EFFECTIVENESS OF A STRUCTURED CIRCUIT CLASS THERAPY MODEL IN STROKE REHABILITATION: A SINGLE BLIND RANDOMIZED CONTROLLED TRIAL.

A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophiae (Physiotherapy) in the Department of Physiotherapy, University of the Western Cape

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KEY WORDS:

Stroke, ICF framework, circuit class therapy, exercise intensity, rehabilitation, motor learning, community participation.

DECLARATION

I hereby declare that **"EFFECTIVENESS OF A STRUCTURED CIRCUIT CLASS THERAPY MODEL IN STROKE REHABILITATION: A SINGLE BLIND RANDOMIZED CONTROLLED TRIAL"** is my own work, that it has not been submitted, or part of it, for any degree of examination at any other university, and that all the sources I have used or quoted have been indicated and acknowledged by means of complete references.

Isa Usman Lawal

Signature…….. December 2016

Witness……

DEDICATION

I dedicate this study to my guardian Abdulazeez Muhammad who nurtured me from childhood and has never stop to show me the path to success and humanity to date. And to my wife Aisha Animashaun who was supportive and motivating throughout this academic exercise. And to my children Mahmoud, Abdurrahman, Asma'u and Luqman who were so patient throughout the period of this study.

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   Topic: Effectiveness of augmenting therapy time in circuit class therapy on mobility of upper/lower extremity post stroke: a randomized pilot study (Platform presentation).
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ABSTRACT

Stroke is a debilitating medical and neurological condition. It is the leading cause of adult disability worldwide. Disability from stroke covers the three key classifications of the WHO-ICF framework on human function centred on health and health related issues, implying that the disability in stroke involve structural and activity limitations to participation restriction. Rehabilitation remains the hallmark of managing the plethora of neurological deficits accompanying stroke. Currently, the key advocacy in neuroscientific studies for stroke rehabilitation is that therapy should be directed towards task specificity. Task Specific Training most recently, the form of Circuit Class Therapy and the intensity of multiple repetition of the task has been identified as physiological mechanisms behind sustained motor learning following stroke.Circuit Class Therapy (CCT) is a form of Task Specific Training (TST) that involves the practice of structuring tasks in a circuit or series of workstations. It offers the patient the ability to practice multiple tasks in a conducive environmental because of its three key features of utilisation of different workstations that allow people to practice intensively in a meaningful and progressive way to suit their respective needs; the efficient utilisation of therapists'/trainees' time; and the group dynamics such as peer support and social support. Although these features are attainable following CCT challenges remain in selecting the most efficient intensity that could produce these benefits in stroke survivors. This study investigated the effectiveness of differing intensities of CCT in the rehabilitation of stroke survivors using the ICF framework to guide patients' response assessments after training. The study is a single blind randomised controlled clinical trial. A total of 91 stroke survivors were randomly allocated into three CCT training

groups (120CCT, 90CCT and 60CCT) and a control. Participants were assessed at baseline, post intervention, and follow-up for body structure/function variables (muscle strength and spasticity) and activity variables (walking distance, gait speed, basic activities of daily leaving, upper extremity function and dexterity, real world upper extremity function, global disability level, community participation and acceptability of the intensities of training. Study findings for the primary outcome measure i.e. six minute walk test indicated to significant time effect, *F(1.52, 121.26) = 151.75, p = 0.001,* on walking distance following CCT with a large effect size, *η2 = 0.66*, suggesting a considerable improvement in walking distance at post intervention periods. Findings for the time by group interaction for walking distance also revealed significant group effect, *F(4.55, 121.26) = 23.83, p = 0.001,* with a medium effect size, *η2 = 0.47*, which also suggest obvious group interaction (in favour of augmented duration of CCT). Multivariate analysis for secondary outcome measures for body structure/function of both muscle strength and spasticity indicated significant time effect (baseline to follow-up) for; *Wilks' λ, F(36.00, 286.00) = 58.69, p = 0.001* (in favour of post-intervention periods) and significant time by group interaction *Wilks' λ, F(4.27, 108.00) = 4.27, p = 0.001* (in favour of augmented duration of CCT). In activity measures, multivariate analysis indicated significant time effects for measures of activity in both upper and lower extremities, *Wilks' λ F(14, 308)= 99.94, p =0.001,* and significant time by group interaction, *Wilk's λ F(42, 725.78) = 9.25, p =0.001* (biased towards augmented duration of CCT). In participation result indicated multivariate analysis indicated significant time effect, *Wilks' λ F(16, 65) = 204.00, p = 0.001* and significant time by group interaction *Wilks' λ F(48, 194) = 5.63, p = 0.001* (in favour of augmented duration of CCT). Study

findings on acceptability of the training durations indicated significance in the total acceptability score, $F(2, 65) = 8.08, p = 0.001$ (with lower duration indicating better acceptability). The outcome of this study suggested generally a trend towards dose-response in all ICF categories. However, improvement was more apparent at the activity levels and lower extremity related functions. In conclusion augmenting duration of CCT has the potential to improve function post stroke in body structure/function, activity and participation after stroke.

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1 CHAPTER ONE: INTRODUCTION

"Much research on disability has contributed little or nothing to improving the quality of life of disabled people, though it might have substantially improved the career prospects of the researchers". (Oliver 1987 p 10)

1.1 Background

Stroke is a growing global health-care crisis, with grave and disabling consequences (Warlow et al, 2008). It is a major cause of morbidity and mortality worldwide (Feigin et al, 2014; Klijn & Hankey, 2003), in high-income countries, it has been identified as an essential cause of death and disability for many years (Connor, Walker, Modi&Warlow, 2007). Until about a decade ago, the importance of stroke in developing countries such as Sub-Saharan Africa (SSA) has been poorly appreciated (Feigin, Lawes, Bennett, Barker-Collo, & Parag, 2009; Connor et al, 2007). This new understanding of the epidemiology of stroke in these regions is influenced by the updated estimate from the Global Burden of Disease study which emphasised that over 80% of all stroke mortalities take place in developing countries of the world (Feigin et al, 2009; Lopez, Mathers, Ezzati, Jamison & Murray, 2006). On a similar note, the World Health Organization (WHO) projected that by 2030 around 80% of all strokes will occur in populations living in the developing countries (WHO, 2008). Substantial evidence, particularly in SSA suggest that mortality occasioned by stroke is higher than those in industrialized countries owing largely to inadequate amenities for healthcare and unchecked risk factors such as hypertension, diabetes, obesity, excessive alcohol consumption, smoking, stress and physical inactivity (Komolafe et al, 2015; Wahab, Kayode, & Musa, 2015).

Stroke is an important cause of acquired adult neurological disability globally (Langhorne, Bernhardt & Kwakkel, 2011). The most recognised impairments leading to a plethora of disabilities and limiting participation after stroke are related to motor function, cognitive ability, speech and mood (Griffin &Hickey, 2013). No less than half of all stroke survivors are partly or fully dependent on caregivers for key activities of daily living (ADL) due largely to these disabilities (Löfgren, Nyberg, & Gustafson, 2015). Adamson, Beswick and Ebrahim (2004) use four evidence-based, compelling terms to describe disability after a stroke, includes: 1. Stroke increases the chances of disability more markedly than any other condition; 2.Stroke has a greater disability impact than other chronic diseases; 3. Stroke causes a greater range of disabilities than any other condition; 4. Stroke is the largest cause of complex disability in adults.

Although the above accounts described the interaction between stroke and disability, it is not exhaustive in describing the characteristics of the disability and the consequences of this complex disability in patients' day to day life perspectives. The WHO has offered a new dimension in defining the complex consequences of health and health-related conditions (including stroke) referred to as the International Classification of Functioning, Disability and Health (ICF) (World Health Organization, 2001) which currently serve as a conceptual framework in many investigations related to disability and stroke. The ICF is a versatile classification system premeditated to assist several disciplines and sectors, including education and transportation, health and community services and across diverse countries and cultures. In the context of functioning and disability, the ICF concepts are multifarious, involving: 1. The body functions and

structures of the person, and impairments they could suffer from (defined as functioning at the level of the body structures); 2. The activities people are involved in (defined as functioning at the level of the individual and his/her abilities) and the activity limitations they could encounter; 3. The participation or involvement of people in various facets of life, and the restrictions in participation they could undergo (defined as the functioning of a person as a member of society); and 4. How the above experiences could be influenced by environment factors (and whether these factors are serving at one time or the other as facilitators or barriers).

Motor impairments (of upper and lower extremities) are by far the major recognizable impairments caused by stroke, and are associated with limitations in activities requiring mobility or independent arm function as required for daily living (Danielsson et al, 2012; Goulding et al, 2004; Kelly-Hayes et al, 2003; WHO, 2001). These limitations often result in a decline in quality of life of the stroke survivors and increased dependence in most ADL, for the remaining part of their life, resulting in participation restriction (WHO, 2001). Despite the increased attention in intensive and efficient rehabilitation procedures, nearly 50-60% of stroke survivors will experience a certain level of motor impairment (Hendricks, Limbeek, Geurts &warts, 2002). While the consequences stroke impairments/disabilitiesare daunting, rehabilitation remainsfavoured as one of the cornerstones of managing sensory and motor deficits accompanying stroke (Brewer, Horgan, Hickey & Williams, 2012).

The rehabilitation of the person with stroke aims to minimize physical and cognitive impairments, increase functional independence, decrease the onus of care/support provided significantly by caregivers, reintegrate the person into the family and community, and restore the person's health-related quality of life (Brewer et al, 2012; Dobkin et al, 2004). Stroke rehabilitation is a dynamic process (Brewer et al, 2012), with a consistent evolution of clinically based approaches to tackling the complex consequences of stroke disability. Rehabilitation of stroke is conventionally made up of several neurophysiological techniques as advanced by many practitioners including Bobath, Rood, Kabat, and Brunstrom (Chan et al, 2006; Paci, 2003). The techniques of neurophysiological approaches (such as Proprioceptive Neuromuscular Facilitation (PNF), Bobath's Neuro-Developmental, Brunnstrom's and Rood's techniques) are centred on motor control and recovery, relying on natural processes as the basis for the enhancement of recovery. Neurophysiological approaches are based on certain key principles including a. Facilitation or inhibition of activity through elicitation of sensory stimuli (reflexes); b. Utilisation of developmental milestone as the key guide in the evaluation and treatment of patients; c. A holistic approach to patient assessment, review and evaluation; d. Predefined close interaction between therapist and patient, as treatment is a one to one therapy.

The neurophysiological rehabilitation techniques have been criticised for a number of reasons including the cost and the time needed to execute the approach. The cost of training practitioners and the time required for training is extensive (Hafsteinsdóttir, Algra, Kappelle & Grypdonck, 2005). The techniques have also been faulted for relying

on old-fashioned philosophies, described as a form of therapy which increases clients' passivity and often with poor carryover effects into practical life events (Belda-Lois et al, 2011; Hafsteinsdóttir et al, 2005). Despite the criticism about these conventional rehabilitation techniques they still remain largely in use. Additionally, the techniques have also been criticised based on the choice of technique, which is essentially discretion centered (eclectic method to treatment), there is no any particular standard style or evidence to inform choice of a specified technique (Rensink, Shuurmans, Lindemann, & Hafsteinsdóttir, 2009; Pollock, Baer, Pomeroy, Langhorne, 2007: Gordon et al, 2004). This suggests that no single rehabilitation technique is evidently the best for advancing recovery post stroke (Rensink et al, 2009; Pollock et al, 2007; Jette et al, 2005). Owing to these limitations researchers have been unrelenting in developing several emerging evidence-based approaches to aid in the rehabilitation of stroke survivors. These new techniques of stroke rehabilitation are largely developed to address most of the limitations often described in the old-fashioned techniques of rehabilitation, especially, the passivity and poor patient centred characteristics of the earlier approaches (Belda-Lois et al, 2011).

Rehabilitation of stroke survivors as a dynamic entity has seen much improvement in the last three decades with several evolving and evidence-based clinical approaches. The emergence of these approaches is secondary to substantial advances in the realisation of the natural history of recovery post stroke and the evolution of techniques to influence recovery processes (Brewer et al, 2013). Among such emerging evidence-based approaches is Task Specific Training (TST). Substantial evidence suggests that

TST assists functional recovery in stroke rehabilitation, with a goal of achieving true recovery of function based on motor learning principles, including purposefulness, multiple repetitions, and intensified activity (Krakauer et al 2006; Kleim &Jones, 2008). TST is an approach that emerged from movement science and motor skill learning literature (Schmidt & Lee, 2005) and it defines training or therapy in which clients practice context-specific motor tasks and receive some form of feedback (often a verbal commendation from the therapist regarding performance of the task and it could be a visual feedback where a patient can appreciate the accomplishment of the task him/herself) (Teasell et al, 2008). Task specific training in rehabilitation is centred on the advancement of performance in functional tasks through goal-directed practice and repetition. The key target of the training is re-engineering functional tasks rather than impairment, such as with muscle strengthening. Clients are actively engaged throughout TST therapy session unlike the passivity is seen in conventional rehabilitation. It is important to emphasise that from the motor skill/motor learning disciplines, TST may be enhanced by different practice conditions, feedback and conditions of transfer (Winstein & Wolf, 2008; Schmidt & Lee, 2005). Task specific training in rehabilitation is centered on advancement of performance in functional tasks through goal-directed practice and repetition. The key target of the training is reengineering functional tasks rather than addressing impairment, such as with muscle strengthening. Clients are actively engaged throughout TST therapy session unlike the passivity seen in previously mentioned conventional rehabilitation.

The administration of TST is largely a one to one therapy/patient ratio, however, Dean, Richards and Malouin (2000) posited that exercise classes are another pattern to administer TST in order to ensure maintenance and/or improved performance following discharge from a rehabilitation programme. They described exercise classes as advantageous; as such classes provide the opportunity for exercise, social interaction and are cost-effective because several individuals participate at the same time. Earlier Carr and Shepherd (1982) suggested that the philosophy of rehabilitation should involve training of daily activities by drawing evidence from movement sciences, especially biomechanics and motor learning coupled with the understanding of the pathology and impairments in stroke. They advocated that training can be arranged in the form of a circuit involving series of workstations, intended to strengthen affected muscles and provide the prospect for task practice (Carr & Shepherd, 1998). The use of evidence drawn from TST and theoretical suggestion about providing training in series of workstations by Carr and Shepherd (1982) gave birth to Circuit Class Therapy.

Circuit Class Therapy (CCT) is a form of Task Specific Training (TST) that involves the practice of structuring tasks in a circuit or series of workstations. It satisfies the three key characteristics of an effective and efficient skill training programme (Wevers et al, 2009) including: (i) using different workstations that allow people to practice intensively in a meaningful and progressive way to suit their respective needs; (ii) efficient utilisation of therapists'/trainees' time; and (iii) it encompasses group dynamics such as peer support and social support (Eng et al, 2003; Dean et al, 2000). Several research trials have shown that CCT is effective in improving balance, transfers, gait, gait-related

activities (such as climbing stairs) and upper limb functions in stroke survivors (Robinson, Mahon, Yeoman, Janssen, 2011; Blennerhassett, & Dite, 2004), especially when applied within the first six months after stroke (van de Port, Wevers, Lindeman, Kwakkel, 2012; Outermans, Van Peppen, Wittink, Takken, Kwakkel, 2010;English, Hillier, Stiller, Warden-Flood, 2007) and even later (Robinson et al, 2011; Mudge, Barber&Stott , 2009).

The administration of circuit class therapy and other therapeutic exercise approaches are recognised to optimise recovery from stroke (Veerbeek et al, 2011). Evidence from several systematic reviews also suggest that if higher doses therapy (in form of increasing duration of therapy or additional number of repetitions) are offered there is enhanced but moderate outcome in some stroke recovery outcome variables (Veerbeek et al, 2011; Cooke et al, 2010a, Galvin et al, 2008; Kwakkel et al, 2004). For example Veerbeek et al (2011) reported that in the six months after stroke increasing the time of exercise therapy is associated with moderate effects in walking ability, walking speed and extended activities of daily living. While the outcomes of the systematic reviews are impressive, authors were unanimous that does-response trials are heterogeneous in methodology (including patient characteristics, study design, mode, frequency and type of exercise). Additionally, none of the studies reviewed in these systematic reviews included a circuit class therapy mode of exercise therapy. However, a recent study (English et al, 2015) found no significant difference between circuit class therapy and usual care in walking distance despite an added 22 hours in the circuit class therapy group over the usual care. In an editorial regarding the contradictory finding in relation

to available evidence English and Veerberk (2015) observed that despite the huge additional time spent in the circuit class therapy group in the original study, there was no difference in dose of walking practice in the two groups. They, therefore, remarked that only augmenting time of practice alone without additional task-specific training time does not seem to benefit patients. It is obvious that evidence for the effectiveness of dose-response relationship exercise and stroke outcomes is inconclusive and particularly in circuit class therapy. Establishing evidence for a dose-response relationship for circuit class therapy may be different compared to what obtains for general exercise procedure primarily because of the features of the approach, such as involvement of several workstations, therapist to patient ratio and the group characteristics. These features make the practice of circuit class therapy different from general exercise protocol and might also produce a different response to increased exercise dose.

A holistic examination of response to the augmented duration of therapy has not been conducted for circuit class therapy, such as using the ICF framework. Reporting outcome based on the concept of the ICF would comprehensively present the response to therapy in different categories of the ICF with clinical clarity and favourable implementation of findings. This study is also the first study testing the effectiveness of differing intensities of CCT (as same type of exercise) in the rehabilitation of stroke survivors and how convenient or acceptable the intensities of therapy are to stroke survivors.

1.2 Problem statement

The goal of CCT in stroke rehabilitation is to institute an enduring motor learning in order to optimise motor/functional recovery, necessary for the achievement of community reintegration of stroke survivors (English, van de Port & Lynch, 2012). To accomplish sustained motor learning, rehabilitation must be geared towards a relatively permanent behavioural change, which is currently believed to manifest as a result of a neuroplastic change in the brain itself (Arya et al, 2011). Compelling evidence from neuroscientific studies suggest that neuroplastic changes in the cerebral cortex and in other parts of the central nervous system (CNS) are the physiological mechanism for effective motor skill retraining following stroke (Jones et al, 2009; Gauthier et al, 2008; Chan et al, 2006). These studies identified TST and intensity of multiple repetitions as critical features to enhancing neural reorganisation and "rewiring" in the CNS. By implication, the damaged brain will, therefore, benefit from repeated sensorimotor inputs (efferent-afferent feedback loops) inputs in order to remodel effectively for the attainment of motor/functional recovery in stroke survivors.

Although the prominent attribute to stroke rehabilitation is not restricted to task repetition, based on evidence it seems that functional recovery and neuroplastic change become manifest following a larger number of task specific repetitions (increased intensity or “dosage”) and not with fewer (Askim et al, 2010; Carey et al, 2007; Wolf et al, 2006). This signifies the need for rehabilitation professionals to focus on meaningful, repetitive and intensive specific tasks during a rehabilitation plan (Kimberly et al, 2010; Daly & Ruff, 2007). Early studies using animal subjects (on neuroplasticity) indicated

that 400-600 repetitions per day of a challenging functional specific task (fine motor grasping) can steer structural neurological changes after induced stroke to the hand area in non-human primates (Kleim et al, 1998; Nudo et al, 1996). In a study (Classen et al, 1998) on apparently healthy human subjects alteration of transcranial magnetic stimulation was evoked after repeated specific movements of thumb practice. This change was evoked following 15-30 minutes of uninterrupted efforts of one movement and wiped-out approximately 20-30 min. In stroke survivors, Carey et al (2002) reported significant cortical reorganisation and functional recovery in subjects with impaired grasp and release function of the upper extremity following 100 repetitions per day (1,200 totals) of a finger tracking activity. Approximately, 1,000 to 2,000 steps per session have been reported as evidence (for lower limbs) to evoke improvement in hind limb stepping and step quality in animal models. It can be concluded from the available evidence that simply engaging a neural circuit in task performance is not sufficient to drive plasticity (Cha et al, 2007; De Leon, Hodgson, Roy, & Edgerton, 1998), rather the repetition of a newly learned or relearned behavior is a requisite to accelerate enduring neuronal changes (Rose et al, 2011). It has been proposed that planning the contents of a session in advance with a predetermined progression of tasks may allow more time for in-session practice (Rose et al, 2011).

Stroke survivors commonly demonstrate activity intolerance (Roth & Harvey, 2000) and ambulatory persons with a history of stroke may be able to perform at ≈50% of peak oxygen consumption and 70% of the peak power output that can be achieved by age- and gender-matched individuals without a history of stroke (Gordon et al, 2004). The

poor tolerance and performance characteristics of stroke survivors might affect the rate of repetitions in the execution of TST and by implication, the duration required for the performance of motor tasks between individuals without a history of stroke will be lower than that required for stroke survivors. Additionally, in CCT, participants are exposed to multiple progressively structured tasks to be accomplished within a session and considering the pathophysiological challenge of stroke survivors, they might need more time to perform multiple repetitions to enable neuroplastic changes. Four meta-analyses have identified that augmentation of exercise therapy and/or time of exercise therapy result in significant small to moderate gains in ADL, walking ability and walking speed (Veerbeek et al, 2011; Cooke et al, 2010a; Galvin et al, 2008; Kwakkel et al, 2004). However, not all questions regarding augmented exercise therapy have been answered by existing studies. In particular, Veerbeek et al (2011) posited that as at 2011, there have been no clinical trials that explicitly investigated the impact of different doses of exercise therapy in which context, focus and timing of therapy are controlled in a systematic way. Hence, they recommended high-quality dose response exercise therapy trials with identical treatment goals, but of incremental levels of intensity. Since two years after these observations by the authors (prior to the commencement of this study in 2013) no clinical trial has been conducted to address the gaps identified by the meta-analysis. The present study is, therefore, is designed as a clinical trial with a clear attempt to examine different doses of same type of exercise therapy (varied doses of CCT), with a defined context (task specificity), focus (using the ICF framework to guide the outcomes measured) and timing (time since stroke above 30 days after stroke).

