Impaired functional mobility
> 30 seconds	Requires assistance	Dependent in most activities – ADL & mobility skills
Unable to complete the test	Requires maximal assistance	Dependent in all ADL and mobility

Table 2.9. Interpretation of TUG and risk of falls (Podsiadlo & Richardson, 1991; Shumway Cook et al, 2000)

Time	The Timed Up and Go Test (TUG)
≥ 14 seconds	High risk of falls
≤ 13 seconds	Low risk of falls

Table 2.10. Interpretation of walking speed and community ambulation (Ada et al, 2009)

Walking speed	Community ambulation
0.3 m/s - 0.8 m/s	Able to mobilise in the community

a. Validity and reliability of the Timed Up and Go Test

Results of two studies conducted by Flansbjer et al (2005) and Ng & Hui-Chan (2005) suggest that the TUG is a reliable and valid measure in patients with stroke. The test-retest reliability of the TUG was found to be excellent (ICC = 0.96) (Flansbjer et al, 2005) and ICC = 0.95 (Ng & Hui-Chan, 2005). An excellent correlation was found between the TUG and various gait performance measures that included comfortable gait speed, fast gait speed, stair climbing ascend, stair climbing descend and the Six-Minute Walk Test (ranging from r = - 0.84 to r = - 0.92) (Flansbjer et al, 2005). The correlation between the various gait performance measures and the TUG is a negative figure because a high score on the TUG indicates abnormal functioning whereas a high score on the gait measures indicate a high level of performance.

2.7.3. Assessment of the effects of treatment on perceptual processing and cognitive function

Outcome measure were selected to assess the effect of visual scanning exercises integrated with task-specific activities received by participants from Group 1 versus participants from Group 2 that received task-specific activities alone on participants that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke's **perceptual processing** and **cognitive functioning** measured with the **Star Cancellation Test** and **Mini-Mental State Examination** on a weekly basis during the intervention period of four (4) weeks as well as eight (8), twelve (12), sixteen (16) and twenty (20) weeks after rehabilitation has been terminated. The use of the **Star Cancellation Test** and **Mini-Mental State Examination** to assess the effects and the direct relationship between saccadic eye movement training with visual scanning exercises on patients' **perceptual processing** and **cognitive functioning** are summarised in Table 2.11.

Table 2.11. The use of the **Star Cancellation Test** and **Mini-Mental State Examination** to assess the effects and the direct relationship between saccadic eye movement training with visual scanning exercises on patients' **perceptual processing** and **cognitive functioning** (underlying impairment), functional activity and participation levels.

PERCEPTUAL PROCESSING AND COGNITIVE FUNCTIONING		
OUTCOME MEASURES	**Body impairment level**	**Functional activity level and participation level**
Star Cancellation Test The assessment of: Unilateral Spatial Neglect	The inability to perceive and integrate stimuli on one side of the body resulting in neglect of one side of body (intrapersonal) or extrapersonal space.	ADLs are limited to one half of the body. Body image impairment due to a lack of spatial orientation and attention to one half of the individual's intrapersonal space. Unsafe mobilisation and impairment of depth perception that results in the subsequent inaccuracy in judgement of distances. Reading and writing difficulty due to absent visual scanning using saccadic eye movements on the affected side of the midline of the body.
Mini-Mental State Examination The assessment of: Attention Orientation Memory Problem solving Arousal (Level of consciousness)	Inability to focus on a specific stimulus without being distracted (Shumway-Cook & Woollacott, 2007). Inability to retrieve knowledge related to a specific person, place and time (Shumway-Cook & Woollacott, 2007). Inability to register, process, store and retrieve previously stored information (Shumway-Cook & Woollacott, 2007).	Difficulty with ADL and mobility. Difficulty in the workplace with relation to accuracy of work, management of workload and working speed. Difficulty in social interaction in the household, workplace and community. Disorientated in terms of person, place and time. Forget names and schedules.

PERCEPTUAL PROCESSING AND COGNITIVE FUNCTIONING		
OUTCOME MEASURES	**Body impairment level**	**Functional activity level and participation level**
	Inability to apply knowledge and information to new or unfamiliar situations (Shumway-Cook & Woollacott, 2007). Decreased basic arousal process allowing the patient to respond to stimuli in the environment (Shumway-Cook & Woollacott, 2007).	Inability to recognise threats to safety.

(1) Star Cancellation Test – Addendum 8

The Star Cancellation Test was developed by Wilson, Cockburn & Halligan (1987) to identify the presence of unilateral spatial neglect (USN) and visual-spatial disorders in participants who have suffered a stroke. Scores of the Star Cancellation Test included (i) the average number of errors made during the completion of the test and (ii) the time taken to complete the test (speed).

Visual-perceptual dysfunction after a stroke may include a disorder of spatial awareness known as unilateral spatial neglect (USN). Unilateral spatial neglect (USN) is the inability to perceive and integrate stimuli on one side of the body, resulting in the neglect of one side of the body in the intrapersonal or extrapersonal space. USN is the most disruptive impairment of visual efficiency processes, which results in fewer eye movements observed on one side of the body or extrapersonal space during the performance of an activity. USN can selectively affect different sensory modalities, cognitive processes, spatial orientation and spatial awareness

(Halligan, Fink, Marshall & Vallar, 2003). The impairment may also affect an individual's ability to perform many everyday tasks such as eating, dressing and reading (Bowen & Lincoln, 2007).

Interpretation of the Star Cancellation Test is displayed in Table 2.12.

Table 2.12. Interpretation of the presence of unilateral spatial neglect

Score of Star Cancellation Test	Level of impairment
< 44 stars	Indicates the presence of unilateral spatial neglect (USN) in the near extrapersonal space.

a. Validity and reliability of the Star Cancellation Test

The Star Cancellation Test presents with excellent validity, sensitivity and test-retest reliability (Intraclass correlation Coefficient = 0.89) (Menon & Korner – Bitensky, 2004; Bailey, Riddoch & Crome, 2004; Bailey, Riddoch & Crome, 2002, Chaikin, 2007).

(2) Mini-Mental State Examination (Folstein, Folstein & McHugh, 1975) – Addendum 3

Impairment of cognitive function is a significant cause of disability following a stroke. Cognitive dysfunction may result in reduced efficiency, pace and persistence of functioning and decreased effectiveness in the performance of routine ADL (Cicerone et al, 2000). The Mini-Mental State Examination (MMSE) was developed to provide a quantitative assessment of cognitive impairment and to record cognitive changes

over time (Folstein, Folstein, & McHugh, 1975). Interpretation of the level of cognitive impairment (Folstein et al, 2001) is displayed in Table 2.13.

Table 2.13. Interpretation of the level of cognitive impairment (Folstein et al, 2001)

Score of MMSE	Level of impairment
≥ 27	No cognitive impairment
21 – 26	Mild cognitive impairment
11 – 20	Moderate cognitive impairment
≤ 10	Severe cognitive impairment

a. Validity of the Mini-Mental State Examination

Concentration, language and praxis, orientation, memory and attention have been identified to support the construct validity of the MMSE as a measure of cognitive mental state in patients (Jones & Gallo, 2000). The MMSE has significant correlates with the Barthel Index (Mahoney & Barthel, 1965) assessing activities of daily living, the Montgomery Asberg Depression Rating Scale (MADRS) (Montgomery & Asberg, 1979) and the Zung Depression Scale (Zung, 1965; Agrell and Dehlin (2000).

b. Reliability of the Mini-Mental State Examination

The internal consistency of the MMSE was reported to range from poor to excellent (alpha = 0.54 to 0.96) (Tombaugh & McIntyre, 1992). McDowell, Kristjansson, Hill and Hebert (1997) examined the internal consistency of the MMSE used as a screening test for cognitive impairment and dementia. The authors noted that the internal consistency of the MMSE was adequate (alpha = 0.78) (McDowell, Kristjansson, Hill and Hebert, 1997). Tombaugh and McIntyre (1992) report that

twenty-four out of thirty studies reported excellent test-retest reliability ($r > 0.75$) for the MMSE.

2.7.4. Assessment of the effects of treatment on quality of life

Few researchers have evaluated the long-term maintenance of improvements produced by motor, perceptual and cognitive rehabilitation. It is strongly recommended that outcome measures used in both the clinical and research setting should assess the specific intended effects of visual therapy to evaluate realistically the rehabilitation programme's effectiveness. These measures should reflect changes in impairment level, performance of everyday activities in the individual's home and community, measures of subjective well-being, and quality of life (Cicerone et al, 2000; Bowen & Lincoln, 2007; Das & Huxlin, 2010; Martin & Huxlin, 2010).

Visual impairments post-stroke may negatively affect the overall rehabilitation process, including motor-, perceptual- and cognitive therapy, by producing visual discomfort and possible loss of visual efficiency, thus affecting an individual's quality of life (Brown et al, 2003; Ciuffreda et al, 2007).

Outcome measure were selected to assess the effect of visual scanning exercises integrated with task-specific activities received by participants from Group 1 versus participants from Group 2 that received task-specific activities alone on participants that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke's **quality of life** measured with the **Stroke Impact**

Scale Version 3.0 and the **Walking ability questionnaire** eight (8), twelve (12), sixteen (16) and twenty (20) weeks after rehabilitation has been terminated.

(1) Stroke Impact Scale Version 3.0 - Addendum 9

The Stroke Impact Scale Version 3.0 is a self-report, health status measure assessing multidimensional functional outcomes in patients who have sustained a stroke. The scale is applicable in both the clinical and research setting (Bode, Lai & Perera, 2003b).

a. Validity and reliability of the Stroke Impact Scale

The stroke-specific outcome measure is valid, reliable and sensitive to change (Duncan, Wallace, Lai, Johnson, Embretson & Laster, 1999; Edwards & O'Connell, 2003). The test-retest reliability was calculated using intraclass correlation coefficients (ICC) that ranged from adequate to excellent (ICC = 0.7 to 0.92) (Duncan et al, 1999). The Barthel Index had an excellent correlation with the SIS ADL domain (r = 0.72) and the SIS Mobility domain (r = 0.69) (Duncan et al, 2002a).

(2) The walking ability questionnaire – Addendum 10

The intervention utilised in this trial consisted of visual scanning exercises integrated with task-orientated activities aimed at improving postural control in order to optimise functional movement post-stroke, promoting independence in ADL in and around the house, in the work environment, community, and recreational environment (Van Vliet, Lincoln & Foxall, 2005; Langhorne et al, 2009).

The questionnaire assesses the social limitations resulting from decreased walking ability in patients who have sustained a stroke (Perry, Garrett, Gronley & Mulroy, 1995:982). Although this questionnaire "offers a quantitative method of relating the social disadvantage of stroke patients to the impairment and disability sustained", no studies that assessed the walking ability questionnaire's reliability and validity have been published. Although the outcome measures' reliability and validity have not been published, it is essential to include these in the study because the test assesses the patient's functional ability on participation level by means of the individual's self-reported ability to mobilise in and around the house, in the work environment, community, and recreational environment.

2.7.5. Assessment of the effects of treatment on anxiety and depression

(1) Hospital Anxiety and Depression Scale – Addendum 11

Evidence indicates that depression and anxiety associated with stroke and visual impairment leads to decreased functional independence in ADL and a significantly poorer quality of life (Brown et al, 2003; Jones & Shinton, 2006). Difficulty with performing functional tasks and incompletion of everyday tasks are a result of motor impairment, inadequate perceptual and cognitive functioning due to a disorder of visual efficiency processes and visual-information processing, which may lead to increased anxiety and depression in patients who sustained a stroke (Chaikin, 2007). Successful and efficient performance of everyday activities in the individual's home and community contribute to a patient's subjective well-being and quality of life (Ccerone et al, 2000; Bowen & Lincoln, 2007; Das & Huxlin, 2010; Martin & Huxlin, 2010). Visual ability has been shown to contribute to the patient's level of satisfaction with life following stroke.

The Hospital Anxiety and Depression Scale was developed by Snaith and Zigmond (1983) to identify the presence of anxiety and/or depression in participants that were hospitalised. The Hospital Anxiety and Depression Scale is a valid and reliable tool for the identification and quantification of depression and anxiety post-stroke. The interpretation of the anxiety and depression subscales of the Hospital Anxiety and Depression Scale is displayed in Table 2.14.

Table 2.14. Interpretation of the anxiety and depression subscales of the Hospital Anxiety and Depression Scale (Snaith & Zigmond, 1983)

Score	**Anxiety subscale**
0 - 7	Normal range
8 - 10	Presence of the state of anxiety
≥ 11	Probable presence of a mood disorder
Score	**Depression subscale**
0 – 7	Normal range
8 – 10	Presence of the state of depression
≥ 11	Probable presence of a mood disorder

a. Validity and reliability of the Hospital Anxiety and Depression Scale

The HADS presents with excellent correlations with the Beck Depression Inventory (BDI) (r = 0.61 to 0.83). Correlation between the General Health Questionnaire, the Clinical Anxiety Scale and the HADS ranged from adequate to excellent (r = 0.50 to 0.68) and (r = 0.69 to 0.75) respectively. The HADS presents with an excellent internal consistency with a Cronbach's alpha = 0.85 (Aben, Verhey, Lousberg, Lodder, and Honig, 2002).

2.8. Selection criteria

Participants in the study were matched and allocated to the control and experimental groups prior to the study based on their functional activity level as measured on the Stroke Activity Scale (SAS) to ensure that participants in the two groups were comparable with regard to their functional activity level.

(1) Stroke Activity Scale – Addendum 12

The SAS was developed to assess motor function in participants who had sustained a stroke (Horgan et al, 2006). Motor function on the SAS is assessed by five (5) subscales assessing (i) getting out of bed on the unaffected side; (ii) static and dynamic sitting balance; (iii) sitting to standing; (iv) stepping and walking; (v) bringing a glass to the mouth with arm supported on a table. The results give an account of the assessment of the five (5) subscales of the SAS. The SAS was also administered weekly over the four-week intervention period as well as eight (8), twelve (12), sixteen (16) and twenty (20) weeks after rehabilitation has been terminated.

a. Validity and reliability of the Stroke Activity Scale

The SAS has an excellent correlation with the Modified Motor Assessment Scale (MMAS) (Pearson's correlation coefficient r = 0.91). The SAS is significantly quicker to complete than the MMAS (2.8 minutes vs. 10.4 minutes, $p < 0.0001$) (Horgan, Cunningham, Coakley, Walsh, O'Regan & Finn, 2006).

2.9. Summary

In Chapter 2 the outcome of interventions used to address ocular and visual impairments and the result of saccadic eye movement training with visual scanning exercises on patients' functional ability, perceptual processing and cognition following a stroke were reviewed. From the literature reviewed in Chapter 2 it is clear that sufficient spontaneous recovery of an impairment of the visual system is poor or almost absent in patients post-stroke. In the absence of specific intervention that addresses ocular and visual impairments including visual-efficiency processes and visual-information processing systems, the visual deficits observed in patients after a stroke may become permanent (Kerkhoff, 2000; Nelles et al, 2001; Gilhotra et al, 2002; Linden et al, 2005, Jones & Shinton, 2006; Bouwmeester et al, 2007; Schuett et al, 2009; Das & Huxlin, 2010).

Visual and ocular impairments resulting in reduced visual perception and cognition caused by stroke lead to substantial functional disability during ADL (Kerkhoff, 2000; Nelles et al, 2009). Intensive training of saccadic eye movements can improve a patient's oculomotor strategies and visual efficiency processes following a stroke. Improved oculomotor strategies will optimise the visual system post-stroke and further improve the patient's ability to use vision in everyday life (Das & Huxlin, 2010; Teasell et al, 2010).

From the literature reviewed in Chapter 2 that assessed the effect of saccadic eye movement training with visual scanning exercises on patients' post-stroke's

functional ability, perceptual processing and cognition post-stroke, it may be summarised that:

(a) decreased visual efficiency processes, specifically impaired saccadic eye movements give rise to slower oculomotor speed, decreased control and coordination of eye movements, resulting in disruption of visual scanning and attention; and

(b) interventions that incorporate saccadic eye movement training with visual scanning techniques post-stroke improve the visual system and associated improvement in perceptual processing, cognitive function and motor behaviour (Weinberg et al, 1977; Weinberg et al, 1979; Weinberg et al, 1982; Carter et al, 1983; Young et al ,1983; Webster et al, 1984; Gordon et al, 1985; Ball et al, 1988; Gur et al, 1992; Kerkhoff et al, 1992; Pizzamiglio et al, 1992; Wagenaar et al, 1992; Kerkhoff et al, 1994; Ladavas et al, 1994; Antonucci et al, 1995; Fanthome et al, 1995; Zihl et al, 1995; Paolucci et al, 1996; Kalra et al, 1997; Wiart et al, 1997; Niemeier et al, 1998; De Sèze et al, 2001; Nelles et al, 2001; Bailey et al, 2002; Brunila et al, 2002; Ciuffreda, 2002; Pierce & Buxbaum, 2002; Cappa et al, 2003; Pambakian et al, 2004; Pizzamiglio et al, 2004; Sabel et al, 2004; Bolognini et al, 2005; Cicerone et al, 2005; Rawstron et al, 2005; Bouwmeester et al, 2007; Mueller et al, 2007; Nelles et al, 2009; Roth et al, 2009).

Limitations were highlighted in the review of studies that assessed the effects of visual therapy in patients who had suffered a stroke.

(1) The effect of intervention that addressed ocular and visual impairments was mainly assessed using paper-and-pencil tasks during visual-perceptual assessment. However, the reviewed studies did not provide an indication of change in an individual's ability to function in the complex everyday activities that are relevant to

his or her life (Weinberg et al, 1977; Weinberg et al, 1979; Weinberg et al, 1982; Carter et al, 1983; Young et al ,1983; Webster et al, 1984; Gordon et al, 1985; Ball et al, 1988; Gur et al, 1992; Kerkhoff et al, 1992; Pizzamiglio et al, 1992; Wagenaar et al, 1992; Ladavas et al, 1994; Fanthome et al, 1995; Zihl et al, 1995; Bailey et al, 2002; Brunila et al, 2002; Ciuffreda, 2002; Pierce & Buxbaum, 2002; Cappa et al, 2003; Cicerone, 2005; Rawstron et al, 2005; Reinhard, 2005; Goh, 2007; Jobke et al, 2009; Nelles et al, 2009).

(2) Few researchers have evaluated the long-term effects of interventions that address ocular and visual impairments in patients post-stroke (Gordon et al, 1985; Ball et al, 1988; Kerkhoff et al, 1994; Niemeier, 1998; Bolognini et al, 2005).

(3) Very few researchers have evaluated whether improvements produced by visual rehabilitation were sustained on the long-term (Webster et al, 1984; Gordon et al, 1985; Ball et al, 1988; Kerkhoff et al, 1994; Nelles et al, 2001; Bolognini et al, 2005).

(4) Only a few studies have assessed the effects of re-training of the visual system on the individual's subjective well-being and quality of life (Kerkhoff et al, 1994; Nelles et al, 2001; Pambakian et al, 2004; Sabel et al, 2004; Bolognini et al, 2005; Reinhard et al, 2005; Goh, 2007; Mueller et al, 2007; Jobke et al, 2009). Kerkhoff (1994) assessed improvement in the subjective rating of the patients' *(n* = 22) perceived visual impairments. Nelles et al (2001) measured patients' *(n* = 21) independence in ADL with the use of a self-rating scale of ADL.

From the limitations identified in the review of literature in Chapter 2, three (3) main conclusions were reached. Firstly, outcome measures used in the research setting to evaluate an intervention that incorporate saccadic eye movement training with visual

scanning techniques should include assessment on body impairment level, and functional activity- and participation level.

Secondly, assessment of the intervention which aims to improve the visual system post-stroke with associated improvements in cognitive function, perceptual processing, motor function and perceived quality of life should include assessment of body impairment level, and functional activity- and participation level.

Thirdly, visual scanning training through saccadic eye movement exercises integrated into increasingly complex visual-perceptual and visual-motor tasks needed to be assessed with a matched-pair randomised controlled trial. A matched-pair randomised controlled trial would assess the extent to which visual scanning training transferred to functional ability and quality of life of patients with visual impairments following stroke.

CHAPTER 3

STUDY DESIGN AND METHODOLOGY

3.1 Introduction

In Chapter 3 a detailed account is given on how the research was performed. This account of the research process includes the research setting, the recruitment of participants, the matching and allocation of participants, the research process and the assessment procedure of participants from Group 1 that received visual scanning exercises integrated with task-specific activities and participants from Group 2 that received task-specific activities alone.

3.2 Ethical approval

Ethical approval to conduct this study was granted by the Ethics Committee of the Faculty of Health Sciences at the University of Pretoria (S33/2009) (Addendum 1).

3.3. Research funding

Research funding to conduct the study was obtained from the Medical Research Council of South Africa.

3.4. Research setting

The study was conducted at the Tshwane Rehabilitation Centre (TRC) in Pretoria, Gauteng, South Africa. It is a public rehabilitation centre setting, but also an academic hospital facility where research is being conducted in different fields of

healthcare. A close working relationship exists between the TRC, Steve Biko Academic Hospital and the University of Pretoria (UP). The Department of Physiotherapy, Faculty of Health Sciences at UP places students at this facility as part of their mandatory clinical blocks. Rehabilitation at this facility is conducted in a multi-disciplinary team approach consisting of physiotherapists, occupational therapists, speech-and-language therapists, dieticians, social workers, nursing staff and doctors. The facility caters for all patients using the public healthcare facilities in need of rehabilitation, including neurological conditions such as stroke, multiple sclerosis, Guillian Barre syndrome, neuropathies, spinal cord injuries as well as head injuries. Patients are referred by a large number of acute healthcare settings, including private and public facilities. Assessment of every patient is done after admission to determine the type and frequency of therapy needed. In-patients receive therapy on a daily basis according to their needs.

3.5. Study design

The study design entailed a matched-pair randomised controlled trial (Chan, Chan & Au, 2006) performed at the TRC. The research approach therefore falls within the quantitative research paradigm.

3.6. Study population

The study population for the study included all participants with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders after they sustained a CVI and were admitted to the TRC for rehabilitation. Participants from various hospitals in Gauteng Province refer participants post-stroke to the TRC for rehabilitation.

3.7. Sample group

Eligibility criteria for participants in the trial are listed below.

3.7.1. Inclusion criteria

(1) Participants presenting with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders were recruited for the trial.

(2) Participants who had sustained a clinical ischaemic or hemorrhagic stroke (Blanton et al, 2006).

(3) Participants in the age group 19 – 74 (Robertson, McMillan, MacLeod, Edgeworth & Brock, 2002; Lennon et al, 2006).

(4) Willingness and cognitive ability of the participant to give written informed consent to participate in the trial.

Written informed consent included a thumb print made in front of witnesses in case of a participant who was unable to give a signature.

(5) Glasgow coma scale of at least 14 (Hafsteinsdóttir, 2005).

Cognition is an essential aspect in the re-education of motor and postural control. Cognitive processes such as attention, emotion and motivation relate to perception and the action (motor) systems. The degree of cognitive impairment of a stroke participant, therefore, determines their response to the

rehabilitation process and functional outcome post-stroke (Shumway-Cook & Woollacott, 2007).

(6) The ability to follow instructions (Lennon et al, 2006).

The ability to follow verbal and visual instructions is essential to intent and goal achievement during task-specific activities. The ability to follow instructions contributes to the participant's response to the rehabilitation process and therefore influences the functional outcome in a participant who has sustained a stroke (Shumway-Cook & Woollacott, 2007).

3.7.2. Exclusion criteria

Participants were excluded if they:

(1) Scored less than seven (<7) on the Mini-Mental State Examination (MMSE) (Hafsteinsdóttir, 2005) – Addendum 3.

Participants suffering from cortical dementia may react poorly to rehabilitation (Linden, Samuelsson, Skoog & Blomstrand, 2005) and were excluded from the study for this reason.

(2) Had a history of an organic disorder or major psychiatric problems likely to influence cerebral function (Blanton et al, 2006).

A cortical dysfunction prior to the stroke may negatively influence a participant's response to rehabilitation and such participants were excluded from the study for this reason (Robertson et al, 2002; Linden et al, 2005).

(3) Other co-morbid disease or disability such as cancer or amputation that would have prevented or limited the assessment of the participants and their participation or follow-up over a period of twenty (20) weeks (Robertson et al, 2002; Blanton et al, 2006; Lennon et al, 2006).

(4) Participation in other pharmacological or rehabilitation intervention studies that could have confounded the results of this study (Blanton et al, 2006).

(5) Participants' eligible for inclusion into the study but who planned to move from their residential areas within twenty (20) weeks after they had been admitted to the study was excluded from the trial (Blanton et al, 2006) because they would not have been able to participate in the follow-up intervention from week 8 to week 20 post discharge.

3.7.3. Sample size

Twenty-four (24) participants with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders after a CVI and who were admitted to the TRC were recruited to participate in the study from October 2009 to February 2011. The sample size of 24 participants was recruited based on the calculation to detect a 1 SD difference with (eighty) 80% power using ANCOVA.

Participants were divided into two groups of twelve (12) participants each: Group 1 = Experimental Group and Group 2 = Control Group.

- Group 1 (Experimental Group) received saccadic eye movement training with visual scanning exercises integrated with task-specific activities from Day 1 for four (4) consecutive weeks since their admission to the TRC.

- Group 2 (Control Group) received task-specific activities from Day 1 for four (4) consecutive weeks since their admission to the TRC.

3.7.4. Matching of the sample group

Participants who met the inclusion and exclusion criteria of the study (paragraph 3.7.1. and paragraph 3.7.2.) were screened based on their functional activity level as measured on the SAS by an independent assessor directly after they had been admitted to the TRC. The first participant who was eligible for participation in the study was allocated to Group 1. When a participant's SAS score matched a participant's score who was previously allocated to a specific group, that particular participant was placed in the opposite group from the existing matched participant. Participants who matched a previous participant's score on the SAS were automatically placed in the opposite group. If a participant had a score that did not match another participant's SAS score, the participant was randomly allocated to either Group1 or Group 2.

Participants were matched and allocated based on their scores on the SAS to ensure that participants in the two groups were comparable with regard to their level of functional activity. The allocation process was repeated until twelve (12) participants

had been allocated to each group. The participants from Group 1 and Group 2 were blinded to the group they were assigned to (Blanton et al, 2006). The two (2) groups of twelve (12) participants in each group did not make provision for drop-out of participants in the study. If participants dropped out of the study for any reason, another participant was recruited to replace him/her during the first four (4) weeks of the study.

3.8. Research process

After a participant was admitted to TRC the study was explained to the participants and informed consent was obtained from them. The participants were also informed that participation in the trial was voluntary and that they would not be coerced to participate. Each potential participant gave his/her written consent before he or she was admitted as a participant into the study (Addendum 4a).

After written consent was obtained from all participants and the allocation of the participants to Groups 1 and 2 was completed, the participants' demographical information was obtained (Addendum 4b) and their level of functional activity was assessed on the SAS. After the demographical information was obtained, participants in both groups were assessed in terms of their functional ability based on the framework of the International Classification of Functioning, Disability and Health (ICF) (Ustun et al, 2003). Within the International Classification of Functioning, Disability and Health (ICF) (Ustun et al, 2003) as the disability framework the participants' were assessed on the levels of body impairment and functional activity by using the selected clinical assessment tools and outcome measures. Outcome measures used in the study are displayed in Table 3.3. Assessment at baseline was

conducted immediately after the participants were allocated to Groups 1 and 2. Their baseline measurement on the selected outcome measures was administered before commencement of the intervention.

The intervention period commenced directly after the baseline assessment and continued for four (4) consecutive weeks, five (5) days per week. The period of intervention consisted of four (4) weeks because it is the average period of time participants spend in the TRC for post-stroke rehabilitation.

3.8.1. Intervention

During the intervention period of four (4) consecutive weeks, Group 1 (Experimental Group) received saccadic eye movement training with visual scanning exercises integrated with task-specific activities five (5) weekdays starting from Day 1 for four (4) consecutive weeks. Group 2 (Control Group) received task-specific activities five (5) weekdays starting from Day 1 for four (4) consecutive weeks.