In summary, pathophysiological and clinical factors might in isolation or collectively support the need to examine the effect of augmented therapy time in CCT. However, while there is the need to investigate the effect of augmenting the duration of therapy, it is equally imperative to determine how acceptable the augmented duration of CCT is, to stroke survivors.

1.3 Research Questions

This study was designed to answer the following questions:

i. What is the effect of a structured augmented CCT model on body structure/function (impairment) in stroke survivors?
ii. What is the effect of a structured augmented CCT model on activity limitations (functional activities) experienced by stroke survivors?
iii. What is the effect of structured augmented CCT model in influencing participation restrictions suffered by stroke survivors?

1.4 Aims of the Study

The aim of this study is to investigate post-stroke disability using augmented durations of CCT.

1.5 Objectives

The specific of objectives of this study are:

The objectives of this study are as follows:

1. To determine the effect of varying durations (intensity) of CCT on body function/structure following CCT in stroke survivors.
2. To determine the effect of varying duration of CCT on activity following CCT in stroke survivors.
3. To determine the effect of varying duration of CCT on participation following CCT in stroke survivors.

These objectives were fragmented as follows:

1. To determine the effect varying duration of CCT on body structure/function in stroke survivors.

   Focusing specifically on:

   1.1. Assessments of the strength of selected muscles of the upper extremity (Using Manual Muscle testing).

   1.2. Assessments of the strength of selected muscles of the Lower extremity (Using Manual Muscle testing).

   1.3. Assessments of spasticity in selected joints of the upper extremity (Using Modified Tardieu Scale).

   1.4. Assessments of spasticity in selected joints of the lower extremity (Using Modified Tardieu Scale).

2. To determine the effect varying the duration of CCT on activity in stroke survivors.

   Focusing on:

2.1. Assessments of global disability post stroke (Using modified Rankin Scale).

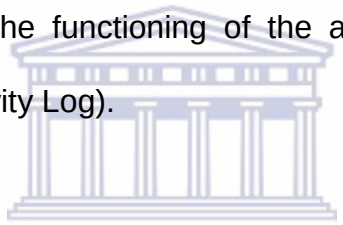
2.2. Assessments of functional tasks of daily living (activities of daily living – ADL) post stroke (Using Modified Barthel Index).

2.3. Assessments of functional capacity (distance covered during walking in six minutes) (using Six-Minute Walk Test).

2.4. Assessments of gait speed (Using 10 Meter Walk Test).

2.5. Assessments of upper extremity activity limitations (Using Action Research Arm Test).

2.6. Assessments of the functioning of the affected hand in daily activities (Using Motor Activity Log).



3. To determine the effect of varying duration of CCT on participation in stroke survivors.

   Focusing on:

   3.1. Assessments of community participation cutting across 12 domains of mobility, energy, upper extremity (UE) function, work/productivity, mood, self-care, social roles, family roles, vision, language, thinking, and personality specific for stroke survivors (using Stroke Specific Quality of Life Questionnaire).

4. Assessments of acceptability of different durations of CCT (using an adapted purpose-designed acceptability questionnaire).

1.6 Outline of the Thesis

The thesis is arranged in six chapters. Chapter one details the background information necessitating the need for the study looking at the current and projected image of stroke in low-income and middle-income countries, it further describes the complex consequences of stroke in the light of disability and the WHO-ICF framework for the description of the disability accompanying stroke. The chapter stresses the dynamic characteristic of stroke rehabilitation. Emphasis was also made in the chapter on pathophysiological and clinical characteristics of stroke disability necessitating the need for in-session augmentation of exercise therapy time by making reference to substantial evidence.

Chapter two of the thesis presents the review of various relevant literature. It gives the recent global picture of stroke epidemiology, with specific bias to the low-income and middle-income countries and particularly sub-Saharan Africa. The chapter also presents the WHO-ICF framework for stroke as is relevant to the study. Recent advances in stroke rehabilitation are briefly reviewed with emphasis on the dynamism of stroke rehabilitation. A of the literature on circuit class therapy was also presented in this chapter and the mechanism of functional recovery following rehabilitation was detailed by a section on neuroplasticity.

In chapter three the methodology employed in this study is presented, ranging from the study design, pilot study, through to the main study. The chapter also detailed the procedure for statistical analysis used in the study.

Chapter four comprises the outcome of the study (results) following statistical analysis. For clarity, this chapter is arranged in six different sections. 1. The outcome of pilot study and its discussion as a whole will be presented in this section; 2. Socio-demographic characteristics of study participants for the main study will be presented here; 3. The outcome of the study based on body structure and function; 4. The outcome of the study based on activity limitation, as in the study objections this section is divided six subsections; 5. Community participation section; 6. Acceptability section.

In chapter five detailed discussion of the study findings in relation to previous studies will be highlighted. The implications of the present findings are discussed in both clinical and research perspectives.

Chapter six of this study presents the conclusion as relevant to the study outcomes. Recommendations for clinical practice, further studies and policy development are also highlighted in this chapter.

1.7 Summary of Chapter

In this chapter, the brief epidemiology of stroke in low-income and middle-income countries particularly is sub-Saharan Africa was put forward and the need for a refocus of this crisis especially in these regions of the world. The dynamic nature of rehabilitation was viewed and the current emphasis in neuro-scientific findings on the importance of task specificity and multiple repetitions in ensuring lasting neuroplastic change post stroke. The chapter also stresses the complex consequence of stroke in limiting the ability for repetitive task practice if time is constrained time and the

characteristics of circuit class therapy that might also limit accomplishment of the required number of multiple repetitions within a limited time period, thereby necessitating the need for in-session augmentation of therapy time. The chapter also gives the significance of this study, its key research questions, primary aim and specific objectives. Finally, the chapter highlights contents of the subsequent chapters in this thesis.

2 CHAPTER TWO: LITERATURE REVIEW

"Declare the past, diagnose the present, foretell the future; Foolish the doctor who despises the knowledge acquired by the ancients" (Hippocrates 480 BC)

2.1 Introduction

This study investigated the effectiveness of a structured Circuit Class Therapy model in stroke rehabilitation. This chapter contains a review of relevant existing literature on stroke, rehabilitation and circuit class therapy as they relate to this study. The chapter is made-up of nine sections (9) besides this introduction: section one focuses on an overview of stroke (definition, types and subtypes), section two gives the epidemiology of stroke (global and Sub-Saharan African incidence and risk factors), section three examines stroke rehabilitation, in particular from the two perspectives in both traditional and newer rehabilitation techniques, section four is on Task Specific Training with emphasis on the development of TST and its principles, section five reviews studies on circuit class therapy, core principles, procedure/administration and evidence for CCT in stroke rehabilitation. Section six discusses relevant studies on augmented exercise therapy for stroke rehabilitation; section seven reviews the concept of neuroplasticity, section eight the WHO-ICF framework. And section nine was a brief summary of the chapter.

The procedure adopted in the conduct of this literature review included an electronic search of relevant databases including Scopus, PeDro, Google scholar, PubMed, Ebscohost (MEDLINE, CINAHL, Health source and SPORTDiscus), Cochrane, and

Science Direct. The main approach to information gathering for this review was focused on published systematic reviews on specific topics representing each section. However, where systematic reviews were not found reviews were performed on randomized controlled trials randomized uncontrolled trials or observational studies.

2.2 Section one: An Overview of stroke

This section describes stroke with regards to its definition, types, and its clinical subtypes.

Stroke, also termed as cerebrovascular accident or apoplexy, has a long standing definition, which has remained the same for decades. The definition has been consistently unchanged when applied on both clinical and epidemiological perspectives. A stroke is defined as a clinical syndrome characterized by rapidly developing symptoms or signs resulting in a focal or global loss of cerebral function, with symptoms lasting more than 24 hours or leading to death, for which there is no other attributable cause other than vascular origin (WHO, 1988).

Stroke as a clinical syndrome is highly heterogeneous, particularly in types and sub-types where the emphasis has generally been on the pathological origin of the condition (Warlow, 1998). The two leading types of stroke are brain ischemia (also known as cerebral infarction or apoplexy) and brain hemorrhage (which could be intracerebral or subarachnoidal). About 80 % of strokes occur as a result of ischaemia and the remaining is due to haemorrhage. Haemorrhagic stroke results from trickling of blood

from the arterial vessel or from a total rupture of the vessel. The escaped blood following this event increases the pressure within the intracranial cavity which damages brain cells. Ischaemic stroke on the other hand results from deficient or disrupted blood circulation in the specific region of the brain, due to occlusion of blood vessels following thrombosis or embolism. This leads to an insufficient amount of oxygen and nutrients available in such region of the brain, thereby damaging the brain cells (Gomes & Wachsman, 2013; Kuklina, Tong, George, & Bansil, 2012; Andersen, Olsen, Dehlendorff, & Kammersgaard, 2009; Amarenco, Bogousslavsky, Caplan, Donnan & Hennerici, 2009). Several classifications of stroke subtypes have been described based on the characteristic nature of the initial lesion, morphologic presentation, topographic location, ethnographic distribution, the onset of the condition and its pattern of evolution. The following figure (2.1) shows a more clinically-based classification by Tejedor, Bruto, Sabin, Munoz and Abiusi (2001):

The mechanism of stroke onset described as stroke types and subtypes is one of the major factors of stroke prognostication. Haemorrhagic stroke has been reported to be frequently more fatal than Ischaemic stroke (Brønnum-Hansen, Davidsen, Thorvaldsen, & Danish, 2001; Truelsen, Begg, & Mathers, 2000), with the subarachnoid subtype being the most fatal in this category. However, in the mechanism of ischaemic stroke, victims of stroke who suffer lacunar infarcts demonstrate up to one year better prognosis above other forms of infarcts of ischaemic origin, but with regards to long-term prognosis lacunar stroke are not too distinct from non-lacunar stroke. Additionally, studies have identified that, of the remaining subtypes of ischaemic strokes cryptogenic

stroke (stroke with uncertain causes) has a better prognosis up to a year after stroke, as infarcts of cardioembolic mechanism or large artery present poorer prognosis compared to all other subtypes of infarcts (Petty et al, 2000; De Jong, Van Raak, Kessels, & Lodder, 2003; Sprigg et al, 2007; Lima et al, 2014).

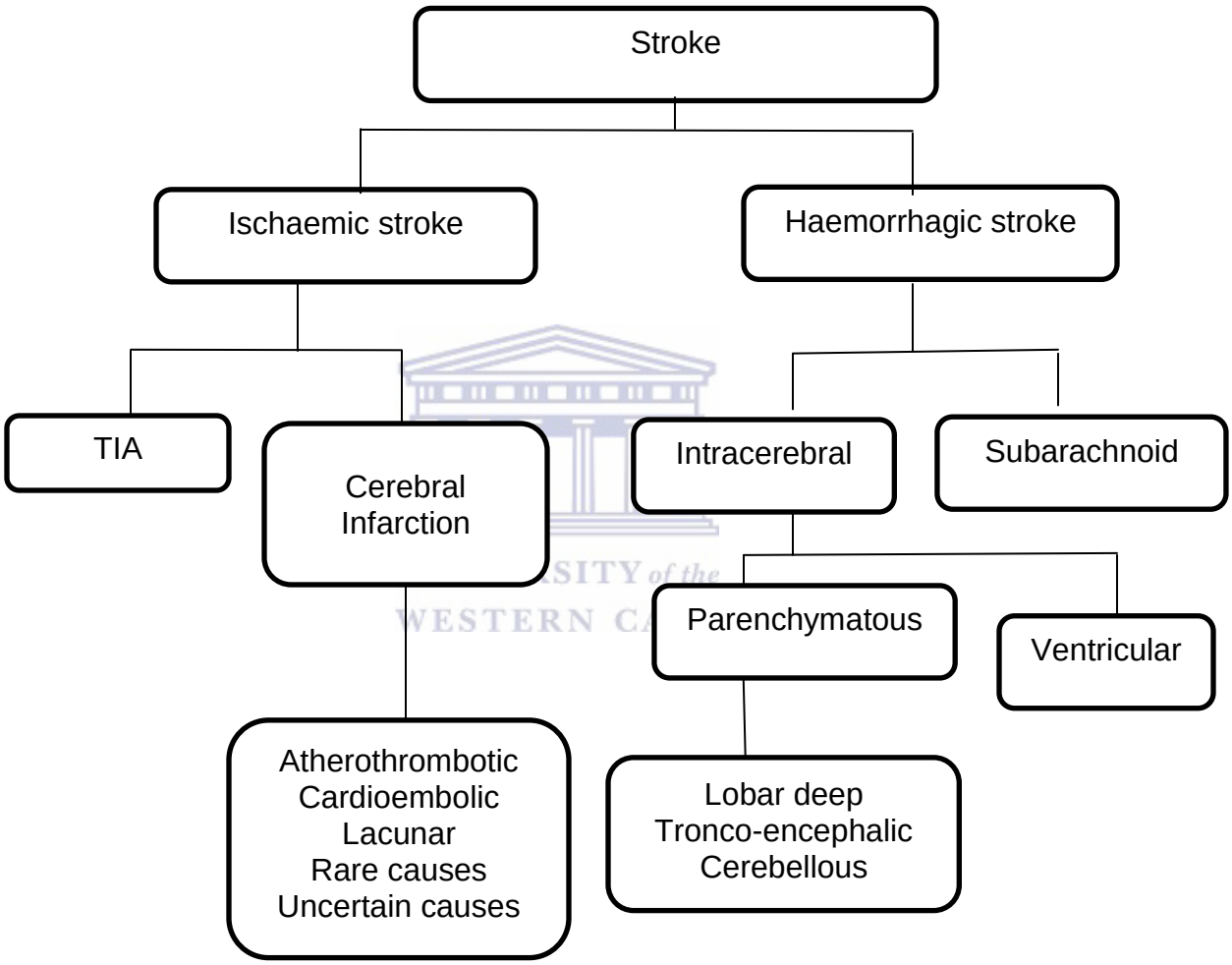


Figure 2.1: Clinical classification of stroke.

2.3 Section Two: Epidemiology of stroke

Most of the incorporated information in this section is derived from reviews coming from the Global Burden of Disease (GDB) and other relevant reviews.

The knowledge of the epidemiology of stroke (incidence and prevalence) is essential in determining the burden of stroke and the outcome of such findings will aid planning with respect to prevention and treatment of victims of stroke (Feigin et al, 2009).

2.3.1 Incidence and prevalence of stroke

Stroke is one of the most disabling neurological conditions. WHO global update 2014 ranked stroke as the second most cause of death globally just behind ischaemic heart disease (Fig. 2.2) accounting for approximately 6.7 million deaths in 2012.

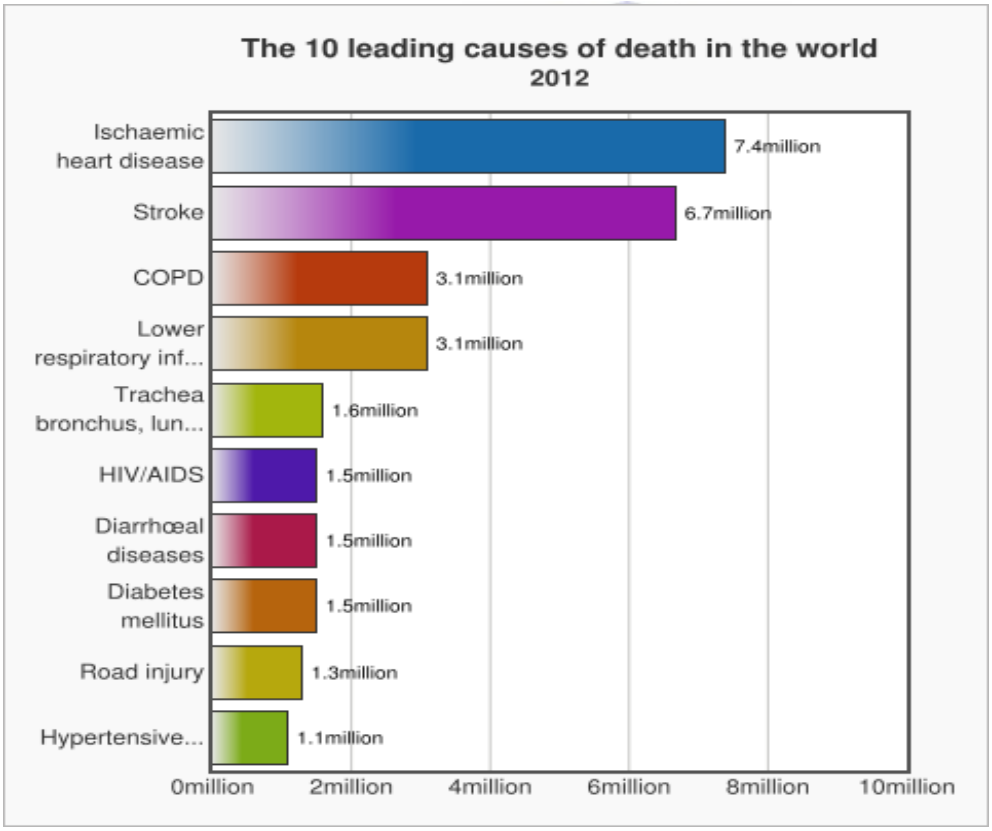


Figure 2.2: Leading causes of death worldwide

The reporting of stroke incidence is usually per 100,000 persons-years in most studies and sometimes standardised using certain demographic factors like age, gender, and risk factors (Feigin et al, 2016; Feigin et al, 2014; Krishnamurthi et al, 2013; Feigin et al, 2009; Feigin et al; 2003).

Incidence and prevalence measures of stroke present considerable differences among regions and countries globally. Several factors affect presentation of results obtained in these studies, some of which include economic inequalities, level of exposure to environmental and other risk factors, gender, genetic predispositions, type of stroke, behavioural/lifestyle variations, and methodological approaches used in accessing and reporting findings (Owolabi et al, 2015; Thrift et al, 2014; Feigin et al, 2009). Although all these factors are important in defining the variation in stroke across regions and countries, one of the main reasons has been variation in the distribution of wealth across countries (i.e. a country's national income). National income has been identified as a strong predictor of stroke burden (Johnston, Mendis & Mathers, 2009). Studies have reported a convincing association between lower national income per capita and a higher burden of stroke despite adjustment for nationally identifiable risks for cardiovascular diseases (such as obesity, hypertension, cigarette smoking, alcohol consumption, diabetes and physical inactivity) (Feigin et al, 2009; Jonston, Mendis & Mathers, 2009). The trends of association between country's national income and the burden of a disease condition like stroke have been linked to epidemiological transition. Epidemiological transition is recognized as a change in global burden of disease pattern, represented by shifting from the commonly known infectious (communicable)

diseases to the less-recognised non-communicable diseases, such that chronic conditions like heart disease and stroke are currently becoming the leading causes of death worldwide (Maredza, Bertram & Tollman, 2015; Feigin et al, 2014; Deaton et al, 2011). Low-income and middle-income countries (LMICs) appear to be the most struck by this phenomenon.

Stroke and heart disease had previously been considered primarily as diseases of the high-income countries (HICs), however, current evidence suggests a completely different situation regarding the burden of stroke between the high income and low to middle-income countries of the world. A systematic review (Feigin et al, 2009) investigating the global incidence of stroke using data from 56 population-based studies published from 1970-2008, reported that there are trends in stroke incidence between high income and low income to middle-income countries. This trend indicated a 42% decline in age-adjusted stroke incidence in high-income countries (from 163 per 100,000 in 1970-79 to 94 per 100,000 in 2000-2008) and a more than 100% increase in low income to middle-income countries (from 52 per 100,000 in 1970-79 to 117 per 100,000 in 2000-2008). Additionally, in 2000-2008, stroke incidence rates in low to middle-income countries for the first time surpassed high-income countries (Feigin et al, 2009).

A more recent systematic review used data from the Global Burden of Disease (GBD) 2010 involving studies from 1990-2010 and covering 21 regions of the world. In this report, Feigin et al (2014) reviewed 119 studies from high income and low to middle

income countries. Results from their review suggested that the age-standardised incidence of stroke decreased significantly by 12% in high income countries and increased by 12% in low to middle-income countries. The absolute number of individuals with the first-ever stroke according to the report was 16.9 million, those surviving stroke were 33 million, deaths due to stroke were 5.9 million, with a high DALYs lost (102 million) and had shown significant increases since 1990 (68%, 84%, 26% and 12% respectively). In the incidence of stroke by age globally in 2010, 31% of strokes constituting 5.2 million, occurred in children (below 20 years of age) and the middle age (20-64 years of age), among which children and young adults living in low to middle-income countries made up a huge proportion (89% and 78% respectively) of the burden (Feigin et al, 2014). Furthermore, the differences in geographical distribution of stroke were found to be significant among GDB regions and countries; it amounted to between three to 10 times the incidence of stroke burden across GDB regions and countries (Feigin et al, 2014; Thrift et al, 2014) with its most disturbing figures in low income and middle-income countries.

These worrying global figures and particularly the ensuing long-term effects of stroke in LMICs, suggest the immediate need for a concerted global effort to combat stroke and reduce the consequence of stroke among victims in regions and countries of the world.

2.3.2 Stroke in Sub-Saharan Africa

Accurate data for stroke in SSA and many other LMICs is poor and it is even more problematic to reliably estimate stroke incidence in the population leaving in these

regions (Owolabi et al, 2015). The problems associated with accessing reliable data in SSA are both practical (deficient manpower and the enormous reality of battling with infectious, perinatal and nutritional diseases) and political (allocations of fewer resources to preventive medicine in order to combat the epidemic of non-communicable diseases such as stroke). Despite the challenge of obtaining reliable data most recent available evidence from three separate systematic reviews suggested that the burden of stroke in African is high and on the increase (Owolabi et al, 2015; Adeloye, 2014; Connor et al, 2007), with an estimated age-adjusted standardised annual incidence of 81-316/100,000 person-years (from 1990 to 2010) (Feigin et al, 2014), which is higher than what is obtained in the HICs with an annual incidence of 114 to 223/100,000 per person years (Feigin et al, 2009). These figures further affirm the declining trend in HICs and increasing trend in LMICs and particularly the SSA. The following table (2.1) presents the incidence of stroke in some countries of the world and the SSA.

Table 2-1: Stroke burden in some countries and Africa (presented in incidence/100,000 person years)

Author/date	Country/region	Incidence/100,000 person-years
Syme et al/2005	Scottish border/Scotland	280
Kulesh et al/2010	Grodno/Belarus	222
Sugama et al/ 2013	Okinawa/Japan	124 and 144
Benamar and Grosset/2009	Arab countries	27.5 to 63
Sridharan et al/2009	Trivandrum, Kerala/India	135
Hallström et al/2008	Southern Sweden/Sweden	144
Tsiskaridze et al/2004	Tbilisi/Georgia	165
Powles et al/2002	Verna city/Bulgaria	909
Hamad et al/2001	Qatar	41
Africa		
Walker et al/2010	Hai/Tanzania	108
Walker et al/2010	Dar-es-Salam/Tanzania	315
Maredza et al/2015	Agincourt/South Africa	244
Danesi et al/2013	Lagos/Nigeria	25
Farghaly et al/2013	Al-Kharga/Egypt	250
El-Tallawy et al/2013	Al-Quseir/Egypt	181
Damasceno et al/2010	Maputo/Mozambique	149

In Africa most data are hospital based or from verbal autopsy (Owolabi et al, 2015; Feigin et al 2014; Connor et al, 2007). In a study conducted in a rural setting in Nigeria, NCDs were found to constitute 63% of all deaths with stroke topping the list of the NCDs (Owolabi et al, 2014; Feigin et al, 2014; Moran et al, 2013). A similar study from Tanzania reported stroke as the leading cause of hypertension-related mortality from 2009 to 2011 (Peck et al, 2013). In Addis Ababa from 2006 to 2009, 11% of deaths due to stroke were reported using verbal autopsy from burial surveillances of 58010 death tolls. The result indicated increasing mortality rate with advancing age (15-34 years = 1%, 35-54 years = 7%, 55-74 years = 16%,> 74% years = 18%), no gender differences

were found (Misganow, 2012). A South African community-based study (Agincourt) reported that 6% of all death from 1992 and 1995 were due to stroke (Maron et al, 2013). The GBD model assessment also confirmed stroke as the leading CVD cause of death and disability in SSA in 2010 (Maron et al, 2013). Overall the GBD reported an estimated age-standardized stroke mortality rate of between 52.0 and 136.7 per 100,000 person-years (Feigin et al, 2014) in SSA and other LMICs. It was emphasised that as much as 10 times difference was found between the lower level of stroke mortality rates in HICs and the upper level of mortality rates in many countries in Western and central African countries plus other LMICs.

2.3.3 Risk Factors

There are many risk factors associated with stroke, some of which are modifiable and some are non-modifiable (Choudhury et al, 2015). The table (2.2) below presents the list of the common modifiable and non-modifiable stroke risk factors.

Table 2-2: Modifiable and Non-modifiable stroke risk factors

Category	Risk factor
Non-modifiable	
	1. Age
	2. Gender (Male > Female except very young and very old
	3. Race (Afro-Caribbean > Asians >Europeans
	4. Hereditary
Modifiable	
	1. Hypertension
	2. Heart diseases
	a. Heart failure
	b. Mitral valvular diseases
	c. Acute myocardial infarction
	d. Atrial fibrillation
	3. Diabetes
	4. Obesity
	5. Smoking
	6. Hyperlipidemia
	7. Excess alcohol consumption
	8. Polycythemia
	9. Oral contraceptives

2.3.3.1 Non-modifiable risks for stroke

Age

Age has been adjudged the single most important non-modifiable risk factor for stroke (Chondhury et al, 2015). The burden of stroke incidence rises with advancing age and almost double after every decade from age 45 to 85 years. The risk of stroke is uncommon below 40 years of age (Miah et al, 2012) but becomes more apparent in the age range of 55-64 years (Choudhury et al, 2015). In sub-Saharan Africa stroke apparently affects a younger population compared to high-income countries (O'Donnell et al, 2010; Owolabi, Ugoya & Platz, 2009). Factors such as genetic, poorly diagnosed

and controlled hypertension and shorter life expectancy have all been attributed to the younger age onset of stroke in these regions (Owolabi et al, 2009; Abegunde et al, 2007).

Gender

Differences in stroke epidemiology between sexes remain largely controversial (Paolucci, 2008;Chong et al, 2006; Kelly-Hayes et al, 2003) and data on gender-specific stroke burden is largely scarce (Carandang et al, 2006; Dyall et al,2006). However, a recent systematic review (Barker-Collo et al, 2015) from the GBD data from both 1990 and 2013 reported that for both stroke types [Ischaemic (IS) and haemorrhagic (HS)] both men and women showed increased incidence of IS and HS; however, women depicted a non-significant decrease in HS mortality compared to their male counterpart. The report found a significantly higher prevalence rates for both types of stroke in men over women in 1990 and 2013, the authors attributed the difference in prevalence to population growth, population ageing and declining stroke mortality in some regions. In mortality rate by sex, both men and women showed declining mortality for IS, although, men showed higher mortality rate in absolute values compared to women. Declining mortality rate was also found in HS for both men and women, but women were slightly lower in 1990 and higher in 2013 (Feigin et al, 2016, Barker Collo et al, 2015).

Race

The incidence and mortality of stroke can be racially discriminatory (Choudhury et al, 2015). A study was conducted to determine the risk for subarachnoid and intracerebral

haemorrhage between black and white Americans (Sacco, Kargman, Gu & Zamanillo, 1995); the outcome of the study suggested that blacks are 2.1 times at the risk of subarachnoid haemorrhage than whites and at 1.4 times risk of intracerebral haemorrhage over whites. The risk is also influenced by age with blacks below 75 years at 2.3 times at risk of intracerebral haemorrhage than whites at above 75 years of age. Intracranial stenosis has also been reported as being a more common cerebrovascular lesion in blacks than other racial groups (Mohammad, Qattan, Prahakaran, 2010).

2.3.3.2 Modifiable risks for stroke

The modifiable risk factors for stroke are many; however, certain risk factors are more important both for clinical reasons and in public health perspective. Feigin et al (2016) in a comprehensive systematic review on the global burden of stroke and risk factors for 188 countries and stretching from 1990 to 2013 reported that an estimated 90.5% of the global stroke burden within the periods reviewed is attributable to modifiable risk factors. The authors identified that the risk factors varied across countries at a range of 80% to 90%; typically it varies in African countries between 72% and 79%. In DALYs 74.2% (i.e. 83.8 million) were due to behavioural/lifestyle factors (including poor diet, sedentary lifestyle, smoking and physical inactivity), 72.4% (81.7 million) were associated with metabolic risks (such as high fasting blood sugar level, high total cholesterol, high systolic blood pressure (SBP), high BMI, high abdominal obesity and low GFR). The five leading modifiable risk factors DALYs (due to stroke) according to the report are high SBP, a diet low in fruits, high BMI, a diet high in sodium and smoking (Feigin et al, 2016). Another finding by the authors which is more specific to SSA was the

preponderance of household air pollution from solid fuels in central, eastern and western sub-Saharan African countries emerging as a risk factor for stroke.

The specific impact of some selected modifiable risk factors is presented below:

Hypertension

Hypertension has been adjudged the single most prominent risk factor for stroke (Feigin et al, 2016; Choudhury et al, 2015; Owolabi et al, 2015; O'Donnell et al, 2010). Hypertension is tagged a silent killer disease because of its poor early warning symptoms, even though it is a prominent aetiology of several health conditions, such as renal diseases, stroke and many other cardiovascular diseases (BeLue et al, 2009). The influence of hypertension on the prevalence of stroke increases with age. A population survey reported about 20% prevalence at the age of 50 years, 30% at 60 years, 40% at 70 years, and 55% at age of 80 and 90 years (Miah et al, 2012). In Africa prevalence rates for hypertension are distinct from one region to the other; and the poor awareness of the condition in the region seems to generally increase the risk of stroke and other cardiovascular diseases (Owolabi et al, 2015).

Diabetes

Diabetes increases susceptibility to atherosclerosis and atherogenic risk factors such as hypertension, obesity and abnormal blood lipids (Feigin et al, 2016; O'Donnell et al, 2010). Patients with diabetes are also estimated to have about two to six times the risk for stroke than normal population and aggressive management of both types I and II

diabetes has been found to reduce the risk for stroke particularly for those with a complication of hypertension (Fleming & Brown, 2004).

Dyslipidaemia

Dyslipidaemia is a condition characterized by abnormalities in the plasma lipids, which could be secondary to elevated levels of plasma total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), triglycerides (TG) and reduced high-density lipoprotein cholesterol (HDL-C), these situations may occur in isolation or in varying combinations (Wahed, El-Khashab & Hassan et al, 2016). The WHO global estimates for 2002 indicated that dyslipidaemia accounted for 18% and 56% of ischaemic heart disease (IHD) and stroke and above four million deaths yearly (WHO, 2002). In a South African study, Norman and associates (2000) reported that high cholesterol levels (≥ 3.8 mmol/L) accounted for 59% of IHD and 29% of ischaemic stroke burden in adults aged 30 years and above.

Smoking

Smoking is one of the most commonly reported lifestyle modifiable risks for both ischaemic and haemorrhagic stroke (Feigin et al, 2016; Broderic et al, 2007). Shinton and Beevers (1989) in a meta-analysis reported an estimated two times risk of ischaemic stroke for smokers over non-smokers and three times heightened risk for subarachnoid haemorrhage. Studies have also recognised passive smoking as a risk factor for stroke (Feigin et al, 2016; O'Donnell et al, 2010). In sub-Saharan African

countries aside from smokes from a cigarette, household air pollution from solid fuels has recently been identified as increasing the risk for stroke (Feigin et al, 2016).

Other modifiable risk factors

There are several other modifiable risk factors for stroke that have been well documented including obesity, alcohol consumption and oral contraceptives (Feigin et al, 2016; Choudhury et al, 2015; O'Donnell et al, 2010). These factors have been reported as stroke-related risk factors predisposing individuals to stroke globally and manifesting at varying degrees across regions and countries worldwide (Feigin et al, 2016; O'Donnell et al, 2010).

2.4 Stroke mortality

Mortality figures are traditionally obtained from vital registration data. However, this organised form of information is not derivable or feasible in many countries particularly, the low income and middle-income countries (Owolabi, 2015; Feigin et al, 2014; Thrift et al, 2014; Connor et al, 2007).

Thrift et al (2014) compiled the global stroke statistics to provide a common repository of published information on the impact of stroke globally. One of the key targets of their investigation is to report the global picture of mortality from stroke. Thrift et al (2014) reported the nearly most current stroke mortality data involving data for 2011 (from 25 countries), 2010 (from 19 countries), 2009 (from nine countries); and previous data coming from 1976–2008. Accordingly, to their report the WHO data for 2003 indicated

Kazhakstan as having higher crude stroke mortality (in deaths numbers per 100 000 population per year) above all other countries reporting mortality data to the WHO. Some other countries with statistics manifesting very high mortality from a stroke at different years according to the report include Russian Federation (in 1998), Bulgaria (2011), Greece (2010), and Romania (2010). Lower mortality rates were found in countries like Papua New Guinea (1977), Bahrain (2009), Nicaragua, 1978), and Kuwait (2011). The report stressed that lower crude stroke mortality rate was found in most of the low-to-middle-income countries (LMICs) compared to the high-income-countries (HICs) listed in the WHO data (Thrift et al, 2014). Thrift et al (2014) observed that the reason for the low stroke mortality in LMICs is attributable to the number of people in the population of those countries who are within the typically known age of stroke onset (≥ 65 years). They cited an example with places like Montserrat, Kazhakstan, and Albania who presented with very high stroke mortality rates but having a small proportion of persons above the aged of ≥ 65 years. Additionally, there are LMICs with a small proportion of the elderly population of age ≥ 65 years below 7% of the country population such as Kyrgyzstan, Trinidad and Tobago, and Uzbekistan having a crude stroke mortality rate comparable to that of HICs. In such LMICs, it is possible that mortality rates are underreported when viewed from the age structure of the population of such countries (i.e. a large younger population). Contrasting finding was found in Japan with a large proportion of its population within ≥ 65 years of age (≈ 23 %), but having a relatively moderate crude mortality rate from stroke. On overall Thrift et al (2014) found a positive association between crude mortality rates and the progressive year in which the mortality data were collected globally, implying that there is increased

crude mortality in the 40 years starting from 1970. However, countries with the lowest stroke mortality rates in more recent years according to the report are Bahrain, France, Israel, and the Netherlands.

According to the global burden of disease in 2001, the estimates of all causes of mortality, despite the high coverage (≥ 85%), less than 1% death registration data of the sub-Saharan African (SSA) population were available for estimation (Mathers, Lopez & Murray, 2006). This, therefore, strengthens the fact that mortality rate data for stroke in SSA will suffer a huge setback in determining its accuracy. Based on combination of available death registration data, some sampled death registration studies (largely of hospital-based) epidemiologic studies and the use of cause-of-death model for the estimation of cause-of-death in places where data are not available, the Global Burden of Disease investigators estimated that 355 000 stroke deaths (3% of all deaths) occurred in sub-Saharan Africa during 2001 (Connor et al, 2007).

In 2002, the global Burden of Disease studies estimated the cause of death in WHO member countries reported about 359 000 stroke deaths (3% of all deaths) in Africa against almost 1.5 million (16% of all deaths) in Europe (Connor et al, 2007). Stroke was reported to be responsible for an estimated 52% of vascular deaths (from either stroke or ischaemic heart disease) in Africa against 38% of vascular deaths in HICs Europe (The World Health Report, 2004), suggesting that Africa was at an earlier stage of health transition with a higher ratio of stroke death to coronary death (Yusuf, Reddy, Ounpuu & Anand, 2001).

2.5 Recovery from stroke

The concept of recovery after has been well researched with a major target on factors influencing the recovery of stroke survivors. This section briefly reviews the common demographic and social factors identified as influencing stroke recovery.

Extrapolating when and how recovery will be achieved the following stroke is a key concern for patient and their family (Edwardson, Dromerick, Kasner, & Dashe, 2016). Health Care Providers (HCPs) are continually being questioned with regard to an anticipated course of the disorder and specific periods of time within which recovery will be realised (Edwardson et al, 2016). Many studies have evaluated outcome after stroke, but quantification of patient recovery patterns are limited. One of the prime model for predicting prognosis of functional recovery after stroke includes neurological state (such as stroke severity, stroke mechanism, clinical findings, infarct location, related complications, and comorbid conditions) and patient's demographics (sex, age and pre-stroke disability), which influence rate of recovery and ultimate outcome post-stroke (Edwardson et al, 2016; Zhou et al, 2013; Kimberly et al, 2013). Additionally, the intervention received in early strokes such as thrombolysis, care at stroke unit and rehabilitation can serve key roles in determining stroke recovery outcome (Edwardson et al, 2016). The knowledge of stroke recovery is important for relevant Health Care Providers (HCPs) to appreciate the various factors influencing stroke prognosis in order to provide a coherent approach to patient treatment, make a reasonable prediction for individual patients' recovery, and to guide patient and family towards understanding the progression of the condition.

During the early onset of stroke, the strongest determinants of outcome are the severity of the stroke and the age of the patient. The severity of stroke at this stage is assessed according to the level of presenting neurologic impairments (disorientation, motor, language, visual, and behavioural deficits) and the volume and location of the infarct (Kimberly et al, 2013; Roth et al, 2011; Saposnik et al, 2011). Other major predictors include mechanism of the injury, complications, epidemiologic and comorbid factors (Edwardson et al, 2016).

2.5.1 Neurologic severity

One of the most important neurologic examinations after stroke is to determine its severity, which is adjudged as the determining factor for both short and long-term stroke recovery outcome (Béjot et al, 2012; Saposnik et al, 2011; Hankey et al, 2007). In general, large strokes with severe initial massive or diffuse clinical deficits are associated with poor outcomes compared with milder strokes (Hankey et al, 2007).

Clinically, neurologic impairment is often assessed quantitatively in several studies using of the National Institutes of Health Stroke Scale (NIHSS) and in few studies the Canadian Neurological Scale (Sumer, Ozdemir, Tascilar, 2003; Frankel et al, 2000). Studies have shown that the NIHSS is a good predictor of stroke outcome (Frankel et al, 2000). A study examined NIHSS scores taken in the first 24 hours following symptom acute ischemic stroke onset in more than 1200 patients recruited in a clinical trial (Adams et al, 1999). The study reported that each extra point on the NIHSS presented a decline in the odds for an excellent outcome at three months by 17% (Adams et al, 1999). At the third month, the fraction of patients with excellent outcomes in NIHSS

scores of 7 to 10 and 11 to 15 was around 46% and 23% respectively. Similarly, the findings indicated that an NIHSS score of ≤ 6 predicted a good recovery (defined as the ability to live independently, with or without the ability to return to work or school functions), and a score ≥ 16 was associated with an increased probability of death or severe disability. Furthermore, the correlation of the NIHSS score and final disability result increases with time (Saver & Altman, 2012). Typically, the relationship of NIHSS score and the final outcome changes based on the time since stroke (Saver & Altman, 2012), partly because acute stroke-related deficits are unstable, and many patients experience stepwise recovery. As such, the NIHSS score fluctuates and to be associated with specific disability outcome shifts to lower values as time progresses (Saver & Altman, 2012; Frankel et al, 2000). A study reported that the best predictor of poor prognosis at 24 hours was an NIHSS of > 22, and at 7 to 10 days the best predictor was an NIHSS score of > 16 (Frankel et al, 2000). Similarly, using the Canadian Neurological Scale (CNS) a score of < 6.5 on admission was found to be associated with a probability of an increased 30-day mortality and poor outcome at six months (Sumer et al, 2003).

2.5.2 Epidemiologic factors

The variation in recovery pattern of stroke is influenced by several other factors such as age, gender, socioeconomic status, and race.

Age

Advancing age is one of the key predictive variables of poor prognosis in stroke identified in many studies. The most likely reason is because age is associated with several physiological changes which largely contribute to the ageing process affecting the system of the body. Age is adjudged to have a substantial negative impact on morbidity, mortality, and long-term outcome of stroke (Andersen, Andersen, Olsen, 2011; Béjot et al, 2012). The impact of age on the outcome of stroke can be seen in major and even minor strokes. The elderly (aged above 65 years) are more likely to die in the first two months post stroke or being discharged to a skilled nursing facility for those who survived (Kammersgaard et al, 2004). Several predictive models use advancing age to determine stroke prognosis. In a systematic review involving 16 studies Russo, Fezani and Marini (2011) found age ≥ 80 years to be associated with higher one month increased stroke fatality, greater dependency and lower use of the diagnostic procedure. Poorer recovery outcome among stroke survivors particularly among older adults over 80; increased mortality rate compared to those below 80 years of age (18.9% against 5.1%); and increased disability (50.9% and 33% respectively) (Denti et al, 2010). Béjot et al (2012) in a population-based study on post-stroke disposition and associated factors found advanced age as one of the factors associated with admission to convalescent and nursing homes. In an earlier study focused on the incidence of stroke in the very old Béjot and associates (2009) reported a significant incidence of stroke in the very old ≥ 80 years (997 per 100,000) as against the < 80 years category (68 per 100,000). The study also reported severe clinical presentation and a worse 1-month case fatality and handicap among those ≥ 80. Additionally, the

very old (in their 80s) demonstrated the most frequent length of stay above 30 days and are less likely to be discharged to the pre-stroke residence. A recent study on factors influencing stroke rehabilitation found an inverse relationship between patient's age and functional gain following rehabilitation (Dusica, Gordana, Mirjana & Nedeljko, 2015). An earlier study (Öneş, Yalçinkaya, Toklu & Çağlar, 2009) also found age as one of the predictors of stroke outcomes after rehabilitation. In contrast, a study did not find age to be a predictor of lower recovery outcome post-stroke (Berlowitz, Hoenig, Cowper, Duncan & Vogel, 2008). While there seem to be differences between these studies, findings by Berlowitz et al (2008) agreed that age could comfound recovery outcome but only with additional commorbidities.