3.8.2. The intervention participants in Group 1 and Group 2 received

Participants from Group 1 (Experimental Group) received saccadic eye movement training with visual scanning exercises integrated with task-specific activities. Only the guide of the principles of the interventions is discussed in this paragraph because the principles were adapted to each participant's functional ability. The flow of each therapy session is presented in Table 3.1.

Table 3.1. The flow of each therapy session of participants from Group 1 (Chan, Chan & Au, 2006)

Steps followed	Task-specific activities
Step 1	• Identification of the deficits and missing components during the performance of tasks. • Assign participant to appropriate steps that the participant need to be trained in to be able to perform the original task.
Step 2	• Select three (3) skills in each session that are specific to the deficits and missing components identified in Step 1 and that share similar performance components with the functional tasks trained in the same session.
Step 3	• Practice the skills and reinforce the practice of the missing components throughout the treatment session.
Step 4	• Transfer the skills practiced in Step 2 and Step 3 to practice of the functional tasks in accordance with the level of balance function of the participant.

The visual scanning exercises integrated with task-specific activities consisted of dual-task activities such as bridging in supine while performing saccadic eye movements on a HART-chart (Addendum 13) or flash cards (UNO play cards / regular playing cards). Dual task activities require the ability to allocate information-processing resources between two relevant tasks and to maintain sufficient attention on the intended task during the dual-task performance (Siu & Woollacott, 2007; Gorman, 2007). Guide of the principles of visual scanning exercises integrated with

task-specific activities and the principles of progression of these exercises are presented in Table 3.2.

Table 3.2. Guide of the principles of visual scanning exercises integrated with task-specific activities and the principles of progression of these exercises

FUNCTIONAL POSITIONS	VISUAL SCANNING EXERCISES INTEGRATED WITH TASK-SPECIFIC ACTIVITY	PROGRESSION OF VISUAL SCANNING EXERCISES INTEGRATED WITH TASK-SPECIFIC ACTIVITY
SUPINE **PROGRESSION:** Bridging with feet on a balance mat Bridging with feet on a balance ball	**BRIDGING:** Turn head towards impaired side. Bridge while doing saccadic eye movements by reading the individual letters or numbers aloud on a HART-chart or flash cards (UNO play cards / regular cards).	Lift buttocks up, read letter, drop buttocks read letter. Start reading on the left (L) of the HART – chart, read letters from (L) to right (R). Reading rows from top to bottom. Progress to larger saccadic eye movements and visual search strategies by reading the letter furthest on the (L) and be able to "jump" with their eyes immediately to the letter furthest on the (R). Repeat by reading the second letter on the (L) and immediately the second letter on the (R). Repeat till the middle of the row inwards. Start in the middle of the row and progress from (L) to (R). Increase the saccadic eye movements by progressing outwards towards the furthest letter/number on the (L) and (R).
SIDE LYING TO SITTING	Move from supine to side lying and from side lying to sitting while fixating the eyes on a card.	Incorporate smooth pursuit eye movements and visual fixation by tracking of an object: (1) Patient fixates on an object that is moving towards the impaired / affected side.

FUNCTIONAL POSITIONS	VISUAL SCANNING EXERCISES INTEGRATED WITH TASK-SPECIFIC ACTIVITY	PROGRESSION OF VISUAL SCANNING EXERCISES INTEGRATED WITH TASK-SPECIFIC ACTIVITY
		(2) Keep eyes fixated on object, head may turn. (3) Progression: Keep head still while continuing to fixate on an object that is moving towards the impaired / affected side.
SITTING **PROGRESSION:** Sitting on a balance mat Sitting on a roller Sitting on an exercise ball	Start reading on the left (L) of the HART – chart, read letters from (L) to right (R). Reading rows from top to bottom. Progress to larger saccadic eye movements and visual search strategies by reading the letter furthest on the (L) and be able to "jump" with their eyes immediately to the letter furthest on the (R). Repeat by reading the second letter on the (L) and immediately the second letter on the (R). Repeat till the middle of the row inwards. Start in the middle of the row and progress from (L) to (R). Increase the saccadic eye movements by progressing outwards towards the furthest letter/number on the (L) and (R).	Progress functional position to: (1) Sitting on a balance mat while performing visual scanning exercises. (2) Sitting on balance disc while performing visual scanning exercises. Progress visual scanning exercises to: Progress to larger saccadic eye movements and visual search strategies by using two (2) HART-charts side by side. Incorporate smooth pursuit eye movements and visual fixation by tracking of an object: (4) Patient fixates on an object that is moving towards the impaired / affected side. Keep eyes fixated on object, head may turn. (5) Progression: Keep head still while continuing to fixate on an object that is moving towards the impaired / affected side.

FUNCTIONAL POSITIONS	VISUAL SCANNING EXERCISES INTEGRATED WITH TASK-SPECIFIC ACTIVITY	PROGRESSION OF VISUAL SCANNING EXERCISES INTEGRATED WITH TASK-SPECIFIC ACTIVITY
SIT TO STAND **PROGRESSION:** With support in front of a table Without support of a table Sit to stand on an even surface Sit to stand on an uneven surface i.e. balance mat	Move from sitting to standing while fixating the eyes on a card.	Progress functional activity to: Move from sit to stand while reading a letter, followed by moving from standing to sitting while reading a letter/number. Start reading on the left (L) of the HART – chart, read letters from (L) to right (R). Reading rows from top to bottom. Progress to larger saccadic eye movements and visual search strategies by reading the letter furthest on the (L) and be able to "jump" with their eyes immediately to the letter furthest on the (R). Repeat by reading the second letter on the (L) and immediately the second letter on the (R). Repeat till the middle of the row inwards. Start in the middle of the row and progress from (L) to (R). Increase the saccadic eye movements by progressing outwards towards the furthest letter/number on the (L) and (R). Progress to larger saccadic eye movements and visual search strategies by using two (2) HART-charts one (1) above and one (1) below each other.
STANDING With support in front of a table Without support of a table	Perform saccadic eye movements with visual scanning exercises while in standing.	Progress functional position to: (1) Standing on a proprioception mat while performing visual scanning exercises. (2) Standing on balance disc/ball while performing visual scanning exercises.

FUNCTIONAL POSITIONS	VISUAL SCANNING EXERCISES INTEGRATED WITH TASK-SPECIFIC ACTIVITY	PROGRESSION OF VISUAL SCANNING EXERCISES INTEGRATED WITH TASK-SPECIFIC ACTIVITY
With an assistive device – walking frame; crutch; quadpod; tripod, walking stick Without an assistive device Standing near a wall for support Stand in the middle of a room without support		(3) Standing on a mini – trampoline while performing visual scanning exercises.
HALF- **STANDING** With support in front of a table Without support of a table With an assistive device – walking frame; crutch; quadpod; tripod, walking stick Without an assistive device Standing near a wall for support Stand in the middle of a room without support	Place one (1) leg on a step while performing saccadic eye movements with visual scanning exercises.	<u>Progress functional position to:</u> (1) Alternate legs on the step while while performing visual scanning exercises. One (1) leg on the floor and one (1) leg on a step. (2) Alternate legs on the step while performing visual scanning exercises. One (1) leg on the floor and one (1) leg on a balance mat / Boso ball. (3) Alternate legs on the step while performing visual scanning exercises. One (1) leg on the balance mat and one (1) leg on a step. (4) Alternate legs on the step while performing visual scanning exercises. One (1) leg on the balance mat and one (1) leg on a balance ball.

FUNCTIONAL POSITIONS	VISUAL SCANNING EXERCISES INTEGRATED WITH TASK-SPECIFIC ACTIVITY	PROGRESSION OF VISUAL SCANNING EXERCISES INTEGRATED WITH TASK-SPECIFIC ACTIVITY
		Progress visual scanning exercises to: Place (L) foot on a step while reading a letter, alternate legs by placing (R) foot on a step while reading a letter/number. Repeat activity until all letters/numbers on the HART-chart are read.
GAIT **PROGRESSION:** With an assistive device – walking frame; crutch; quadpod; tripod, walking stick Without an assistive device While holding a tray	Walking on an even surface while performing saccadic eye movements with visual scanning exercises on either a HART-chart or flash cards during gait.	Progress functional position to: (1) Walking with one (1) foot on an AIREX balance beam and the other foot on the floor (even surface) while performing saccadic eye movements with visual scanning exercises. (2) Walking in a figure of eight (8). Keep eyes fixated on a card on either the (L) or the (R) wall, while turning. Alternate card on (L) and (R) wall. (3) Walking on uneven surfaces while performing saccadic eye movements with visual scanning exercises on either a HART-chart or flash cards during gait. (4) Walking while holding a tray, placing cards on the tray while walking, reading the numbers on the cards aloud.

Participants from Group 2 (Control Group) received task-specific activities five (5) weekdays starting from Day 1 for four (4) consecutive weeks. The flow of each therapy session of Group 2 is presented in Table 3.1.

To monitor the participants' progress during the intervention, consecutive in-hospital assessments on the outcome measures were repeated once a week on a Friday during the intervention period of four (4) weeks.

In-hospital weekly assessments were performed as follows:

↓ ↓ ↓ ↓ ↓

Day 1----------Day 8----------Day 15----------Day 22----------Day 28

3.9. Control of bias in the research process

A qualified physiotherapist from the principal investigator's practice treated participants in Group 1 (experimental group) and one (1) physiotherapist from the TRC treated participants in Group 2 (control group). The principal investigator orientated and trained the two (2) physiotherapists in the task-specific treatment approach to rehabilitation of participants who had sustained a stroke and who suffered from unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke, to ensure that there was no difference in the application of the task-specific treatment approach to participants post-stroke between the two (2) physiotherapists.

Orientation and in-service training of the two (2) physiotherapists took place prior to the commencement of the trial. The participants in Group 1 and 2 were treated in

separate venues to control blinding of the participants throughout the study. The two (2) physiotherapists who treated the participants in Group 1 and Group 2 based their treatment on a client-centered approach to rehabilitation. The client-centered approach to rehabilitation entails the facilitation of active participation and responsibility of the participants and their caregivers in the rehabilitation process (Hammell, 2004).

An independent assessor (also a qualified physiotherapist) with sufficient experience in administration of the outcome measures used during the trial conducted the assessment of the participants on Day 1, Day 8, Day 15, Day 22 and Day 28, as well as week eight (8), week twelve (12), week sixteen (16) and week twenty (20) after the participants were discharged from TRC. All participants were assessed on the same day of the week. The independent assessor and participants in the clinical trial were blinded to the groups the participants were assigned to (Blanton et al, 2006).

Because rehabilitation is a multidisciplinary team approach, the participants in the clinical trial's treatment by other members of the rehabilitation team (namely, the occupational therapist, speech-and-language therapist and social worker) continued as usual at the TRC.

The average duration of physiotherapy sessions was approximately forty-five (45) minutes. Time spent on report writing, advice given to participants, family or caregivers and discussions with other members of the multi-disciplinary team were not included in the forty-five (45) minutes. Informal therapy that consisted of the implementation of acquired movement skills into tasks of daily living was regarded as

part of the 'home' / 'ward' exercise programme performed in addition to the formal therapy setting.

In order to determine whether there was a difference in the quality of life of participants in the experimental group (Group 1) and the control group (Group 2) as well as their ability to re-integrate into their communities, participants were followed up on a monthly basis and re-assessed at week eight (8), twelve (12), sixteen (16) and week twenty (20) after their rehabilitation (participation in the study) started on the Stroke Impact Scale Version 3.0 (SIS) and the walking ability questionnaire.

3.10. Reliability and validity of the clinical trial

In order to ensure reliability of the research data, a skilled assessor who was blinded to the groups that the participants were assigned to conduct all the assessments of the participants in the trial. All outcome measures that were used are internationally recognised and validated (refer to paragraph 2.7. and paragraph 2.8.). This ensured the reliability of the data captured and the data obtained. The results of this study may therefore be compared to those of similar studies where the same data capture methods or outcome measures were implemented nationally and internationally. The use of multiple outcomes measures could have resulted in a learning effect specifically the Mini-Mental State Examination and the SAS.

3.11. Assessment instruments

In this study the ICF (Ustun et al, 2003) was used as the model of disablement within which participants were assessed and treated. The outcome measures used in the

assessment of the effects of treatment on body impairment, functional activity and participation level are discussed in paragraph 2.7.

3.11.1. Body impairment level

The outcome measure used to assess the effects of treatment on body impairment level and the validity of the measures used are described in detail in paragraph 2.7. Assessments of impairment level were done using the following selected outcome measures:

(1) King-Devick Test © (Zoltan, 1996) (Addendum 5) was selected to assess the effect of visual scanning exercises integrated with task-specific activities received by participants from Group 1 versus participants from Group 2 that received task-specific activities alone on participants that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke's **oculomotor function**.

(2) Star Cancellation Test (Addendum 8) was selected to assess the effect of visual scanning exercises integrated with task-specific activities received by participants from Group 1 versus participants from Group 2 that received task-specific activities alone on participants that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke's **perceptual processing**.

(3) The Mini-Mental State Examination (MMSE) (Addendum 3) was selected to assess the effect of visual scanning exercises integrated with task-specific activities received by participants from Group 1 versus participants from Group

2 that received task-specific activities alone on participants that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke's **cognitive function**.

(4) The Hospital Anxiety and Depression Scale (HADS) (Addendum 11) was selected to assess the effect of visual scanning exercises integrated with task-specific activities received by participants from Group 1 versus participants from Group 2 that received task-specific activities alone on participants that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke's **level of anxiety and depression**.

3.11.2. Functional activity level

The outcome measure used to assess the effects of treatment on functional activity level and the validity of the measures used are described in detail in paragraph 2.7. and paragraph 2.8. Assessments on functional activity level were done using the following selected outcome measures:

(1) Stroke Activity Scale (Addendum 12) was selected to match and allocate participants in the study to the control and experimental groups prior to the study based on their functional activity level (as measured on the SAS) to ensure that participants in the two groups were comparable with regard to their functional activity level. The SAS was further selected to assess the effect of visual scanning exercises integrated with task-specific activities received by participants from Group 1 versus participants from Group 2 that received task-specific activities alone on participants that presented with

unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke's **functional ability**.

(2) Barthel Index (Addendum 6) was selected to assess the effect of visual scanning exercises integrated with task-specific activities received by participants from Group 1 versus participants from Group 2 that received task-specific activities alone on participants that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke's **functional ability**.

(3) The Timed Up and Go Test (TUG) (Addendum 7) was selected to assess the effect of visual scanning exercises integrated with task-specific activities received by participants from Group 1 versus participants from Group 2 that received task-specific activities alone on participants that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke's **functional ability**.

3.11.3. Participation level

The outcome measure used to assess the effects of treatment on participation level and the validity of the measures used are described in detail in paragraph 2.10.1.3. Assessments on participation level were done using the following selected outcome measures:

(1) Stroke Impact Scale Version 3.0 (SIS) (Addendum 9) was selected to assess the effect of visual scanning exercises integrated with task-specific activities received by participants from Group 1 versus participants from Group 2 that received task-specific activities alone on participants that presented with

unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke's **quality of life**.

(2) The walking ability questionnaire (Addendum 10) was selected to assess the effect of visual scanning exercises integrated with task-specific activities received by participants from Group 1 versus participants from Group 2 that received task-specific activities alone on participants that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke's **quality of life**.

3.11.4. Summary of assessments completed during the trial

Summary of weekly in-hospital assessments and post-discharge assessments completed during the trial are indicated in Table 3.3.

Table 3.3. Summary of assessments completed during the trial

Outcomes measure	Day 1	Day 8	Day 15	Day 22	Day 28	Week 8	Week 12	Week 16	Week 20
Mini-Mental State Examination (MMSE)	X	X	X	X	X	X	X	X	X
King-Devick Test ©	X	X	X	X	X	X	X	X	X
Star Cancellation Test	X	X	X	X	X	X	X	X	X
The Hospital Anxiety and Depression Scale	X	X	X	X	X	X	X	X	X
Stroke Activity Scale (SAS)	X	X	X	X	X	X	X	X	X
Barthel Index (BI)	X	X	X	X	X	X	X	X	X

Timed Up and Go Test (TUG)	X	X	X	X	X	X	X	X	X
Stroke Impact Scale Version 3.0 (SIS)						X	X	X	X
The walking ability questionnaire						X	X	X	X

Post-discharge assessments were conducted at TRC out-patient facility. Participants were required to travel to and from TRC for the follow-up assessments at week eight (8), week twelve (12), week sixteen (16) and week twenty (20) post initiation of the clinical trial.

3.12. Retention of participants until study completion – attempting to minimise subjects lost to follow-up (Blanton, et al, 2006)

The researcher provided remuneration to cover transportation costs for participants to enable them to attend the follow-up assessments. Reimbursement of costs of travelling was based upon the residential area and individual participant's needs that were identified on completion of the demographical information sheet at baseline and subjective information provided by the participant prior to discharge from the TRC (Blanton et al, 2006).

Two (2) weeks prior to each scheduled re-assessment appointment the researcher made a telephone call to all the participants in the trial to remind them of their scheduled follow-up assessment date and time. Another telephone phone call was made one (1) week prior to the scheduled follow-up assessment to remind the

participant of the scheduled appointment. Regular phone calls were made to maintain communication with the subjects after discharge from the TRC and to minimise subjects lost to follow-up during the study (Blanton et al, 2006).

3.13. Pilot study

A pilot study was performed prior to commencement of the trial. The main aim of the pilot study was to test the research procedure and techniques of data gathering. Three (3) participants, who met the inclusion and exclusion criteria, participated in the pilot study. Two (2) participants were allocated to Group 1 (experimental group (n = 2)) and one (1) participant to Group 2 (control group (n = 1)). The participants were treated by the two (2) physiotherapists who treated the participants in Group 1 and Group 2. The independent assessor conducted the assessment of the participants on Day 1, Day 8, Day 15, Day 22 and Day 28 post-admission to TRC as well as week eight (8), week twelve (12), week sixteen (16) and week twenty (20) post discharge from the TRC. The assessor was blind to the participants assigned to the two (2) groups. Assessments were done by using the previously described outcome measures, with the exception of the Hospital Anxiety and Depression Scale (HADS) as described in paragraph 2.7.5.

Two (n = 2) participants showed improvement on the Mini-Mental State Examination, King-Devick Test ©, Star cancellation test, SAS, Barthel Index, Timed-up and Go Test, Stroke Impact Scale and Walking ability questionnaire from baseline to week twenty (20). One (n = 1) participant demonstrated illogical progress in performance on the Mini-Mental State Examination, Star Cancellation Test, Barthel Index, TUG Test during the period of intervention from baseline to week four (4). A careful

analysis of the results and investigation into the participant's daily routine following the illogical sequence of the results indicated that the participant's performance was in retrospect related to her emotional status. The participant presented with a state of anxiety and depression that seemed to have influenced her participation in therapy and influenced the participant's performance on the functional outcomes.

The HADS was, therefore, included as an outcome measure in the clinical trial and was implemented on a weekly basis (refer to Table 3.4). The HADS is a valid and reliable tool for the identification and quantification of depression and anxiety post-stroke, as described in paragraph 2.7.5.

No other changes were made to the research procedure.

3.14. Data analysis

For descriptive purposes it was assumed that given the small number of participants in each group, all data were non-normally distributed. Results were thus described with medians and 25th and 75th percentiles. For comparisons Mann Whitney U tests were done without adjustment for multiple comparisons. For comparing outcomes at week four (4), adjusting for baseline values, as well as the fact that subjects were matched a mixed model rank ANCOVA analysis was used where the week four (4) and baselines values were ranked and the ranked values used in the regression analyses. P values <=0.05 were regarded as statistically significant. All analyses were done in R 2.14.2.

3.15. Summary

In summary, Chapter 3 describes the study design and research methodology used in the clinical trial. All the participants who were included in the clinical trial underwent a four-week inpatient rehabilitation period at TRC. The rehabilitation (intervention) was based on the task-specific approach to rehabilitation that consisted of activities or components of activities that participants had to re-learn to perform in order to optimise their functional ability.

All participants received task-specific activities for the intervention period of four (4) consecutive weeks. The participants in Group 1 received saccadic eye movement training with visual scanning exercises integrated with their task-specific activities as part of the treatment as an “add on” intervention in this trial. In order to assess the participants’ quality of life and re-integration into their communities, participants were followed up on a monthly basis and re-assessed at week eight (8), twelve (12), sixteen (16) and week twenty (20) after their rehabilitation (participation in the study) commenced.

A detailed account of the analysis of the data and the discussion of the results gathered during the period of intervention of four (4) consecutive weeks of the double blind matched clinical trial is presented in Chapter 4. The demographic data of all the participants who participated in this clinical trial and the results of the outcome measures obtained at the pre-determined times are identified and described in the following chapter. Results gathered at week eight (8), week twelve (12), week sixteen (16) and week twenty (20) are presented in Addendum 14 because a large number of

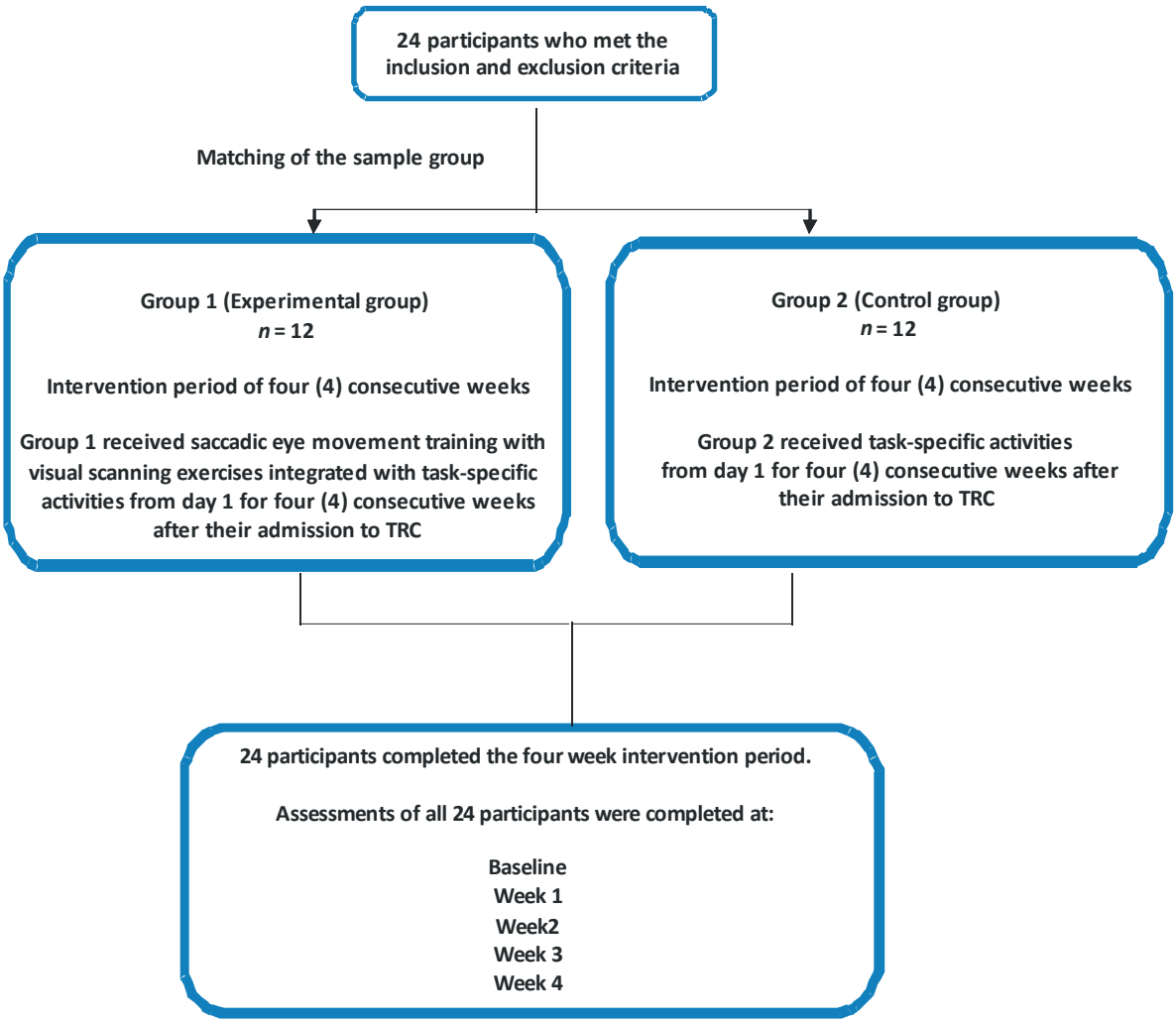
participants were lost to follow-up following discharge from the TRC after the first four (4) weeks (intervention period) of the study. The results and findings gathered at week eight (8), week twelve (12), week sixteen (16) and week twenty (20) after admission to the rehabilitation facility are therefore incomplete but are presented in Addendum 14.

CHAPTER 4

RESULTS OF THE STUDY

4.1. Introduction

A detailed account of the analysis of the data and a discussion of the results gathered during the period of intervention of four (4) consecutive weeks of the matched-pair randomised controlled trial are presented visually by means of tables in Chapter 4. The discussion of the results gathered during this matched-pair randomised controlled trial will be presented based on the aims and the objectives stated in Chapter 1 (paragraphs 1.7 & 1.8). The course of the study is displayed in Figure 4.1.



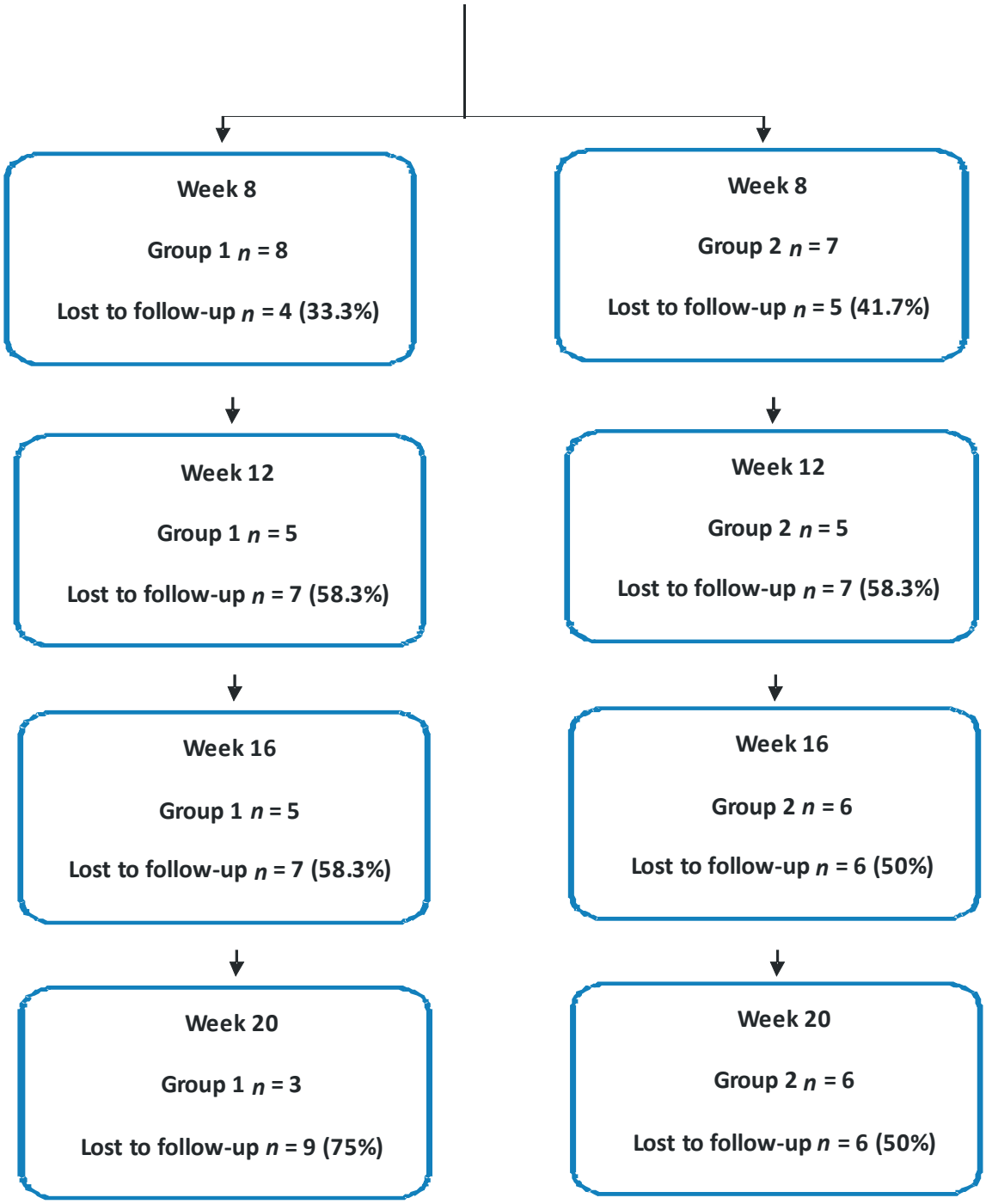


Figure 4.1. The course of the study

4.2. Demographical data of the participants in the clinical trial

The demographical data of participants from Group 1 and Group 2 is displayed in Table 4.1.