2.5.3 Gender and other epidemiologic factors

Findings are conflicting concerning the role of gender in stroke recovery outcome. A number of studies reported that male gender is associated with poor outcome after stroke (Kimberly et al, 2013; Saposnik et al, 2011), several others studies reported female gender as being associated with worse stroke outcomes (Santalucia et al, 2013; Roth et al, 2011), while some studies found no significant gender differences in stroke outcomes (Béjot et al, 2012; Adams et al, 1999).

Several studies have identified ethnic and racial differences as variables influencing stroke recovery outcomes; in particular studies in the United States, reported a higher risk of poor stroke outcomes among blacks or non-whites than the whites (Zhou et al, 2013; Roth et al, 2011). Low socioeconomic status, educational qualification, and low level of social support have all been linked to poor outcome after stroke (Grube et al,

2012; Putman et al, 2007); additionally, low socioeconomic status has been found to correlate with a poorer health-related quality of life at five years following stroke (Dhamoon et al, 2010).

2.5.4 Complications of stroke and stroke recovery

There is a host of medical complications influencing stroke outcome. Some of the most commonly reported complications of acute stroke are pneumonia, pulmonary embolism, intubation need and mechanical ventilation, congestive heart failure, cardiac arrest, deep vein thrombosis, urinary tract infection and gastrointestinal bleeding (Edwardson et al, 2016). Studies have also reported neurologic complication occurring in the early post-stroke period affecting a significant few of stroke survivors as contributing to the high risk of morbidity, mortality and also influencing stroke outcome (Siegler, & Martin-Schild, 2011; Ward, Brown, Thompson, & Frackowiak, 2003) in the early post-stroke period and sometimes beyond, a high prevalence of stroke has been reported (Pohjasvaara et al, 2002). The risk for post-stroke depression increases with severity of the stroke and cognitive impairment (Pohjasvaara et al, 2002).

2.5.5 Predicting recovery after stroke

In the early 12 hours to first seven days of stroke onset, several patients who do not suffer complications will enjoy moderate albeit steady improvement in neurological impairments (Ward et al, 2003). Most of the recovery post stroke takes place within the first three to six months (Cramer, 2008; Hankey et al, 2007), although some categories of stroke survivors may still enjoy improved significant outcome up to 18 months

(Hankey et al, 2007). In a prospective study that evaluated more than 1100 patients from Denmark with acute stroke, findings show recovery pattern to be associated with severity of stroke at onset. The study reported that stroke survivors who presented with mild disability recovered in about two months, moderate disability recovered within three months, severe disability recovered in about four months and most severe disability in about five months from stroke onset (Jørgensen, Nakayama, Raaschou, & Olsen, 1999) and often neurological recovery was found to precede functional recovery by an average of two weeks (Jørgensen et al, 1999). Other studies have found the functional outcome in the first three months as a predictor of survival at four years and at six months as a predictor of a long-term chance of survival (Kissela et al, 2009; Slot et al, 2008).

2.5.6 Identified neurologic deficits and stroke recovery

Neurologic deficits accompanying stroke and their severity were also reported as predictors of stroke recovery outcome. Some of the common deficits reported in the literature are as follows:

Upper extremity function and weakness of the hand

In the Copenhagen Stroke Study, Nakayama and associates (1994) found that with arm disability, 80% of stroke survivors did attain maximum degree of functional recovery in three weeks and 95% do so in nine weeks. The also reported that complete function arm recovery was attained by patients who presented with mild and severe paresis of the arm by 79% and 18% respectively. A prospective study involving 188 patients with

ischaemic stroke found that patients having some voluntary finger extension and shoulder abduction on the hemiplegic side on the second day post stroke have a high probability (0.98) to achieve some dexterity by six months of stroke onset, while those who do not have such voluntary movements have a probability in two and nine days were at 0.25 and 0.14 of recovery respectively.

Lower extremity function and ambulation

Lower extremity function in form of ability to walk has been examined in relation to stroke outcome. In a study using a multivariate modeling involving 154 stroke survivors who could not walk, it was reported that participants who could afford 30 seconds of sitting balance and perform muscular contraction (whether or not they can produce limb movement) with the paretic lower extremity in the first 72 hours post stroke have a 98% chance of being able to ambulate independently at six months after stroke onset. (Veerbeek et al, 2011). And only 27% of those who could not functional level in the first 72 hours would probably attain ambulation after six months (Veerbeek et al, 2011).

Other reported neurologic deficits

There are several other neurological deficits that have been reported in the literature influencing stroke outcomes such as aphasia, dysphagia, sensory, visuospatial neglect and hemianopia, with each factor affecting outcomes in varying degrees.

2.6 Section Three: Stroke rehabilitation

Effective delivery of healthcare services require proper organisation of the channels of the delivery system in order to ensure that services reach the target population as well as benefit them. Evaluation of the services for its effectiveness will assist in determining the quality of healthcare and investigation of the relationship of key features of the healthcare to patient outcomes. To meaningfully evaluate these outcomes researchers have advocated the use of the health services research (Hoenig, Horner, Duncan, Clipp, & Hamilton, 1999; Hoenig et al, 2002). The framework focuses on three interrelated groups of information regarding healthcare, which include structure, process and outcome (SPO). Heonig et al (2002) described the three categories under this framework for stroke rehabilitation. They referred to the structure of healthcare as features of medical care that are somewhat fixed, such as the equipment and personnel providing the services; the process of healthcare was described as the services rendered to the patient or how such services are packaged; and the outcomes signify the results obtained from these structures and processes of healthcare or how these results can be evaluated. In this review stroke rehabilitation is presented using the SPO framework.

2.6.1 Definition and structure of stroke rehabilitation

Rehabilitation is a term with diverse contextual definitions/descriptions. In its broadest sense, it involves a host of processes aimed at alleviating physical, psychological and social challenges originating mainly from chronic ill-health. However, there is no consensus on the definition of rehabilitation. This review focused on neurological

rehabilitation, which itself has no standardised definition. Several descriptions of neurological rehabilitation are available in the literature. Some of these include:

> *"The use of all available means to tame the impact of a disease and to optimise physical, psychological and social functions in persons with impairment and disabilities" (McLellan, 1997; page 1)*

> *"A complex set of programmes often involving several professionals from varied disciplines and with a planned goal of improving quality of life among people experiencing daily living difficulties caused by chronic disease" (Young & Forster, 2007; page 86)*

> *"A programme structured with the aim of optimising persons with neurological challenge's participation in the society and his/her sense of well-being" (Donaghy, 2009; page 41)*

These descriptions/definitions suggest a number of key features; in particular, all the definitions recognised that the main aim of rehabilitation is to improve patients' well-being. However, different terms such as quality of life and functioning were also used to describe well-being, the definitions also suggested that rehabilitation targets improving participation in the society among patients, the processes of rehabilitation were mainly described as dynamic, suggesting that they are malleable to patients needs with regards to condition and environmental circumstances, planning and implementation of

the processes are determined by multidisciplinary teams of professionals, making the entire process complex.

Rehabilitation for stroke survivors is, therefore, a problem-solving approach which aims to restore or maintain function (as the case may be) to as optimum as possible. Such functional restorations or maintenance are not restricted to physical functions alone but encompass psychological and social domains of functioning. To accomplish optimum rehabilitation goals the processes require comprehensive structuring involving programmes directly centred on the patient, formulated to include the family, planned by a multidisciplinary team and suited to individual patient's need. Some key members of the stroke rehabilitation multidisciplinary (Duncan et al, 2005; Nair & Wade, 2003) team and their roles are presented in the table below (2.3):

Table 2-3: Members of the stroke rehabilitation team and their responsibilities are listed below (Duncan et al, 2005)

Healthcare, provider	**Rehabilitation role**
Physicians (Neurologists)	These are specialists in the brain, spinal cord, peripheral and other neurological disorders, they engage in the prevention, diagnosis and management of such disorders.
Nurse (Rehabilitation)	These team members have their roles split into three as 1. Providers of care to stroke survivors 2. Facilitators of stroke survivors' personal recovery 3. Managers of stroke survivors' multidisciplinary provision of services by mediating between patients and professionals.
Physiotherapists	These professionals are concerned with stroke survivors' problems in movement and balance as it relates to levels of impairment, disability and participation; they suggest activities for strengthening muscles, facilitating standing, walking and other areas of functioning.
Occupational Therapists	These professionals provided stroke survivors with skills to manage daily activities like bathing, dressing, eating, cooking, writing and facilitation of return to work
Speech and language pathologists	These therapists help stroke survivors acquire language skills such as talking, reading and writing); shares strategies to help with swallowing problems
Dieticians	These are responsible for educating stroke survivors about healthy dietary habits and suggestion of special diets such as low salt, low fat and caloric balance in food
Social workers	These care providers help survivors to make decisions about the structure rehabilitation programmes, home setting, sourcing for available support services and insurance coverage.
Psychologists	These professionals help in the diagnoses and treatment stroke survivors with potentials for changes in emotional stability, thinking, memory, behavioural or any mentally related challenges post stroke
Recreation therapists	These therapists retrain stroke survivors on skills to help them return to recreation activities through improved thinking and

	movement faculties

Several authors have long identified certain requirements for a comprehensive stroke rehabilitation process (Roth et al, 1998, Roth 1992; Bradstater & Basmajian, 1987). A summarised version of the evidence-based stroke rehabilitation processes are presented in the table (2.4) below:

Table 2-4: Processes of stroke rehabilitation (Roth et al, 1998, Roth 1992; Bradstater & Basmajian, 1987)

Items	Rehabilitation process
1.	Assessment to identify patients' problems using the World Health Organization's International Classification of Functioning, Disability, and Health (WHO-ICF).
2.	Timely introduction of specific goal oriented treatment using the patient's maximal level of available potentials and checking disabilities to as minimum as possible.
3.	Acceleration of best level of psychological adaptation and coping strategies in patients and their family members, through planned educational programme designed in the rehabilitation process.
4.	Focused attention towards prevention, identification, and management of diseases and consequential complications.
5.	Addressing patient spectrum of challenges through an interdisciplinary set of professionals committed to the rehabilitation process.
6.	Methodical assessment of the progress of the patient during rehabilitation, with an adaptation of treatment to maximise benefits.
7.	Timely comprehensive discharge plan aimed at ensuring a remarkable transition to the community post hospital discharge and a planned effort to promote continuity of care towards accomplishing social reintegration and return to usual roles at home, family, recreation and vocational activities.
8.	Dogged efforts towards continuity of care from the acute phase of stroke rehabilitation to the long-term follow-up period.

2.6.2 Rehabilitation resources

This section presents the rehabilitation settings where stroke rehabilitation can be offered.

The key target of rehabilitation post stroke is to help stroke survivors to resume as closely as possible their premorbid status in all facets of well-being including physical, psychological and social domains. However, the success of rehabilitation programs relies largely on the commitment and close working relationship of the multidisciplinary team who together develop a comprehensive rehabilitation program relevant for each stroke patient (Foley, Teasell, Bhogal, Speechley & Hussein, 2013). Characteristically, these programs are distinct in types, intensities, and duration (Foley et al, 2013). Rehabilitation of stroke is offered at different settings depending on the recovery state of the patient (acute, sub-acute or chronic); as such stroke rehabilitation resources are provided and made available at three levels of care, including inpatient, outpatient, and community.

2.6.2.1 The inpatient level of care

During the early onset of stroke, patients are mainly admitted into the hospital where initial care takes place. Historically, patients were admitted into the inpatient general medical wards, which do not place special attention on the stroke patient since other medical conditions are housed in such wards (Stroke unit Trialists' Collaboration, 2013; Foley et al, 2013). However, in the past few decades, attention has been shifting to a more intensive method of care at the early stage of stroke onset. This organised form of care is called the Stroke unit. In a comprehensive systematic review, which included 28

trials comparing the Stroke unit and other forms of service, and 21 trials comparing Stroke unit and the general wards, the Stroke unit showed a reduction in the odds of death at a final median one year follow-up (OR 0.87, 95%, CI 0.69 to 0.94; p = 0.005). The study also reported a reduction in the pooled outcome of death or institutionalised care (OR 0.78, 95% CI 0.68 to 0.89, p=0.0030) and the odds of dying or dependency (OR 0.79, 95% CI 0.68 to 0.90, p=0.0007). The findings were independent of age, sex, early onset of stroke severity or stroke type. In keeping with these findings, several other studies reported a comparative positive outcome in favour of Stroke units in the initial management of stroke (Langhorne et al, 2010; Terént et al, 2009; Seenan, Long, & Langhorne, 2007).

There are a few studies about stroke unit care in LMICs such as China (Ma, Wang, Qu & Yang, 2004), Thailand (Suwanwela, Eusattasak, Phanthumchinda, Piravej, Locharoenkul, 2007), South Africa (de Villiers, Kalula & Burch, 2009) and India (Pandian et al, 2011). Finindgs from these studies all suggested remarkable outcome similar to recovery outcome in HICs. Typically, the South Sfrica study (de Villiers et al, 2009) reflected that multidisciplinary stroke care can successfully be implemented in a resource-constrained secondary-level hospital in Africa, as the study reported significant reduction in inpatient mortality rate and recorded increase referral for inpatient rehabilitation which suggested an improved care post stroke.

It is, however, noteworthy that while evidence for Stroke Units is largely convincing, this does not apply to certain early treatment practices such as Early Mobilization. A recent review found no conclusive evidence for Early Mobilization post-stroke particularly in the first 24 hours (Bernhardt, English, Johnson, & Cumming, 2015).

The authors (Bernhardt et al, 2015) described three clinical challenges currently associated with the practice of early mobilisation, these challenges include:

1. Lack of shared understanding of what constitutes an early mobilisation intervention.
2. Lack of evidence to help in deciding which categories of patients can safely commence early mobilisation.
3. Lack of understanding of the mechanism by which early mobilisation might aid recovery or cause harm to patients when used in the first hours or days of stroke.

It is, therefore, evident to say that the stroke unit remains a standard in the early stage of stroke treatment/rehabilitation; however, certain practices (such as early mobilisation) during this period still await evidence before they can be considered safe (Bernhardt et al, 2015).

2.6.2.2 The outpatient level of care

One of the most important resources in stroke rehabilitation is the outpatient facility. The outpatient facility provides a continued rehabilitation service to stroke patients after discharge from the inpatient facility. The outpatient rehabilitation facility is usually an appendage of a larger hospital; it provides contacts to physicians and a wide range of other professionals (therapists) involved in stroke rehabilitation (Walker, Sunnerhagen, &Fisher, 2013). The outpatient facility is made of different forms of schedules, among

which include Early Supported Discharge (ESD) and Home-based Rehabilitation Programme (HBRP).

Using data from 14 trials a Cochrane review conducted by the Early Supported Discharge Trialists (Fearon & Langhorne, 2012) reported significant reductions in length of hospital stay ($p < 0.0001$) corresponding closely to seven days. The findings also showed that the ESD group was associated with significant overall reduction in death, death or institutionalisation, death or dependency based on planned follow-up OR 0.91 (95% CI 0.67 to 1.25, P = 0.58), OR 0.78 (95% CI 0.61 to 1.00, P = 0.05) and OR 0.80 (95% CI 0.67 to 0.97, P = 0.02) respectively. The most profound effect was found in ESD trials conducted among stroke survivors with mild to moderate severity and in organised ESD interdisciplinary teams. Participants in the ESD group also showed improvement in extended activities of daily living and satisfaction with services (standardised mean difference 0.12, 95% CI 0.00 to 0.25, P = 0.05 and OR 1.60, 95% CI 1.08 to 2.38, P = 0.02 respectively). However, these improvements were not extended to carers with regard to their subjective health status, mood or satisfaction with the ESD services. The achievements seen in patients were not sustained at five years follow-up. This study provided strong evidence on the benefits of structured outpatient rehabilitation such as the ESD (Fearon & Langhorne, 2012). Two earlier reviews (Noorani, 2003; Anderson et al, 2002) on this subject have both indicated the effectiveness of ESD on various domains of stroke limitations post hospital discharge. It is, however, important to stress that while such practices are already in their advanced

stages in the developed economies evidence is obscure about their existence in LMICs and particularly, in SSA.

2.6.2.3 Home-Based/Community-based Stroke Rehabilitation

Stroke rehabilitation services are usually received largely in two key hospital-based settings, which are the inpatient and outpatient. However, several constraints may render these services inaccessible to numerous categories of patients. Home-based sometimes referred to as Community-based rehabilitation is primarily targeted at such patients in need of continuing rehabilitation who could not find entrance into the traditional outpatient hospital-based rehabilitation services after being discharged into the community setting, largely in SSA. Constraining issues to hospital-based outpatient rehabilitation services include transportation, proximity, availability, convenience and affordability. The delivery of home-based rehabilitation as in any other form of the neurological rehabilitation programme is also supported by a team of professionals, though not necessarily as large as what is obtained in the hospital-based programmes. Some recognised members of home-based rehabilitation teams include the physiotherapist, occupational therapist, speech-language pathologist, social worker, nurse, and recreational therapist. However, the central team members in most cases are the physiotherapists and occupational therapists. A systematic review found physiotherapists and occupational therapists in the multidisciplinary team of all the eight RCTs included in a review centred on early discharge to therapy-based rehabilitation at home in patients with stroke, they were closely followed by registered nurses who were in five studies, followed speech therapists who were found in four studies and then other

professionals making up the team (Winkel, Ekdahl & Gard, 2013). Other studies have also reported the home-based rehabilitation team members, where physicians were also included in some teams (Markle-Reid et al, 2011; Crotty, Halbert, Harding, & Miller, 2008).

Studies have reported several benefits to home-based stroke rehabilitation including provision of rehabilitation service directly in the patient's home or community, being a patient-centred form of rehabilitation where what guides rehabilitation plans are patient's specific/individualised needs, improving sense of belonging in patients and their ability to overcome community-related barriers to functioning as therapy is offered within patient's comfort based setting, it offers more opportunity to take care of handicap; as well as it addresses psychological challenges more efficiently (Markle-Reid et al, 2011; Anderson, Mhurchu, Rubenach, Clark, Spencer & Winsor, 2000; von Koch, Holmqvist, Wottrich, Tham & dePedro-Cuesta, 2000). Evidence in support of home-based stroke rehabilitation is not particularly conclusive because of diverse methodological approaches and principal aims of the existing studies. Typically, Winkel et al (2013) reported that there are contradictory findings for the effect of home-based rehabilitation on basic activities of daily living and quality of life, with the result indicating no effect on instrumental activities of daily living. However, a systematic review involving 14 RCTs reported minimal evidence for the effectiveness of multidisciplinary care for stroke survivors discharged home (Fens, Vluggen, van Haastregt, Verbunt, Beusmans & van Heugten, 2013). An earlier study by Legg and Langhorne in collaboration with the Outpatient Service Trialists (2004) recounted that selected community-dwelling stroke

survivors who took part in therapy-based rehabilitation services showed improved ability to commence individualised activities of daily living and an associated declining risk of worsening function.

2.6.3 Stroke rehabilitation processes

Stroke rehabilitation is a multidimensional process which involves highly coordinated and blended use of medical, physical, social, psychological, educational, recreational, and vocational approaches to rejuvenate many of the lost functions in stroke survivors to as optimum as possible. This section describes stroke rehabilitation processes and in particular the physical rehabilitation.

The core concept of physical rehabilitation for stroke survivors emphasises an active dynamic programme targeted at empowering patients with the required skills and knowledge to assist them to maximally improve in physical, social and psychological functioning. Mobility constitutes the main focus of physical rehabilitation and by extension how it influences social and psychological constructs. As such physiotherapist are vested with a major responsibility for physical rehabilitation needs of stroke survivors. The processes of stroke rehabilitation focusing on restoration of mobility in stroke are largely classified into traditional neurophysiological, motor learning and orthopaedic principles (Pollock et al, 2007). This review focused on the three approaches and other emerging techniques largely derived from these principles.