Table 4.1. The demographic data of participants from Group 1 and Group 2

DEMOGRAPHIC DATA – Participant characteristics Group 1: *n* = 12 Group 2: *n* = 12	***P* – value** P values < = 0.05 (statistically significant)
AGE	p = 0.315
GENDER	p = 1
RACE	p = 0.68
AFFECTED SIDE POST-STROKE	p = 1
DOMINANT SIDE PRIOR TO THE STROKE	p = 1
FUNCTIONAL ABILITY ON THE SAS BEFORE THE TRIAL	p = 0.24
RESIDENTIAL AREAS	p = 0.37
ACCESS TO ELECTRICITY IN RESIDENCE	p = 1
ACCESS TO RUNNING WATER IN RESIDENCE	p = 0.64
DISTANCE TO RUNNING WATER NEAR RESIDENCE	p = 0.42
ACCESS TO A TOILET IN RESIDENCE	p = 1
WALKING DISTANCE TO TOILET NEAR RESIDENCE	p = 0.92
ACCESS TO TRANSPORT	p = 1
WALKING DISTANCE TO PUBLIC TRANSPORT	p = 0.55
ACCESS TO A HEALTH CARE SETTING	p = 1
TRAVELLING DISTANCE TO A HEALTH CARE SETTING	p = 0.08
ACCESS TO A CARE GIVER AFTER DISCHARGE FROM THE REHABILITATION FACILITY	p = 0.48

DEMOGRAPHIC DATA – Participant characteristics Group 1: *n* = 12 Group 2: *n* = 12	***P* – value** P values < = 0.05 (statistically significant)
LEVEL OF SCHOOLING	p = 0.68
EMPLOYMENT STATUS AT THE TIME OF THE STROKE	p = 0.679
TYPE OF WORK	p = 0.301

No statistical difference in the demographic data between the groups was found at baseline. Based on the results in Table 4.1 it can be concluded that the two groups were comparable with each other regarding age, gender, race, affected side post-stroke and dominant side prior to the stroke at the beginning of the study. These factors were therefore not expected to have any influence on the outcome of the intervention(s) on the dependent variables.

No statistical difference between the demographic data regarding the residential areas, access to basic services and level of education between the groups was found at baseline. Based on the interpretation, it can be concluded that the two groups were comparable with each other regarding home environment, socio-economic status and level of education at the beginning of the study and the demographic data was therefore not expected to have any influence on the outcome of the intervention(s) on the dependent variables.

4.2.1. Matching based on functional activity level

Participants in the study were matched and allocated to the control and experimental groups prior to the study based on their functional activity level as measured on the SAS to ensure that participants in the two groups were comparable with regard to their functional activity level. The SAS score at baseline was fairly similar between Group 1 and Group 2 before the study commenced. No statistical difference was noted between the groups at baseline ($p = 0.24$). Based on the interpretation of the SAS, the motor function of participants from Group 1 and Group 2 was similar at the beginning of the intervention period (baseline).

It can be concluded that the two groups were comparable with each other regarding their functional activity level, specifically their motor function at the beginning of the study. Participants' functional activity level, specifically their residual motor function prior to the intervention, was therefore not expected to have any influence on the outcome of the intervention(s) on the dependent variables.

4.3. Results from outcome measures over the four-week intervention period

4.3.1. Results of the assessment of participants' oculomotor function

4.3.1.1. The King-Devick Test ©

(1) Time taken to complete the King-Devick Test © over the four-week intervention period

Results of the King-Devick Test © over the four-week intervention period are displayed in Table 4.2.

Table 4.2. Results of the time taken to complete the King-Devick Test © over the four-week intervention period for Group 1 and Group 2

King-Devick Subtest 1	[ALL]	Group 1	Group 2	
	(Time) n=24	(Time) n=12	(Time) n=12	
	Median [25th; 75th percentiles]	Median [25th; 75th percentiles]	Median [25th; 75th percentiles]	p.overall
Baseline	53.5 [32.8; 65.5]	53.5 [32.8; 68.9]	53.5 [39.6; 60.0]	0.82
Week 1	43.3 [30.4; 57.4]	52.1 [30.4; 59.9]	32.3 [30.6; 48.4]	0.30
Week 2	39.9 [34.4; 57.4]	41.7 [36.2; 58.5]	37.5 [34.4; 50.7]	0.73
Week 3	32.7 [27.6; 43.4]	34.1 [26.9; 58.3]	32.7 [28.3; 37.6]	0.82
Week 4	32.3 [28.7; 40.1]	34.8 [28.8; 50.4]	31.3 [28.6; 35.9]	0.56
King-Devick Subtest 2	[ALL]	Group 1	Group 2	
	Median [25th; 75th percentiles]	Median [25th; 75th percentiles]	Median [25th; 75th percentiles]	p.overall
Baseline	70.8 (75.9)	61.5 (17.8)	80.1 (107.4)	0.57
Week 1	52.4 (35.4)	57.1 (25.6)	47.6 (43.7)	0.52
Week 2	57.5 (36.7)	60.7 (41.4)	54.3 (32.8)	0.68
Week 3	49.0 (27.4)	54.9 (35.9)	43.1 (14.2)	0.31
Week 4	46.1 (26.2)	49.0 (31.2)	43.2 (21.2)	0.60
King-Devick Subtest 3	[ALL]	Group 1	Group 2	
	(Time) n=24	(Time) n=12	(Time) n=12	
	Median [25th; 75th percentiles]	Median [25th; 75th percentiles]	Median [25th; 75th percentiles]	p.overall
Baseline	71.4 [46.7; 106.9]	55.5 [42.6; 79.9]	92.0 [63.3; 115.0]	0.15
Week 1	55.8 [36.8; 71.7]	59.1 [47.8; 84.4]	48.9 [31.7; 61.8]	0.36
Week 2	44.6 [35.8; 68.2]	47.9 [35.8; 68.4]	43.2 [35.2; 66.3]	0.95
Week 3	43.8 [36.4; 67.9]	49.5 [36.1; 74.1]	42.4 [36.9; 55.7]	0.64
Week 4	41.6 [34.0; 68.6]	41.6 [37.4; 79.5]	43.3 [32.9; 61.1]	0.82

For descriptive purposes it was assumed that given the limited number of participants in each group, all data were non-normally distributed. Group 1 and Group 2 were thus described by means of medians, 25th and 75th percentiles in Table 4.2. For comparisons between groups at weekly assessments, Mann Whitney U tests were done without adjustment for multiple comparisons. No statistical difference was noted on the King-Devick Subtest 1 ($p = 0.82$), King-Devick Subtest 2 ($p = 0.57$) and King-Devick Subtest 3 ($p = 0.15$) at baseline between Group 1 and Group 2. The implications of the King-Devick Subtest 1, King-Devick Subtest 2 and King-Devick Subtest 3 scores at baseline are that the residual oculomotor function in participants from Group 1 and Group 2 was similar at the beginning of the study. Based upon the interpretation of the King-Devick Subtest 1, 2 and 3 scores, participants in both groups suffered from poor oculomotor function and impairment of the visual efficiency processes, specifically slow saccadic eye movements, at the beginning of the study.

Impairment of the oculomotor function and visual efficiency processes specifically slow saccadic eye movements, in participants from Group 1 and Group 2 improved over the four-week intervention period. For comparing outcomes at week four (4) adjusting for baseline values as well as the fact that subjects were matched, the mixed model rank ANCOVA analysis was used where the week four (4) and baseline values were ranked and the ranked values were used in the regression analyses. Thus, comparing ranks of both groups after the four-week intervention period adjusting for matching and baseline values, the King-Devick Subtest 1 ($p= 0.45$) and King-Devick Subtest 2 ($p= 0.76$) scores at week four (4) was not significantly different for the two groups.

Comparing ranks of both groups after the four-week intervention period and adjusting for matching and baseline values, the King-Devick Subtest 3 score at week four (4) was statistically significantly better in participants from Group 1 compared to those from Group 2 (p= 0.02). The oculomotor strategies and visual efficiency processes, specifically the saccadic eye movements, required to complete the King-Devick Subtest 3 were significantly better in participants from Group 1 compared to those from Group 2 (p= 0.0211). The implication is that participants from Group 1 presented with better oculomotor function, visual efficiency processes and saccadic eye movements compared to participants from Group 2 post-intervention. The King-Devick Subtest 3 is the most advanced subtest of the King-Devick Test © in the sense that the King-Devick Subtest 3 requires larger saccadic eye movements and visual search strategies than King-Devick Subtest 1 and King-Devick Subtest 2. It is interesting to note that the difference in the two groups only presented in the more difficult test which displays a higher level of oculomotor function, visual efficiency processes and saccadic eye movements and not in the easier King Devick Subtest 1 and King Devick Subtest 2.

(2) Average errors during completion of the King-Devick Test © over the four (4) – week intervention period

Results of the average number of errors made during the completion of the King-Devick Test © over the four-week intervention period are displayed in Table 4.3.

Table 4.3. The average number of errors made during the completion of the King-Devick Test © over the four-week intervention period

Average errors - King-Devick Subtest 1	[ALL]	Group 1	Group 2	
	(Average errors) n=24	(Average errors) n=12	(Average errors) n=12	
	Median [25th; 75th percentiles]	Median [25th; 75th percentiles]	Median [25th; 75th percentiles]	p.overall
Baseline	<0.1 [0.0; 0.2]	0.1 [<0.1; 0.2]	0.0 [0.0; 0.3]	0.21
Week 1	<0.1 [0.0; 0.1]	<0.1 [0.0; 0.2]	<0.1 [0.0; <0.1]	0.39
Week 2	<0.1 [0.0; 0.1]	<0.1 [0.0; 0.2]	<0.1 [0.0; 0.1]	0.81
Week 3	0.0 [0.0; 0.1]	<0.1 [0.0; 0.1]	0.0 [0.0; 0.1]	0.73
Week 4	0.0 [0.0; <0.1]	<0.1 [0.0; 0.1]	0.0 [0.0; <0.1]	0.17
Average errors - King-Devick Subtest 2	[ALL]	Group 1	Group 2	
	(Average errors) n=24	(Average errors) n=12	(Average errors) n=12	
	Median [25th; 75th percentiles]	Median [25th; 75th percentiles]	Median [25th; 75th percentiles]	p.overall
Baseline	<0.1 [0.0; 0.2]	<0.1 [0.0; 0.1]	0.0 [0.0; 0.2]	0.88
Week 1	<0.1 [0.0; 0.1]	<0.1 [0.0; 0.2]	<0.1 [0.0; 0.1]	0.57
Week 2	<0.1 [0.0; 0.2]	0.1 [0.0; 0.3]	<0.1 [0.0; 0.1]	0.20
Week 3	0.0 [0.0; 0.2]	<0.1 [0.0; 0.1]	0.0 [0.0; 0.2]	0.38
Week 4	<0.1[0.0; 0.1]	<0.1 [0.0; 0.2]	<0.1 [0.0; 0.1]	0.70
Average errors - King-Devick Subtest 3	[ALL]	Group 1	Group 2	
	(Average errors) n=24	(Average errors) n=12	(Average errors) n=12	
	Median [25th; 75th percentiles]	Median [25th; 75th percentiles]	Median [25th; 75th percentiles]	p.overall
Baseline	0.2 [<0.1; 0.4]	0.1 [<0.1; 0.5]	0.2 [0.1; 0.3]	0.45
Week 1	0.2 [0.1; 0.3]	0.3 [0.1; 0.6]	0.2 [0.1; 0.2]	0.49
Week 2	0.2 [<0.1; 0.3]	0.2 [<0.1; 0.5]	0.2 [<0.1; 0.2]	0.49
Week 3	0.2 [0.1; 0.3]	0.2 [<0.1; 0.4]	0.2 [0.1; 0.2]	0.95
Week 4	0.1 [<0.1; 0.3]	0.2 [0.0; 0.4]	0.1 [0.1; 0.2]	0.73

For descriptive purposes it was assumed that given the limited number of participants in each group, all data were non-normally distributed. Group 1 and Group 2 were thus described by means of medians, 25th and 75th percentiles in Table 4.3. For comparisons between groups at weekly assessments, Mann Whitney U tests were completed without adjustment for multiple comparisons. The average number of errors made during the completion of the King-Devick Subtest 1 ($p = 0.21$), King-Devick Subtest 2 ($p = 0.88$) and King-Devick Subtest 3 ($p = 0.45$) at baseline by participants from Group 1 and Group 2 were not significantly different. The implications of the average number of errors made at baseline are that the accuracy with which the participants from Group 1 and Group 2 completed the King-Devick Subtest 1, King-Devick Subtest 2 and King-Devick Subtest 3 was similar at the beginning of the study.

No statistical difference was noted in the average number of errors made during the completion of the King-Devick Subtest 1 ($p = 0.17$), King-Devick Subtest 2 ($p = 0.70$) and King-Devick Subtest 3 ($p = 0.73$) by participants from Group 1 and Group 2 after the four-week intervention period.

4.3.2. Results of the assessment of participants' functional ability

4.3.2.1. The Stroke Activity Scale

Results of the Stroke Activity Scale of participants from Group 1 and Group 2 over the four-week intervention period are displayed in Table 4.4.

Table 4.4. Results of the Stroke Activity Scale of participants from Group 1 and Group 2 over the four-week intervention period

Stroke Activity Scale	[ALL]	Group 1	Group 2	
	n=24	n=12	n=12	
	Median [25th; 75th percentiles]	Median [25th; 75th percentiles]	Median [25th; 75th percentiles]	p.overall
Baseline	10.0 [7.8; 13.0]	10.5 [9.0; 13.2]	8.5 [6.8; 12.2]	0.24
Week 1	8.0 [5.8; 10.0]	8.5 [6.8; 10.0]	7.5 [5.0; 9.8]	0.52
Week 2	11.0 [8.0; 14.0]	12.0 [10.2; 14.2]	9.0 [7.8; 12.5]	0.12
Week 3	11.0 [9.8; 14.0]	11.5 [11.0; 14.5]	10.0 [7.8; 12.5]	0.09
Week 4	12.0 [9.8; 14.2]	13.0 [11.0; 15.2]	10.5 [9.0; 13.2]	0.09

For descriptive purposes it was assumed that given the limited number of participants in each group, all data were non-normally distributed. Group 1 and Group 2 were thus described by means of medians, 25th and 75th percentiles in Table 4.4. For comparisons between groups at weekly assessments, Mann Whitney U tests were completed without adjustment for multiple comparisons. The SAS score at baseline was fairly similar between Group 1 and Group 2 before the study commenced. No statistical difference was noted between the groups at baseline ($p = 0.24$). Based on the interpretation of the SAS, the motor function of participants from Group 1 and Group 2 was similar at the beginning of the intervention period (baseline).

The SAS score of participants in both groups improved over the four-week intervention period. Participants from Group 1 and Group 2's motor function improved over the four-week intervention period. No statistical difference was noted on the SAS between Group 1 and Group 2 after the intervention period of four (4) weeks ($p = 0.09$). For comparing outcomes at week four (4) adjusting for baseline values as well as the fact that subjects were matched, the mixed model rank ANCOVA analysis was used where the week four (4) and baseline values were ranked and the ranked values were used in the regression analyses. Thus, comparing the difference on

ranks adjusted for matching and baseline values was also not statistically significant (p = 0.09) between Group 1 and Group 2 after the four-week intervention period. The motor function of participants from both groups was fairly similar after the four-week intervention period as measured on the SAS.

4.3.2.2. The Barthel Index

Results of the Barthel Index (BI) of participants from Group 1 and Group 2 over the four-week intervention period are displayed in Table 4.5.

Table 4.5. Results of the Barthel Index of participants from Group 1 and Group 2 over the four-week intervention period

Barthel Index	[ALL]	Group 1	Group 2	
	n=24	n=12	n=12	
	Median [25th; 75th percentiles]	Median [25th; 75th percentiles]	Median [25th; 75th percentiles]	p.overall
Baseline	45.0 [33.8; 53.8]	40.0 [28.8; 50.0]	45.0 [35.0; 53.8]	0.54
Week 1	55.0 [40.0; 80.0]	57.5 [48.8; 81.2]	45.0 [35.0; 65.0]	0.20
Week 2	60.0 [48.8; 90.0]	62.5 [58.8; 95.0]	47.5 [35.0; 71.2]	0.02
Week 3	70.0 [53.8; 95.0]	77.5 [60.0; 96.2]	57.5 [43.8; 78.8]	0.07
Week 4	85.0 [55.0; 100.0]	90.0 [72.5; 100.0]	55.0 [45.0; 95.0]	0.04

For descriptive purposes it was assumed that given the limited number of participants in each group, all data were non-normally distributed. Group 1 and Group 2 were thus described by means of medians, 25th and 75th percentiles in Table 4.5. For comparisons between groups at weekly assessments, Mann Whitney U tests were done without adjustment for multiple comparisons. The BI score at baseline was fairly similar between Group 1 and Group 2. No statistical difference was found between the groups at baseline (p = 0.54). Based on the interpretation, the BI score at

baseline of participants in Group 1 and Group 2 was an indication of severe dependence in the performance of ADL at the beginning of the intervention period. Prior to the intervention, the levels of dependence in participants from Group 1 and Group 2 were fairly equal.

The BI score of participants in Group 1 increased to a large extent over the four-week intervention period indicating that the level of dependence of participants in Group 1 decreased over the four-week intervention period. Participants from Group 1's level of functional performance in ADL improved over the intervention period. Based on the interpretation of the BI, participants from Group 1 presented with a "moderate" level of dependence post-intervention.

The BI score of participants in Group 2 increased minimally over the four-week intervention period. The interpretation of the BI post-intervention implies that participants from Group 2 continued to present with a severe dependence in the performance of ADL. A statistically significant difference ($p = 0.04$) was noted when comparing the functional improvement between the two groups after the intervention period. For comparing outcomes at week four (4) adjusting for baseline values as well as the fact that subjects were matched, the mixed model rank ANCOVA analysis was used where the week four (4) and baseline values were ranked and the ranked values were used in the regression analyses. Thus, comparing the difference on ranks adjusted for matching and baseline values was also statistically significant ($p = 0.004$) between Group 1 and Group 2 after the four-week intervention period. Participants from Group 1 presented with a higher level of functional performance in ADL compared to participants from Group 2 after the intervention period.

4.3.2.3. The Timed Up and Go Test

Results of the Timed Up and Go Test (TUG) of participants from Group 1 and Group 2 over the four-week intervention period are displayed in Table 4.6.

Table 4.6. Results of the TUG of participants in Group 1 and Group 2 over the four-week intervention period

Timed Up and Go Test (TUG)	[ALL]	Group 1	Group 2	
	n=24	n=12	n=12	
	Median [25th; 75th percentiles]	Median [25th; 75th percentiles]	Median [25th; 75th percentiles]	p.overall
Baseline	0.1 [0.0; 0.1]	0.1 [0.1; 0.1]	0.0 [0.0; 0.1]	0.19
Week 1	0.1 [0.1; 0.4]	0.2 [0.1; 0.4]	0.1 [0.1; 0.2]	0.17
Week 2	0.1 [0.1; 0.2]	0.1 [0.1; 0.2]	0.1 [<0.1; 0.1]	0.40
Week 3	0.1 [0.1; 0.3]	0.1 [0.1; 0.3]	0.1 [<0.1; 0.2]	0.36
Week 4	0.1 [0.1; 0.4]	0.1 [0.1; 0.4]	0.1 [<0.1; 0.2]	0.23

For descriptive purposes it was assumed that given the limited number of participants in each group, all data were non-normally distributed. Group 1 and Group 2 were thus described by means of medians, 25th and 75th percentiles in Table 4.6. For comparisons between groups at weekly assessments, Mann Whitney U tests were done without adjustment for multiple comparisons. The TUG score at baseline was fairly even between Group 1 and Group 2. No statistical difference was noted between the groups at baseline (p = 0.19). Prior to the intervention, the locomotor performance and the ability to perform sequential motor tasks relative to walking and turning in participants from Group 1 and Group 2 were fairly similar.

The TUG score of participants in both groups improved over the four-week intervention period. Participants from Group 1 and Group 2's locomotor performance and the ability to perform sequential motor tasks relative to walking and turning improved over the four-week intervention period. No statistical difference was noted on the TUG between Group 1 and Group 2 after the intervention period of four (4) weeks ($p = 0.23$). For comparing outcomes at week four (4) adjusting for baseline values as well as the fact that subjects were matched, the mixed model rank ANCOVA analysis was used where the week four (4) and baseline values were ranked and the ranked values were used in the regression analyses. Thus, comparing the difference on ranks adjusted for matching and baseline values was also not statistically significant ($p = 0.56$) between Group 1 and Group 2 after the four-week intervention period.

4.3.3. Results of the assessment of participants' perceptual processing and cognitive function

4.3.3.1. The Star Cancellation Test

(1) Number of stars cancelled during the completion of the Star Cancellation Test over the four-week intervention period

Results of the number of stars "cancelled" during the completion of the Star Cancellation Test over the four-week intervention period are displayed in Table 4.7.

Table 4.7. Results of the number of stars "cancelled" during the completion of the Star Cancellation Test over the four-week intervention period

Star Cancellation Test	[ALL]	Group 1	Group 2	
	(Number of stars) n=24	(Number of stars) n=12	(Number of stars) n=12	
	Median [25th; 75th percentiles]	Median [25th; 75th percentiles]	Median [25th; 75th percentiles]	p.overall
Baseline	39.0[24.2; 51.2]	26.0 [19.5; 44.8]	45.0 [36.8; 53.0]	0.06
Week 1	40.5 [30.5; 50.2]	44.0 [30.5; 51.2]	39.0 [31.2; 44.0]	0.54
Week 2	48.5 [32.5; 53.0]	50.0 [41.0; 53.0]	46.5 [32.5; 51.5]	0.45
Week 3	44.0 [41.0; 52.2]	49.5 [43.0; 53.2]	42.5 [38.0; 52.0]	0.15
Week 4	45.0 [35.5; 53.0]	50.5 [43.0; 53.0]	41.0 [33.5; 47.8]	0.17

For descriptive purposes it was assumed that given the limited number of participants in each group, all data were non-normally distributed. Group 1 and Group 2 were thus described by means of medians, 25th and 75th percentiles in Table 4.7. For comparisons between groups at weekly assessments, Mann Whitney U tests were done without adjustment for multiple comparisons. Near statistical difference was noted on the Star Cancellation Test at baseline between Group 1 and Group 2 ($p = 0.06$). The implications of the Star Cancellation score at baseline are that the level of USN in the near extrapersonal space observed in both groups was fairly similar at the beginning of the study, prior to the intervention.

The number of "cancelled" stars by participants in Group 1 increased over the intervention period of four (4) weeks. Based on the interpretation of the Star Cancellation Test, the USN in the near extrapersonal noted in participants from Group 1 improved over the four-week intervention period. For comparing outcomes at week four (4) adjusting for baseline values as well as the fact that subjects were matched, the mixed model rank ANCOVA analysis was used where the week four (4)

and baseline values were ranked and the ranked values were used in the regression analyses. Thus, comparing the difference on ranks of stars "cancelled" after adjusting for matching and baseline values was statistically significant (p = 0.02) between Group 1 and Group 2. The number of "cancelled" stars by participants from Group 2 decreased over the intervention period of four (4) weeks. Based on the interpretation of the Star Cancellation Test, the USN noted in participants from Group 2 at baseline increased over the four-week intervention period.

(2) The time taken to complete the Star Cancellation Test over the four (4) – week intervention period

Results of the time taken to complete the Star Cancellation Test over the four-week intervention period are indicated in Table 4.8.

Table 4.8. Results of the time taken to complete the Star Cancellation Test over the four-week intervention period

Time taken to complete the Star Cancellation Test	[ALL]	Group 1	Group 2	
	(Time) n=24	(Time) n=12	(Time) n=12	
	Median [25th; 75th percentiles]	Median [25th; 75th percentiles]	Median [25th; 75th percentiles]	p.overall
Baseline	124.7 [108.6; 166.7]	119.8 [108.6; 142.5]	131.0 [106.0; 175.9]	0.77
Week 1	118.5 [70.1; 196.7]	129.8 [69.4; 196.7]	116.1 [73.7; 167.9]	0.69
Week 2	108.2 [66.9; 181.8]	108.2 [56.0; 146.2]	105.8 [71.1; 216.9]	0.49
Week 3	110.6 [77.1; 164.0]	123.0 [78.2; 164.0]	102.5 [77.1; 156.2]	1.00
Week 4	86.9 [71.7; 165.9]	91.1 [74.6; 176.3]	86.9 [70.9; 127.2]	0.73

For descriptive purposes it was assumed that given the limited number of participants in each group, all data were non-normally distributed. Group 1 and Group 2 were thus described by means of medians, 25th and 75th percentiles in Table 4.8. For comparisons between groups at weekly assessments, Mann Whitney U tests were completed without adjustment for multiple comparisons. No statistical difference was noted in the time taken to complete the Star Cancellation Test at baseline between Group 1 and Group 2 ($p = 0.77$). The implications of the Star Cancellation score at baseline imply that the speed with which the Star cancellation Test is completed by both groups was similar at the beginning of the study.

The speed with which both groups completed the Star Cancellation Test improved over the four-week intervention period. For comparing outcomes at week four (4) adjusting for baseline values as well as the fact that subjects were matched, the mixed model rank ANCOVA analysis was used where the week four (4) and baseline values were ranked and the ranked values were used in the regression analyses. Thus, comparing the difference on ranks adjusted for matching and baseline values was not statistically significant ($p = 0.55$) between Group 1 and Group 2 after the four-week intervention period.

4.3.3.2. The Mini-Mental State Examination

(1) Results of the Mini-Mental State Examination over the four-week intervention period

Results of the MMSE over the four-week intervention period are displayed in Table 4.9.

Table 4.9. Results of MMSE over the four-week intervention period of Group 1 and Group 2

MMSE	[ALL]	Group 1	Group 2	
	n=24	n=12	n=12	
	Median [25th; 75th percentiles]	Median [25th; 75th percentiles]	Median [25th; 75th percentiles]	p.overall
Baseline	21.0 [18.0; 24.2]	21.0 [19.5; 23.0]	21.5 [17.0; 25.0]	0.98
Week 1	23.0 [21.0; 24.2]	23.0 [21.8; 25.0]	22.5 [19.0; 24.2]	0.23
Week 2	23.5 [21.0; 25.0]	23.5 [21.0; 25.5]	23.5 [21.8; 25.0]	0.88
Week 3	23.5 [23.0; 26.0]	25.0 [23.0; 26.2]	23.0 [22.8; 24.0]	0.07
Week 4	24.0 [23.8; 26.0]	24.5 [24.0; 26.2]	24.0 [22.8; 25.0]	0.15

For descriptive purposes it was assumed that given the limited number of participants in each group, all data were non-normally distributed. Group 1 and Group 2 were thus described by means of medians, 25th and 75th percentiles in Table 4.9. For comparisons between groups at weekly assessments, Mann Whitney U tests were completed without adjustment for multiple comparisons. The MMSE score of participants in Group 1 and Group 2 at baseline was fairly similar. No statistical difference was noted on the MMSE at baseline between Group 1 and Group 2 ($p = 0.98$). The implications of this baseline MMSE score is that the level of cognitive impairment observed in the two groups was similar at the beginning of the study. Based upon the interpretation of the MMSE scores, participants in both groups suffered from mild cognitive impairment at the beginning of the study (baseline).