2.6.3.1 Traditional neurophysiological principles

Traditional theories underscore the value of mobility as a precondition to the commencement of more active or strong restorative rehabilitation. The techniques as implied are centred on neurophysiological philosophies relating to motor control and recovery of function. The philosophies of neurophysiological techniques include: utilisation of sensory stimuli for the facilitation or inhibition of activity; using patient's developmental milestone for evaluation and treatment of health constraints; facilitation and inhibition of motor activities through the use of reflexes; applying close interaction between patient and therapist to achieve treatment outcome such that the therapists provides the precise movement patterns for the patient, initiate the right activity, attempt to solve the problem directly and the patient playing a relative role of passive recipient (particularly at the early onset). The most commonly used neurophysiological techniques and a brief note on their principles are presented in table 2.5 below:

Table 2-5: Neurophysiological Techniques of stroke rehabilitation

Principles	Core concept and practice
Bobath approach or Neurodevelopmental Therapy (NDT)	The approach is premised on inhibition of primitive patterns of movement to restore normal tone through mobilisation along with tactile and proprioceptive inputs. In practice the quality of motor response is shaped by therapeutic management, which is intelligently matched with the capability of the patient to utilize sensory inputs and accommodate patterns of movements (Vaughan-Graham, Cott, & Wright, 2015). The approach involves attempting to inhibit spasticity through passive mobilisation along with the use of tactile and proprioceptive inputs (Belda-Lois et al, 2011). This approach is viewed as being opposite to Brunnström's approach.
Proprioceptive Neuromuscular Facilitation (PNF)	This approach was developed based on Sherrington's codes of reciprocal innervation, irradiation and inhibition. The approach emphasises the use of rhythmic and reflexive actions to facilitate coordinated motion. This approach theorised that normal movements follow synergistic and functional patterns. For this reason nerve, muscle and sensory receptors are manually stimulated through diagonal movement patterns, which encourage larger functionally related patterns more than traditional movement planes (Moros , Ballero, Jáuregui, & Carroza, 2000).
Brunnström approach or Movement therapy	The Brunnström's approach core premises consists of the theory that the reflexes of the spinal cord and brain stem are adapted in normal persons during development and their mechanisms reorganised into focused movement under the control of the higher centres (Belda-Lois et al, 2011; Moros et al, 2000). Summarily, Brunnström opined that as reflexes constitute core parts of normal development, reversal of the CNS to the primitive developmental stage following injury (e.g. stroke) can be reverted by following earlier developmental stages via central facilitation. In practice since the approach is rooted in the concept that injured CNS reverted to primitive patterns of movements (including primitive reflexes and limb synergies); as such primitive reflexes, synergies, and other abnormal patterns of movements are viewed as normal pathways of recovery which are apparent to occur before normal patterns of movements' surface. In practice, primitive synergistic patterns are used to bring about improvement in motor control by central facilitation (Belda-Lois et al, 2011).
Rood's approach or Sensorimotor approach	This approach is centred on the developmental sequence of attaining recovery and the use of peripheral sensory inputs to enhance posture and movement responses based on the reflex sequence they are known to be initiated with (Belda-Lois et al, 2011). Several techniques are used in this approach to influence sensory stimulation, muscular activation is facilitated by a stretch, sensory stimulation is initiated by stroking or brushing at varying speeds, and cold is applied to facilitate visceral stimulation and somatic relaxation (Montgomery & Connolly, 2003).
Johnstone's approach	This approach contends that postural and movement impairment occur secondary to reflex mechanisms responsible for spasticity (Johnstone, 1996). In practice to control such pathological reflexes tonic neck reflexes are inhibited by splinting and positioning. The approach emphasises that treat should commence by facilitating gross motor function before introducing finely skilled motor activities (Belda-Lois et al, 2011; Montgomery & Connolly, 2003).
Vojta approach	This approach is premised on activation of innately stored movement patterns which are subsequently distributed as coordinated movements to muscles of the trunk and extremities (Kolar, 2014). In the concept combined developmental kinesiology with neurophysiological model and rely upon the inferences of neurosciences relevant with contemporary principal physical mechanical understandings (Kolar, 2014). Demonstratively, it involves facilitation of sensory stimuli from nerve endings through specific key points to enhance physiological movement patterns. The was initially developed for the management of children with neurological disorders (such as congenital or acquired brain damage), however, it is being used in adults stroke survivors on the assumption that the stored movement patterns in the brain are not interrupted but are only inhibited (Belda-Lois, 20110).
Effectiveness and limitation of the neurophysiological approaches	The approaches have diverse underlying theories; though, two systematic reviews using best evidence synthesis suggested that no single approach showed any marked significant difference over the other (Kollen et al, 2009; Pollock, Baer, Pomeroy & Langhorne, 2007;). The limitation of these approaches lie in the lack of independence of patients in decision making in performing tasks as the procedures of all the approaches are literally passive (Belda-Lois et al, 2011). The approaches influence performance but do not have a lasting effect (Montgomery & Connolly, 2003).

2.6.3.2 Motor learning

Motor learning comprises of processes developed as a result of practice or experience capable of enhancing lasting changes in accomplishing skilled tasks (Montgomery & Connolly, 2003). In concept, it comprises of skill acquisition, motor adaptation and decision making (Krakuer & Mazzoni, 2011; Wolpert, Diedrichsen, & Flanagan, 2011). Motor learning in practice is described as an opposite motor related functional approach to the neurophysiological approaches, because motor learning approaches emphasise active participation of the patient in all stages of the therapeutic task (Carr & Shepherd, 1987). As such a core prerequisite of this approach is teaming-up with the patient to set and achieve therapeutic goals and neuropsychological evaluation to determine progress in all realms of well-being (Carr & Shepherd, 1987; Carr & Shepherd, 2006). Theoretically, the framework in which motor learning operates includes motor tasks which are context-specific and task-relevant feedback (Belda-Lois et al, 2011). Several techniques of motor learning focusing on similar or distinct aspects have been proposed and implemented. Some of the commonly known motor learning techniques are presented in the table (2.6) below:

Table 2-6: Motor learning techniques of stroke rehabilitation

Techniques	Concept and practice
Conductive Education technique; Peto's approach	This is an intensive and comprehensive technique targeted primarily at educating persons with physical disability with knowledge on physical, emotional and cognitive aspects dealing with their challenges (Ratliffe & Sanekane, 2009) and at secondary level it focuses on functional limitations. One of the key features of this technique is the conception that perceived failure is associated with dysfunctional behaviour which could alter the course of rehabilitation (Belda-Lois et al, 2011). In practice, stroke survivors are taught appropriate procedures aimed at training them to cope with disability.
Perfetti technique	This technique is centred on the use of cognitive sensory motor training (CSMT) to facilitate recovery in diminished functional capacity in stroke survivors. In practice, Perfetti technique underscores tactile-kinesthetic recovery to achieve enhanced level of motor recovery (Dominguez-Ferraz, da-Silva-Ribeiro, de-Matos-Pinheiro & Pedreira-da Fonseca, 2014). The procedure commences with a tactile identification of varying stimuli and progresses through passive utilisation of muscles and joints to active mobilisations (Belda-Lois et al, 2011).
Motor Relearning Technique (MRP) or Carr and Shepherd approach (1982)	This technique is based on the principle that the brain is dynamic and capable of reorganisation and adaptation. It is based on theories of kinesiology that stress distributed motor control model instead of the hierarchical model. The MRP is founded on three theoretical frameworks including postural adjustments, motor behaviours rooted in context/regulatory conditions and nature of deficits as determinants of models of action/task. In practice, this technique formed the basis for modern techniques such as Task Specific Training, Circuit Class therapy and other similar techniques. This technique is discussed more closely beyond this table.
Effectiveness/limitation of the motor learning approach	Techniques of motor learning have been largely linked with neuroplasticity; they contribute to the accomplishment of maximum functional gain, those techniques performed using high-intensity repetitive tasks seems to be more effective (Langhorne, Couper & Pollock, 2009; Takeuchi & Izumi, 2013). The motor relearning technique of Carr and Shepherd (1987) is the most advanced of this approach and has been progressed to many other techniques based on the same concepts. Other limitations are that some of the techniques have not been well investigated or existing trials are not enough to affirm their benefits e.g. the Perfetti and Affolter techniques (Belda-Lois et al, 2011).

2.6.3.3 Basic principles of motor learning and neurorehabilitation

Motor learning forms the bedrock of most of the current techniques used in rehabilitation, the development of such techniques rely primarily on the basic principles of motor learning. These principles include motor adaptation, skill learning and making an appropriate judgment (i.e. sound decision-making in the choice of proper technique, which is vested first on the therapist and second making the client decide on the best performance features during treatment).

The process of motor adaptation as a principle of motor learning is premised on motor responses to peripheral perturbations and body modifications that induce errors in movement (Kitago & Krakauer, 2013). Investigations have shown that adaptation is gained from implicit knowledge, often unconsciously achieved by subjects (Kitago & Krakauer, 2013). Learning among healthy subjects occur in successions of trials secondary to error feedbacks, which might necessitate the need for engendering more efforts within a single session, to take performance near baseline (Lackner & DiZio, 2005; Krakauer et al, 2005). Moreover, attaining adaptations has been linked with the variation between the outcome of the brain's predicted movement and the prediction error of the movement observed outcome (Tseng et al, 2007; Mazzoni & Krakauer, 2006). It has been emphasised that the main characteristics of learning are that it produces sustainable changes in behaviours that outlive the specific period of training (Schmidt & Lee, 2005). Studies agreed that one unique feature of adaptation is that it can be attained in a single intervention trial session (Kitago & Krakauer, 2013; Karni et al, 1998).

Skill learning or skill acquisition has been described as the ability to accomplish a goal in an environmental sphere with maximum confidence and limited energy expenditure and time (Schmidt & Lee, 2005). It is also described as the "ability to reliably deliver accurate execution" (Kitago & Krakauer, 2013; page 94) of a task. In contrast to adaptation, skill acquisition requires prolonged practice sessions to be accomplished; it could assume several days, weeks, months and sometimes years (Karni et al, 1998). Hence, the "power law of practice" emphasised that performance to demonstrate skill acquisition is strongly driven by the number of times a task is practised (Korman, Raz, Flash, & Karni, 2003). Studies have, therefore, over the

years shown that varying task training enhances generalisation of learning to new activities (Braun et al, 2009; Catalano & Kleiner, 1984; McCracken & Stelmach, 1977). Part of skill acquisition and practice is the manner in which practice sessions are 'scheduled' or organised. A major concept in task scheduling is contextual intrusion, which is expressed in terms of random scheduling of tasks in a training session. This has been said to be associated with greater retention of the learned task compared with practising a single task at a time (Tsutsui et al, 1998). Random scheduling of tasks has been proposed as a strong aid to learning, this is because varying of tasks necessitates a need to view, as well as practice each task /activity as a separate obstacle to overcome during a rehabilitation process (Grafton et al, 2008; Krakauer, 2006; Winstein & Stewart, 2006). Other scheduling features similarly include constant versus variable practice or part versus whole practice of the task or skill. The adaptation and skill acquisition concepts, when summarised, involve administration of specific relevant tasks to initiate a change, repetition of the task, variability/multiplicity of the task.

An essential principle in motor learning is that the quantity of practice determines the degree of improvement in performing a task (Muratori, Lamberg, Quinn, & Duff, 2013), where practice itself has been simply described as the persistent repetition of the same movement continually (Krakauer, 2006). While such practice might effectively improve performance within a training session (adaptation), it cannot guarantee retention of learning (skill acquisition) (Krakauer, 2006; Korman et al, 2003; Karni et al, 1998). It is well known in the literature that practice can be attained by several ways more effectively than blocked repetition of a single task (massed practice) as expressed in motor adaptation (Krakauer, 2006). Two key convincing

findings from the literature deserved emphasis while discussing motor adaptation and skill acquisition. One, the literature recognised that frequent and longer rest periods, when introduced amidst repetitions result in improved performance and learning, this is regarded as distributed practice; two, varying task in skill learning practice results in improved retention in successive session (Kitago & Krakauer, 2013; Krakauer, 2006; Shea & Kohl, 1991). Varying of practice is associated with generalisation of learning of new skills which is of a particular interest to rehabilitation outcome (Krakauer, 2006), as repeated practice of a task (alone) could lead to improved performance in such task, but often can't be transferred to other activities of daily living.

Current practice in neurorehabilitation postulates that these motor learning principles can be implemented to accomplish motor recovery post injury, and that lasting improvements can be achieved through training of motor function in patients presenting with motor deficits (Krakauer, 2006). Using these principles several notable neurorehabilitation techniques have been developed, of relevance to this study is Task Specific Training (TST) and particularly its derivative, i.e. Circuit Class Therapy (CCT), which shall be discussed in more details in subsequent sections of this review.

2.6.4 Stroke rehabilitation outcome

The identification of specific problems presented by individual patients is the most critical aspect of rehabilitation process; this is because the planning of rehabilitation programme can only be successful when patients' problems are properly identified and understood (Pieber et al, 2015). Thecurrent standard of practice recognises the

use of the WHO-ICF framework to guide in both identification and classification of problems in stroke survivors (Carter, Lubinsky & Domholdt, 2011; Salter et al, 2005). This premise informed the use of the ICF as a conceptual framework for the choice of outcome measures in this study (Lawal et al, 2015).

Rehabilitation of people with stroke is centred on re-educating and retraining multiple spheres of the presented challenge. Identification of specific limitations of stroke survivors using common terms via the application of stroke scales allows for the development of a shared language among professionals caring for stroke survivors (Harrison, McArthur, & Quinn, 2013). The use of common nomenclature will aid in appreciating transition from one stage of stroke recovery to another, transferability of stroke survivors for continuity or other specialist management requests and distributing responsibility for care (to various professionals) as it is deemed appropriate by team members. The use of common metrics for comprehensive description and organisation of information on functioning and disability has been put together by the World Health Organization through the International Classification of Functioning, Disability and Health (ICF) (WHO, 2001). One of the key aims of the ICF concept is to establish a common language for describing health and health-related states in order to improve communication between different users, such as healthcare workers, researchers, policy-makers and the public, including people with disabilities (WHO 2001:5).

The ICF is not disease specific in its classification of functioning and disability, and explicit or implicit variation is not emphasised between different health conditions, whether ‘mental' ‘Social' or 'physical'. The framework emphasises functioning rather

than specific health condition, this approach places all health conditions on equal status, allowing them to be equated using a common metric. The use of the ICF common metric promotes a comprehensive, multidisciplinary, and patient-centred stance in health care delivery (Starrost et al, 2008). The ICF has gained acceptance in physiotherapy and rehabilitation, particularly in neurorehabilitation, for ease of multidisciplinary team communication, an organization of rehabilitation protocol, towards a certain set of goals, documentation, evaluations and reporting of findings (Sherrington et al, 2008; Tempest & McIntyre, 2006). Stroke is one of the widely researched conditions using the ICF, with a specific core set developed to address stroke disability and functioning, particularly because long-term disability is key in stroke care and rehabilitation (Algurén, Bostan, Christensson, Fridlund, & Cieza, 2011; Warlow et al, 2008; Bonita et al, 2004). Using the ICF framework, the following table (2.7) presents a spectrum of some major core sets for stroke under different components:

Table 2-7: The ICF core sets for stroke as relevant to this study

ICF Components	ICF Code	ICF Category
Body function		
	b110	Consciousness function
	b114	Orientation function
	b730	Muscle power function
	b167	Mental functions of language
	b140	Attention function
	b144	Memory function
Body structure		
	s110	Structure of brain
	s730	Structure of upper extremity (spasticity)
Activity and participation		
	d450	Walking
	d330	Speaking
	d530	Toileting
	d550	Eating
	d510	Washing oneself
	d540	Dressing
	d310	Communicating with-receiving-spoken messages
	d910	Community life
Environmental factors		
	e315	Extended family
	e320	Friends
	e325	Acquaintances, peers, colleagues, neighbours and community members
	e355	Health professionals
	e360	Health-related professionals
	e580	Health services, systems, and policies

The ICF describes functioning in three categories, including body structure/function, activity limitation and participation restriction (WHO-ICF, 2001). Using this classification some of the stroke sequelae due to body structure and function include: diminished motor function, muscle atrophy, muscle tone, speech disorder, psychological impairment (post-stroke depression), cognitive dysfunction, poor bladder control, dysphagia, diminished consciousness/orientation, attention and memory dysfunction and poor mental function of language (Geyh et al, 2004, Lawrence et al, 2001); in activity limitation researchers have identified affectation of factors like mobility, learning, toileting, bathing, communication, walking, self-care, transfer, along with both basic and instrumental activities of daily living (Miller, et al,

2010; Salter, Foley, Jutai, & Teasell, 2007); participation is a complex phenomenon which has been described as involvement in life situation and as a restriction it is described as a problem that prevents the patient from regaining or initiating a societal life, such as going back to work (Miller, et al, 2010; Salter et al, 2007), participation is the most complex component of the ICF to evaluate, particularly because most of the existing tools are not primarily developed to assess the construct (Jette, Haley & Kooyoomjian, 2003; Perenboom & Chorus, 2003), thus factors determining participation are equally complex to determine, the rule of thumb in this regard is to consider all factors that define involvement in life situations such as involvement in social gathering, attending weddings, going out for shopping, walking to religious functions, providing for the family and other social engagements as situations defining participation (Scott, Phillips, Johnston, Whyte & MacLeod, 2012). Accordingly, to evaluate progress/effectiveness of stroke rehabilitation processes in a manner that will ensure efficient communication between professionals tailoring selection of outcome measures towards ICF framework has been well advocated (Salter et al, 2007). In this study the following table (8) presents the outcome measures used and their ICF categories, their reliability and validity and a brief motivation for their choice for use in this study.

Table 2-8: Stroke rehabilitation outcome measures

Name of tool	Aim and description	Reliability	Validity	Motivation
Body structure and function assessment				
Modified Tardieu Scale (MTS)	The MTS is a measure of spasticity. Descriptively, the MTS has two measurements, the quality of muscle reaction (ordinal scale) and the angle of reaction or angle of catch (ratio). The quality of muscle is scored from 0-5; 0 implies no resistance to Passive Range of Movement (PROM) and 5 indicating joint immobile. On the other hand, Angle of catch can be understood via two factors of PROM, the speed of movement and joint angle.	It has excellent test-retest reliability (ICC=0.86) in stroke patient (Paulis, Horemans, Brouwer & Stam, 2011).	It has a good convergent validity for both elbow and ankle joints (r=0.86 and r=0.62 respectively) (Patrick & Ada, 2006).	The MTS is superior to other instruments used for the clinical assessment of spasticity, like the (modified) Ashworth Scale, because it targets, velocity-dependent increase in muscle tone
Manual muscle Testing (MMT)	Manual muscle testing (MMT) of Medical Research Council of Great Britain (MRC) system is a muscle strength grading system and it is otherwise known as the Oxford Scale (James, 2007). It has a score range of 0-5, with 0 being the minimum and 5/5 the maximum.	It has an excellent test-retest reliability for both right and left hip joints (ICC=0.98 and ICC=0.97 respectively) with osteoarthritis (Youdas, Madson, Hollman, 2010).	It has an excellent convergent validity when related to Barthel index (r = 0.87) (Tilley et al, 1996).	It is a widely acceptable measure of muscle strength and does not need formal training to be administered
Activity assessment				
Modified Rankin Scale (MRS)	The MRS is a hierarchical scale of 0-6 points that indicate “global disability”. Lower scores on the scale suggest more independence and higher scores signify increased dependency. The score ranged from 0 to 6, with 6 suggesting death.	Its test-retest reliability ranged between adequate to excellent (Kappa=0.67-0.96) (Quinn, Dawson, Walters & Lees, 2009).	It has an excellent convergent validity when related to Barthel index (r = 0.87) (Tilley et al, 1996).	It is a common scale for measuring the degree of disability or dependence. It requires no formal training before use
Modified Barthel Index (MBI)	The MBI assesses ten functional tasks of daily living (activities of daily living – ADL). It scores the individual based on independence in each task. Scores range from 0 and 100, with a higher score indicating greater independence.	The inter-rater reliability is sufficient at the item level (kappa 0.50–0.78) and good for the overall inter-rater agreement [ICC] 0.77) (Anderson et al, 2008; Shah, Vanclay & Cooper, 1989).	It has an excellent correlation with Functional Independent Measure (FIM) motor (r ≥ 0.92)	It is the most prevalently use outcome measure in stoke. It does not require formal training before being us

Table 2-9: Stroke rehabilitation outcome measures continued

Name of tool	Aim and description	Reliability	Validity	
Activity measures				
Six-Minute Walk Test (6MWT)	6MWT is a clinically useful measure of walking ability and exercise tolerance post stroke, which incorporates the important requirements of ambulation, such as walking speed, dynamic balance, and submaximal endurance. It is performed at the individually determined fastest speed possible during walking, making it ideal for stroke survivors (Fulk, Echternach, Nof & O'Sullivan, 2008). It measures an individual's ability to walk for a maximum distance (meters) within 6 minutes.	This test exhibits excellent test-retest reliability (ICC = 0.973; 95% CI = 0.925 to 0.988), a minimal detectable change of 54.1m (Fulk et al, 2008).	It has an acceptable concurrent validity (*r* = 0.52 to 0.89) (Fulk et al, 2008).	It a valid and reliable methods use in the measurement of walking distance in stroke. There is no need for sophisticated gargets before use.
Ten Meter Walk Test (10MWT)	The 10MWT is a generic quantitative mobility and leg function performance test for the assessment of gait speed (Scrivener, Schurr & Sherrington, 2014).The 10MWT as a measure of gait speed has been found to be responsive to change during inpatient stroke rehabilitation in motor performance (Scrivener et al, 2014).	The test shows a high intra-observer reliability (ICC=0.95) and validity (r=0.79) in stroke survivors (Fulk et al, 2008).	It has an excellent correlation with Barthel Index (r = 0.76) (Tyson & Connell, 2009).	It is a performance speed assessment. There is no need for specialised to monitor changes. It is easy to administer and does not need specialized training.
Action Research Arm Test (ARAT)	The ARAT is a criterion-rated assessment of upper extremity activity limitations (Nijland et al, 2010). The ARAT includes 19 items divided into four subscales: grasp, grip, pinch, and gross movement. The items within each subtest are ranked based on a four-point ordinal scale ranging from zero to three, where three symbolises normal performance on each item. The items are ordered in a hierarchy, allowing skipping some items if the person is unable to do an earlier item normally. A score of 57 indicates normal performance.	The test has a good test-retest reliability for both chronic and acute stroke, ICC=0.963 (Platz, Eickhof, Nuyens & Vuaden, 2005)	It has an excellent construct validity in relation to the arm section of Fugl Meyer, ICC=0.925 (Platz et al, 2005).	This is the most common objective measure of upper extremity function and dexterity. There is no training required before administering