The level of cognitive impairment in participants from Group 1 and Group 2 improved over the four-week intervention period. For comparing outcomes at week four (4) adjusting for baseline values as well as the fact that subjects were matched, the

mixed model rank ANCOVA analysis was used where the week four (4) and baseline values were ranked and the ranked values were used in the regression analyses. Thus, comparing the difference on ranks between the groups at week four (4) was not significant (p= 0.096) after adjusting for matching and baseline values. However, participants' MMSE scores at baseline (week 0) and four (4) weeks were further compared with a reference group based on age and education level (Crum et al, 1993).

(2) The Mini-Mental State Examination scores compared to a reference group based on age and educational level

Participants' MMSE scores at baseline (week 0) and four (4) weeks were compared with a reference group based on age and education level (Crum et al, 1993) (Table 4.10).

Table 4.10. MMSE scores at baseline level compared to a reference group based on age and educational level of Group 1 and Group 2 at baseline and week four (4) (Crum et al, 1993)

PARTICIPANTS	BASELINE MMSE score correlate with age and educational-level norm	BASELINE MMSE score does not correlate with age and educational-level norm	WEEK 4 MMSE score correlate with age and educational-level norm	WEEK 4 MMSE score does not correlate with age and educational-level norm
Group 1 (n = 12)	*n* = 2	*n* = 10	*n* = 8	*n* = 4
Group 2 (n = 12)	*n* = 2	*n* = 10	*n* = 4	*n* = 8

The MMSE scores compared to the norm for age and educational level were equal between Group 1 and Group 2 at baseline. Interpretation of the level of cognitive

functioning observed in both Group 1 and Group 2 indicated that two-thirds (66.67%) of participants in Group 1's functioning on cognitive level improved compared to only one third (33.33%) of participants from Group 2's cognitive functioning improved over the first four (4) weeks of intervention.

4.3.4. Results of the assessment of participants' level of anxiety and depression

4.3.4.1. The Hospital Anxiety and Depression Scale

(1) Anxiety subscale over the four-week intervention period

Results of the anxiety and depression subscales over the four-week intervention period are displayed in Table 4.11.

Table 4.11. Results of the anxiety and depression subscales of participants from Group 1 and Group 2 over the four-week intervention period

Anxiety subscale	[ALL]	Group 1	Group 2	
	n=24	n=12	n=12	
	Median [25th; 75th percentiles]	Median [25th; 75th percentiles]	Median [25th; 75th percentiles]	p.overall
Baseline	10.0 [6.8; 12.2]	9.5 [5.8; 13.2]	10.0 [7.8; 11.2]	0.91
Week 1	10.0 [5.5; 11.0]	9.0 [6.8; 11.0]	10.5 [4.0; 11.2]	0.79
Week 2	9.0 [3.8; 11.0]	7.0 [4.5; 10.2]	10.0 [3.8; 11.0]	0.58
Week 3	7.0 [3.8; 9.0]	7.5 [3.0; 9.5]	6.0 [4.8; 8.2]	0.66
Week 4	6.0 [4.8; 11.0]	4.5 [2.0; 10.2]	7.0 [6.0; 11.0]	0.17

Depression subscale	[ALL]	Group 1	Group 2	
	n=24	n=12	n=12	
	Median [25th; 75th percentiles]	Median [25th; 75th percentiles]	Median [25th; 75th percentiles]	p.overall
Baseline	8.0 [5.8; 10.2]	8.0 [3.8; 10.2]	8.5 [6.0; 9.8]	0.64
Week 1	8.0 [4.0; 11.2]	6.0 [3.8; 12.2]	9.5 [5.5; 11.0]	0.51
Week 2	10.0 [6.0; 11.2]	7.0 [5.8; 10.5]	10.5 [9.8; 11.2]	0.23
Week 3	9.5 [4.8; 11.2]	5.0 [2.8; 11.0]	10.0 [8.0; 12.2]	0.14
Week 4	8.5 [3.0; 11.2]	4.0 [3.0; 8.2]	11.0 [8.8; 13.0]	0.03

For descriptive purposes it was assumed that given the limited number of participants in each group, all data were non-normally distributed. Group 1 and Group 2 were thus described by means of medians, 25th and 75th percentiles in Table 4.11. For comparisons between groups at weekly assessments, Mann Whitney U tests were completed without adjustment for multiple comparisons. The anxiety and depression subscale scores at baseline was fairly even between Group 1 and Group 2. No statistical difference was noted between the groups with regard to their level of anxiety ($p = 0.91$) and depression ($p = 0.64$) at baseline. Based on the interpretation of the anxiety and depression subscales at baseline of participants in Group 1 and Group 2 were indicative of the presence of anxiety and depression in both groups at the beginning of the study.

The anxiety and depression subscale scores of participants in Group 1 and Group 2 improved over the four-week intervention period. No statistical difference was noted on the anxiety subscale score between Group 1 and Group 2 after the intervention period of four (4) weeks ($p = 0.17$). The difference on ranks adjusted for matching and baseline values was not statistically significant ($p = 0.10$) between Group 1 and

Group 2 after the four-week intervention period. The level of anxiety post-intervention was fairly equal in participants from both groups.

A statistical difference was noted on the depression subscale between Group 1 and Group 2 after the intervention period of four (4) weeks ($p = 0.03$). For comparing outcomes at week four (4) adjusting for baseline values as well as the fact that subjects were matched, the mixed model rank ANCOVA analysis was used where the week four (4) and baseline values were ranked and the ranked values were used in the regression analyses. Thus, comparing the difference on ranks adjusted for matching and baseline values was statistically significant ($p = 0.02$) between Group 1 and Group 2 after the four-week intervention period. Participants from Group 1's level of depression improved over the four-week intervention period. However, the level of depression in participants from Group 2 increased over the intervention period. The depression subscale score after the four-week intervention period indicated the probable presence of a mood disorder in seven (7) participants in Group 2. Participants from Group 1 demonstrated a decreased level of depression compared to participants from Group 2 after the intervention period.

4.4. Results gathered at week eight (8), week twelve (12), week sixteen (16) and week twenty (20) of participants in Group 1 and Group 2

As result of the small sample group at week eight (8), week twelve (12), week sixteen (16) and week twenty (20), these results were not discussed in this chapter because no valid conclusions can be drawn from these results. Results gathered at week eight (8), week twelve (12), week sixteen (16) and week twenty (20) are, however, presented in Addendum 14.

4.5. Conclusion

In Chapter 4 the demographical data of the participants who participated in this clinical trial and the results of the outcome measures at the pre-determined times during the intervention were described. The participants in the study's functional progress on body impairment level (King-Devick Test ©, Star Cancellation Test, Mini-Mental State Examination and the Hospital Anxiety and Depression Scale) and functional activity level (Stroke Activity Scale, Barthel Index and the Timed Up and Go Test) were assessed and documented on a weekly basis during the four-week intervention period.

A large number of participants were lost to follow-up following discharge from the TRC after the intervention period of four (4) weeks. Contributing factors to the large number lost to follow-up from week eight (8) to week twenty (20) were:

(1) A few participants returned to work and were unable to attend post-discharge follow-up assessments at TRC.

(2) A small number of participants moved from their local residential areas to family members a great distance from TRC and were therefore unable to travel to and from TRC.

(3) Other participants reported that there were no caregivers available to accompany him/her to and from TRC by means of public transport to attend the follow-up appointment.

(4) A large number of participants changed their contact details after discharge from TRC. The researcher was unable to contact the participants to arrange post-discharge follow-up assessments from week eight (8) to week twenty (20). The social worker at TRC was approached for updated contact details and in some cases no additional information was available.

(5) One (n = 1) participant attended physiotherapy as an out-patient at a governmental hospital setting close to her residence, accompanied by her spouse. The participant reported that she and her spouse were unable to travel to and from TRC for post-discharge follow-up assessments, as her husband was unable to take time off from work additional to the once weekly out-patient physiotherapy sessions close to home. The participant was unable to travel independently.

In Chapter 5, the results and findings of the trial will be discussed in the context of relevant literature. The conclusion of the effect of saccadic eye movement training with visual scanning exercises integrated with task-specific activities on the post-stroke functional outcome of participants that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders after four (4) weeks of rehabilitation will also be discussed in Chapter 5.

CHAPTER 5

DISCUSSION AND CONCLUSION

5.1 Introduction

In Chapter 5, the results of the matched-pair randomised controlled trial are discussed in relation to the literature. This study was based on the limitations indicated in the literature as well as on observations by the researcher in clinical practice. The results in this chapter are discussed in logical sequence based on the aims and objectives of the study.

5.2 Comparison between the demographical data of the participants in Group 1 and Group 2

No statistical difference in the demographical data between the groups was found at baseline. It can be concluded that the two groups were comparable with each other regarding age, gender, race, side of the body that was affected post-stroke and dominant side prior to the stroke at the beginning of the study. No statistical difference between the demographical data regarding the residential areas, access to basic services and level of education between the groups was found at baseline. Based on the interpretation, it can be concluded that the two groups were also comparable with each other regarding home environment, socio-economic status and level of education at the beginning of the study and the demographical data. These factors were therefore not expected to have any influence on the outcome of the intervention(s) on the dependent variables.

No statistical difference between the the participants in the two groups' level of functional activity was found at baseline. It can also be concluded that the two groups

were comparable with each other regarding their level of functional activity, specifically their motor function at the beginning of the study. Participants' functional activity level, specifically their residual motor function prior to the intervention, was therefore not expected to have any influence on the outcome of the intervention(s) on the dependent variables.

5.3. The effect of the intervention(s) on body impairment level, functional activity and participation levels

5.3.1. The effect of visual scanning exercises integrated with task-specific activities received by participants from Group 1 versus participants from Group 2 that received task-specific activities alone on participants that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke's oculomotor function.

The objective related to the first aim was to determine the effect of visual scanning exercises integrated with task-specific activities received by participants from Group 1 versus participants from Group 2 that received task-specific activities alone on participants that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke's oculomotor function measured with the King-Devick Test © that consisted of Subtest 1, Subtest 2 and Subtest 3. In each subtest scores taken included (i) the time taken to complete the test (the time indicated the speed with which the test was completed); and (ii) the average errors made during the completion of the subtests on a weekly basis during the intervention period of four (4) weeks as well as eight (8), twelve (12), sixteen (16) and twenty (20) weeks after rehabilitation has been terminated.

In this study, the King-Devick Test © was used to assess residual oculomotor functions and oculomotor visual performance for eye movements during reading (Markowitz, 2006; Chaikin, 2007) over the intervention period of four (4) weeks and to record changes in oculomotor visual performance over time. Participants in Group 1 and Group 2 presented with the following impairments at baseline: (1) decreased residual oculomotor function; and (2) poor oculomotor visual performance during reading.

After the four-week intervention period, participants in Group 1 presented with improved (1) oculomotor function; and (2) oculomotor visual performance during reading as assessed on the King-Devick Subtest 3 compared to participants in Group 2 post-intervention. From the literature summarised in paragraph 2.3 it is clear that oculomotor function have an effect on body impairment, functional activity and participation level. The functional activities that theoretically should improve when visual efficiency improves are personal-hygiene and self-care activities; dressing; walking up and down stairs; walking over uneven surfaces; walking through an aisle; communication; finding objects and reading (Maddock et al, 1981; Schulmann et al, 1987; Zoltan, 1996; Kerkhoff, 2000; Leigh & Kennard, 2004; Chaikin, 2007; Shumway-Cook & Woollacott, 2007; Spering & Gegenfurtner, 2008; Schuett et al, 2009). The result of the change in oculomotor function was compared to the functional ability of participants from Group 1 that received visual scanning exercises integrated with task-specific activities and participants from Group 2 that received task-specific activities alone.

5.3.2. The effect of visual scanning exercises integrated with task-specific activities received by participants from Group 1 versus participants from Group 2 that received task-specific activities alone on participants that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke's functional ability.

The second objective related to the first aim was to determine the effect of visual scanning exercises integrated with task-specific activities received by participants from Group 1 versus participants from Group 2 that received task-specific activities alone on participants that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke's functional ability measured with the Barthel Index on a weekly basis during the intervention period of four (4) weeks as well as eight (8), twelve (12), sixteen (16) and twenty (20) weeks after rehabilitation has been terminated. The result of the change in oculomotor function was compared to the functional activities that are part of the Barthel Index. The activities that are included in the Barthel Index correspond with the activities listed above from the literature.

The interpretation of the Barthel Index at baseline implies that participants in both groups presented with a severe dependence in the performance of ADL. The level of functional performance in ADL of participants in Group 1 improved more during the intervention period compared to participants in Group 2's level of functional performance in ADL whom improved **minimally** over the intervention period. The interpretation of the BI post-intervention implies that participants from Group 2 continued to present with a **severe dependence** in the performance of ADL after four

(4) weeks of intervention. Participants from Group 1 presented with a moderate level of dependence post-intervention.

The decreased oculomotor function and poor oculomotor visual performance during reading noted in participants in Group 2 were associated with a severe dependence in the performance of ADL after the intervention period. The improved oculomotor function and oculomotor visual performance during reading noted in participants in Group 1 were associated with a significantly higher level of functional performance in ADL compared to participants from Group 2 after the four (4) week intervention period. Greater improvement in functional ability was noted over a shorter period of time in participants from Group 1 compared to participants from Group 2.

The results of this study are supported by findings of the previously reviewed literature (Table 2.2.) in the sense that:

(1) Impaired oculomotor function is associated with impairment of postural stability and postural orientation that affects an individual's ability to perform activities of daily living and participation in everyday life situations.

(2) The effect of saccadic eye movement training with visual scanning exercises as an intervention has a statistically significant effect on the oculomotor function of participants that presented with visual perceptual disorders post stroke. Intensive saccadic eye movement training can re-train and strengthen a patient's oculomotor strategies and visual efficiency processes.

(3) The significantly improved oculomotor function improved participants in Group 1's ability to use vision in everyday life with associated improvements in functional ability. The outcome of this study is in line with the outcome in studies listed in Table 2.2.

5.3.3. The effect of visual scanning exercises integrated with task-specific activities received by participants from Group 1 versus participants from Group 2 that received task-specific activities alone on participants that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke's perceptual processing and cognitive functioning.

The third objective related to the first aim was to determine the effect of visual scanning exercises integrated with task-specific activities received by participants from Group 1 versus participants from Group 2 that received task-specific activities alone on participants that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke's **perceptual processing** and **cognitive functioning** measured with the **Star Cancellation Test** and **Mini-Mental State Examination** on a weekly basis during the intervention period of four (4) weeks as well as eight (8), twelve (12), sixteen (16) and twenty (20) weeks after rehabilitation has been terminated.

Based on the literature reviewed in Chapter 2, that the presence of decreased oculomotor function, visual efficiency processes and saccadic eye movements are associated with visual perceptual dysfunction and decreased cognitive functioning which leads to substantial functional disability during daily life activities (Kerkhoff, 2000; Nelles et al, 2009). Perceptual impairments and impairment of cognitive

function are a significant cause of disability following a stroke. Impairments of the perceptual system can adversely affect a patient's ability to safely and efficiently mobilise in and around the house as well as at work and in the community. Perceptual impairments also affect the patient's ability to perform most tasks in the work environment, reading and enjoyment of many recreational activities and as such severely affect a stroke survivor's overall quality of life (Martin & Huxlin, 2010).

Cognitive dysfunction may result in reduced efficiency, speed and persistence of functioning and decreased effectiveness in the performance of routine ADL. Cognitive impairment also causes failure to adapt to novel or problematic situations. Stroke patients with cognitive impairments present with extensive functional disability at discharge from acute hospital settings, increased length of stay in rehabilitation facilities, increased hospital resource use, and increased duration of therapy input (Kalra, 1997; Carter, 1983; Chaikin, 2007; Martin & Huxlin, 2010).

The presence of USN (unilateral spatial inattention), visual-spatial disorders and cognitive functioning in participants in Group 1 and Group 2 were assessed weekly by the Star Cancellation Test and Mini-Mental State Examination (MMSE) based on age and educational norm during the four-week intervention period. Based on the interpretation of the Star Cancellation Test, the USN and perceptual processing noted in participants in Group 2 were better than participants in Group 1 at baseline. Participants from Group 1 demonstrated a significant improvement in the USN and perceptual processing in the near extrapersonal space over the four-week intervention period. The USN noted prior to the intervention period was absent in participants of Group 1 post-intervention. The USN noted in participants from Group

2 at baseline **increased** over the four (4) week intervention period. Participants of Group 2 **continued to present** with USN in the near extrapersonal space post-intervention. After the four-week intervention period, participants in Group 1 presented with (1) decreased USN and; (2) better perceptual processing as assessed on the Star Cancellation Test compared to participants in Group 2 post-intervention.

With regard to cognitive functioning assessed by the Mini-Mental State Examination (MMSE) based on age and educational norm, participants in both groups suffered from mild cognitive impairment at the beginning of the study. A tendency towards improvement of cognitive functioning in participants in Group 1 and Group 2 over the four-week intervention period was noted. However, based on the interpretation of the Mini-Mental State Examination (MMSE) based on age and educational norm more (two thirds) participants in Group 1's cognitive functioning improved than participants in Group 2 (one third) after the four-week intervention period.

From the literature summarised in paragraph 2.4 it is clear that the functional activities that theoretically should improve when perceptual processing and cognitive functioning improve are; (1) hygiene and self-care activities; (2) dressing; (3) eating; (4) kitchen activities; (5) walking up and down stairs; (6) walking over uneven surfaces; (7) walking through an aisle; (8) communication; (9) finding objects; (10) writing; (11) reading; (12) driving; (13) recreational activities and hobbies; and (14) social interactions

The result of the change in perceptual processing and cognitive functioning is compared to the functional activities tested on the Barthel Index. The activities that were included in the Barthel Index correspond with the activities listed above from the literature. As the retraining of visual scanning through saccadic eye movement training in the treatment of visual-perceptual dysfunction and cognitive impairment is based on oculomotor strategies and visual efficiency processes, the results of the King-Devick Subtest 3 also need to be highlighted. Perceptual processing, cognitive function and associated functional ability, oculomotor function and visual efficiency processes of participants in Group 1 and Group 2, were assessed weekly by the Star Cancellation Test, the MMSE based on age and educational norm, the King-Devick Subtest 3 and the Barthel Index during the four-week intervention period.

Participants in Group 2 presented with decreased perceptual processing and cognitive functioning compared to participants from Group 1 after the four-week intervention period. The decreased perceptual processing and cognitive functioning noted in participants in Group 2 were associated with poor oculomotor function, decreased visual efficiency processes, slow saccadic eye movements and a severe dependence in the performance of ADL after the intervention period. The improved perceptual processing and cognitive function noted in participants in Group 1 were associated with a significantly improved oculomotor function, visual efficiency processes, saccadic eye movements and a higher level of functional performance in ADL compared to participants from Group 2 after the four-week intervention period.

The results of this study are supported by findings from previously reviewed literature in Chapter 2 (Table 2.3.) in the sense that; (1) an individual's ability to move effectively and efficiently in their environment is affected by the successful interaction of the individual's cognitive and perceptual systems that precedes the motor response and determines the success or failure of the motor action and task completion within a particular environment. (2) An individual with visual impairment and decreased oculomotor visual performance caused by a stroke may present with cognitive and perceptual deficits affecting their movement and, as such also their functional outcome. (3) The effect of saccadic eye movement training with visual scanning exercises as an intervention has a significant effect on the perceptual processing and cognitive function of participants that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke. (4) The significant improved perceptual processing and cognitive function post-stroke translate to significantly better visual function and ability to perform visually guided activities of daily living following the stroke. (5) Intensive saccadic eye movement training can re-train and enhance a patient's perceptual processing and cognitive functioning with associated improvements in functional ability.

5.3.4. The effect of visual scanning exercises integrated with task-specific activities received by participants from Group 1 versus participants from Group 2 that received task-specific activities alone on participants that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke's anxiety and depression.

Based on literature review it can be concluded that anxiety disorder following stroke (1) significantly interacts with depression to aggravate the severity and course of depression and (2) influences the severity and slowed down the course of recovery from stroke. The presence of depression is significantly associated with the presence of cognitive impairment following stroke (Dam et al, 1989, Egelko et al, 1989; Burvill et al, 1995; Shimoda & Robinson, 1998; Talelli et al, 2004; Kalaria & Ballard, 2001; Jaillard et al, 2010). Murata et al (2000) concluded that major post-stroke depression leads to cognitive impairment, although cognitive impairment does not result in post-stroke depression. The presence of anxiety and depression were assessed weekly by the anxiety and depression subscales of the Hospital Anxiety and Depression Scale (HADS) during the four-week intervention period.

Results from the study demonstrated an improvement in the level of anxiety in participants in Group 1 and Group 2 over the four-week intervention period. However, a difference in level of depression between participants in Group 1 and Group 2 was noted after the four-week intervention period. The level of depression increased in participants from Group 2 compared to participants from Group 1. The level of depression was within normal range in participants in Group 1 compared to Group 2's level of depression that indicated the probable presence of a mood disorder post-intervention.

The effects of the presence of anxiety and depression on cognitive function and functional ability in participants in Group 1 and Group 2 were assessed by the MMSE and the Barthel Index during the four-week intervention period. Based upon the interpretation of the MMSE and depression subscale at baseline, participants in both

groups suffered from mild cognitive impairment and presented with a state of depression at the beginning of the intervention period (baseline). The improved level of depression noted in participants in Group 1 is associated with a significantly improved cognitive function and a higher level of functional performance in ADL compared to participants from Group 2 after the four-week intervention period. A greater amount of improvement in level of depression, cognitive function and functional ability was noted over a shorter period of time in participants from Group 1 compared to participants from Group 2. Participants in Group 2 presented with an increased level of depression compared to participants from Group 1 after the four-week intervention period. The increased level of depression noted in participants in Group 2 is associated with decreased cognitive function and a severe dependence in the performance of ADL after the intervention period.

The results of this study are supported by findings of previously reviewed literature in Chapter 2 (paragraph 2.5) in the sense that;

(1) The state of depression noted in participants from Group 1 and Group 2 before rehabilitation commenced may have contributed to the impaired cognitive functioning prior to intervention.

(2) The presence of depression may significantly be associated with the presence of cognitive impairment following stroke (Dam et al, 1989; Egelko et al, 1989; Burvill et al, 1995; Talelli et al, 2004; Kalaria & Ballard, 2001; Jaillard et al, 2010).

(3) The cognitive and physical outcome of stroke is influenced by the presence of depressive disorders in patients who have suffered a stroke. A major depressive disorder is associated with a significantly greater degree of cognitive impairment following the stroke.

(4) Anxiety disorder significantly interacts with depression to influence the severity and course of depression, outcome of ADL and course of recovery in social functioning at long-term follow-up (Astrom, 1996; Shimoda & Robinson, 1998).

(5) Because anxiety disorder does not affect cognitive impairment, it may be concluded that the cognitive impairment observed in the trial was not affected by the presence of anxiety. However, the presence of anxiety interacts with depression and plays an important role in the functional prognosis of patients with post-stroke depression (Astrom, 1996; Shimoda & Robinson, 1998).

5.4. Participation level

The fourth objective related to the second aim of the study was to determine the effect of visual scanning exercises integrated with task-specific activities received by participants from Group 1 versus participants from Group 2 that received task-specific activities alone on participants that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke's **quality of life** measured with the **Stroke Impact Scale Version 3.0** and the **Walking ability questionnaire** eight (8), twelve (12), sixteen (16) and twenty (20) weeks after rehabilitation has been terminated.

However, during the follow-up following discharge from the TRC after the intervention period of four (4) weeks a large number of participants were lost to follow-up. As a result of the small sample group at week eight (8), week twelve (12), week sixteen (16) and week twenty (20), these results are not discussed in this chapter because no valid conclusions can be drawn from these results. . Results gathered at week

eight (8), week twelve (12), week sixteen (16) and week twenty (20) are, however, presented in Addendum 14.

5.5. Discussion on the aims of the study

Based on the results of the oculomotor visual performance and the associated functional ability, perceptual processing and cognitive functioning, as well as the level of anxiety and depression, noted in participants in Group 1 and Group 2 after four (4) weeks of rehabilitation as indicated in the preceding paragraphs, the first aim of the study was only partially reached. The effect of task-specific activities as an intervention approach versus the effect of visual scanning exercises integrated with task-specific activities as an intervention approach on participants that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke's (1) oculomotor visual performance; (2) functional ability; and (3) perceptual processing and cognitive functioning was determined on a weekly basis during the intervention period of four (4) weeks.

However, the effect of task-specific activities as an intervention approach versus the effect of visual scanning exercises integrated with task-specific activities as an intervention approach on participants that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke's (1) oculomotor visual performance; (2) functional ability; and (3) perceptual processing and cognitive functioning was not determined at eight (8), twelve (12), sixteen (16) and twenty (20) weeks after rehabilitation has been terminated. The aim was therefore only partially reached due to a large number of participants that were lost to

follow-up following discharge from the TRC after the intervention period of four (4) weeks. As a result of the small sample group at week eight (8), week twelve (12), week sixteen (16) and week twenty (20), these results will not be discussed in this chapter because no valid conclusions can be drawn from these results. Results gathered at week eight (8), week twelve (12), week sixteen (16) and week twenty (20) are, however, presented in Addendum 14.

The second aim of the study was not reached. The effect of task-specific activities as an intervention approach versus the effect of visual scanning exercises integrated with task-specific activities as an intervention approach on participants that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke's quality of life eight (8), twelve (12), sixteen (16) and twenty (20) weeks after rehabilitation has been terminated was not determined. As a result of the small sample group due to a large number of participants lost to follow-up following discharge from the TRC after the intervention period of four (4) weeks, these results will not be discussed in this chapter because no valid conclusions can be drawn from these results. Results gathered at week eight (8), week twelve (12), week sixteen (16) and week twenty (20) are, however, presented in Addendum 14.

5.6. Limitations of the study

(1) The sample size was limited by the number of participants that could be recruited in a reasonable time. The small size of the sample group limits the generalisability of the findings of the double blind matched clinical trial. Nevertheless, the results of the study corresponded with previous findings in the stroke population. This fact emphasises the importance of saccadic eye movement training with visual scanning

exercises integrated with task-specific activities as an intervention with participants that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke.

To fit the trial into an acceptable timespan, a double blind randomised matched clinical trial was conducted. Although a randomised controlled trial was not conducted, participants who met the inclusion and exclusion criteria of the study (paragraph 3.7.1. and paragraph 3.7.2.) were screened based on their functional activity level as measured on the Stroke Activity Scale (SAS) by an independent assessor when they were admitted to the TRC. The process was repeated until twelve (12) participants were recruited and allocated to each group. The participants from Group 1 and Group 2 were blinded to the group they were assigned to (Blanton et al, 2006). Following the matching procedure, all participants were adequately matched with regard to their physical condition and randomised based on the outcome. The randomised principle (matched-pair randomised controlled) was applied in combination with the matching of the participants (Chan, Chan & Au, 2006).

Participants were matched, randomly paired and allocated based on their scores on the SAS to ensure that participants in the two groups were comparable with regard to their functional activity level. The two (2) groups were comparable with each other regarding demographic (age, gender, race, affected side post-stroke and dominant side prior to the stroke), home environment, socio-economic status and level of education at the beginning of the study. The demographical data was therefore not expected to have any influence on the outcome of the intervention(s) on the dependent variables.