Table 2-10: Stroke rehabilitation outcome measures continued

Name of tool	Aim and description	Reliability	Validity	
Activity measures				
Motor Activity Log (MAL)	The motor activity log (MAL) is a rating scale that evaluates how the affected hand is used to perform 30 daily activities (e.g. feeding, turning a door handle). For each activity, the patient rates how much the affected hand is used (amount of use, AOU) and how well the activity is performed (quality of use, QOU). Ratings are usually on a scale of 0 to 5, with higher scores representing better functions. Scores on each scale are calculated as the mean of the scored items attempted with the affected arm.	Its test-retest reliability is excellent (r>0.91) and stability ratio >3 for the QOU and AOU (Uswatte, Taub, Morris, Light & Thompson, 2006).	Excellent concurrent validity with ARAT (r = 0.68) (Uswatte et al, 2006).	Measures real world upper extremity function and does not require training to be used
Participation measure				
Stroke Specific Quality of Life Questionnaire (SSQOL)	SS-QOL is selected to assess community participation, as it content has compared with the ICF, with result indicating participation content more in defining the scale (Teixeira-Salmela, Neto, Magalhaes, Lima & Faria, 2009). The SS-QOL is a self-report questionnaire consisting of 49 items (score ranged 49-245) cutting across 12 domains of mobility, energy, upper extremity (UE) function, work/productivity, mood, self-care, social roles, family roles, vision, language, thinking, and personality specific for stroke survivors. The domains are graded individually, and a total grade is also rendered (Lin, Fu, Wu & Hsieh, 2011).	Internal consistency for all domains showed Cronbach's alpha = 0.81-0.94 (Muus, Williams & Ringsberg, 2007). Test-retest indicated excellent stability (r = 0.65 – 0.99)	SS-QOL has a good content validity, kappa coefficient ranged from 0.75-1.00 (Teixeira-Salmela et al, 2006).	Does not require formal training before the administration
Treatment Acceptability questionnaire (TAQ)	To assess acceptability participants will complete a purpose-designed questionnaire (Hunsley, 1992). The tool is a six-item scale adapted from the original treatment acceptability questionnaire; it is a seven-point scale, with lower score indicating lower acceptability. Possible score on the scale ranged from 6-42.	Test-retest reliability is excellent (r = 0.78) (Hunsley, 1992).	Excellent correlation with Treatment Evaluation Inventory (r = 0.87)	It could be a self-administered or by face to face interview

2.7 Section Four: Task Specific Training

Task-specific training (TST) is an approach that emerged from movement science and motor skill learning paradigms (Schmidt and Lee, 2005). There is growing evidence supporting the use of TST in the management of neurological disorders (French et al, 2007; Schmidt and Lee, 2005; Winstein et al, 2006). It has been defined as a training or therapy in which clients practice context-specific motor tasks and obtain certain level of feedback (Teasell et al, 2008). It has also been described as a training/intervention programme utilizing specific conventional everyday activities which are intrinsically and/or extrinsically important to the patient or client as the primary medium of administering therapy (Hubbard, Parsons, Neilson & Carye, 2009; page 181). Based on motor skill/motor learning disciplines, it is assumed that TST is enhanced by different practice conditions, feedback and conditions of transfer (Schmidt and Lee, 2005; Winstein et al, 2008); the technique of TST is centred on advancement of performance in functional tasks through goal-directed practice and repetition (Hubbard et al, 2009). In stroke rehabilitation, TST is being advocated, based on the rationale that we learn what we practice, for this reason, studies have suggested that competencies can be accelerated after stroke when practice is implemented in an intensive and task specific mode (Michaelsen et al, 2006; Wolf et al, 2006; Wood-Dauphinee & Kwakkel, 2005; Salbach et al, 2004; Blennerhassett & Dite, 2004). This is particularly achievable because it has been established that task-specific practice is a prerequisite for motor learning (Langhorne et al, 2011). To implement TST the tasks must, therefore, be tailored towards the appropriate level of the patients' ability, and as patients improve, task difficulty is made to progress. One of the features of TST is the dose-response relationship between the intensity of practice employed in the training and the corresponding

increase in recovery of motor function after stroke (Cooke et al, 2010a; Galvin et al, 2008; Kwakkel et al, 2004). A key factor in the implementation of TST is the intensity of the repetitiveness of the activity. Researchers have demonstrated that repetition is a requisite factor for motor learning and specifically thousands of repetitions of new tasks are required to facilitate cortical reorganisation and recovery following stroke (Boyd et al, 2010;Koski et al, 2004; Johansen-Berg et al, 2002). Hubbard et al (2009) recommended five clinical practice strategies for the implementation of TST using guidelines from previous studies; they tagged the strategies the 'five Rs'. The five strategies proposed by Hubbard and associates (2009) are as follows:

1. Task-specific training should be 'RELEVANT' to the patient and to the context.

This strategy describes the need to ensure that the training programme should be patient centred, where both intrinsic and extrinsic needs of the patient are prioritised (Hubbard et al, 2009; Teasell et al, 2008). The other side of this strategy is that training should be tailored towards context-specificity, implying that the choice of training should reflect the real-world situation, not just pieces of non-context directed movements (Hubbard et al, 2009; Michaelsen et al, 2006; Wolf et al, 2006; Wood-Dauphinee & Kwakkel, 2005).

2. Task-specific training practice sequences should be 'RANDOMLY' ordered.

One of the key targets of TST is to attain generalizability post-rehabilitation and to achieve this targeted goal studies have identified variability of tasks in a random fashion as an important strategy to facilitate retention and transfer and subsequently generalisation of learning new tasks (Krakauer, 2006; Schmidt & Lee, 2005). Based on this strategy TST should, therefore, be applied using random ordering of tasks at

varying contexts, settings and level of demand (Bayona, Bitensky, Salter& Teasell, 2015; Davies, 2006).

3. Task-specific training should be 'REPETITIVE'.

Repetition and massed practice of tasks have been recommended in TST (Koski et al, 2004; Boyd et al, 2010; Johansen-Berg et al, 2002). A substantial body of evidence suggests that better performances following training programmes are products of the amounts of practice (Michaelsen et al, 2006; Wolf et al, 2006; Wood-Dauphinee & Kwakkel, 2005; Salbach et al, 2004; Blennerhassett & Dite, 2004).

4. Task-specific training should aim towards 'RECONSTRUCTION' of the whole task

This strategy is focused on organising tasks in a manner that will best benefit the patient. Complex tasks are to be fragmented into parts to afford the patient the ability to perform such tasks. This will require assessing the patient's performance characteristics in performing such tasks, identifying which skills and components parts are largely affected and what is/are responsible for the patient's limitation and finally developing a treatment plan aimed at considering both what the patient can do favourably and what the patient can't in order to reconstruct the missing/lost function (Hubbard et al, 2009).

5. Task-specific training should be positively 'REINFORCED'

Studies suggest that timely and positive feedback during TST aids improved performance in patients (Davies, 2006; Dobkin and Carmichael, 2005; Seitz, 2005). The aim of feedback is to promote accomplishment of set objectives, afford the

understanding of how the task is being conducted, and consolidate conduct of the task (Irrespective of the type of reinforcement whether verbal or nonverbal, positive reinforcement promotes improved learning above negative reinforcement) (Cano-de-la-Cuerda et al, 2015). Reinforcement aids delivering of the information as regards the stages that constitute the action performed, thereby, leading the patient to develop a mental model of the events and analyse his/her abilities in performing the action (Cano-de-la-Cuerda et al, 2015; Hubbard et al, 2009). Positive reinforcement can provide an instant effect on patient's motivation, attention span and improved focus on the task (Cano-de-la-Cuerda et al, 2015). However, reinforcement may result into dependence and discourage the patient from exerting effort and self-interpreting the features of the required action; this is why reinforcement has to be effected when necessary and should be withdrawn over the time of the task.

Task specific training is made up of a wide range of training activities targeting both upper and lower extremity functions. Suchactivities include household tasks (involving opening and closing of jars, eating and spring-loaded clothespin) and fine motor skills (involving grasping/using of spoon plus picking objects using prescribed grasp style) treadmill training, bicycling, sit to stand exercises, circuit training and mental imagery (Rensink, Schuurmans, Lindeman & Hafsteinsdóttir, 2008).Harvey (2009) identified some principles of task-specific training to be considered in order to achieve improved motor skills and function. These principles are essential when planning therapy towards enhancing enduring neuroplastic change. The principles are listed below:

1. Specificity of training
2. Constrained use of the impaired limbs
3. Mass practice (repetition)
4. Shaping of skill
5. Saliency of task
6. Knowledge of performance and results

2.8 Section Five: Circuit class therapy

Circuit class therapy (CCT) is a form of task–specific training (TST) which involves providing therapy to patients in a group setup with the twin benefit of augmenting therapy time/progression within existing staff resources and allowing opportunities for social interaction plus peer support among participating patients (English & Hillier, 2010; English, van de Port & Elizabeth Lynch, 2012; Wevers et al, 2009; English et al, 2007; Dean et al, 2000). CCT has been variously described as the practice of systematically structuring tasks in a series of progressive workstations to create the necessary platform to encourage more practice (task repetition), which is requisite to achieving a specific high level of training intensity. This same feature makes the training program adaptable for both acute (Verma et al, 2015; Outermans et al, 2010; English et al, 2007; Blennerhasset & Dite, 2004) and chronic (Mudge et al, 2009; Yang et al, 2006; Pang et al, 2005; Salbach et al, 2004; Dean et al, 2000) stroke survivors. A few earlier descriptions of CCT are as follows:

- "Training organized in a circuit with a series of workstations designed to strengthen affected muscles and provide the opportunity for task practice" (Deanetal, 2000; page 409).

- "*A model therapy (that is) provided to more than 2 participants, involving a tailored intervention program with a focus on practice of functional tasks received within a group setting, provided to participants with similar or different degrees of functional ability and involving a staff to patient ratio of no greater than 1:3" (English, et al, 2007; page 955)*

- *"A mode of exercise training using a series of systematically progressed workstations" (Roseetal, 2010; page 141)*

- *"A model of therapy delivery that utilizes active exercises and activities which are task-specific (practicing the functional task itself or parts thereof) and is provided in an intensive manner. The key components of circuit class therapy are that therapy is provided in a group setting with more than 2 participants per therapist and there is a focus on the repetitive practice of functional tasks and continual progression of exercises" (English & Hillier, 2010; page 2).*

From the above descriptions the core principles of CCT can simply be generated based on the common features described in the above definitions, these principles include:

a. Activities are arranged in systematically progressed workstations
b. Activities are generally functional tasks
c. Therapy is offered in a group setting where more than two patients are allocated to a therapist
d. Activities are practised repetitively

e. Activities involve different types of repetitive tasks

Wevers et al (2009) described CCT as satisfying the three fundamental features of an effective and efficient exercise training programme which include: 1. Utilisation of varied workstation that accord patient the ability to practice intensely in a meaningful and systematically progressive manner to accommodate the respective needs of each patient; 2. proficient usage of therapists'/trainees' time; and 3. encouraging group dynamics like peer support and social support within the context of training. Accordingly, the goal of CCT in stroke rehabilitation is to institute enduring motor learning in order to optimise motor and functional recovery, which could possibly lead to the achievement of community reintegration after stroke.

Several research trials have shown that CCT is effective in improving balance, transfers, gait, gait-related activities (such as climbing stairs) and upper limb functions in stroke survivors, especially when applied within the first six months after stroke (Verma et al, 2015; Outermans et al, 2010; English et al, 2007; Blennerhasset & Dite, 2004) and even later (Mudge et al, 2009; Yang et al, 2006; Pang et al, 2005; Salbach et al, 2004; Dean et al, 2000). Studies have evaluated several outcomes with most outcomes suggesting benefits following CCT training.

The rationale for the administration of CCT is premised on two theories, the first as discussed earlier, is to increase the amount of active repetitive practice and the second is to enhance cost-effective rehabilitation.

The need for increased opportunities to be active and engaged in stroke rehabilitation has been the focus of research for several decades. West and Bernhardt (2011) conducted a systematic review of studies assessing activity levels in hospital-based stroke survivors; the review included 24 studies from 1980 to 2009. The focus of the studies were in two categories; assessment of activity levels for the whole day and physical activity levels during therapy sessions (with 15 and 10 studies for each of the categories respectively), both groups of the studies used techniques such as behavioural mapping, video recording and therapist report to track physical activity levels among participants. Using the recorded information the duration spent in performing physical activity was categorised into various levels according to the estimated minutes spent (i.e. none, low, moderate and high). The authors reported that the majority of patients spent their day inactive (median 48.1%, IQR 39.6%–69.3%), in solitary (median 53.7%, IQR 44.2%–60.6%) and largely staying inside their bedroom (median 56.5%, IQR 45.2%–72.5%). They reported that only approximately one hour was spent in physiotherapy and occupational therapy sessions per day (median 63.2 minutes, IQR 36.0–79.5, median 57.0 minutes, IQR 25.1–58.5 respectively).

Findings in the 10 studies investigating levels of physical activity within therapy sessions indicated that cumulatively participants were found to be inactive in their therapy for between 20% and 58% of the sessions (West & Bernhardt, 2011). Kaur, English and Hillier (2012) examined the accuracy with which are physiotherapists estimate therapy time in stroke rehabilitation session, the outcome of the study suggested that physiotherapists over estimate patients' active therapy time by an average of 28%, while under estimating the inactive time by an average of 36%. An

earlier study (Elson et al, 2009) reported that participants spent a comparable active time in a therapy sessions in circuit class therapy and individual therapy. Elson et al (2009) therefore, opined that since circuit class therapy extends for a longer period in a day, it is expected to allow for more duration of practice and an assumed better outcome. In a commentary regarding this study Purton (2011; page 83) observed that:

> *"It is vital that within physiotherapy treatment sessions there is a high content of therapeutic activity and that the time when a patient is inactive is kept to a minimum"*

From the foregoing, it is obvious that one of the most observable rationales for circuit class therapy is the versatility of the approach in improving the active time of practice within the therapy session. And it has been well established that the time spent practicing motor tasks largely influences the level of skill acquisition and stroke recovery outcome (Shaffer et al, 2016; Boyd et al, 2010). Hence, circuit class therapy is becoming a popular approach to enhance improved practice in motor tasks during stroke rehabilitation programme (Lawal et al, 2015; Verma et al, 2015; van de Port et al, 2012; Outermans et al, 2010). This is centrally, due to the systematic administration and supervision provided during the therapy sessions which allows participants to augment the amount of practice of functional tasks targeted at the individual patient's ability (English et al, 2007; Blennerhassett and Dite, 2004; Salbach et al, 2004). Although the duration of practice is longer in circuit class therapy, a study found patients' expressing high degrees of satisfaction with the approach (Lynch et al, 2008). The study reported that respondents expressed

they had a positive experiences with the classes and found the classes well-tolerable. Patients' areas of satisfaction include: the amount of supervision and support received, the opportunity to practice tasks specific for their individual rehabilitation needs and the overall encouragement and motivation associated with therapists' assistance/supervision (Lynch et al, 2008). Two earlier studies anecdotally reported satisfaction of patients with circuit class therapy (English et al, 2007; Blennerhassett and Dite, 2004). These findings, therefore, pacify any form of fear that clinicians might be nursing about implementing circuit class therapy due to its longer duration of administration.

Another rationale for the inclusion of circuit class therapy in stroke rehabilitation is the cost-effectiveness of the approach. Presently, research into the cost-effectiveness if circuit class therapy is still scarce, however, available evidence indicated that the approach is promising (English et al, 2007). Englishetal(2007) placed six stroke patients under the supervision of one physiotherapist and one assistant, making a ratio 1:3 therapist to a patient in each circuit class therapy session. Based on time spent in a therapy per day the study found that stroke patients in the circuit class therapy group received a significantly superior amount of time than stroke patients in the traditional one to one therapy group (129 minutes per day to 37 minutes per day respectively). This approach (circuit class therapy) potentially provides more therapy time to the stroke patient and saves the therapist's time, as a therapist needs 129 minutes to provide circuit class therapy for six patients a day compared to 222 minutes needed for six patients in individual therapy (English et al, 2007).

In summary, there are two major rationales for circuit class therapy in stroke rehabilitation, which are the quest to increase the amount of practice for enhancing a lasting neuroplastic change and the ever increasing need to minimize cut the costs of health care. Circuit class therapy has been found effective based on existing evidence for a number of stroke sequelae due to the increased practice time. However, evidence for the dose-response hypothesis is still unclear and evidence for cost-effectiveness is still scarce.

2.8.1 Evaluated outcomes for Circuit Class Therapy

This section presents the various study findings regarding the use of CCT in the management a number of recovery outcome variables in stroke survivors. This review is derived from a summary of two available meta-analyses, a Cochrane review by English and Hillier (2010) and the meta-analysis by Wevers et al (2009). Three later studies (Verma et al, 2015;van de Port et al, 2012;Outermans et al, 2010) not included in the two meta-analyses were also reviewed. These later studies are included in this review because they conform to the criteria for inclusion in both of the earlier meta-analyses.

Functional outcome

A review of both the meta-analyses (English & Hillier, 2010; Wevers et al, 2009) indicated that both reviews included six studies each. In both reviews the majority of studies examined the outcome of circuit class therapy using tools centred on activity limitations, such as physical functions (mobility functions) and enhancement of activities of daily living. Similarly, both studies have closely related objectives, as they were both focused on lower extremity function, mobility function (English &

Hillier, 2010) and walking competency (Wevers et al, 2009). Table 2.9 below presents studies from both of the reviews.

Walking competency

Six of the studies (Dean et al, 2000; Blennerhassett& Dite 2004;Salback et al, 2004; Pang et al, 2005; Yang et al, 2006; Mudge et al, 2009) from the two meta-analyses and the three added studies(Verma et al, 2015; Outermans et al, 2010) all reported the use of 6MWT to assess walking distance. The result of both of the meta-analyses indicated improved walking distance among stroke survivors in favour of circuit class therapy. Both studies showed significant homogeneous improvement in walking distance, with a mean difference of 42.3 meters reported in Wevers et al (2009) and 76.6 meters reported in English and Hillier (2010). Study outcome also seems to be favourable in the early onset of stroke (acute), this is particularly evident with the study conducted by Blennerhassett and Dite (2004) which was conducted in stroke survivors at the sub-acute stage post-stroke presenting the most remarkable improvement of 116 meters between circuit class therapy and the control. The difference of 116 is well above the 13% clinically important difference reported for stroke survivors in previous studies (Fulk et al, 2008; Flasbjer et al, 2004). Three other studies reported in both meta-analyses also indicated clinically impressive improvements (Mudge et al, 2009; Pang et al, 2005; Salbach et al, 2004). Moreover, all the three added studies (Verma et al, 2015; van de Port et al, 2012Outermans et al, 2010;) showed improved walking distance in favour of circuit class therapy. In particular, a difference of 58 meters, which is 14% change, was found between circuit class therapy and the control in the study conducted by van de Port et al (2012).

Table 2-11: Studies on Circuit Class therapy from available reviews

Author (date)	Sample	Mean age in years	Onset in months	Structure of the therapy	Alternative treatment for control group	Baseline characteristics	Outcome measures
Dean et al (2000)	9	66.2	15.6	Mobility based CCT, 3 times weekly, 60 minutes, for 4 weeks	Seated upper limb activities, 60 minutes per session, 3 times weekly for 4 weeks.	Able to walk 10 m independently	6MWT, Step Test TUG Gait speed GRF paretic LL Gait kinematics
Blennerhassett & Dite (2004)	30	55.1	1.5	Mobility based CCT added to usual care, 5 times weekly, 60 minutes for 4 weeks	60 minutes per session, 5 days/week upper limb related CCT plus usual care for 4 weeks	Able to walk 10 metres with supervision	6MWT, Step Test TUG MAS (upper limb) JTHFT Length of stay
Salbach et al (2004)	91	>70	8.1	Mobility based CCT 3 times weekly, 60 Minutes for 6 weeks.	Upper extremity CCT activities. 3 times weekly, 60 Minutes for 6 weeks	Able to walk 10m alone, no assistive device	6MWT, 5MW BBS TUG
Pang et al (2005)	63	65.3	61.8	Mobility based CCT 60 minutes, 3 times weekly for 19 weeks	Upper limb related CCT. 60 minutes per session, 3 times a week for 19 weeks	Able to walk Independently	6MWT, BBS, VO2max Knee extension strength PASIPD Femur BMD
Marigold et al. 2005	59	67.8	44.4	Mobility based CCT, 60 minutes per session, 3 times weekly for 10 weeks	Stretching and tai-chi like exercises 60 minutes per session, 3 times weekly for 10 weeks.	Able to walk 10 m independently	TUG, BBS ABC NHP Force platform measures Falls diary
Yang et al (2006)	48	58.4	64.2	Mobility based TST 30 minutes, 3 times weekly, for 4 weeks	No, any rehabilitation training	Able to walk 10m independently no assistive device.	6MWT, Step test TUG, LEMS, Gait speed Cadence Stride length

CCT, Circuit class therapy, TUG, Timed up and go; 6MWT, Six-minute walk test; GRF paretic LL, Peak vertical ground reaction force of the paretic lower limb during sit to stand; MAS, Motor assessment scale for stroke; JTHFT, Jebsen Taylor Hand Function Test; 5MW, Five minute walk; BBS, Berg Balance Scale; PASIPD: Physical Activity Scale for Individuals with Physical Disability; BMD: bone mineral density; ABC: activities-specific balance confidence scale; NHP: Nottingham Health Profile

Table 2-12: Continued (Studies on Circuit Class therapy from available reviews)

Author (date)	Sample	Mean age in years	Onset in months	Structure of the therapy	Alternative treatment for control group	Baseline characteristics	Outcome measures
Mead et al (2007)	64	72	10.6	Mobility based resistant exercises, 40 minutes, 3 times weekly for 12 weeks.	Relaxation exercises performed 3 times a week for 12 weeks	Independently ambulant patients	FIM, NEADL, RMI, Functional reach, STS, EMS; TUG; SF-36 version 2; HADS; Physical fitness (Gait speed, Walking economy, and LEP)
English et al (2007)	68	61.6	0.8	Mobility and upper limb CCT. In 2, 90mins sessions in a day, delivered, in 2, 90mins sessions/ day, 5 days weekly	Usual care therapy during hospital stay	Able to stand with the assistance of 1 person	Gait speed, BBS MAS (upper limb) ILAS Patient satisfaction Length of stay
Mudge et al (2009)	58	73.7	53.8	Mobility based CCT 60 minutes, 3 times weekly for 4 weeks	Social and education 2 times a week, 90-min per session for 4 weeks	Able to walk Independently	6MWT, Gait speed RMI, ABC, PADS Free-living step counts
Outermans et al (2010)	43	56.6	0.8	High-intensity mobility CCT, 45 minutes, 3 times weekly for 4 weeks	Low-intensity physiotherapy	FAC ≥ 3	6MWT Gait speed Functional reach
Verma et al (2015)	30	53.27	1.3	Mobility based CCT plus Motor imagery, 40 min/session, 7-days a week for 2 weeks	Bobath's neurodevelopmental technique		6MWT Gait speed FAC, RVGA, Step length
van de Port et al (2012)	242	57	3.5	Mobility based CCT, 90 minutes, 2 times weekly for 12 weeks	Usual care physiotherapy	Able to walk 10m without physical assistance	SIS (version 3.0), RMI, FES, NEADL, HADS, FSS, MI-arm, MI-leg, 6MWT, 5MW, TUG, MDT, LC, TBT

CCT, Circuit class therapy; FIM, Functional Independence Measure; NEADL, Nottingham Extended Activities of Daily Living; STS, Sit-to-Stand; EMS, Elderly Mobility Scale; 6MWT, Six-minute walk test; TUG, Timed up and go; LEMS, Lower extremity muscle strength; RMI, Rivermead Mobility Index; HADS, Hospital Anxiety and Depression Score; BBS, Berg Balance Scale; MAS, Motor assessment scale; ILAS, Iowa Level of Assistance Scale; PADS, Physical Activity and Disability Scale; FAC, Functional Ambulation Classification; RVGA, Rivermead Visual Gait Assessment; ABC, Activities-specific Balance Confidence scale; SIS, Stroke impact scale (version 3.0) FES, Fall efficacy scale; FSS, Fatigue severity scale; MI, Motricity index; LC, Letter Cancellation; TBT, Timed Balance Test.

Gait speed

Two measures (10MWT and 5MW) predominates assessment of gait speed. Five studies assessed gait speed amongst the studies included in both meta-analyses (Mudge et al, 2009; English et al, 2007; Yang et al, 2006; Salbach et al, 2004; Dean et al, 2000), as well as all the three included studies in this review (Verma et al, 2015; van de Port et al, 2012; Outermans et al, 2010;). Results suggested improved gait speed with a mean difference of 0.07 m/s (Wevers et al, 2009) and 0.12 m/s (English & Hillier, 2010) post circuit class therapy intervention. Both of these outcomes on gait speed fell below the minimal clinically important difference for stroke survivors' estimated gait speed of 0.16 m/s (Tilson et al, 2010). However, four studies (Verma et al, 2015;van de Port et al, 2012; Mudge et al, 2009; Yang et al, 2006) and the pilot study of Outermans et al (2010) showed impressive clinically important differences in walking speed post circuit class therapy intervention.

Impairment centred recovery using circuit class therapy

Both meta-analyses (English & Hillier, 2010; Wevers et al, 2009) primarily focused on mobility function (activity limitation). However, some of the included studies assessed parameters of body structure/function (impairment). Pang et al (2005) reported significantly improved leg muscle strength in stroke survivors receiving circuit class therapy compared to the control. Similarly, Yang et al (2006) assessed the lower extremity muscle strength (focusing on the hip, knee and ankle) and reported significant improvement in strength in the circuit class therapy group above the control. In contrast Mead et al (2007) found no significant difference in leg power between the circuit class

therapy group and the control. Similarly, van de Port et al (2012) also reported no significant difference in both upper and lower extremity impairment between the circuit class therapy group and the control in an assessment conducted using motricity index.

Assessment of cardiorespiratory impairment was conducted in two studies, Mead et al (2007) measured participants' oxygen consumption during walking (VO2mL/kg/m), while Pang et al (2005) conducted the measurement using maximal exercise test (VO_2max). Improved walking economy was reported in favour of circuit class therapy over the control group receiving relaxation therapy by Mead et al (2007). Pang et al (2005) also reported significantly improved cardiorespiratory fitness among participants in the circuit class therapy group compared to the control.

Activity/participation centred recovery using circuit class therapy

Facilitation of activity and enhancing improved participation using circuit class therapy has been variously measured by researchers. Typically, the earlier sections (walking competency and gait speed) of this review have highlighted evidence with regards to walking competence and gait speed. The assessment of postural control (balance) suggested diverse evidence from the two meta-analyses (English & Hillier, 2010; Wevers et al, 2009) due to the varying approaches used in assessing balance. Four studies (English et al, 2007; Marigold et al, 2006; Pang et al, 2005; Salbach et al, 2004) used the Berg Balance Scale (BBS); seven studies used Timed Up and Go (Mudge et al, 2009; Mead et al, 2007; Yang et al, 2006); three studies used Step Test (Yang et al, 2006; Blennerhassett & Dite 2004; Dean et al, 2000); two studies used Activities Balance Confidence (Mudge et al, 2009; Marigold et al, 2006); a study from the two

meta-analyses used Functional Reach test (Mead et al, 2007; Outerman et al, 2010) used both Functional reach test and Berg Balance Scale; Verman et al (2015) used Step length while van de Port et al (2012) used Timed Balance Test. There are mixed findings on the effectiveness of circuit class therapy on measures of postural control (step test, BBS and TUG). Both of the meta-analyses found no significant difference between circuit class therapy and the control for BBS. However, while English and Hillier (2010) reported no significant difference for TUG and a significant difference in favour of circuit class therapy for step test, Wevers et al reported a literally contrasting finding, indicating a significant difference in favour of circuit class therapy for TUG and no significant between difference for step test. English and Hillier (2010) reported a significant overall effect for Activities Balance Confidence in favour of the intervention group (circuit class therapy) above the control. In the study of Mead et al (2007) and Outermans et al (2010) study findings suggested no significant differences between circuit class therapy and the control for functional reach test. Outermans et al (2010) also found no significant difference between circuit class therapy and the control for BBS. A study by van de Port et al (2012) used Timed Balance Test and reported no significant difference between circuit class therapy and the control.

Direct assessment of participation among stroke survivors following circuit class therapy has not been reported. However, assessment of mobility function and activities of daily living have been conducted following circuit class therapy in several studies.

Assessment of mobility using the subscales of the Stroke Impact Scale (van de Port et al, 2012; Mead et al, 2007) no study indicated significant between differences in any of

the measures. Some studies that included ADL outcome measures like Nottingham extended ADL (van de Port et al, 2012; Mead et al, 2007) or mobility scales like the Rivermead Mobility Index (van de Port et al, 2012; Mudge et al, 2009; Mead et al, 2007) or Elderly Mobility Scale (Mead et al, 2007), also found no significant differences for the above measures. However, Verma et al (2015) reported a significant difference in favour of the circuit class therapy for the Rivermead Visual Gait Assessment. Considering the Mobility subscale of the Stroke Impact Scale (SIS) as a primary outcome measure, van de Port et al (2012) reported no significant difference between circuit class therapy and the control; and on a similar account using the remaining subscales of the SIS as secondary measures also yielded no significant difference. English et al (2007) investigated the level of physical assistance required by stroke survivors during walking using the Iowa level of Assistance Scale, their finding indicated that stroke survivors receiving circuit class therapy were significantly less dependent after discharge from inpatient hospital facility compared to their counterpart in the control group (receiving one-to-one therapy).

2.9 Section 6: Augmented exercise therapy and stroke rehabilitation outcomes

The idiomatic expression “Practice makes perfect” denotes that the frequency of engaging in something makes one better at doing it. It is an oft-repeated maxim used largely in schools to encourage children. Deliberate repeated practice for the purpose of gaining and preserving skilled performance has been recognised in a host of human endeavours including typing (Lee & Genovese, 1988), playing musical instruments (Ericsson, 2004), chess playing (Ericsson, 2006) and sports (Macnamara, Moreau &

Hambrick, 2016; Ericsson, 2006; Ericsson, 2004;Taha & Thomas, 2003), suggesting a dose-response relationship (Kwakkel, 2009). The implication of this is that more time dedicated to skilful training is associated with better performance (Kwakkel, 2009). Rehabilitation of stroke survivors involves training to accomplish multiple demanding tasks like walking competency and upper extremity motor tasks (such as washing, reaching, dressing and washing). It is, therefore, not surprising if mastery of such complex skills will be determined by the amount of training received.

2.9.1 Evidence for increasing intensity of rehabilitation

Seven systematic reviews (Schneider, Lannin, Ada & Schmidt, 2016; Lohse, Lang, & Boyd, 2014; Sehatzadeh, 2013; Veerbeek et al, 2011; Cooke et al, 2010a; Galvin et al, 2008; Kwakkel et al, 2004), have all suggested evidence for improved performance following increased intensity or duration of therapy (table 2.8). One of the earliest systematic reviews on this subject was conducted by Kwakkel et al (2004), in their study involving 20 RCTs of 2686 patients, presenting with diverse characteristics of patients stroke onset (acute, sub-acute, post-acute and chronic cases), and with all the included studies using standardised ADL measures; the pooled ADL yielded a small, but statistically significant Summary of Effect Size (SES) in favour of an augmented duration of therapy (SES [fixed] = 0.13 Standard Deviation Units [SDUs; CI = 0.06 – 0.23; 3.252, $p < 0.001$). An overall change in SES of 5% was observed in favour of more intensive training. The authors concluded that augmented exercise therapy has a small but favourable effect on ADL post stroke (Kwakkel et al, 2004). However, the evidence for a dose-response relationship is not limited to the intensity of ADL practice

but also extend to related domains in stroke, like aphasia and overall quality of life (Bhogal et al, 2003a; Bhogal et al, 2003b). The trials in this study were identified to be heterogeneous in terms of focus and timing of the augmented exercise therapy (Veerbeek et al, 2011; Cooke et al, 2010a; Galvin et al, 2008; Kwakkel et al, 2004).

Galvin et al (2008) investigated the impact of increased duration of exercise therapy on functional recovery post stroke. Their study included 20 RCTs with a median methodological quality of 6-points on the 10-point PEDro scale. A meta-analysis conducted on studies with similar outcome measures indicated that augmented duration of exercise therapy time has a small but positive effect on ADL as assessed by Barthel Index (SES 0.13; CI 0.01–0.25; Z = 2.15; p = 0.03), which was sustained over a six-month period post intervention (SES 0.15; CI 0.05–0.26; Z = 2.8; p =0 .001). In contrast, the author found no significant differences in the results of upper and lower extremity outcome measures after pooling together the reported differences. However, the authors concluded that based on the overall finding of their study, the meta-analysis supports the hypothesis that additional, dedicated exercise therapy practice has a positive effect on lower extremity impairment and walking competency post stroke.

Cooke et al (2010a) in a study focused on determining the strength of current evidence for provision of a higher dose of the same types of exercise-based therapy to enhance motor recovery post stroke, included both RCTs and non-RCTs. The seven studies incorporated were largely heterogeneous with regard to outcome measures used, types of therapy employed and time-points for outcome and follow-up assessments. The

study presented an effect size based on one study, suggesting evidence for a better recovery with increased dose following therapy, which was less evident at follow-up. The authors concluded that limited support is available for the hypothesis that dose of the same type of exercise therapy enhances motor recovery post stroke.

In a systematic review and meta-analysis investigating the effects of augmented exercise therapy on gait, gait-related activities, plus basic and extended ADL in the first six months post-stroke; using 14 trials with a total of 725 stroke survivors, Veerberk and associates (2011) found that does-response stroke rehabilitation trials are heterogeneous in terms of type of intervention, i.e. how several authors define and implement the increased intensity of training. The outcome of their meta-analysis suggests that increasing duration of therapy on exercise for gait and gait-related tasks in the first six months after stroke results in significant small to moderate effects with regards to walking competency, walking speed, and extended ADL. Similarly, in a recent meta-analysis Lohse et al (2014) modelled the effect of increased therapy time schedule on standardised to assess recovery post stroke. The study included 37 trials; findings from this study suggested improved outcome in the intervention groups receiving higher scheduled time of therapy above the control that received lower (SMD = 0.35, 95% CI, 0.26-0.45). In a more recent study (Schneider et al, 2016) conducted a systematic review involving 14 trials to investigate the effect of increased amount of usual rehabilitation on activity after stroke. The study examined activity as ability in the upper and lower extremities. The outcome of the study after pooling data from all the 14 trials indicated that additional rehabilitation enhanced activity immediately post

intervention (SMD = 0.39, 95% CI, 0.07 – 0.71, I^2 = 66%). The authors concluded that augmenting the amount of usual rehabilitation targeted at improving activity limitation post-stroke enhances activity, but the amount of additional rehabilitation required to facilitate such achievement is large (Schneider et al, 2016). See table 2.10 for the systematic reviews on augmented exercise therapy.

Table 2-13: Reviews on augmented intensity of exercise therapy

Studies/dates	Type of study	Studies reviewed	Aim of study
Kwakkel et al, 2004	Systematic review	RCTs	To determine the effects of intensity of augmented exercise therapy time (AETT) on activities of daily living (ADL), walking, and dexterity in patients with stroke
Galvin et al, 2008	Systematic review	RCTs	To determine the impact of increased duration of exercise therapy on functional recovery after stroke
Cooke et al, 2010a	Systematic review	RCTs plus Quasi RCTs	To determine the strength of current evidence for provision of a higher dose of the same types of exercise-based therapy to enhance motor recovery post stroke
Veerbeek et al, 2011	Systematic review	RCTs	To determine the effects of augmented exercise therapy on gait, gait-related activities, plus basic and extended ADL first six months post stroke
Sehatzadeh, 2013	Rapid review	RCTs plus Non-RCTs	To determine whether increasing the intensity of rehabilitation enhance the motor and functional recovery of patients after stroke
Lohse et al, 2014	Systematic review and meta-analysis	RCTs	To determine dose-response relationships
Schneider et al, 2016	Systematic review	RCTs	To determine whether increasing amount of usual rehabilitation improves activity after stroke

RCTs, Randomised Controlled Trials

In summary, there is a medium level of evidence for improved performance following increased intensity of practice, supporting the hypothesis that increased the dose of

practice enhances better recovery post stroke. A study (Galvin et al, 2008) also reported that while the improvement may be minimal it is also sustained six months post intervention. All the studies reported the heterogeneity of studies on augmented stroke rehabilitation, among which are focus and timing of the augmented therapy, outcome measures used, types of intervention used, time-points for the assessments of outcome and follow-up and characteristics of patients (acute or chronic).

2.10 Section 7: Neuroplasticity

One of the major challenges in clinical practice is to support findings with evidence. Understanding the principles of neuroplasticity is a key to appreciating the basis to which rehabilitation outcomes can be linked to scientific evidence. Additionally, the principles of neuroplasticity will also avail the clinician with relevant information that will aid planning of rehabilitation in order to maximise patients' benefit during a rehabilitation programme. Neuroplasticity has been defined as the capacity of the brain to remodel in structure, function or connection in response to both intrinsic and extrinsic stimuli (Shaffer, 2016; Crammer et al, 2011; Kleim and Jones, 2008). The response of the brain cells could be either positive or negative; however, the effort in clinical practice is to influence the pattern of the response of the brain cells so that a positive influence can be made based on clinically based evidence (Shaffer, 2016). Extensive studies have been conducted using animal models to understand the principles of neuroplasticity, one of the earliest researchers in this area is Marian Diamond, whose work influenced a paradigm shift amongst scientists when she proved for the first time that the brain shrinks with impoverishment and grows in an enriched environment at any age

(Diamond et al, 1984, Diamond et al, 1971; Malkasian and Diamond, 1971). According to Diamond, useful the brain plasticity could occur in humans irrespective of age. She identified five principles essential for brain plasticity namely: newness, challenge, exercise, diet and love. However, more contemporary findings do not use exactly the same terms but use terms that carry about the same implication. Typically, studies have identified that novelty, challenge and purposefulness are important mechanisms to enhance behavioural change (Houillon et al, 2013; Mahncke et al, 2006) and it is reported that perceived challenge is associated with satisfaction with a given task (Abuhamden & Csikszentmihalyi, 2012) and it serves as a reinforcement for humans (Shaffer, 2016). In an ageing study Vemuri et al (2014) studied intellectual enrichment; their finding suggested that at the 75th percentile academic and career accomplishments showed advanced levels of cognition and a delay in cognitive impairment of 8.7 years compared to persons in the 25th percentile. The result indicated that focused intellectual enrichment in midlife was associated with significant gains; as such novelty and challenge can possibly serve as a powerful approach to extend the "healthy lifespan" (Shaffer, 2016). In circuit class therapy the inclusion of different activities and varying them progressively in intensity across workstations (Verma et al, 2015;van de Port et al, 2012; English et al, 2007) is thought to aid in attaining both newness and challenge to promote neuroplastic change among participants.

Substantial evidence indicated that physical activity prescriptions should be considered an essential part of healthcare to facilitate brain health (Ryan & Nolan, 2016; Hallal & Lee, 2013). While physical activity enhances brain plasticity, the specificity of the input

contributes largely to the impact of the exercise in the brain. This is because evidence has shown that experiences that are appropriate are potentially going to induce speedy neuronal remodelling than inappropriate experiences (Kolb & Muhammad, 2014). Specificity or relevance of the sensory input is not enough to drive lasting neuronal changes, of significant importance is the number of repetitions. It has now been established that thousands of repetitions of novel demanding tasks are requisite to instituting enduring neuronal changes in the brain (Barbay, Guggenmos, Nishibe & Nudo, 2013; Boyd et al, 2010; Harvey, 2009) and the repetition has to be sustained even after obvious functional and behavioural changes have been seen in order to solidify neuroplastic changes in the CNS (Harvey, 2009; Kleim & Jones, 2008). A study reported that coordination exercise increases hippocampal volume in older adults (Niemann, Godde, & Voelcker-Rehage, 2014). Coordination exercises are characterised by specificity and are progressive in intensity. It is not clear whether such gains as found in the elderly are possible following circuit class therapy in stroke survivors.

The social interaction being promoted by circuit class therapy through the benefit of the group dynamics may also contribute to improved performance and subsequent neuroplastic change. This is possible due to the interaction between participants which is expected to promote love, sharing and support; one of the essential intentional emotional experiences is love, which can promote brain plasticity positively (Shaffer, 2016). Studies of affective neurosciences have reported a significant association between neuroplastic gains and thought (Ferrarelli et al., 2013; Davidson & Lutz, 2008) the friendly environment such as created by circuit class therapy (Kaur et al, 2012)

might enhance positive neuroplastic change. However, evidence based research is still needed to understand different perspective with which the brain can positively remodel following circuit class therapy.

2.11 Section 8: Summary of this chapter

It was identified that epidemiologically stroke incidence is on a declining trend in the high-income countries and escalating in low income and middle-income countries, increasing by more than double from 2000 – 2008. This alarming trend has been linked to poor national economic indices in the countries hugely affected. Studies have indicated that rehabilitation remains a hallmark as a treatment regimen required for stroke recovery. It is also obvious that rehabilitation for stroke is continuously advancing and among such advances is Task Specific Training including circuit class therapy. Circuit class therapy has a host of advantages including the opportunity to conduct multiple repetitive motor tasks, novelty of task specific tasks, peer support and cost-effectiveness of the approach. Evidence supporting its use in the treatment of several sequelae accompanying stroke is rich in the literature. Meanwhile, the intensity of practice to enhance lasting change has not been reported. The literature, however, shows evidence of improved recovery in stroke survivors following augmentation of exercise time and intensity of practice. And the improvement following therapeutic exercise practice and particularly when multiple repetitions are involved has been linked scientifically with enduring neuroplastic change. Finally, it is important to identify specific challenges being presented by stroke survivors and equally important is to communicate the improvement gained following rehabilitation for both clinical and

scientific evidence. To ensure uniformity in the dissemination of information regarding both the identification of stroke-related problems and recovery pattern, the WHO-ICF framework was developed and has been helpful in both scientific and clinical perspectives as reviewed in this chapter.

3 CHAPTER THREE: METHODS

We learn more by looking for the answer to a question and not finding it than we do from learning the answer itself. Lloyd Alexander ***(1964):*** The Book of Three

3.1 Introduction

This study investigated the effectiveness of a structured circuit class therapy model for the rehabilitation of stroke survivors. This chapter focuses on the various methods employed in the conduct of this study, including a detailed description of the setting, population, sample size and sampling procedure of the participants. This chapter also outlines the study design, with particular clarity on the randomization, data collection procedure, methods of data analysis and ethical consideration. The protocol to this study has been published (Lawal et al, 2015: appendix 1 [abstract]).