(2) The drop-out of participants after they were discharged from TRC was a major limitation, although participants received remuneration for travelling costs and were contacted telephonically on a regular basis. The large loss of participants to follow-up prevented the researcher from determining if the long-term effect of the treatment was sustained and whether oculomotor function, perceptual processing, cognitive function, the level of anxiety as well as depression and the associated functional ability spontaneously improved in the control group.

(3) Although two (2) physiotherapists were responsible for the treatment of one (1) group, the principal investigator orientated and trained the two (2) physiotherapists in the task-specific treatment approach to rehabilitation of participants who had sustained a stroke and who suffered from unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke, to ensure that there was no difference in the application of the task specific treatment approach to participants post stroke.

Orientation and in-service training of the two (2) physiotherapists took place prior to the commencement of the trial. The participants in Group 1 and 2 were treated in separate venues to control blinding of the participants throughout the study. The two (2) physiotherapists who treated the participants in Group 1 and Group 2 based their treatment on a client-centered approach to rehabilitation. The client-centered approach to rehabilitation entails the facilitation of active participation and self-responsibility of the participants and their caregivers in the rehabilitation process (Hammell, 2004). The fact that the two physiotherapists may not have complied with

the principles of the task-based client-centered approach may be a potential limitation.

(4) The fact that visual-perceptual processing and cognitive function could have been addressed by the occupational therapist and/or the speech-and language therapist is a possibility and is not accounted for in this study.

(5) The researcher did not find any publication with regards to the King-Devick Test's reliability in the stroke population (Lieberman et al, 1983; Oride et al, 1986).

(6) The weekly assessments on the outcome measures may have caused bias because participants probably got to know the outcome measures very well. Using the Mini-Mental State Examination and the SAS regularly could have contributed to a learnt effect and influenced the results.

(7) Emotional liability of participants may have contributed to the level of depression noted in the participants and is not accounted for in this study.

(8) The probable presence of the human immunodeficiency virus (HIV) in the participants, and whether the presence of the HIV may have had an influence on the visual-perceptual processing, cognitive function and associated functional disability and their response and maintenance of their functional gain after the stroke, in the participants were not verified in this study.

5.7. Suggestions for future research

(1) In any follow-up study a larger sample group of participants needs to be recruited. To achieve this, other rehabilitation facilities that are equipped to perform assessments and the intervention need to be incorporated to participate in a multicentre clinical trial.

(2) Inputs from multiple sensory systems including the vestibular system, somatosensory (proprioceptive, cutaneous and joint receptors) and visual system to detect the body's position, motion in space in relation to gravity and the environment are integrated to provide information to establish postural orientation and stability. The vestibular system provides the CNS with information relating to the position and motion of the head with respect to gravity and inertial forces, and as such provide a reference for postural control (Shumway-Cook & Woollacott, 2007). The vestibular system specifically the vestibulo-ocular reflex (VOR) and the optokinetic systems (eye movements) regulate gaze stabilisation. The function of these systems is to maintain a stable retinal image during head motion. Failure to maintain gaze stabilisation may result in the perception that the environment surrounding the individual is blurry or in motion, thereby affecting the individual's ability to stabilise him or herself in relation to the world, which results in impaired postural control and limitation of motor behaviour. Functional impairments as a result of impaired postural control and motor behaviour include difficulty with ambulation and ADL, including driving (Gorman, 2007; Shumway-Cook & Woollacott, 2007).

It is therefore recommended that a continuation of this research should include the assessment of the VOR in a similar trial on patients post-stroke. It is recommended that the follow-up study should determine the effect of an intervention consisting of

VOR-training and saccadic eye movement training integrated with task-specific activities on participants presenting with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders' functional ability and quality of life on patients post-stroke.

(3) Assessment and documentation of participants' functional progress on body impairment, functional activity and participation level as well as their perceived quality of life in response to an intervention consisting of VOR-training and visual scanning techniques through saccadic eye movement training integrated with task-specific activities should include Dynamic Gait Index (DGI). The DGI was developed by Shumway-Cook (1997) to assess a patient's ability to modify gait in response to changing task demands in ambulatory patients with balance impairments. The outcome measure has been used:

a. To measure mobility in older adults with a score below nineteen (>19) as an indicator of increased fall risk (Shumway-Cook & Woollacott, 2007); and

b. To predict fall risk in patients with vestibular dysfunction (Whitney et al, 2000).

5.8. Conclusion

Motor impairment is the most common and widely recognised impairment caused by a stroke. Motor impairment entails the loss or limitation of muscle control, impaired movement and decreased mobility (Langhorne et al, 2009). The combination of motor disability and visual-perceptual defects all contribute to an individual's disability in the home environment, workplace, community participation and decreased quality of life.

Appropriate and effective movement in complex and various environments is guided by the visual system. The importance of the visual system on body impairment-, functional activity-and participation levels has been identified and described in the previous chapters. A lack of evidence on the integration of visual scanning exercises as part of, and integrated with Physiotherapy has been identified in the literature regardless of the important role vision plays in movement and ultimately the functional ability of the patient. The lack of the integration of saccadic eye movement training with visual scanning exercises with task-specific activities described in the literature and regular application thereof in clinical practice urged the researcher to investigate the effect of visual scanning exercises integrated with the task-specific activities as part of physical rehabilitation in participants who have sustained a stroke, and who suffered from unilateral spatial inattention, visual-spatial disorders or visual-constructive disorders as result thereof.

Results of the matched-pair randomised controlled trial indicated that the effect of saccadic eye movement training with visual scanning exercises integrated with task specific activities as an intervention for participants that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke resulted in significant improvement in impairment level. This improvement is related to improved oculomotor visual performance, visual attention, depression as well as results on functional activity level with regard to the ability to independently complete ADL after four (4) weeks of rehabilitation.

It may therefore be concluded that saccadic eye movement training with visual scanning exercises integrated with task-specific activities as an intervention tend to

improve functional ability in participants that presented with unilateral spatial inattention, visual-spatial disorders and visual-constructive disorders post-stroke.

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ADDENDUMS

ADDENDUM 1: Ethical approval by the Ethics Committee of the Faculty of Health Sciences at the University of Pretoria (S33/2009)

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UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Health Sciences Research Ethics Committee

6/05/2009

Number :	**S33/2009**
Title :	The effect of visual scanning exercises integrated into task-specific activities on the functional ability in patients with visual perceptual disorders post stroke
Investigator :	Andoret van Wyk, Department of Physiotherapy, University of Pretoria (SUPERVISOR: Dr Carina A Eksteen)
Sponsor :	**None**
Study Degree:	M.Physt (Research)

This Student Protocol has been considered by the Faculty of Health Sciences Research Ethics Committee, University of Pretoria on 5/05/2009 and found to be acceptable.

Prof AG Nienaber	(female) BA (Hons) (Wits); LLB (Pretoria); LLM (Pretoria); LLD (Pretoria); Diploma in Datametrics (UNISA)
Prof V.O.L. Karusseit	MBChB; MFGP (SA); M.Med (Chir); FCS (SA)
Prof J A Ker	Deputy Dean: MBChB (Pretoria); MMed (Int) (Pretoria); MD (Pretoria)
Prof M Kruger	(female) MBChB.(Pretoria) M. Med.Paed.(Pretoria) M. Phil. (Applied Ethics) (Stell) PhD.(Leuven) (Special Advisory Member)
Dr N K Likibi	MBChB.; Med.Adviser (Gauteng Dept. of Health)
Dr T S Marcus	(female) BSc (LSE), PhD (University of Lodz, Poland)
Mrs M C Nzeku	(female) BSc (NUL); MSc Biochem (UCL,UK)
Snr Sr J. Phatoli	(female) BCur (Et.Al); BTech Oncology
Mr Y M Sikweyiya	MPH (Umea University Umea, Sweden); Master Level Fellowship (Research Ethics) (Pretoria and UKZN); Post Grad. Diploma in Health Promotion (Unitra); BSc in Health Promotion (Unitra)
Dr L Schoeman	(female) BPharm (North West); BAHons (Psychology)(Pretoria); PhD (KwaZulu-Natal); International Diploma in Research Ethics (UCT)
Dr R Sommers	Deputy Chairperson: (female) MBChB; M.Med (Int); MPhar.Med
Prof C W van Staden	CHAIRPERSON: MBChB (Pretoria); MMed(Psych) (Pretoria); MD (Warwick,UK); FCPsych (SA); FTCL (London); UPLM (UNISA)
Prof TJP Swart	BChD, MSc (Odont), MChD (Oral Path)
Dr AP van der Walt	BChD, DGA (Pretoria)

Student Ethics Sub-Committee

Prof R S K Apatu	MBChB (Legon,UG); PhD (Cantab); PGDip International Research Ethics (UCT)
Dr A M Bergh	(female) BA (RAU); BA (Hons) (Linguistics) (Stell); BA (Hons) (German) (UNISA); BEd (Pretoria); PhD (Pretoria); SED (Stell)
Mrs N Briers	(female) BSc (Stell); BSc Hons (Pretoria); MSc (Pretoria); DHETP (Pretoria)
Dr S I Cronje	BA (Pretoria); BD (Pretoria); DD (Pretoria)
Dr M M Geyser	(female) MBChB (Pretoria); BSc (Computer Science)(Pretoria); BSc Hons (Pharm) (Potchefstroom); MpraxMed (Pretoria); MSc (Clinical Epidemiology) (Pretoria); FCEM (SA); Dip PEC (SA)
Prof D Millard	(female) B.lur (Pretoria); LLB (Pretoria); LLM (Pretoria); AIPSA Diploma in Insolvency Law (Pretoria); LLD (UJ)
Dr S A S Olorunju	BSc (Hons). Stats (Ahmadu Bello University –Nigeria); MSc (Applied Statistics (UKC United Kingdom); PhD (Ahmadu Bello University – Nigeria)
Dr L Schoeman	CHAIRPERSON: (female) BPharm (North West); BAHons (Psychology)(Pretoria); PhD (KwaZulu-Natal); International Diploma in Research Ethics (UCT)
Dr R Sommers	Deputy Chairperson (female) MBChB; M.Med (Int); MPhar.Med

DR L SCHOEMAN; BPharm, BA Hons (Psy), PhD;
Dip. International Research Ethics
CHAIRPERSON of the Faculty of Health Sciences
Student Research Ethics Committee, University of Pretoria

DR R SOMMERS; MBChB; M.Med (Int); MPhar.Med.
DEPUTY CHAIRPERSON of the Faculty of Health Sciences
Research Ethics Committee, University of Pretoria

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7.

Number	:	**S33/2009**
Title	:	The effect of visual scanning exercises integrated into task-specific activities on the functional ability in patients with visual perceptual disorders post stroke
Investigator	:	Andoret van Wyk, Department of Physiotherapy, University of Pretoria (SUPERVISOR: Dr Carina A Eksteen)
Sponsor	:	**None**
Study Degree:		M.Physt (Research)

Comments/Suggestions received from members

Dr R Sommers	Acceptable
Dr S A S Olorunju	Acceptable
Dr M M Geyser	• Acceptable, awaiting consent from Tshwane rehabilitation centre **(Comments received from Investigator. Available on file.)**
Dr S I Cronje	Acceptable
Prof D Millard	No comment

Minutes of Meeting: 5 May 2009

- Investigator, Andoret van Wyk and Supervisor, Dr Carina A Eksteen present at the meeting.
- The CEO of the Tshwane Rehabilitation Centre has signed the Gautneg Application Form.
- The visual scanning exercises not included for the one group is problematic. This is at the moment not part of the "standard of care" in physiotherapy, therefore this study is acceptable as it is.
- Approved.

ADDENDUM 2: Permission granted by the Acting Chief Executive Officer of the Tshwane Rehabilitation Centre

Updated 28-02-2007

Permission to access Records / Files / Data base at TSHWANE REHABILITATION CENTER.

TO: ..... [Name]
Chief Executive Officer/Information Officer

.....
Hospital / Clinic

FROM : MISS ANDORET VAN WYK [Name]
Investigator

.....
Hospital / Clinic OR University of Pretoria

Re: Permission to do research at TSHWANE REHABILITATION CENTER Hospital / Clinic

TITLE OF STUDY: THE EFFECT OF VISUAL SCANNING EXERCISES INTEGRATED INTO TASK-SPECIFIC ACTIVITIES ON THE FUNCTIONAL ABILITY IN PATIENTS WITH VISUAL PERCEPTUAL DISORDERS POST STROKE.

This request is lodged with you in terms of the requirements of the Promotion of Access to Information Act. No. 2 of 2000.

I am a researcher / student at the Department of PHYSIOTHERAPY at the University of Pretoria.
I am working with DR CARINA A EKSTEEN[1]. I herewith request permission on behalf of all of us to conduct a study on the above topic on the hospital / clinic grounds. This study involves access to patient records.

The researchers request access to the following information: clinical files, record books and data bases.

We intend to publish the findings of the study in a professional journal and/ or to present them at professional meetings like symposia, congresses, or other meetings of such a nature.

We intend to protect the personal identity of the patients by assigning each individual a random code number.

We undertake not to proceed with the study until we have received approval from the Faculty of Health Sciences Research Ethics Committee, University of Pretoria.

Yours sincerely

Avanwyk
Signature of the Principal Investigator

Permission to do the research study at this hospital / clinic and to access the information as requested, is hereby approved.

Title and name of Chief Executive Officer: Ms FB Law

Name of hospital / ~~clinic~~: Tshwane Rehab Centre

Signature: _____

Date: 3/4/07

GAUTENG PROVINCIAL GOVERNMENT
DEPARTMENT OF HEALTH
~~Official Stamp~~
- 3 APR 2009
TSHWANE REHABILITATION CENTRE
Cnr DR SAVAGE & SOUTPANSBERG ROADS
PRETORIA

[1] Title(s) and surname(s) of co-investigator(s) / supervisor(s)

INITIAL CONSENT BY DEPARTMENTAL HEAD

I Anna Maria Marais head of Physiotherapy department of Faculty of Health Sciences ~~hospital~~ in consultation with the Chief Executive Officer / Superintendent of this Hospital grant permission to submit an application to conduct a clinical trial/evaluation to the Chairperson (s) of the relevant Ethics, Research and Therapeutic Committees of this Hospital.

The officer conducting the trial/evaluation will be Andoret van Wyk.

Designation / Rank _____

HEAD OF DEPARTMENT			DATE		
Signature	Initial(s)	Surname	Day	Month	Year
[signature]	AM	Marais	27	03	2009

TRIALIST-INVESTIGATOR			DATE		
Signature	Initial(s)	Surname	Day	Month	Year
[signature]	A	VAN WYK	25	03	2009

APPROVAL BY HOSPITAL CHIEF EXECUTIVE OFFICER:

I Francoise Law Chief Executive Officer / ~~superintendent of~~ Tshwane Rehab Centre ~~Hospital~~, hereby agree that this trial / evaluation be conducted in the Physiotherapy Department of this hospital.

The officer conducting the trial will be : Andoret van Wyk

The officer controlling supplies will be: _____

HOSPITAL C.E.O. / Superintendent			DATE		
Signature	Initial(s)	Surname	Day	Month	Year
[signature]	FB	LAW	3	April	2009

ADDENDUM 3: The Mini-Mental State Examination

MINI-MENTAL STATE EXAMINATION (MMSE)

Patient Name: _____
Rater Name: _____
Date: _____

Activity	Score
ORIENTATION – one point for each answer	
Ask: "What is the: (year)(season)(date)(day)(month)?"	____
Ask: "Where are we: (state)(county)(town)(hospital)(floor)?"	____
REGISTRATION – score 1,2,3 points according to how many are repeated	
Name three objects: Give the patient one second to say each.	
Ask the patient to: repeat all three after you have said them.	
Repeat them until the patient learns all three.	____
ATTENTION AND CALCULATION – one point for each correct subtraction	
Ask the patient to: begin from 100 and count backwards by 7.	
Stop after 5 answers. (93, 86, 79, 72, 65)	____
RECALL – one point for each correct answer	
Ask the patient to: name the three objects from above.	____
LANGUAGE	
Ask the patient to: identify and name a pencil and a watch. (2 points)	____
Ask the patient to: repeat the phrase "No ifs, ands, or buts." (1 point)	____
Ask the patient to: "Take a paper in your right hand, fold it in half, and put it on the floor " (1 point for each task completed properly)	____
Ask the patient to: read and obey the following: "Close your eyes." (1 point)	____
Ask the patient to: write a sentence. (1 point)	____
Ask the patient to: copy a complex diagram of two interlocking pentagons. (1 point)	____
TOTAL (0–30):	____

References

Folstein MF, Folstein SE, McHugh PR. "Mini-mental state." A practical method for grading the cognitive state of patients for the clinician.
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ADDENDUM 4a: Informed consent to participate in the study

Informed consent to participate in the study

Informed consent to participate in the study

The effect of visual scanning exercises integrated into task-specific activities on the functional ability in patients with visual perceptual disorders post stroke.

INTRODUCTION

You are invited to volunteer for a research study. This information leaflet is to help you to decide if you would like to participate. Before you agree to take part in this study you should fully understand what is involved. If you have any questions, which are not fully explained in this leaflet, do not hesitate to ask the investigator. You should not agree to take part unless you are completely happy about all the procedures involved in the study. In the best interests of your health, it is strongly recommended that you discuss with or inform your personal doctor of your possible participation in this study, wherever possible.

WHAT IS THE PURPOSE OF THIS TRIAL?

You had recently suffered a stroke and the investigator would like you to consider taking part in a research study on the rehabilitation of patients post stroke. The rehabilitation will consist of activities that you have to re-learn to perform in order to resume functional activities in everyday life (task-specific activities). Visual scanning exercises (specific eye movements) together with above-mentioned activities also form part of the intervention. We know that this treatment has a positive effect on the functional outcome of people who sustained a stroke.

During the study you will receive either visual scanning exercises (specific eye movements) together with task-specific activities or task-specific activities without visual scanning exercises (specific eye movements). Both interventions are a standard form of treatment nationally and internationally and are not something "strange".

WHAT IS THE DURATION OF THIS TRIAL?

If you decide to take part you will be one of approximately 20 patients. The study will last for 16 weeks. You will be asked to visit the investigator seven times as during the 16 weeks as per the following schedule:

↓ ↓ ↓ ↓ ↓

Day 1----------Day 8----------Day 15----------Day 22----------Day 28

Week 8 post discharge ----------Week 16 post discharge

Assessment of your functional ability and progress will be conducted at each visit. You will be asked to fill in forms with questions pertaining to your ability to participate in all activities of daily living and re-integration into the community after discharge from the facility as well as how the stroke affects your life.

HAS THE TRIAL RECEIVED ETHICAL APPROVAL?

This clinical trial Protocol was submitted to the Faculty of Health Sciences Research Ethics Committee, University of Pretoria and written approval has been granted by that committee. The study has been structured in accordance with the Declaration of Helsinki (last update: October 2000), which deals with the recommendations guiding doctors in biomedical research involving human/subjects. A copy of the Declaration may be obtained from the investigator should you wish to review it.

WHAT ARE MY RIGHTS AS A PARTICIPANT IN THIS TRIAL?

Your participation in this research trial is entirely voluntary and you can refuse to participate or stop at any time without stating any reason. Your withdrawal will not affect your access to other medical care for your stroke. The investigator retains the right to withdraw you from the study if it is considered to be in your best interest. If it is discovered that you did not give an accurate history or did not follow the guidelines of the trial you may be withdrawn from the trial at any time.

IS ALTERNATIVE TREATMENT AVAILABLE?

Alternative treatment in the form of general exercise therapy is often used to treat patients with stroke. If you decide not to take part in this study it is possible that your physiotherapist may treat you with other forms of exercise therapy.

MAY ANY OF THESE TRIAL PROCEDURES RESULT IN DISCOMFORT OR INCONVENIENCE?

None of the trial procedures will result in discomfort or inconvenience to you.

WHAT ARE THE RISKS INVOLVED IN THIS TRIAL?

There are no risks involved in this trial.

ARE THERE ANY WARNINGS OR RESTRICTIONS CONCERNING MY PARTICIPATION IN THIS TRIAL?

Other co-morbid disease or disability such as cancer or amputation that will prevent or limit assessment of your functional progress as well as the participation in other pharmacological or rehabilitation intervention studies which can lead to confounding of the results of this study will restrict your participation in this trial. Also if you are planning to move from your local area within twenty (20) weeks since you had been admitted to the study you will be excluded from the trial.

INSURANCE AND FINANCIAL ARRANGEMENTS

Neither you nor your medical scheme or the rehabilitation centre will be expected to pay for any study assessments and treatment during the course of the trial.

SOURCE OF ADDITIONAL INFORMATION

For the duration of the trial, you will be under the care of Tshwane Rehabilitation Centre. If at any time between your visits you have any questions during the trial, please do not hesitate to contact the facility. The telephone number is (012) 354 1000 through which you can reach the authorized person. Please stay in contact with your medical doctor at Tshwane Rehabilitation Centre or Steve Biko Academic Hospital and attend all appointments arranged with the doctor.

CONFIDENTIALITY

All information obtained from the patients during the course of this trial is strictly confidential. Information that may be reported in scientific journals will not include any information which identifies you as a participant in this trial. In connection with this trial, it might be important for the Faculty of Health Sciences Research Ethics Committee, University of Pretoria as well as your personal doctor to have access to your medical records pertaining to this trial.

Any information uncovered regarding your trial results will be held in strict confidence. You will be informed of any finding of importance to your health or continued participation in this trial but this information will not be disclosed to any third party in addition to the ones mentioned above without your written permission.

INFORMED CONSENT

I hereby confirm that I have been informed by the investigator, Andoret van Wyk about the nature, conduct, benefits and risks of clinical trial I have also received, read and understood the above written information (Participant Information Leaflet and Informed Consent) regarding the clinical trial.

I am aware that the results of the trial, including personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed into a trial report.

I may, at any stage, without prejudice, withdraw my consent and participation in the trial. I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the trial.

Participant's name _____
(Please print)

Participant's signature _____ Date _____

I, Andoret van Wyk herewith confirm that the above participant has been informed fully about the nature, conduct and risks of the above trial.

Investigator's name _____
(Please print)

Investigator's signature _____ Date _____

Witness's name* _____ Witness's signature _____

ADDENDUM 4b: Participant characteristics

a. Age ___ **years**

b. Gender

Male ☐

Female ☐

c. Race

White ☐

Black ☐

Coloured ☐

Indian ☐

d. Affected side

Left ☐

Right ☐

e. Dominant side

Left ☐

Right ☐

f. Stroke type

Ischeamic ☐

Hemorrhagic ☐

g. Type of residence

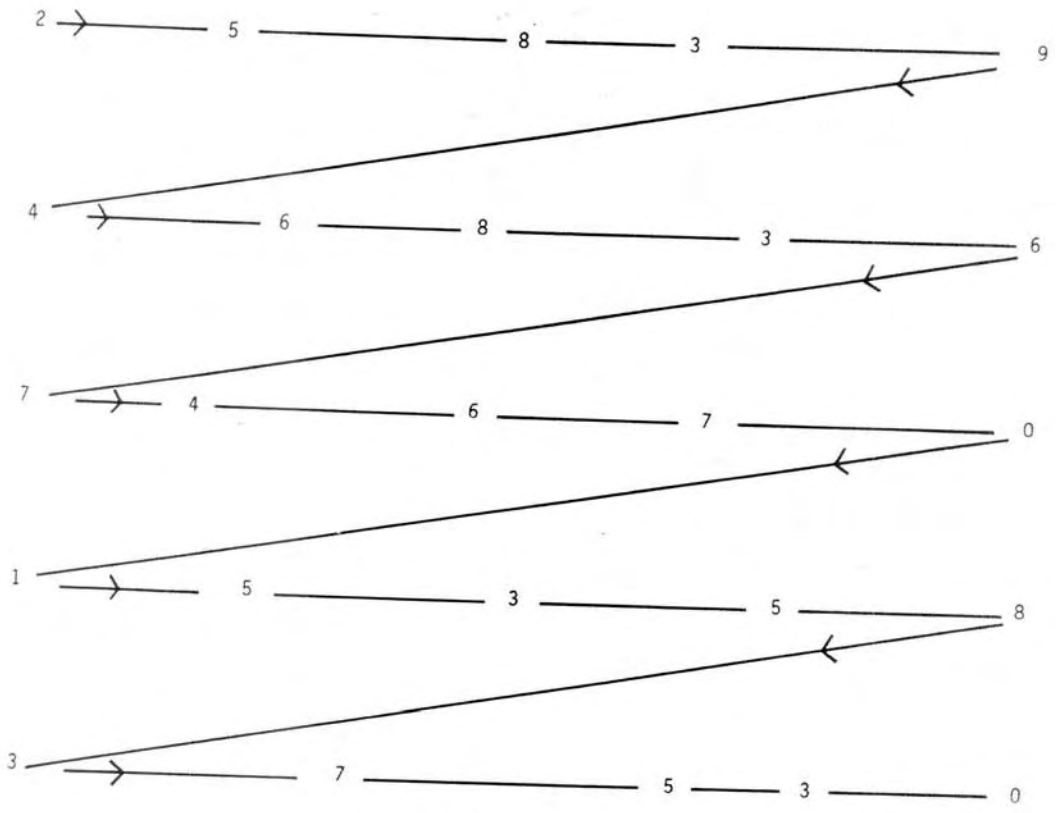
Brick house	☐
Informal housing (“shack”)	☐
Retirement village: Room	☐
Retirement village: House	☐

h. Level of education

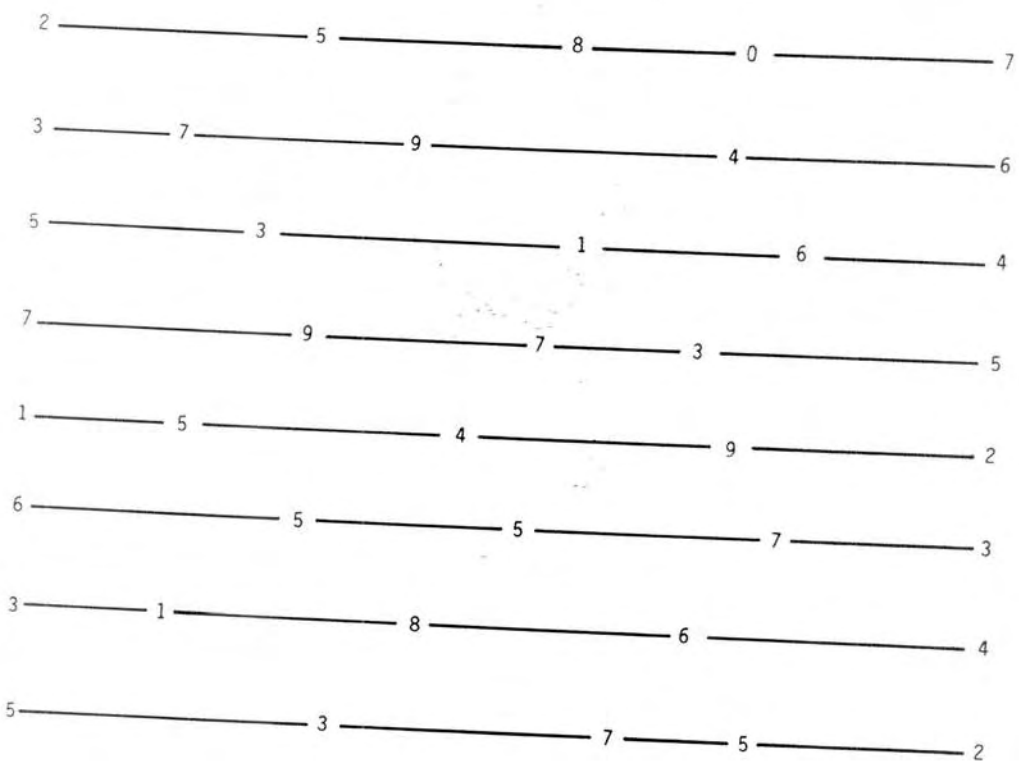
Primary school	☐
High School	☐
Tertiary education	☐

i. Type of work .....

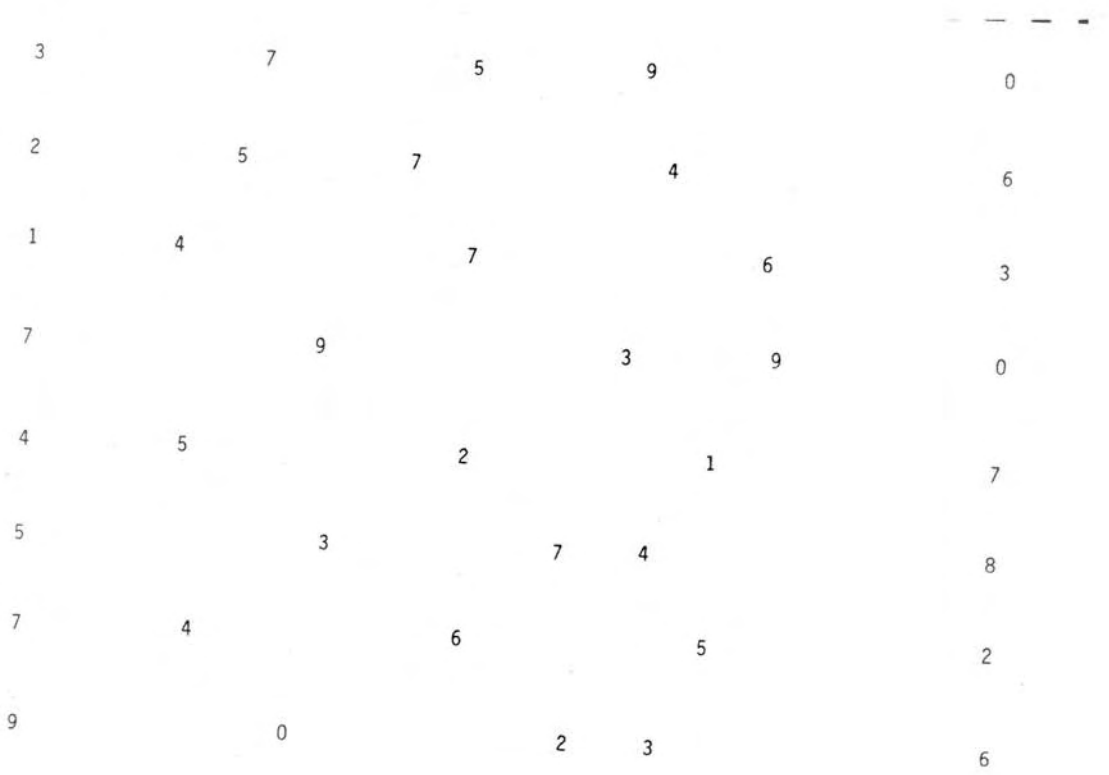
ADDENDUM 5: The King-Devick Test ©



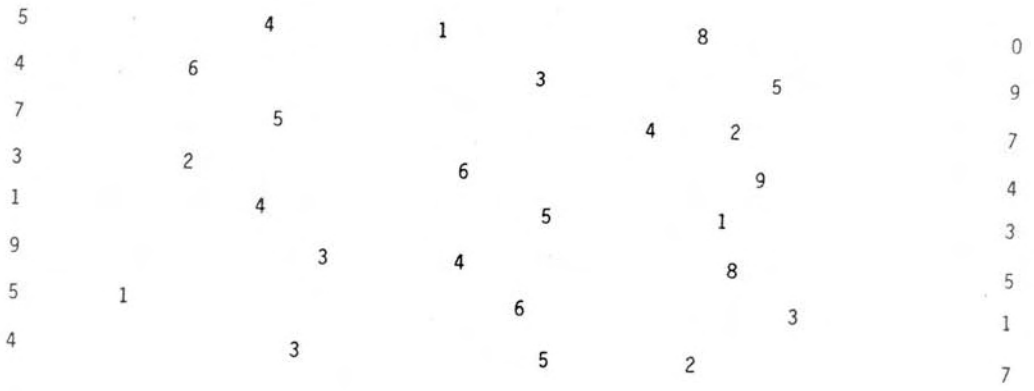
DEMONSTRATION CARD



TEST I



TEST II



TEST III

NYSOA K-D TESTS

Sample Score Sheet

I	II	III
2 - 5 - 8 - 0 - 7	3 - 7 - 5 - 9 - 0	5 - 4 - 1 - 8 - 0
3 - 7 - 9 - 4 - 6	2 - 5 - 7 - 4 - 6	4 - 6 - 3 - 5 - 9
5 - 3 - 1 - 6 - 4	1 - 4 - 7 - 6 - 3	7 - 5 - 4 - 2 - 7
7 - 9 - 7 - 3 - 5	7 - 9 - 3 - 9 - 0	3 - 2 - 6 - 9 - 4
1 - 5 - 4 - 9 - 2	4 - 5 - 2 - 1 - 7	1 - 4 - 5 - 1 - 3
6 - 5 - 5 - 7 - 3	5 - 3 - 7 - 4 - 8	9 - 3 - 4 - 8 - 5
3 - 1 - 8 - 6 - 4	7 - 4 - 6 - 5 - 2	5 - 1 - 6 - 3 - 1
5 - 3 - 7 - 5 - 2	9 - 0 - 2 - 3 - 6	4 - 3 - 5 - 2 - 7

ADDENDUM 6: The Barthel Index

THE BARTHEL INDEX

Patient Name: _____
Rater Name: _____
Date: _____

Activity	Score
FEEDING 0 = unable 5 = needs help cutting, spreading butter, etc., or requires modified diet 10 = independent	_____
BATHING 0 = dependent 5 = independent (or in shower)	_____
GROOMING 0 = needs to help with personal care 5 = independent face/hair/teeth/shaving (implements provided)	_____
DRESSING 0 = dependent 5 = needs help but can do about half unaided 10 = independent (including buttons, zips, laces, etc.)	_____
BOWELS 0 = incontinent (or needs to be given enemas) 5 = occasional accident 10 = continent	_____
BLADDER 0 = incontinent, or catheterized and unable to manage alone 5 = occasional accident 10 = continent	_____
TOILET USE 0 = dependent 5 = needs some help, but can do something alone 10 = independent (on and off, dressing, wiping)	_____
TRANSFERS (BED TO CHAIR AND BACK) 0 = unable, no sitting balance 5 = major help (one or two people, physical), can sit 10 = minor help (verbal or physical) 15 = independent	_____
MOBILITY (ON LEVEL SURFACES) 0 = immobile or < 50 yards 5 = wheelchair independent, including corners, > 50 yards 10 = walks with help of one person (verbal or physical) > 50 yards 15 = independent (but may use any aid; for example, stick) > 50 yards	_____
STAIRS 0 = unable 5 = needs help (verbal, physical, carrying aid) 10 = independent	_____
TOTAL (0–100):	_____

Provided by the Internet Stroke Center — www.strokecenter.org

The Barthel ADL Index: Guidelines

1. The index should be used as a record of what a patient does, not as a record of what a patient could do.
2. The main aim is to establish degree of independence from any help, physical or verbal, however minor and for whatever reason.
3. The need for supervision renders the patient not independent.
4. A patient's performance should be established using the best available evidence. Asking the patient, friends/relatives and nurses are the usual sources, but direct observation and common sense are also important. However direct testing is not needed.
5. Usually the patient's performance over the preceding 24-48 hours is important, but occasionally longer periods will be relevant.
6. Middle categories imply that the patient supplies over 50 per cent of the effort.
7. Use of aids to be independent is allowed.

References

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Maryland State Medical Journal 1965;14:56-61. Used with permission.

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***Arch Phys Med Rehabil.* 1980;61:355-358.**

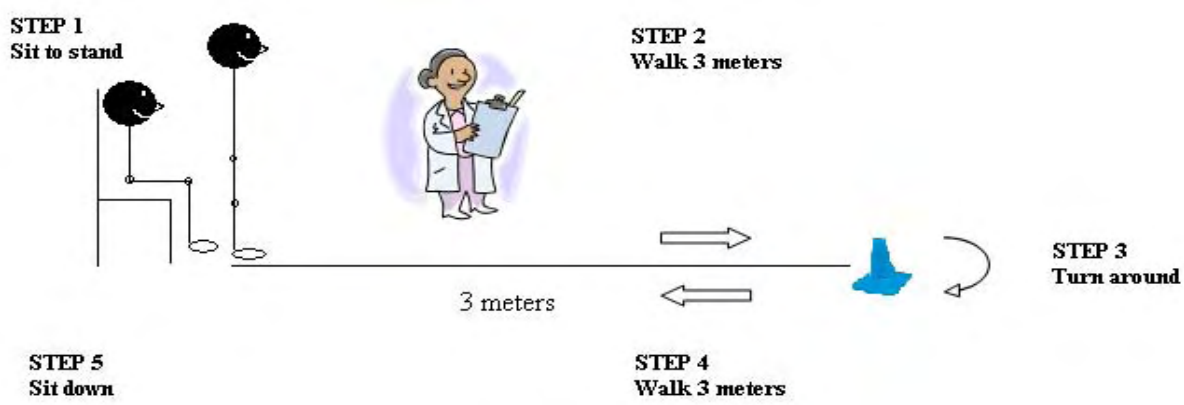
Collin C, Wade DT, Davies S, Horne V. "The Barthel ADL Index: a reliability study."
***Int Disability Study.*1988;10:61-63.**

Copyright Information

ADDENDUM 7: The Timed Up and Go Test

The individual must stand up from the chair, walk a distance of 3 metres, turn around and walk back to the chair and sit down. The test is performed as safe and quickly as possible.

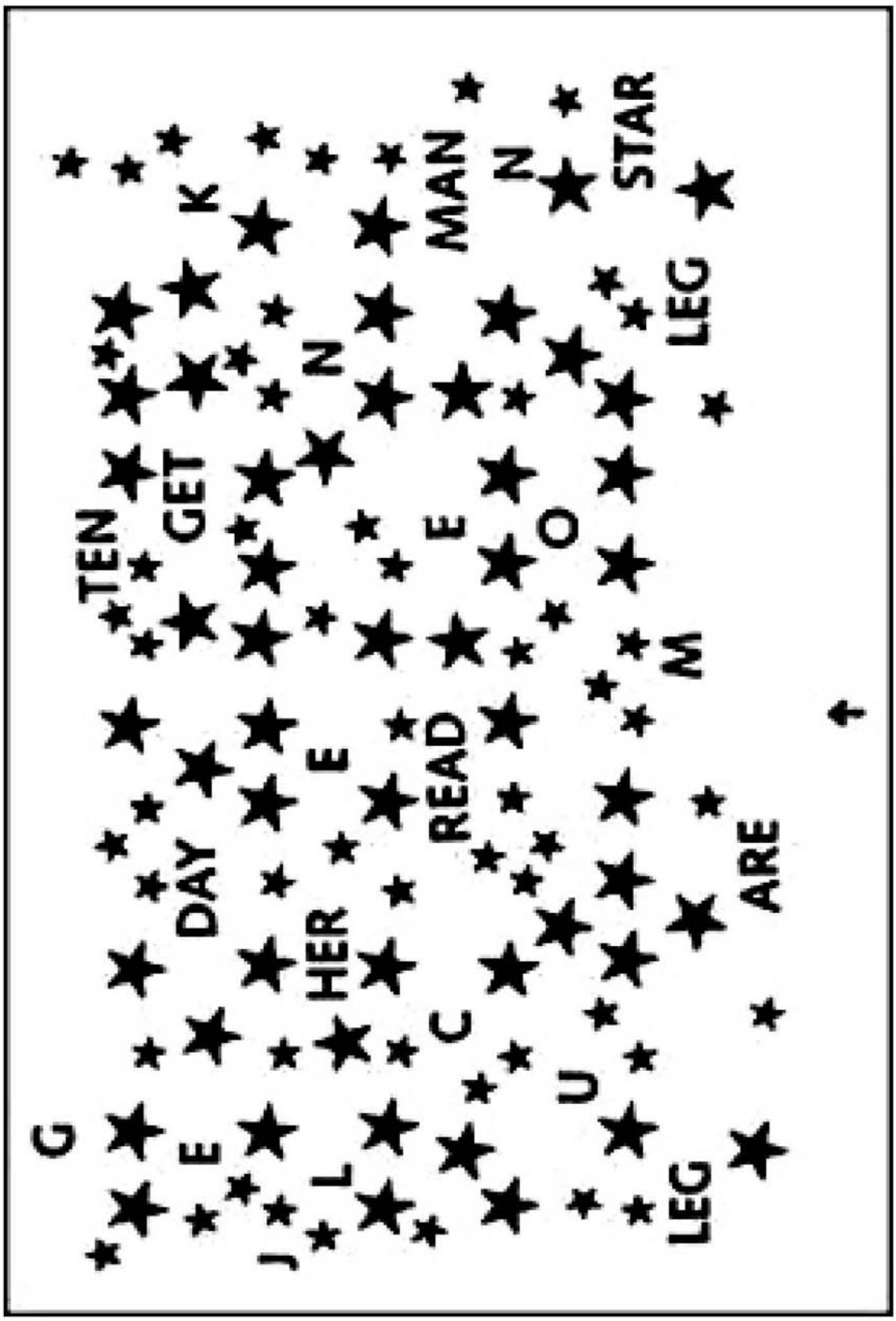
One practice trial is permitted to allow the participant to familiarise himself/herself with the task. Timing commences with the verbal instruction of "GO" and stops when the client return to his seated position. Participants wear their regular footwear and are permitted to use their walking aid. Use of a walking aid needs to be indicated on the data collection form. No physical assistance may be given.



Requirements:

- A standard chair with armrests (46cm seat height and 63 – 65 armrest height).
- Brightly coloured tape to mark off the 3 metre path.
- The 3 metre path should be free from obstruction.
- Stopwatch needs to be used to time the performance of the activity.

ADDENDUM 8: The Star Cancellation Test



Scoring

The maximum score = 54 points (56 small stars minus 2 used for demonstration).

Score < 44 = The presence of unilateral spatial neglect.

A Laterality Index / Star Ratio = The ratio of stars cancelled on the left of the page to the total number of stars cancelled.

Score: 0 – 0.46 = Unilateral space neglect in the left hemi space.

Score: 0.54 – 1 = Unilateral space neglect in the right hemi space.

ADDENDUM 9: The Stroke Impact Scale Version 3.0

Stroke Impact Scale
VERSION 3.0

The purpose of this questionnaire is to evaluate how stroke has impacted your health and life. We want to know from **YOUR POINT OF VIEW** how stroke has affected you. We will ask you questions about impairments and disabilities caused by your stroke, as well as how stroke has affected your quality of life. Finally, we will ask you to rate how much you think you have recovered from your stroke.

Stroke Impact Scale

These questions are about the physical problems which may have occurred as a result of your stroke.

1. In the past week, how would you rate the strength of your....	**A lot of strength**	**Quite a bit of strength**	**Some strength**	**A little strength**	**No strength at all**
a. Arm that was most affected by your stroke?	5	4	3	2	1
b. Grip of your hand that was most affected by your stroke?	5	4	3	2	1
c. Leg that was most affected by your stroke?	5	4	3	2	1
d. Foot/ankle that was most affected by your stroke?	5	4	3	2	1

These questions are about your memory and thinking.

2. In the past week, how difficult was it for you to...	**Not difficult at all**	**A little difficult**	**Somewhat difficult**	**Very difficult**	**Extremely difficult**
a. Remember things that people just told you?	5	4	3	2	1
b. Remember things that happened the day before?	5	4	3	2	1
c. Remember to do things (e.g. keep scheduled appointments or take medication)?	5	4	3	2	1
d. Remember the day of the week?	5	4	3	2	1
e. Concentrate?	5	4	3	2	1
f. Think quickly?	5	4	3	2	1
g. Solve everyday problems?	5	4	3	2	1

These questions are about how you feel, about changes in your mood and about your ability to control your emotions since your stroke.

3. In the past week, how often did you...	**None of the time**	**A little of the time**	**Some of the time**	**Most of the time**	**All of the time**
a. Feel sad?	5	4	3	2	1
b. Feel that there is nobody you are close to?	5	4	3	2	1
c. Feel that you are a burden to others?	5	4	3	2	1
d. Feel that you have nothing to look forward to?	5	4	3	2	1
e. Blame yourself for mistakes that you made?	5	4	3	2	1
f. Enjoy things as much as ever?	5	4	3	2	1
g. Feel quite nervous?	5	4	3	2	1
h. Feel that life is worth living?	5	4	3	2	1
i. Smile and laugh at least once a day?	5	4	3	2	1

The following questions are about your ability to communicate with other people, as well as your ability to understand what you read and what you hear in a conversation.

4. In the past week, how difficult was it to...	Not difficult at all	A little difficult	Somewhat difficult	Very difficult	Extremely difficult
a. Say the name of someone who was in front of you?	5	4	3	2	1
b. Understand what was being said to you in a conversation?	5	4	3	2	1
c. Reply to questions?	5	4	3	2	1
d. Correctly name objects?	5	4	3	2	1
e. Participate in a conversation with a group of people?	5	4	3	2	1
f. Have a conversation on the telephone?	5	4	3	2	1
g. Call another person on the telephone, including selecting the correct phone number and dialing?	5	4	3	2	1

The following questions ask about activities you might do during a typical day.

5. In the past 2 weeks, how difficult was it to...	Not difficult at all	A little difficult	Somewhat difficult	Very difficult	Could not do at all
a. Cut your food with a knife and fork?	5	4	3	2	1
b. Dress the top part of your body?	5	4	3	2	1
c. Bathe yourself?	5	4	3	2	1
d. Clip your toenails?	5	4	3	2	1
e. Get to the toilet on time?	5	4	3	2	1
f. Control your bladder (not have an accident)?	5	4	3	2	1
g. Control your bowels (not have an accident)?	5	4	3	2	1
h. Do light household tasks/chores (e.g. dust, make a bed, take out garbage, do the dishes)?	5	4	3	2	1
i. Go shopping?	5	4	3	2	1
j. Do heavy household chores (e.g. vacuum, laundry or yard work)?	5	4	3	2	1

The following questions are about your ability to be mobile, at home and in the community.

6. In the past 2 weeks, how difficult was it to...	Not difficult at all	A little difficult	Somewhat difficult	Very difficult	Could not do at all
a. Stay sitting without losing your balance?	5	4	3	2	1
b. Stay standing without losing your balance?	5	4	3	2	1
c. Walk without losing your balance?	5	4	3	2	1
d. Move from a bed to a chair?	5	4	3	2	1
e. Walk one block?	5	4	3	2	1
f. Walk fast?	5	4	3	2	1
g. Climb one flight of stairs?	5	4	3	2	1
h. Climb several flights of stairs?	5	4	3	2	1
i. Get in and out of a car?	5	4	3	2	1

The following questions are about your ability to use your hand that was MOST AFFECTED by your stroke.

7. In the past 2 weeks, how difficult was it to use your hand that was most affected by your stroke to...	Not difficult at all	A little difficult	Somewhat difficult	Very difficult	Could not do at all
a. Carry heavy objects (e.g. bag of groceries)?	5	4	3	2	1
b. Turn a doorknob?	5	4	3	2	1
c. Open a can or jar?	5	4	3	2	1
d. Tie a shoe lace?	5	4	3	2	1
e. Pick up a dime?	5	4	3	2	1

The following questions are about how stroke has affected your ability to participate in the activities that you usually do, things that are meaningful to you and help you to find purpose in life.

8. During the past 4 weeks, how much of the time have you been limited in...	**None of the time**	**A little of the time**	**Some of the time**	**Most of the time**	**All of the time**
a. Your work (paid, voluntary or other)	5	4	3	2	1
b. Your social activities?	5	4	3	2	1
c. Quiet recreation (crafts, reading)?	5	4	3	2	1
d. Active recreation (sports, outings, travel)?	5	4	3	2	1
e. Your role as a family member and/or friend?	5	4	3	2	1
f. Your participation in spiritual or religious activities?	5	4	3	2	1
g. Your ability to control your life as you wish?	5	4	3	2	1
h. Your ability to help others?	5	4	3	2	1

9. Stroke Recovery

On a scale of 0 to 100, with 100 representing full recovery and 0 representing no recovery, how much have you recovered from your stroke?

____ 100 Full Recovery

____ 90

____ 80

____ 70

____ 60

____ 50

____ 40

____ 30

____ 20

____ 10

____ 0 No Recovery

Item Clarifications

1. If patient says "I don't have an affected side", then instruct them to score using their perceived weaker side. If they still insist there is no affected, or weaker, side instruct them to score using their dominant side.

4. If patient says s/he does not do any or all of the items listed, code item(s) as *Extremely Difficult.*
   (Item f) If patient does not call but is handed the phone this is OK.
   (Item g) If patient cannot hold a phone book, if they can read it this is OK. This item addresses whether the patient is able to initiate a phone call, look up the number, and dial this number correctly.

5. If patient says s/he does not do any or all of the items listed, code item(s) as *Cannot do at all.*
   (Item a) If person is on pureed food, even if they feel they could cut the food, code as *Cannot do at All* (1/5/98)
   (Item c) Bathing oneself does not include getting into the tub.
   (Item e) This question is associated with movement. Does the person have the physical ability to get to the bathroom quickly enough?
   (Item f) Losing a little urine/dribbling is considered an accident.
   If person has intermittent catheter and is having no leaking problems code them as per report. (1/5/98)
   If person has an in-dwelling Foley catheter, code as *Cannot do at all.* (1/5/98)
   (Item g) Constipation is not counted here, person has to have an accident.
   (Item i) "Shopping" means any type of shopping and does not include driving.

6. If patient hasn't done any of the items in the past two weeks code as *Cannot do at all.*
   (Item h) If patient hasn't "climbed several flights of stairs" in two weeks, they may be prompted by saying "have you gone up and down one flight of stairs a couple of times in a row." If they still say they have not done it then they must be coded as *Cannot do at all.*
   (Item i) If the patient wants to know what kind of car say "your car" or "the car you ride in most."

7. If patient says "I don't have an affected side", then instruct them to score using their perceived weaker side. If they still insist there is no affected, or weaker, side instruct them to score using their dominant side.
   (Item a) If the patient says s/he has not been to the grocery store say "have you carried anything heavy with that hand."
   (Item d) This item is to tie a shoelace/bow using both hands.

8. If patient does not do any of the specific items (and has never done), code interference as *None of the time.*

ADDENDUM 10: The walking ability questionnaire

The Walking Ability Questionnaire

NAME: _____ RLAH#: _____ AGE: _____ SEX: ____ ONSET: ____
ADDRESS: _____ DIAGNOSIS: _____
_____
TELEPHONE: _____ DATE ADMINISTERED _____ HEIGHT _ WEIGHT _____

I. MOBILITY AIDS

Wheelchair use

- ☐ None
- ☐ Sometimes
- ☐ Always

Walking Aids Use

- ☐ Straight cane
- ☐ Quad cane
- ☐ Walk cane
- ☐ Forearm crutch
- ☐ Walker (wheeled)
- ☐ Walker (pick-up)
- ☐ Other

Orthoses Use

AFO: R ☐ L ☐

Sometimes ☐ Always ☐ Sometimes ☐ Always ☐

II. EVALUATION

	Flexor Control	Extensor Control	Proprio-ception
HIP			
KNEE			
ANKLE			

III. CURRENT CUSTOMARY MODE OF MOBILITY

AREA	N/A	W/C	WALK				Comments
			Unable	Assist	Standby	Indep	
HOME							
Bathroom							
Kitchen							
Bedroom							
Entering and exiting home							
Stairs with rails							
Stairs without rails							
Curbs							
Rough uneven ground, grass, carpet, etc.							
COMMUNITY							
Appointments (Dr, Dentist)							
Church							
Grocery Store							
Neighbourhood							
Shopping center							
Uncrowded times/areas							
Unlimited							
Recreation							
Visiting friend							
Restaurant							
Vacation/trips							
Other							
Unlimited							

1. How often do you leave your home? _____
   Is this MORE OFTEN, LESS OFTEN, or the SAME as before your injury? (circle one)
2. We are developing a research program to improve walking ability. If we feel that this program would be helpful to you, are you interested in coming in for an evaluation?
   Yes ☐ No ☐

Physiological Ambulator ☐ Limited Household ☐ Unlimited Household ☐
Most Limited Community ☐ Least Limited Community ☐ Community ☐

Classification	**Scoring**
Independent	4
Supervised	3
Assisted	2
Wheelchair	1
Unable	0

Total score	**76**

ADDENDUM 11: The Hospital Anxiety and Depression Scale

THE HOSPITAL ANXIETY AND DEPRESION SCALE

Claimant's name: _____ Date: _____

Clinicians are aware that emotions play an important part in most illnesses. If your clinical knows about these feelings she or he will be able to help you more. This questionnaire is designed to help your clinician to know how you feel. Ignore the numbers printed on the left of the questionnaire. Read each item and **underline** the reply which comes closest to how you have been feeling in the past week. Don't take too long over your replies; your immediate reaction to each item will probably be the more accurate than a long thought-out response.

	A	**I feel tense or 'wound' up:**
	3	Most of the time
	2	A lot of the time
	1	From time to time, occasionally
	0	Not at all
D		**I still enjoy the things I used to enjoy:**
0		Definitely as much
1		Not quite as much
2		Only a little
3		Hardly at all
	A	**I get sort of frightened feeling as if something awful is about to happen:**
	3	Very definitely and quite badly
	2	Yes, but not too badly
	1	A little, but it doesn't worry me
	0	Not at all
D		**I can laugh and see the funny side of things:**
0		As much as I always could
1		Not quite so much now
2		Definitely not so much now
3		Not at all
	A	**Worrying thoughts go through my mind:**
	3	A great deal of the time
	2	A lot of the time
	1	From time to time but not too often
	0	Only occasionally

(continued overleaf)

D		**I feel cheerful:**
3		Not at all
2		Not often
1		Sometimes
0		Most if the time
	A	**I can sit at ease and feel relaxed:**
	0	Definitely
	1	Usually
	2	Not often
	3	Not at all
D		**I feel as if I am slowed down:**
3		Nearly all the time
2		Very often
1		Sometimes
0		Not at all
	A	**I get a sort of frightened feeling like 'butterflies' in the stomach:**
	0	Not at all
	1	Occasionally
	2	Quite often
	3	Very often
D		**I have lost interest in my appearance:**
3		Definitely
2		I don't take as much care as I should
1		I may not take quite as much care
0		I take just as much care as ever
	A	**I feel restless as if I have to be on the move:**
	3	Very much indeed
	2	Quite a lot
	1	Not very much
	0	Not at all

(continued overleaf)

0		**I look forward with enjoyment to things:**
0		As much as ever I did
1		Rather less than I used to
2		Definitely less than I used to
3		Hardly at all
	A	**I get sudden feelings of panic:**
	3	Very often indeed
	2	Quite often
	1	Not very often
	0	Not at all
D		**I can enjoy a good book or radio or TV programme:**
0		Often
1		Sometimes
2		Not often
3		Very seldom

Now check that you have answered all the questions

For office use only:

D:		Borderline 8 – 10
A:		Borderline 8 – 10

ADDENDUM 12: The Stroke Activity Scale

ITEM 1: GETTING OUT OF BED ON THE UNAFFECTED SIDE

Score	Grade	Description
0	Unable	• Patient demonstrates no active movement; there is no attempt to perform activity.
1	Attempts with adaptive movement	• Initiates with head. • Pulls side of bed with intact arm. • Unable to/or may bring hemiplegic arm across body. • Some/or no movement of hemiplegic lower limb • Brings intact leg over edge of bed. • Some/or no trunk rotation. • Unable to sit up but may get to side lying position. • Over activity intact side. • Unsuccessful in completing activity-assistance 1 person required.
2	Achieves with adaptive movement	• Head initiates flexion. • Pulls side of bed with intact upper limb. • May leave or bring hemiplegic arm across body. • Flexion lower limbs/or may hook hemiplegic lower limb with intact lower limb. • Trunk rotation – but may leave hemiplegic arm behind, brings legs over side of bed and sits up at edge of bed. • Over activity of intact side persists. • Pushes into sitting and may overbalance. • Static sitting achieved but poor alignment and uneven weight bearing.
3	Achieves 'normal' 'Nearly normal'	• Patient flexes/rotates head to side and brings arm across body. • Trunk rotation with flexion of lower limbs. • Rolls onto one side with trunk elongation and lateral flexion of neck & trunk. • Brings legs over edge of bed, lower arm abducts to provide leverage up into sitting. • Acquisition of sitting at edge of bed in

		midline with symmetrical alignment and weight.

ITEM 2: STATIC AND DYNAMIC SITTING BALANCE

score	Grade	Description
0	Unable 'Static sitting'	• No active movement. • Unable to maintain seated position. • Requires assistance/support.
1	Attempts with adaptive movement 'Static sitting'	• Maintains static seated position but with asymmetrical alignment of head, shoulder girdle, trunk & pelvis. • Poor trunk control – lateral flexion and poor extension. • Uneven weight distribution buttocks. • Poor position of lower limbs with wide base of support (BOS), knees apart and poor foot placement. • Supervision required. • May hold bed with intact upper limb.
2	Achieves with adaptive movement 'Dynamic sitting'	• Achieves static sitting balance with good alignment. • Ability to extend trunk. • Poor position of lower limbs – poor foot placement and wide base support. • Reaches forward to touch stool-bias to one side with increased weight bearing intact side/or poor forward movement over BOS and asymmetry. • May leave hemiplegic arm by side, or grasp with intact hand. • Difficulty returning to upright sitting.
3	Achieves 'normal' 'Nearly normal' Dynamic sitting'	• Symmetrical alignment of head shoulders and hips. • In midline position. • Hip flexion with trunk extension. • Feet and knees close together. • Ability to move forward symmetrically over BOS to touch stool with both hands and returned symmetrical to seated position. • Even weight distribution. • Selective movement.

ITEM 3: SITTING TO STANDING

Score	Grade	Description
0	Unable	• No active movement. • Patient demonstrates no attempt to • perform activity. • Maintains seated position only.
1	Attempts with adaptive movement	• Unable to/or attempts to move hips to edge of bed. • Forward flexion of head with prolonged flexion of trunk. • Unequal foot placement with hemiplegic foot forward/not on ground • Uneven weight bearing (WB) lower limbs with wide BOS. • Unable to transfer weight forward over feet and unable to lift buttocks off bed. • Pushes back/or to intact side with trunk extension. Over activity sound side pushes with intact upper limb. • Asymmetrical postural alignment. • Unable to stand without assistance.
2	Achieves with adaptive movement	• Brings hips to edge of bed. Forward flexion of head, trunk flexes forward but leans to intact side. • Difficulty placing hemiplegic foot, uneven WB lower limbs with increased weight bearing through intact foot. • Difficulty transferring centre of gravity forward over feet. • Lifts buttocks off bed, pushing with intact upper limb. • Over activity of intact leg. • Tendency to flexed asymmetrical posture. • Unsteady in initial standing, steps to correct or may overbalance. • May or may not require supervision.
3	Achieves 'normal' 'Nearly normal'	• Good alignment in sitting with even foot placement. • Forward inclination of trunk by flexion of hips with extension of neck and spine. • May use both hands-lifts buttocks of bed.

		• Even WB lower limbs with extension of hips and knees for symmetrical standing alignment. • Selective movement-independent.

ITEM 4: STEPPING AND WALKING

Score	Grade	Description
0	Unable	• Maintains standing position with maximum assistance of 1-2 people. • Poor alignment. • Unable to walk. • Stands with hemiplegic leg in flexion, no weight bearing hemiplegic foot.
1	Attempts with adaptive movement	• Poor alignment in standing. • Requires assistance of 1-2/support. • Swings hemiplegic leg forward with excessive trunk side bending to opposite side and lateral pelvic shift. • Difficulty placing hemiplegic foot on ground, poor knee control, difficulty weight bearing hemiplegic leg. • Difficulty transferring body weight forward. • Over activity intact side. • Steps with intact leg but lose balance-unsafe/almost falls.
2	Achieves with adaptive movement	• Stance: narrow BOS difficulty lifting hemiplegic leg forward. • Heel contact achieved but poor knee control-unstable buckles/hyperextends. • Excessive lateral shift of pelvis to intact side. • Inability to weight- bear on hemiplegic leg. • Over activity intact side. • Swing: difficulty achieving ankle plantar flexion for push off. • Decreased ankle dorsiflexion, knee and hip flexion. • Inability to shorten lower limb for swing through. • Adaptive movement, lateral trunk bending to intact side/hip hitching or circumduction. • Poor control of hemiplegic limb at initial heel contact. • Uneven step length/over activity intact side. • Asymmetrical posture. • Use of aid/supervision.

3	Achieves 'Nearly normal'	• Mobilizes as for 2 with aid unsupervised.
4	Achieves 'normally'	• Stance: heel contact with control of ankle dorsiflexion at initial heel contact. • Hip extension and abduction, good foot placement and acceptance of BOS. • Transfer of bodyweight forward. • Symmetrical posture with more selectivity of movement. • Swing: hip extension with ankle plantar flexion for push off. • Foot clears ground. • Knee extension/ankle dorsiflexion on heel strike. • Transfer of body weight forward. • Walks independently with no aid.

ITEM 5: BRINING A GLASS TO THE MOUTH WITH ARM SUPPORTED ON A TABLE

Score	Grade	Description
0	Unable	• No active movement. • Patient demonstrates no attempt at activity. • Sits with arm supported on table, elbows at 90°. Able to maintain starting position (Patient may use intact upper limb to lift hemiplegic arm).
1	Attempts with adaptive	• Able to assume seated position. • Very little activity at shoulder. • Leans forward or to intact side. • Elevates hemiplegic shoulder girdle or initiates flexion at shoulder but weak. • Over activity intact side. • Increased elevation of hemiplegic shoulder girdle and trunk side bending to intact side. • Unable to complete task.
2	Achieves with adaptive movement	• Forward flexion of shoulder with some over abduction. • Increase elbow flexion/pronation. • Increase flexion of wrist and fingers. • Difficulty extending wrist, increase finger flexion and poor thumb opposition. • Difficulty grasping glass and bringing it to the mouth. • Asymmetrical trunk posture. • Able to take a drink from glass by extending head to compensate. • Achieves task but with decreased co-ordination/over activity.
3	Achieves 'normal' ' Nearly normal'	• Reaches forward with shoulder flexion and some elevation. • Wrist extension combined with radial deviation. Grasps glass with finger flexion and thumb opposition. • Brings glass to mouth with supination and elbow flexion. • Movement is smooth and co-ordinated.

Stroke Activity Scale – standardisation

Standardized patient instructions:

Item 1: Getting out of bed on the unaffected side – *'Sit up/over the edge of the bed'.*

Item 2: Sitting balance – static and dynamic – *'Sit on the edge of the bed/with your hands on your lap/and feet on the floor/reach forward to touch the stool with both hands/you may hold the weak arm/then sit back up straight'.*

Item 3: Sitting to standing – '*Stand up'.*

Item 4: Stepping and walking – *'I want to see you walking'.*

Item 5: Brining a glass to the mouth with the arm supported on a table – *'Pick up the glass/take a drink/then put it down again'.*

Stroke Activity Scale – Standardised starting positions:

Getting off bed on the unaffected side – supine lying on treatment plinth with one pillow under head.

Sitting balance – static and dynamic – height of treatment plinth adjusted so that lower limbs are at a 90-degree angle at the hip, knee and ankle. A wooden stool is positioned at 50cm from treatment plinth.

Sitting to standing – height of treatment plinth as for item 2.

Stepping and walking – from the initial standing position – there is a walkway of three metres.

Bringing a glass to the mouth with arm supported on a table – treatment plinth height as for item 2. The height of a treatment table is adjusted so that the patient's elbows are supported. A drinking glass is positioned at 25cm from the patient at the edge of the table.

ADDENDUM 13: HART-chart

Hart Chart

2	4	6	8	10
O F N P V D T C H E				
Y B A K O E Z L R X				
E T H W F M B K A P				
B X F R T O S M V C				
R A D V S X P E T O				
M P O E A N C B K F				
C R G D B K E P M A				
F X P S M A R D L G				
T M U A X S O G P B				
H O S N C T K U Z L				

ADDENDUM 14: Results gathered at week eight (8), week twelve (12), week sixteen (16) and week twenty (20) of participants in Group 1 and Group 2

Table 1. Results of MMSE from week eight (8) to week twenty (20) of participants in Group 1 and Group 2

MMSE	[ALL]	Group 1	Group 2	p.overall
Week 8	26.0 [24.0; 28.0]	25.0 [23.8; 28.0]	26.0 [25.0; 27.5]	0.769
Week 12	25.0 [22.5; 28.0]	28.0 [25.0; 28.0]	24.0 [22.0; 25.0]	0.287
Week 16	27.5 [24.8; 28.0]	28.0 [27.0; 29.0]	27.0 [24.0; 28.0]	0.396
Week 20	27.0 [24.0; 30.0]	30.0 [25.0; 30.0]	27.0 [24.8; 28.5]	0.598

Table 2. The MMSE of participants in Group 1 and Group 2 from week eight (8) to week twenty (20)

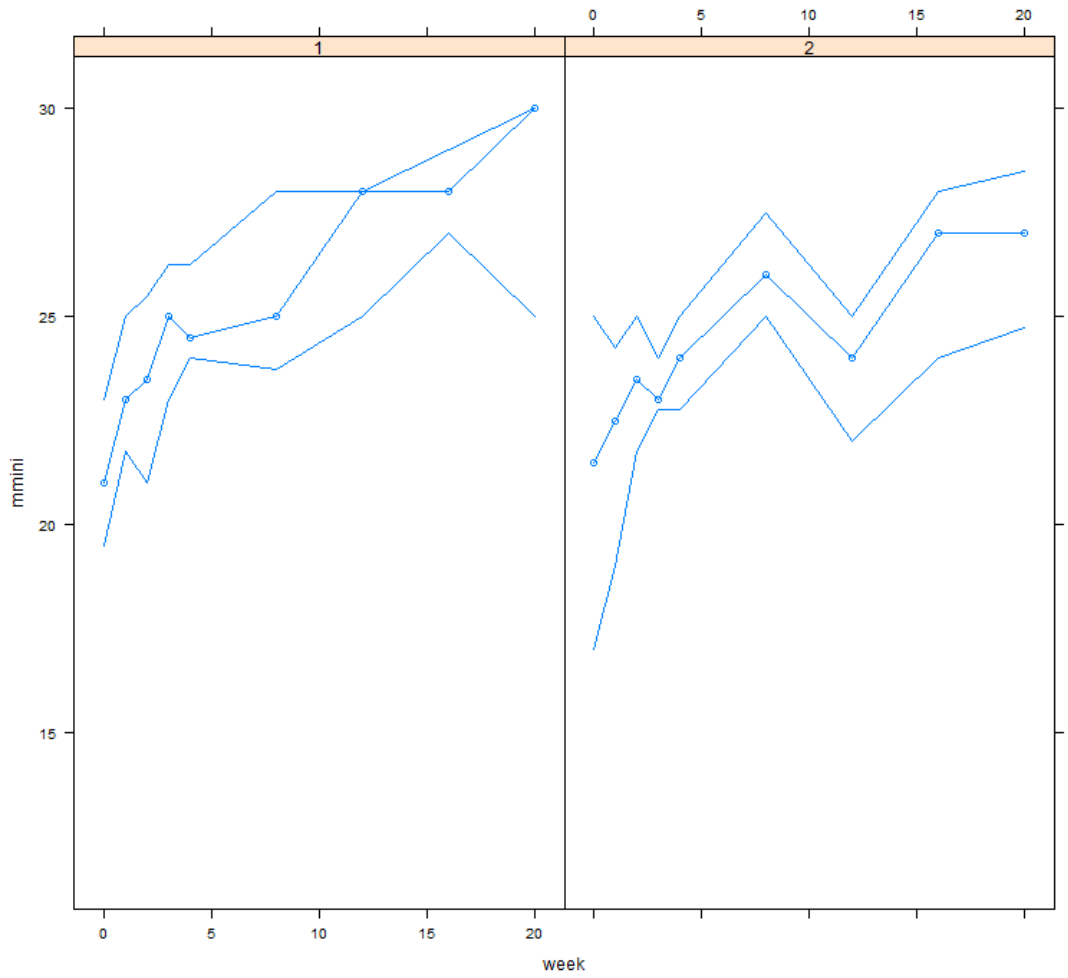
Mini-Mental State Examination (MMSE)	**Baseline**	**Baseline**	**Week 4**	**Week 4**	**Week 8**	**Week 8**
	Group 1 (*n* = 12)	**Group 2 (*n* = 12)**	**Group 1 (*n* = 12)**	**Group 2 (*n* = 12)**	**Group 1 (*n* = 8)**	**Group 2 (*n* = 7)**
Score	21.0	20.7	25.4	24.1	25.6	26.0
SD	3.95428	5.12274	2.02073	3.05877	2.44584	1.82574
	Week 12	**Week 12**	**Week 16**	**Week 16**	**Week 20**	**Week 20**
	Group 1 (*n* = 5)	**Group 2 (*n* = 5)**	**Group 1 (*n* = 5)**	**Group 2 (*n* = 6)**	**Group 1 (*n* = 3)**	**Group 2 (*n* = 6)**
Score	25.6	24.2	26.8	26.0	26.7	26.7
SD	4.50555	2.48998	3.96232	2.34521	5.77350	2.73252

Table 3. Interpretation of individual levels of cognitive impairment of participants from Group 1 and Group 2 at baseline and week twenty (20) (Folstein et al, 2001)

Score of MMSE	**Level of impairment**	**Baseline Group 1 (n = 12)**	**Week 20 Group 1 (n = 3)**	**Baseline Group 2 (n = 12)**	**Week 20 Group 2 (n = 6)**
≥ 27	No cognitive impairment	*n* = 1	*n* = 2	*n* = 1	*n* = 4
21 – 26	Mild cognitive impairment	*n* = 7	*n* = 0	*n* = 6	*n* = 2
11 – 20	Moderate cognitive impairment	*n* = 4	*n* = 1	*n* = 5	*n* = 0
≤ 10	Severe cognitive impairment	*n* = 0	*n* = 0	*n* = 0	*n* = 0
NO SCORE	DROP -OUT	*n* = 0	*n* = 9	*n* = 0	*n* = 6

Table 4. MMSE-scores at baseline level and week twenty (20) compared to a reference group based on age and education level of Group 1 and Group 2 (Crum et al, 1993)

	BASELINE MMSE score correlated with age and educational-level norm	**BASELINE MMSE score did not correlate with age and educational-level norm**	**WEEK 4 MMSE score correlated with age and educational-level norm**	**WEEK 4 MMSE score does not correlate with age and educational-level norm**	**WEEK 20 MMSE score correlate with age and educational-level norm**	**WEEK 20 MMSE score does not correlate with age and educational-level norm**
	Group 1 (n = 12)	**Group 1 (n = 12)**	**Group 1 (n = 12)**	**Group 1 (n = 12)**	**Group 1 (n = 3)**	**Group 1 (n = 3)**
Participants	*n* = 2	*n* = 10	*n* = 8	*n* = 4	*n* = 2	*n* = 1
	Group 2 (n = 12)	**Group 2 (n = 12)**	**Group 2 (n = 12)**	**Group 2 (n = 12)**	**Group 2 (n = 6)**	**Group 2 (n = 6)**
Participants	*n* = 2	*n* = 10	*n* = 4	*n* = 8	*n* = 4	*n* = 2



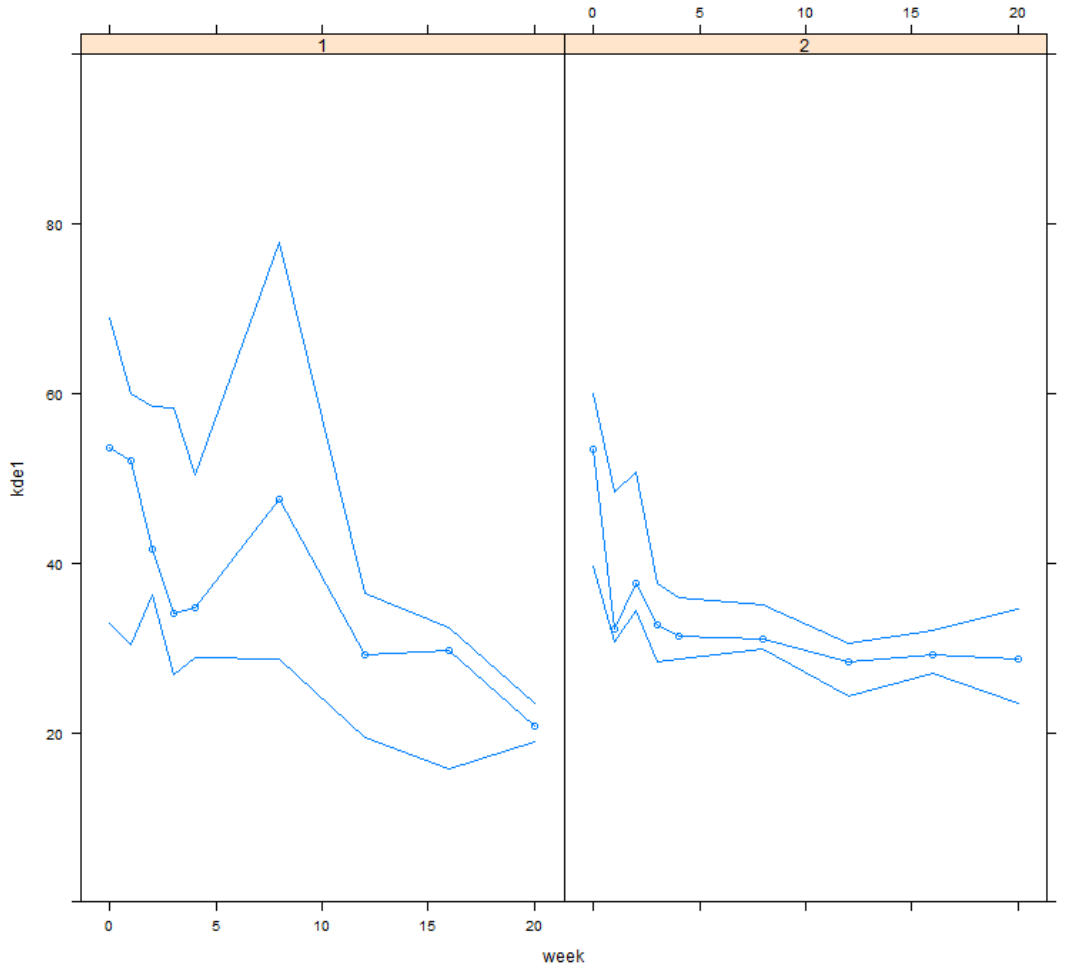
Graph 1. The plot of quartiles of the Mini-Mental State Examination of participants from Group 1 and Group 2 from week eight (8) to week twenty (20)

Table 5. Results of the King-Devick Subtest 1 from week eight (8) to week twenty (20) of participants in Group 1 and Group 2

King-Devick Subtest 1	[ALL]	Group 1	Group 2	p.overall
Week 8	32.1 [29.8; 47.5]	47.5 [28.6; 77.7]	31.0 [29.8; 35.1]	0.165
Week 12	28.8 [21.1; 34.9]	29.2 [19.4; 36.4]	28.4 [24.2; 30.5]	0.917
Week 16	29.3 [22.4; 32.7]	29.7 [15.6; 32.4]	29.2 [27.0; 32.0]	0.855
Week 20	26.0 [20.8; 31.1]	20.8 [18.9; 23.4]	28.7 [23.4; 34.6]	0.121

Table 6. Results of the time taken to complete the King-Devick Subtest 1 from baseline to week twenty (20) in participants in Group 1 and Group 2

The King-Devick Subtest 1	**Baseline**	**Baseline**	**Week 4**	**Week 4**	**Week 8**	**Week 8**
	Group 1 (*n* = 12)	**Group 2 (*n* = 12)**	**Group 1 (*n* = 12)**	**Group 2 (*n* = 12)**	**Group 1 (*n* = 8)**	**Group 2 (*n* = 7)**
Score	54.7	72.0	43.7	36.2	55.5	31.2
SD	20.94687	73.62671	25.81725	18.19574	35.36823	6.46367
	Week 12	**Week 12**	**Week 16**	**Week 16**	**Week 20**	**Week 20**
	Group 1 (*n* = 5)	**Group 2 (*n* = 5)**	**Group 1 (*n* = 5)**	**Group 2 (*n* = 6)**	**Group 1 (*n* = 3)**	**Group 2 (*n* = 6)**
Score	36.9	28.8	27.6	29.1	21.2	28.4
SD	25.58389	7.80356	12.34976	6.68986	4.54933	7.04975



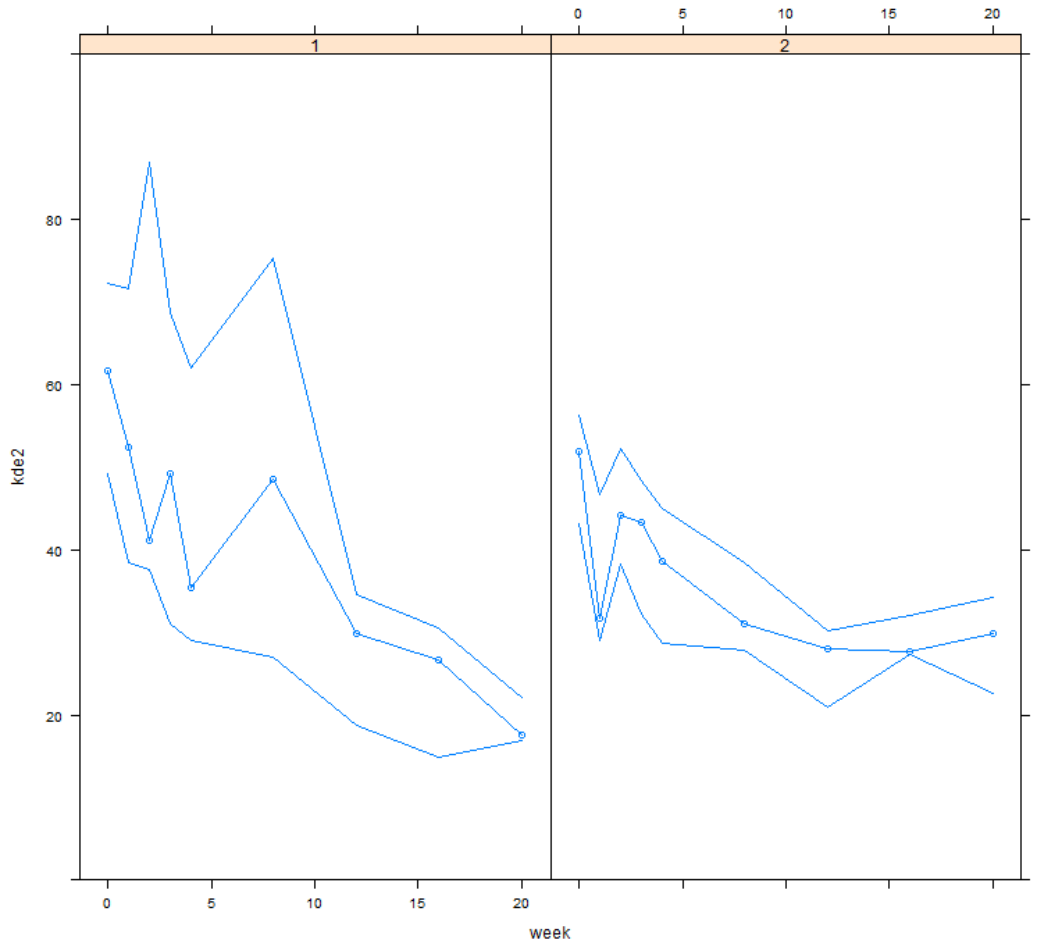
Graph 2. The plot of quartiles of the King-Devick Subtest 1 of participants from Group 1 and Group 2 from week eight (8) to week twenty (20)

Table 7. Results of the King-Devick Subtest 2 from week eight (8) to week twenty (20) of participants in Group 1 and Group 2

King-Devick Subtest 2	[ALL]	Group 1	Group 2	p.overall
Week 8	36.8 [27.9; 51.0]	48.5 [27.1; 75.3]	31.0 [27.9; 38.4]	0.354
Week 12	28.9 [19.6; 33.4]	29.9 [18.8; 34.5]	28.0 [21.0; 30.2]	0.917
Week 16	27.4 [22.7; 31.9]	26.6 [14.9; 30.5]	27.6 [27.3; 32.0]	0.465
Week 20	25.5 [19.9; 34.1]	17.6 [17.0; 22.1]	29.8 [22.6; 34.2]	0.121

Table 8. Results of the time taken to complete the King-Devick Subtest 2 (from baseline to week twenty (20) in participants in Group 1 and Group 2

The King-Devick Subtest 2	**Baseline**	**Baseline**	**Week 4**	**Week 4**	**Week 8**	**Week 8**
	Group 1 (*n* = 12)	**Group 2 (*n* = 12)**	**Group 1 (*n* = 12)**	**Group 2 (*n* = 12)**	**Group 1 (*n* = 8)**	**Group 2 (*n* = 7)**
Score	61.5	80.1	49.0	43.2	51.4	32.2
SD	17.79461	107.40739	31.17894	21.21469	29.73442	7.96464
	Week 12	**Week 12**	**Week 16**	**Week 16**	**Week 20**	**Week 20**
	Group 1 (*n* = 5)	**Group 2 (*n* = 5)**	**Group 1 (*n* = 5)**	**Group 2 (*n* = 6)**	**Group 1 (*n* = 3)**	**Group 2 (*n* = 6)**
Score	34.8	28.3	26.7	29.7	20.2	30.0
SD	22.52067	9.50015	13.14700	8.23726	5.59319	9.38452



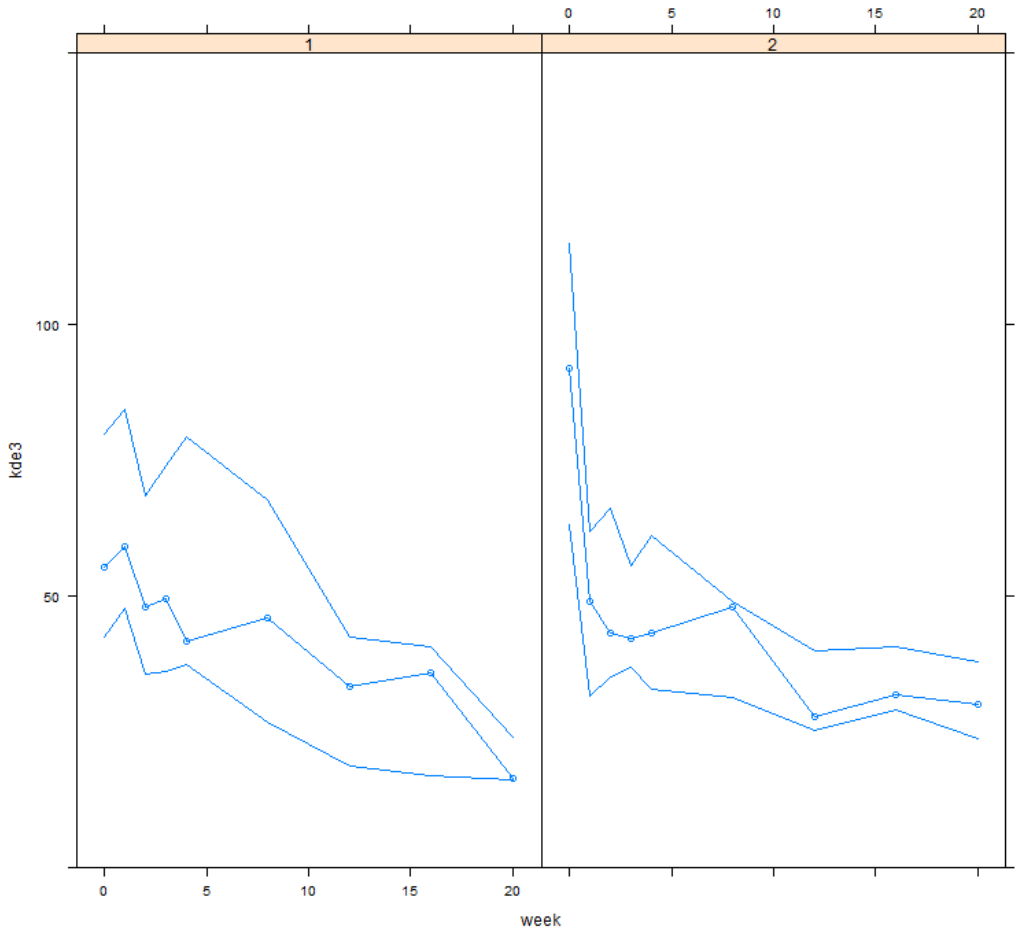
Graph 3. The plot of quartiles of the King-Devick Subtest 2 of participants from Group 1 and Group 2 from week eight (8) to week twenty (20)

Table 9. Results of the King-Devick Subtest 3 from week eight (8) to week twenty (20) of participants in Group 1 and Group 2

King-Devick Subtest 3	[ALL]	Group 1	Group 2	p.overall
Week 8	48.1 [26.9; 60.9]	46.1 [26.8; 67.8]	48.1 [31.4; 49.0]	0.817
Week 12	30.7 [21.8; 41.8]	33.5 [18.7; 42.4]	27.9 [25.2; 40.0]	0.917
Week 16	32.2 [24.0; 42.2]	35.9 [17.0; 40.8]	32.0 [29.2; 40.7]	0.715
Week 20	26.1 [18.2; 34.0]	16.5 [16.3; 24.1]	30.1 [23.8; 37.9]	0.121

Table 10. Results of the time taken to complete the King-Devick Subtest 3 from baseline to week twenty (20) in participants in Group 1 and Group 2

The King-Devick Subtest 3	**Baseline**	**Baseline**	**Week 4**	**Week 4**	**Week 8**	**Week 8**
	Group 1 (*n* = 12)	**Group 2 (*n* = 12)**	**Group 1 (*n* = 12)**	**Group 2 (*n* = 12)**	**Group 1 (*n* = 8)**	**Group 2 (*n* = 7)**
Score	65.5	131.0	59.3	54.5	48.7	42.6
SD	28.80263	156.72184	45.46268	32.63114	27.68208	17.80101
	Week 12	**Week 12**	**Week 16**	**Week 16**	**Week 20**	**Week 20**
	Group 1 (*n* = 5)	**Group 2 (*n* = 5)**	**Group 1 (*n* = 5)**	**Group 2 (*n* = 6)**	**Group 1 (*n* = 3)**	**Group 2 (*n* = 6)**
Score	39.4	34.8	30.9	37.2	21.5	32.3
SD	26.86877	15.98192	13.49240	16.82928	8.96750	12.76612



Graph 4. The plot of quartiles of the King-Devick Subtest 3 of participants from Group 1 and Group 2 from week eight (8) to week twenty (20)

Table 11. Results of the average number of errors in completion of the King-Devick Subtest 1 from baseline to week twenty (20) in participants in Group 1 and Group 2

Average number of errors in completion of the King-Devick Subtest 1	**Baseline**	**Baseline**	**Week 4**	**Week 4**	**Week 8**	**Week 8**
	Group 1 (*n* = 12)	**Group 2 (*n* = 12)**	**Group 1 (*n* = 12)**	**Group 2 (*n* = 12)**	**Group 1 (*n* = 8)**	**Group 2 (*n* = 7)**
Score	0.3	0.3	0.2	0.1	0.1	0.0
SD	0.30214	0.29473	0.24042	0.10388	0.17928	0.06856
	Week 12	**Week 12**	**Week 16**	**Week 16**	**Week 20**	**Week 20**
	Group 1 (*n* = 5)	**Group 2 (*n* = 5)**	**Group 1 (*n* = 5)**	**Group 2 (*n* = 6)**	**Group 1 (*n* = 3)**	**Group 2 (*n* = 6)**
Score	0.0	0.0	0.1	0.0	0.0	0.0
SD	0.06504	0.01342	0.14758	0.02582	0.00000	0.02160

Table 12. Results of the average number of errors made in completion of the King-Devick Subtest 2 from baseline to week twenty (20) in Group 1 and Group 2

Average number of errors in completion of the King-Devick Subtest 2	**Baseline**	**Baseline**	**Week 4**	**Week 4**	**Week 8**	**Week 8**
	Group 1 (*n* = 12)	**Group 2 (*n* = 12)**	**Group 1 (*n* = 12)**	**Group 2 (*n* = 12)**	**Group 1 (*n* = 8)**	**Group 2 (*n* = 7)**
Score	0.1	0.1	0.1	0.0	0.1	0.0
SD	0.11523	0.18729	0.20982	0.04479	0.11548	0.01890
	Week 12	**Week 12**	**Week 16**	**Week 16**	**Week 20**	**Week 20**
	Group 1 (*n* = 5)	**Group 2 (*n* = 5)**	**Group 1 (*n* = 5)**	**Group 2 (*n* = 6)**	**Group 1 (*n* = 3)**	**Group 2 (*n* = 6)**
Score	0.1	0.0	0.1	0.0	0.0	0.0
SD	0.12418	0.01342	0.10954	0.03251	0.00000	0.00000

Table 13. Results of the average number of errors made in completion of the King-Devick Subtest 3 from baseline to week twenty (20) in Group 1 and Group 2

Average number of errors in completion of the King-Devick Subtest 3	**Baseline**	**Baseline**	**Week 4**	**Week 4**	**Week 8**	**Week 8**
	Group 1 (*n* = 12)	**Group 2 (*n* = 12)**	**Group 1 (*n* = 12)**	**Group 2 (*n* = 12)**	**Group 1 (*n* = 8)**	**Group 2 (*n* = 7)**
Score	0.3	0.3	0.2	0.1	0.2	0.1
SD	0.30214	0.29473	0.24042	0.10388	0.19984	0.12830
	Week 12	**Week 12**	**Week 16**	**Week 16**	**Week 20**	**Week 20**
	Group 1 (*n* = 5)	**Group 2 (*n* = 5)**	**Group 1 (*n* = 5)**	**Group 2 (*n* = 6)**	**Group 1 (*n* = 3)**	**Group 2 (*n* = 6)**
Score	0.2	0.2	0.1	0.1	0.0	0.1
SD	0.28874	0.18281	0.09370	0.13706	0.01732	0.10539

Table 14. Results of the correct number of stars cancelled during the completion of the Star Cancellation Test from baseline to week twenty (20)

The Star Cancellation Test	Baseline	Baseline	Week 4	Week 4	Week 8	Week 8
	Group 1 (*n* = 12)	Group 2 (*n* = 12)	Group 1 (*n* = 12)	Group 2 (*n* = 12)	Group 1 (*n* = 8)	Group 2 (*n* = 7)
Score	31.8	42.1	46.7	40.3	47.1	46.9
SD	14.56100	13.22160	9.09878	10.55828	12.47211	6.51738
	Week 12	Week 12	Week 16	Week 16	Week 20	Week 20
	Group 1 (*n* = 5)	Group 2 (*n* = 5)	Group 1 (*n* = 5)	Group 2 (*n* = 6)	Group 1 (*n* = 3)	Group 2 (*n* = 6)
Score	48.6	44.4	46.6	45.5	52.7	45.0
SD	6.98570	5.94138	13.81304	6.53452	1.52753	4.42719

Table 15. Results of the time taken to complete the Star Cancellation Test from baseline to week twenty (20)

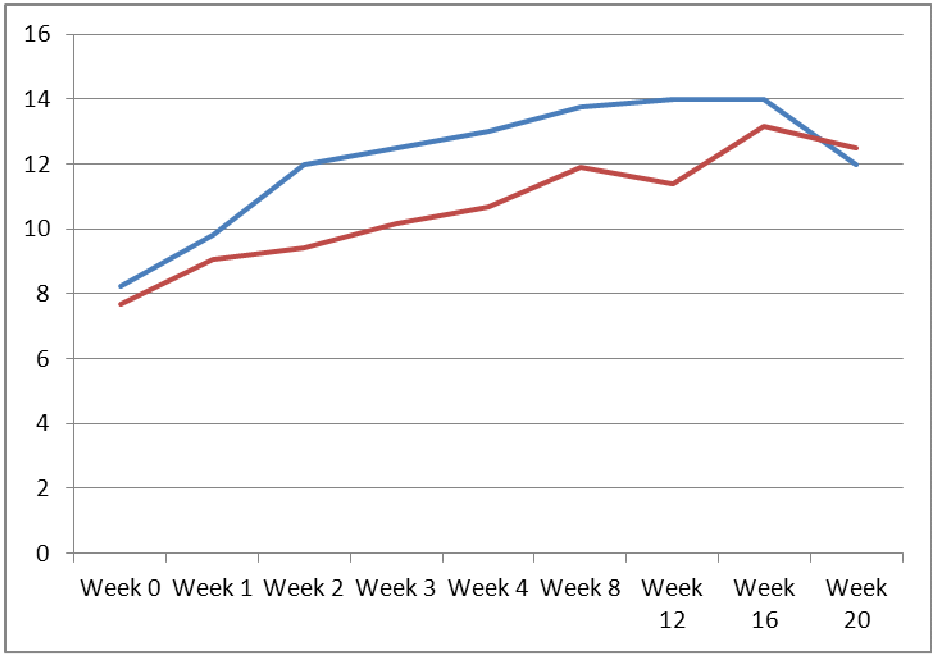
The time taken to complete the Star Cancellation Test	Baseline	Baseline	Week 4	Week 4	Week 8	Week 8
	Group 1 (*n* = 12)	Group 2 (*n* = 12)	Group 1 (*n* = 12)	Group 2 (*n* = 12)	Group 1 (*n* = 8)	Group 2 (*n* = 7)
Score	160.1	174.7	129.3	110.7	133.0	146.4
SD	125.70537	152.16529	87.72886	64.90929	101.15302	126.07061
	Week 12	Week 12	Week 16	Week 16	Week 20	Week 20
	Group 1 (*n* = 5)	Group 2 (*n* = 5)	Group 1 (*n* = 5)	Group 2 (*n* = 6)	Group 1 (*n* = 3)	Group 2 (*n* = 6)
Score	74.2	84.9	69.2	91.3	48.2	83.7
SD	45.53695	58.63820	34.42727	69.01976	24.95330	56.87049

Table 16. Results of anxiety subscale from baseline to week twenty (20) for Group 1 and Group 2

Anxiety subscale	Baseline	Baseline	Week 4	Week 4	Week 8	Week 8
	Group 1 (*n* = 12)	Group 2 (*n* = 12)	Group 1 (*n* = 12)	Group 2 (*n* = 12)	Group 1 (*n* = 8)	Group 2 (*n* = 7)
0 - 7	*n* = 4	*n* = 3	*n* = 8	*n* = 6	*n* = 6	*n* = 2
8 - 10	*n* = 3	*n* = 4	*n* = 1	*n* = 2	*n* = 1	*n* = 2
≥ 11	*n* = 5	*n* = 5	*n* = 3	*n* = 4	*n* = 1	*n* = 3
	Week 12	**Week 12**	**Week 16**	**Week 16**	**Week 20**	**Week 20**
	Group 1 (*n* = 5)	**Group 2 (*n* = 5)**	**Group 1 (*n* = 5)**	**Group 2 (*n* = 6)**	**Group 1 (*n* = 3)**	**Group 2 (*n* = 6)**
0 - 7	*n* = 4	*n* = 2	*n* = 3	*n* = 3	*n* = 2	*n* = 2
8 - 10	*n* = 0	*n* = 1	*n* = 2	*n* = 1	*n* = 0	*n* = 2
≥ 11	*n* = 1	*n* = 2	*n* = 0	*n* = 2	*n* = 1	*n* = 2

Table 17. Results of HADSD of the HADS from baseline to week twenty (20) for Group 1 and Group 2

Depression subscale	Baseline	Baseline	Week 4	Week 4	Week 8	Week 8
	Group 1 (*n* = 12)	Group 2 (*n* = 12)	Group 1 (*n* = 12)	Group 2 (*n* = 12)	Group 1 (*n* = 8)	Group 2 (*n* = 7)
0 - 7	*n* = 5	*n* = 4	*n* = 8	*n* = 2	*n* = 7	*n* = 1
8 - 10	*n* = 4	*n* = 5	*n* = 3	*n* = 3	*n* = 0	*n* = 2
≥ 11	*n* = 3	*n* = 3	*n* = 1	*n* = 7	*n* = 1	*n* = 4
	Week 12	**Week 12**	**Week 16**	**Week 16**	**Week 20**	**Week 20**
	Group 1 (*n* = 5)	**Group 2 (*n* = 5)**	**Group 1 (*n* = 5)**	**Group 2 (*n* = 6)**	**Group 1 (*n* = 3)**	**Group 2 (*n* = 6)**
0 - 7	*n* = 4	*n* = 1	*n* = 5	*n* = 0	*n* = 2	*n* = 0
8 - 10	*n* = 0	*n* = 3	*n* = 0	*n* = 2	*n* = 1	*n* = 2
≥ 11	*n* = 1	*n* = 1	*n* = 0	*n* = 4	*n* = 0	*n* = 4



Graph 5. Results of the Stroke Activity Scale (SAS) for Group 1 and Group 2 from baseline to week twenty (20)

Table 18. Results of the Barthel Index (BI) for Group 1 and Group 2 from baseline to week twenty (20)

Barthel Index	Baseline	Baseline	Week 4	Week 4	Week 8	Week 8
	Group 1 (*n* = 12)	Group 2 (*n* = 12)	Group 1 (*n* = 12)	Group 2 (*n* = 12)	Group 1 (*n* = 8)	Group 2 (*n* = 7)
Score	42.9	46.3	85.4	65.4	89.4	71.4
SD	18.39693	18.10638	16.43974	27.83542	16.56966	22.49339
	Week 12	**Week 12**	**Week 16**	**Week 16**	**Week 20**	**Week 20**
	Group 1 (*n* = 5)	Group 2 (*n* = 5)	Group 1 (*n* = 5)	Group 2 (*n* = 6)	Group 1 (*n* = 3)	Group 2 (*n* = 6)
Score	91.0	76.0	92.0	87.5	85.0	88.3
SD	17.46425	24.08319	17.88854	12.14496	25.98076	8.75595

Table 19. Results of the Timed Up and Go Test (TUG) for Group 1 and Group 2 from baseline to week twenty (20)

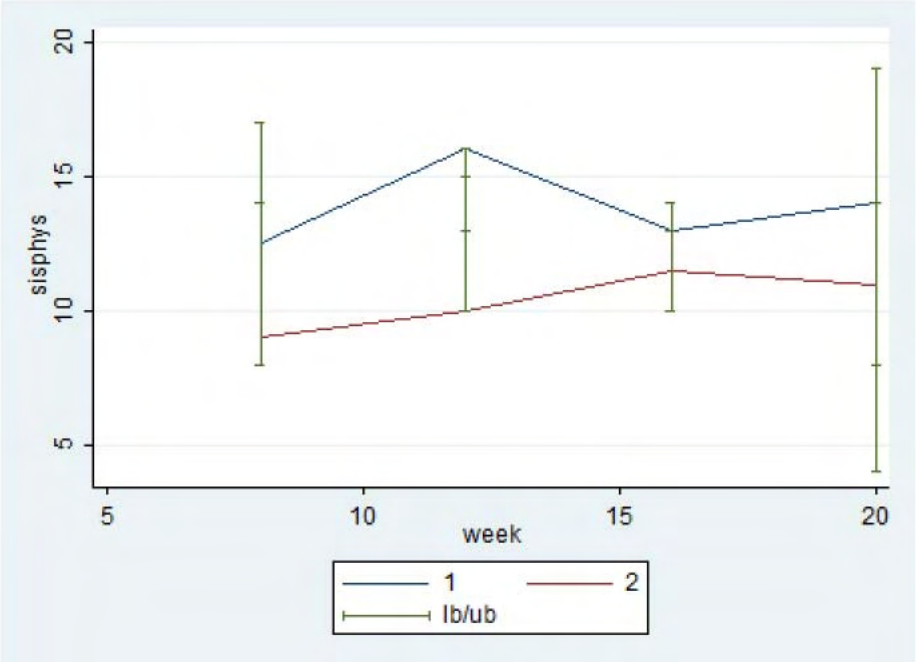
WEEK 20			
Time	**Timed-up and-go Test**	**Group 1 (*n* = 3)**	**Group 2 (*n* = 6)**
< 10 seconds	Completely independent	*n* = 1	*n* = 1
< 20 seconds	Independent for main transfers; May require assistance / supervision and/or an assistive device for safe ambulation	*n* = 1	*n* = 0
20 - 30 seconds	Dependent	*n* = 0	*n* = 1
> 30 seconds	Requires assistance	*n* = 1	*n* = 3
Unable to complete the test	Requires maximal assistance	*n* = 0	*n* = 1
≥ 14 seconds	High risk of falls	*n* = 1	*n* = 5
≤ 13 seconds	Low risk of falls	*n* = 2	*n* = 1

Table 20. The use of a walking aid by participants from Group 1 and Group 2 at week twenty (20)

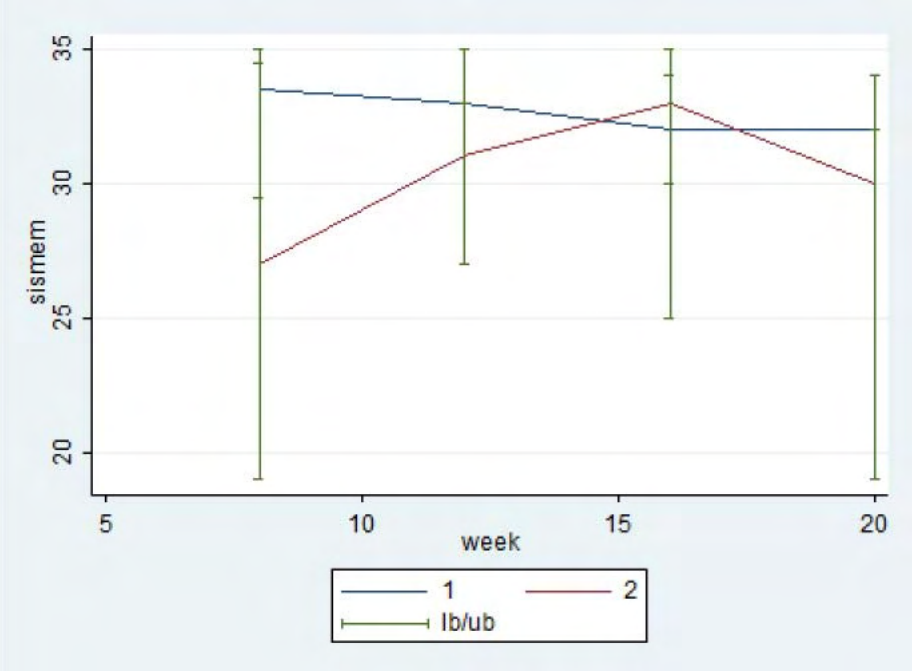
	Week 20	**Week 20**
Walking aid	**Group 1 (*n* = 3)**	**Group 2 (*n* = 6)**
No walking aid	*n* = 2	*n* = 3
Walking stick	*n* = 0	*n* = 0
Tripod	*n* = 0	*n* = 0
Quadropod	*n* = 1	*n* = 1
Elbow crutch	*n* = 0	*n* = 0
Rollator frame	*n* = 0	*n* = 0
Walking frame	*n* = 0	*n* = 1
Wheelchair / Other	*n* = 0	*n* = 1

Table 21. The walking aid used and assistance required by participants from Group 1 and Group 2 to complete the TUG at week twenty (20)

	Week 20	**Week 20**
Walking aid & Assistance required	**Group 1 (*n* = 3)**	**Group 2 (*n* = 6)**
No walking aid & independent (no assistance)	*n* = 2	*n* = 2
No walking aid & supervision of 1 person	*n* = 0	*n* = 1
No walking aid & moderate assistance of 1 person	*n* = 0	*n* = 0
No walking aid & moderate assistance of 2 persons	*n* = 0	*n* = 0
No walking aid & maximal assistance of 2 persons	*n* = 0	*n* = 0
Walking stick & independent (no assistance)	*n* = 0	*n* = 0
Tripod & independent (no assistance)	*n* = 0	*n* = 0
Tripod & minimal assistance of 1 person	*n* = 0	*n* = 0
Quadropod & independent (no assistance)	*n* = 0	*n* = 1
Quadropod & supervision of 1 person	*n* = 0	*n* = 0
Quadropod & minimal assistance of 1 person	*n* = 0	*n* = 0
Quadropod & moderate assistance of 1 person	*n* = 1	*n* = 0
Quadropod & maximal assistance of 1 person	*n* = 0	*n* = 0
Quadropod & maximal assistance of 2 persons	*n* = 0	*n* = 0
Elbow crutch & independent	*n* = 0	*n* = 0
Rollator frame	*n* = 0	*n* = 0
Walking frame & independent	*n* = 0	*n* = 1
Wheelchair / Other & Assistance of more than 2 persons (> 2 persons)	*n* = 0	*n* = 1



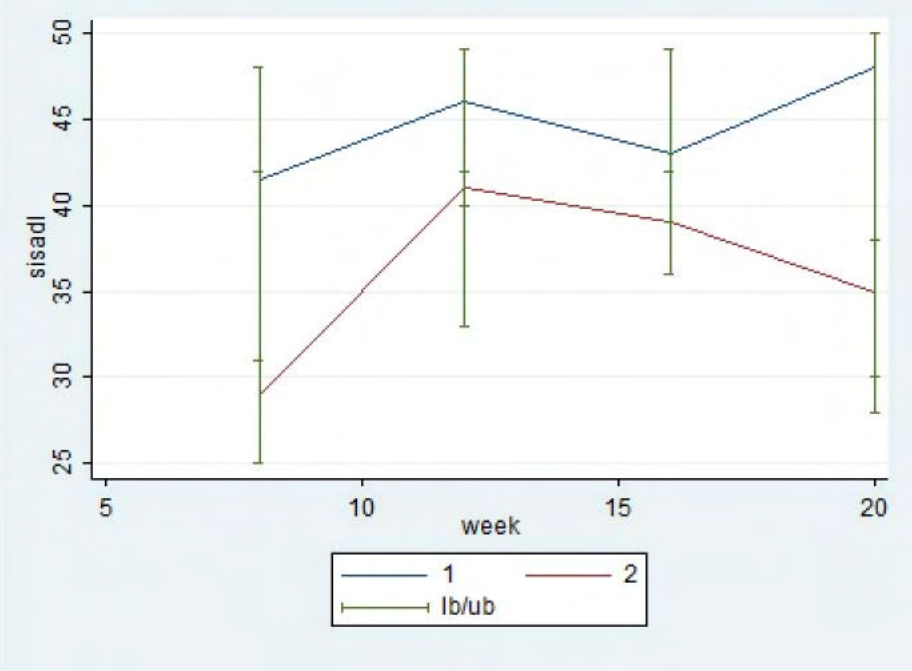
Graph 6. Results of self-reported physical strength (SIS) for Group 1 and Group 2 from week eight (8) until week twenty (20)



Graph 7. Results of self-reported memory and thinking impairment (SIS) for Group 1 and Group 2 from week eight (8) until week twenty (20)

Graph 8. Results of self-reported changes in mood and ability to control emotions (SIS) in participants for Group 1 and Group 2 from week eight (8) until week twenty (20)

Graph 9. Results of self-reported changes in the ability to communicate and the ability to understand what participants read as well as hear in a conversation (SIS) from week eight (8) till week twenty (20)

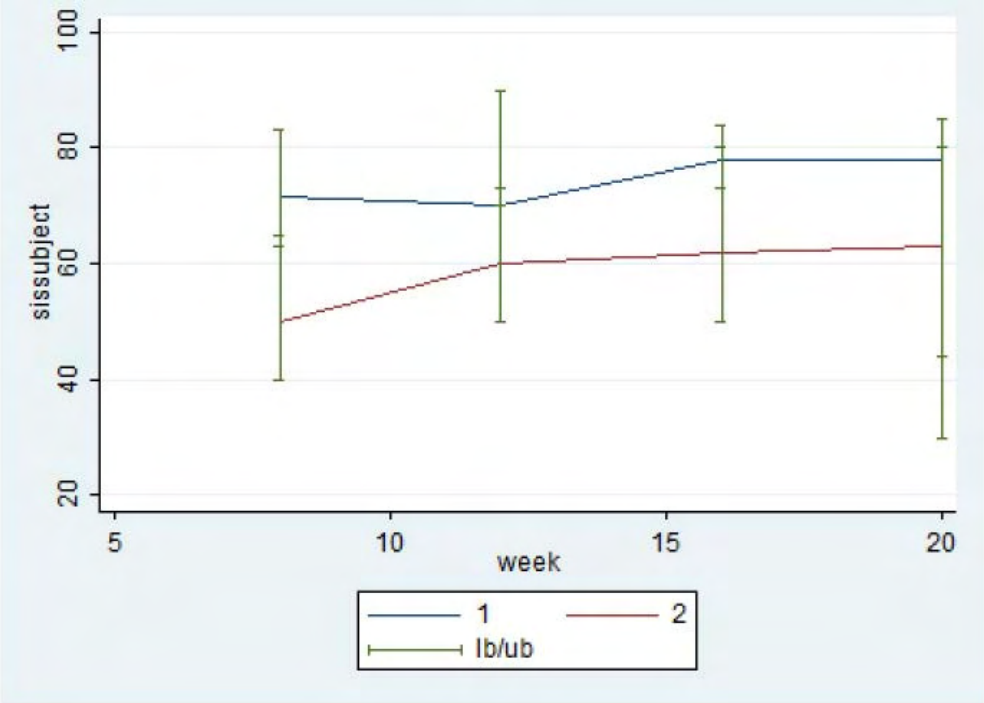


Graph 10. Results of self-reported difficulty experienced with performance of activities during a typical day (SIS) from week eight (8) till week twenty (20)

Graph 11. Results of self-reported difficulty experienced with mobility at home and in the community (SIS) from week eight (8) till week twenty (20)

Graph 12. Results of self-reported difficulty experienced with the use of the hand that was most affected by the stroke (SIS) from week eight (8) till week twenty (20)

Graph 13. Results of self-reported ability to participate in meaningful activities (SIS) from week eight (8) till week twenty (20)



Graph 14. Results of self-reported subjective recovery (SIS) for Group 1 and Group 2 from week eight (8) till week twenty (20)

Graph 15. Results of the total score of the Stroke Impact Scale Version 3.0 (SIS) for Group 1 and Group 2 from week eight (8) till week twenty (20)

Table 22. Results for the walking ability questionnaire for Group 1 and Group 2 from week eight (8) till week twenty (20)

Score of Walking ability questionnaire	**Group 1**	**Group 2**	**Group 1**	**Group 2**
	Week 8 (*n* = 8)	**Week 8 (*n* = 7)**	**Week 12 (*n* = 5)**	**Week 12 (*n* = 5)**
0 – 19	*n* = 3	*n* = 2	*n* = 1	*n* = 1
20 – 39	*n* = 1	*n* = 3	*n* = 1	*n* = 0
40 – 59	*n* = 1	*n* = 1	*n* = 0	*n* = 3
60 – 76	*n* = 3	*n* = 1	*n* = 3	*n* = 1
Score of Walking ability questionnaire	**Group 1**	**Group 2**	**Group 1**	**Group 2**
	Week 16 (*n* = 5)	**Week 16 (*n* = 6)**	**Week 20 (*n* = 3)**	**Week 20 (*n* = 6)**
0 – 19	*n* = 1	*n* = 0	*n* = 1	*n* = 0
20 – 39	*n* = 0	*n* = 3	*n* = 0	*n* = 1
40 – 59	*n* = 0	*n* = 0	*n* = 0	*n* = 4
60 – 76	*n* = 4	*n* = 3	*n* = 2	*n* = 1