3.2 Research Setting

This study was conducted in Kano, north-west, Nigeria. Kano city is the capital of Kano state, located in the Sahelian geographical region of Southern Sahara. According to the 2006 Nigerian National census, Kano state is the most populous state in Nigeria with over 9.3 million inhabitants (Population Council, 2007). The city of Kano covers an area of 137Km^2, within which are six local government areas, namely: Dala, Gwale, Fagge, Kano municipal, Nassarawa and Tarauni. The population of the city is over 2.1 million (Population Council, 2007). Kano is also rated as the most densely populated state in northern Nigeria with about 442 people per square kilometre. The inhabitants of Kano are largely the Hausa/Fulani tribe. However, the cosmopolitan nature of the city and

especially its commercial activity has led other major and minority tribes in Nigeria to find Kano a home.

There are three specialist hospitals in the city of Kano (Murtala Muhammad Specialist Hospital, Muhammad Abdullahi Wase Specialist Hospital and Women and Child Specialist Hospital, Kano) and one teaching hospital (Aminu Kano Teaching Hospital). This study was conducted in the teaching hospital, Aminu Kano Teaching Hospital (AKTH). AKTH was specially chosen for the conduct of this study because of the availability of enough facilities and its strategic position as a research and training institution. AKTH is a tertiary health institution established in 1988 (owned by the Federal government of Nigeria); it is a 500-bed capacity hospital that receives patients from within Kano, the neighbouring states of Jigawa, Katsina, Kaduna, Bauchi and Zamfara states. The patronage list comprises mainly the indigenous Hausa-Fulani tribe, although the Ibo and Yoruba ethnic groups also constitute a sizeable number of the clientele. The hospital has 20 clinical departments and seven non-clinical departments. The hospital provides outpatient consultations and inpatient services to patients presenting to the hospital with other levels of care or on self-referral (Iliyasu et al, 2010). Outpatient services are provided in the General Outpatient Department, speciality clinics, Physiotherapy, Emergency Paediatric Unit and Accident and Emergency unit. About 353,026 outpatients and 19,513 inpatients were attended to in 2011 (AKTH, 2011).

The Physiotherapy Department of the hospital is established to provide a tripartite function of clinical services, teaching and training research. The Department functions under two units: Outpatient Unit and In-patients Unit. The department has a separate functional stroke and general neuro-rehabilitation clinics (AKTH, 2016). The stroke clinic has two trained senior specialists with both clinical and academic postgraduate qualifications; these specialists are supported by seven other trained physiotherapists two of who have masters' degrees and the other five have bachelor's degrees. There are no occupational and speech therapists in the hospital.

The stroke clinic runs a five-day weekly schedule (Monday - Friday) from 8 o'clock am to 16 o'clock pm for both in-patient and out-patient. The weekend schedule in this clinic starts from 8 o'clock am and ends at 14 o'clock pm, but strictly for in-patients. The routine physiotherapy management of stroke patients in this clinic is not based on any specific guideline, however, the most favoured approaches are the neurodevelopmental therapy of Bobath and Proprioceptive neuromuscular facilitation (PNF), another form of therapeutic exercises, balance retraining, massage, electrotherapy including electrical stimulation (not functional) and thermotherapy.

Patient appointment for treatment is averagely a twice weekly session but could be below for many patients and as such may be regarded as inadequate for most of the stroke survivors. Unfortunately, as is the case in most third world countries there are no empirical data to describe the practice and services in the stroke clinic of the physiotherapy department of AKTH.

All participants in this study were recruited from AKTH healthcare facility and the study itself was also conducted in this facility. All the three research assistants who contributed to data collection and implementation of the study intervention were the staff of the stroke clinic.

3.3 Study Design

This study is strictly a quantitative study, designed as a single blind Randomized Controlled Trial (RCT). The RCT is chosen as the appropriate study design because of the study involved comparing different training schedules involving three intervention categories of Circuit Class Therapy (120CCT, 90CCT and 60CCT) and a control. The intervention categories are differing intensities of therapy defined with regards to augmented time of therapy, i.e. the more the time the higher is the intensity. The amount of time involved in practice has been referred to as a measure of the intensity of exercise training programmes (Veerbeek et al, 2011; Cooke et al, 2010a). Using an RCT as a design will expectedly ensure the best basis for making a comparison between groups by eliminating all perceived causes of bias and at the same time allow drawing conclusion with a sound quality of generalizability of findings.

Randomized Controlled Trials (RCT) are a research design in which participants are randomly allocated to one of two or more clinically based intervention categories (Akopeng, 2005), they prevent selection biases and maximise the precision of the estimates of treatment effects. They are the most scientifically rigorous method of testing a hypothesis of causality (Last, 2001) and are considered the gold standard trial

for evaluating the effectiveness of intervention protocols (McGovem, 2001). According to the Oxford Centre for Evidence-Based Medicine (OCEBM), RCTs offer Level 1b scientific evidence in answering clinical questions, this is because RCTs are designed to be unbiased and have less risk of systematic errors (OCEBM, 2011). Additionally, in this study, the design involved blinding to further enhance elimination of bias in the outcome generated. Blinding is a systematic research plan that involves intentional concealment of information from individuals playing one role or the other in a study (as a subject, trainer or assessor). It is largely accepted as a strategy to decrease ascertainment biases that can arise from peoples' awareness of study participants' treatment groups, specifically, in judging the outcomes of interventions. Combining blinding and randomization in trial design decreases the rate of conscious and unconscious bias that could arise in clinical trials (performance bias) and interpretation of study findings (ascertainment bias) (Boutron et al, 2006). Blinding is typical of two types, double and single, although triple blinding also exists in the literature. Each of these terms has differing definitions from one study to the other and as such, it has been encouraged that researchers should explicitly describe who was blinded in the study (Devereaux et al, 2001; Schulz & Grimes, 2002). This study adopted a single-blind trial for two reasons: 1. Trainers could not be blinded as they needed to know the exact duration allotted to each participant to be able to implement the study protocol accurately. 2. Participants could not be fully blinded as they need to be informed of the study protocol, which typically differentiated them from one another so as not to perceive unhealthy or preferential treatment for certain categories of participants and prompt certain questions like why are others allowed to leave while I remained or why

are others allowed to stay longer than me? A single-blind trial of the outcome assessor was thus used in this trial. This design has been identified as one of the features of a well-designed RCT (Kendall, 2003).

This study design gained trial registration with the Pan African Clinical Trial Registry (PACTR) with a trial registration number: PACTR201311000701191 (appendix 2)

3.4 Study Population and Sample

The study population included stroke survivors in Aminu Kano Teaching Hospital (AKTH), which is a tertiary health institution in Kano, Northwest Nigeria. The specific population size for all cases of stroke seen from November 2013 to June 2014 is not available in the hospital's annual statistical bulletin. This study, therefore, considered all the population of stroke survivors attending or being referred after inpatient acute stroke care to attend the outpatient Physiotherapy or outpatient hypertension clinic of AKTH (from November 2013-June, 2014).

3.4.1 Sample

Participants included in this study were stroke survivors in AKTH who met study inclusion criteria, who were either consecutively referred directly for physiotherapy by consulting physicians or those considered eligible by the researcher from the hypertension clinic and were further certified fit to participate in the study by consulting physicians. However, participants were only randomised into the study groups (three intervention groups and one control) after satisfying the inclusion criteria. Participants

with stroke onset ≥ 30 days were recruited to ensure patients were not under observation (acute medical care) at the point of recruitment, as the probability of long-term survival improved significantly during the observation period based on the level of care given (Brønnum-Hansen, Davidsen & Thorvaldsen, 2001). A key criterion for recruitment into a training programme like the CCT in several studies (Verma et al, 2015; van de Port et al, 2012; English et al, 2007) is the ability to walk a minimum of 10 meters post stroke, implying that participants with a certain level of function such as ability to walk before stroke and to a certain extent post-stroke are presumably going to benefit from CCT. Similarly, with regards to the upper extremity participants with at least grade $^{2}/_{5}$ muscle strength on MMT scale were expected to profit from most of the CCT activity. Hence, the following criteria were the other criteria considered for inclusion and exclusion of participants:

- Stroke ascertained clinically to be due to cerebrovascular accident; leading to unilateral sensorimotor deficits (English, Hillier, Stiller & Warden-Flood, 2007),
- All included participants gave written informed consent
- Adult stroke survivors of ≥18 years of age;
- Sufficient cognition to participate (scoring ≥24 points on mini-mental state examination);
- Willingness to participate in an 8-week intensive CCT programme

Participants were excluded if:

- They presented with precluding medical comorbidity to exercise as confirmed by a physician.
- Inability to stand from sitting without assistance and walk a minimum of 50 metres independently prior to morbidity.
- They presented with a history of any major surgical procedure significant enough to interfere with performance (general or orthopaedic) in an exercise therapy intervention.

3.4.2 Sample Size and Power Calculation

Using power calculations to detect a between-group difference of 42.5m (0.43 effect size) for a 4-group repeated measure MANOVA in walking distance with 90% power at α=0.05, a total sample size of 56 was generated, using an estimated standard deviation (SD) for the calculation as adopted from a meta-analysis (Wevers et al, 2009). The 42.5m was reported as the minimum clinically important difference in walking distance, based on implicit measurement error following repeated measurement of speed (Wevers et al, 2009). The generated total sample size of 56, by implication, will give 14 participants as samples for each group. Considering 10-15% attrition rate against drop-out during follow-up, the study targeted approximately a total of 84-88participants which was hoped to give between 21-22 participants per group. The power calculation was conducted using G*Power version 3.0.10. Detail of the sample determination is presented in table 3.1 below:

Table 3-1: Sample size determination details

Analysis	Output	
F tests	MANOVA: Repeated measures, within-between interaction	
Options	Wilk's U, Muller-Peterson Algorithm	
Analysis	A priori: Compute required sample size	
Input		
	Effect size f(U)	= 3
	α err prob.	= 0.05
	Power (1-β err prob)	= 0.90
	Number of groups	= 4
	Repetitions	= 3
Output		
	Noncentrality parameter λ	= 18.859800
	Critical F	= 2.188761
	Numerator df	= 6.000000
	Denominator df	= 102
	Total sample size	= 56
Attrition rate against drop-out (10-15%)	≈84-88	

3.4.3 Randomization

Participants who conformed to the study inclusion criteria and signed written informed consent (appendix 3) were randomised, using a computer-generated random allocation sequence schedule held by a third party, who randomly allocated participants into four involving three intervention groups (120-minutes CCT, 90-minutes CCT and 60-minutes) and one control. Allocation of participants was concealed, through off-site concealment.To achieve concealment the on-site researcher contacted (telephone contact) the off-site schedule holder for allocation, after being satisfied with the potential participant's eligibility and upon obtaining consent from such participant.

After randomization into the four groups and considering the level of literacy of the participants (based on experience from the pilot study), participants' groups were

renamed for ease of recall of grouping by participants. This was done by using colours to represent each group as follows:

i. 120CCT= Yellow
ii. 90CCT=Green
iii. 60CCT=White
iv. Control= Blue

While participants could easily identify their individual groups, participants were instructed not to disclose their individual groups to the assessor. Althouh, the groups were tagged by colours for the participants' ease of identification, the groups were represented in the study as groups A, B C, and D (for 120CCT, 90CCT, 60CCT and the control respectively).

3.5 Instrumentation (outcome measures)

The data collected included socio-demographic details of the participants and Criterion Based Outcome Measures (CBOMs). Both measures were integrated on a prepared proforma (appendix 4) for easy documentation. The integrated pro forma was made up of four sections: section one involved the participants' socio-demographic data, section two the CBOMs, section three the outcome data and section four the follow-up (which was conducted six months post intervention). Both socio-demographic measures and the CBOMs were assessed within the first week of recruitment as pre-intervention measures otherwise known as baseline measures. The socio-demographic and criterion based outcome measures are detailed as follows:

3.5.1 Socio-demographic Characteristics of Participants

The socio-demographic and baseline measures of the participants were assessed prior to randomization. Accordingly, the socio-demographic characteristics were divided into two to capture demographic information from two perspectives of the participants, the personal demographic information and stroke specific information. The personal demographic information included age, sex, marital status, educational qualification, occupation, tribe, height, weight. The stroke specific information included time since stroke, type of stroke, the use of cane, and hemispheric side of the lesion.

3.5.2 Criterion Based Outcome Measures (CBOM)

These are a battery of tests deliberately selected to meet the World Health Organization's International Classification of Functioning, Disability and Health model (WHO-ICF, 2001). The selected measures represented each domain of the ICF classification. All the tests were conducted at specific time points including baseline, post intervention and 6-months follow-up of the intervention. The primary outcome measure in this study was functional capacity or walking distance (as measured by Six-Minute Walk Test). The assessments of the primary objectives of this study was made possible by the use of battery of measures deliberately selected to conform with the WHO-ICF model, hence the outcome measures used in this study involving the main and secondary outcome measures were categorized in the table below:

Table 3-2: Study assessment tools

ICF category and Outcome measure	Purpose	Administration
Body structure and function assessment		
Modified Tardieu Scale (MTS)	Assessment of spasticity	The assessor performed all measures through goniometric evaluation, attention were focused on flexor spasticity for upper extremity components of the shoulder, elbow and wrist and extensor spasticity for lower extremity components of hip, knee and ankle joints (appendix 9).
Medical Research Council Manual Muscle Testing (MMT)	Assessment of muscle strength	Measurements were conducted along sagittal plane for both upper and lower extremities, involving flexion/extension. The upper extremity components included shoulder, elbow and wrist, while the lower extremity components were hip, knee and ankle muscle strengths (appendix 10).
Activity assessments		
Modified Rankin Scale (MRS)	Assessment of level of disability	Patients were interviewed about their activities of daily living as well as outdoor activities. The assessor also obtained information patients' neurological deficits such as aphasia and intellectual deficits. The assessor obtained a score for MRS by combining physical, mental and speech performances of the patient (appendix 11)
Modified Barthel Index	Basic activities of daily living	To arrive at a single of MMT score in this study, participants were tested by the assessor in terms of whether they can complete a given activity independently, through assistance or they cannot do it at all (appendix 12)
Six-minute Walk Test (6MWT)	Walking distance	Assessment of 6MWT in this study was performed according to the guideline of the American Thoracic Society (2002) including use of a 30-m course with 10-m increments marked discretely on the wall. Participants were instructed to walk the course back and forth. Rests were allowed as participant walk along the length of the pavement (if needed) and continue subsequently. The assessor offered usual encouragement every 30 seconds as present in 6MWT administration (Gibbons, Frucher, Sloan & Levy, 2001).The total distance accomplished was ascertained by counting the laps, using the floor markers and measuring the distance covered from the last marker with a tape measure to the nearest centimeter, with the assessor setting the time with a stopwatch.
Ten Meter Walk Test (10MWT)	Gait speed	The test was performed on a 14-meter walkway, to avoid the effects of acceleration and deceleration; therefore individuals accelerated 2-meters before entering the 10-meter distance and 2-meter to decelerate afterward, this ensured steady velocity within the 10-meter mark. An average of two trials of the 10 meter walk was recorded as the gait speed.

Table 3-3: Study assessment tools continued

ICF category and Outcome measure	Purpose	Administration
Activity assessment		
Action Research Arm Test (ARAT)	Upper extremity function and dexterity	The assessor asked each participant undergoing the test to sit and assume comfortable position in a chair in front of the assessment table. The assessor detailed the test procedure to each participant (where necessary the activity was demonstrated to the participant by the assessor). To obtain a single score each participant underwent the ARAT two times and the average was taken as a score. Participants were made to either lift testing materials up from the surface of the table to the top of the shelf or to move them from one location on the table to another location on the table. Detail of scoring has been provided elsewhere (Yozbatiran, Der-Yeghiaain & Cramer, 2008) (appendix 13).
Motor Activity Log (MAL)	Real world upper extremity function	A semi-structured interview was used to examine participants' use of their affected upper extremity. Rating is based on how much (frequency or Amount of Use) and how well (value or Quality of Use) a participant uses the affected upper extremity in his daily activity. Participants were informed on how to differentiate between the AOU and QOU and the rating. The assessor informed the participants that they can give half scores (such as 0.5, 1.5, 2.5, 3.5, and 4.5) where appropriate. In all participants the assessor starts the test with the AOU scale prior to the QOU scale (appendix 14).
Participation assessment		
Stroke specific Quality of Life Questionnaire (SS-QOL)	Community participation	This test was administered to all participants (and their proxies) through a face to face interview. The assessor initially explained what the questionnaire is targeting and the pattern of responses expected. The participants responded to each question with what they considered suitable to each question with the transcript related to each number between 1-5 (as Total help/Couldn't do it at all/Strongly agree=1 or No help needed/No trouble at all/Strongly disagree=5) where necessary the proxy corroborated the participant's response or in rare circumstances provided the answer. Each domain scores were aggregated to arrive at individual domain scores for the 12 domains and subsequently total score (appendix 15).
Acceptability	Acceptance of treatment schedule	To determine acceptability each participants took part in a semi-structured interview to answer questions bothering on the specific therapy they received on a seven-point Likert scale. Participants' responses were recorded both as individual content score and total acceptability score by the assessor (appendix 16).

3.5.3 Assessments

Assessments were all conducted by a blinded assessor at three time periods including baseline, outcome and six-month follow-up. All assessments were performed according to standard procedures outlined for each assessment tool (table 3.1). Three tools (SSQOL, MBI and Acceptability) were translated into the Hausa language for ease of administration as the Hausa language is the predominant language in Kano, north-west, Nigeria. Two independent translators (from the department of Nigerian languages, Bayero University, Kano, Nigeria) were contacted (individually) for the translation of the three questionnaires. This effort yielded two independent forward translations for each questionnaire. The three translated questionnaires (for SSQOL, MBI and Acceptability) were evaluated by two research assistants (RAs) and the researcher and were later back translated using the standard rule for translation of scientific document. If the translation by both translators were the same and favourably convey the correct meaning from English then it can be adopted. However, where there appears to be a difference between the translators they (translators) were contacted (individually) to give information on the target of the question in order to arrive at a consensus. Where some difficulties were encountered the two RAs and the researcher chose a conceptually comparable meaning that was as close as possible to the original meaning and which equally conveyed the required message. Typically, a decision was taken to modify certain items so as to accommodate cultural/environmental differences. In SSQOL, the item which states “Did she/he have difficulties zipping/unzipping a zipper?” respectively” was modified because zippers are uncommon for both male and female clothing in our society and female wears are different from the male wears so the item was modified as

“Did she/he have difficulties in tying/untying a trouser lace or wrapper cloth respectively?”. In the Modified Barthel Index (MBI) the eighth and ninth items related to “Dressing and Stairs” were respectively modified. In the eighth item which has to do with dressing zipping and buttoning were de-emphasised for trouser laces and wrapper clothes in male and female respectively. Item nine was modified because houses are rarely built with staircases in our setting, this item will, therefore, become redundant, under or overrated. The item is therefore modified to reflect Outdoor ambulation with specific consideration for the immediate environment. All changes were agreed upon by the RAs and the researcher during the pilot phase of the study. It is note worthy that the RAs in this study were all traditionally Hausa speaking. One of the RAs was responsible for all assessments from baseline to the follow-up phase, he possessed a Masters degree in neurorehabiltation with an average of 10-years experience as a practicing physiotherapist and 7-years experience in teaching. The other two RAs (were involved in implementing the intervention and recruitment of participants); they both have about 5-years experience as general practitioners (physiotherapists), with one of them having a Masters degree in neurorehabilitation while the other possessed Bachelors degree in physiotherapy.

Participants’ attendance rate at the sessions within the study duration (8-weeks) and task execution frequency in each workstation were documented (by a literate relation where available or the therapist where the relation is illiterate) and often utilised to encourage participants in proceeding sessions.

3.6 Procedure

The study was divided into two phases (pilot and main). Prior to the commencement of the pilot study phase RAs were appointed. RAs were recruited in this study because of (1) the characteristics of the CCT model, in which therapist to patient ratio is defined as at least 1:3 (English et al, 2007); (2) To enable implementation of blinding of outcome assessment, which is a characteristic of standardized RCT (Akobeng, 2005). Hence, the responsibility of the RAs included recruitment of participants, implementation of intervention and assessment of outcome measures at baseline, outcome (post intervention) and six-month follow-up. All RAs had a minimum of five years of experience in stroke rehabilitation but were not at any point trained in CCT. For the purpose of this study, the RAs received a week-long training on specific aspects of their responsibilities. The training was conducted by the researcher in conjunction with a representative of the Department of Community Medicine, AKTH. One RA plus the researcher recruited all the participants,two RAs plus the researcher implemented the CCT intervention programme and one RA who was blinded to both participants' allocation and the structure of the intervention conducted all assessments in this study. Finally, the two RAs involved in the implementation of CCT were also involved in the validation of translated questionnaires to ensure conformity with the original terms of the three translated tools (SSQOL, MBI and acceptability).

3.6.1 Pilot Study Phase

The study commenced with an initial pilot study. In this pilot, study participants were recruited after being certified as eligible to participate using the stipulated study

inclusion criteria. Recruitment was conducted by reviewing records of the outpatient physiotherapy clinic on a weekly basis. A total of 15 participants recruited participated in this pilot study with 5 participants each randomised into the three treatment categories (120CCT, 90CCT and 60CCT). All participants were assessed at baseline before randomization and prior to the commencement of intervention, post intervention (outcome) and at follow-up. The programme was structured for 2-weeks, 3-days activity per week and 2-weeks follow-up. A minute change period was allowed for a change from one workstation to the next. Participants trained within a total of 10 workstations, these stations were made up of task specific activities for both upper and lower extremities, placed alternately across the circuit (i.e. after every lower extremity workstation follows an upper extremity workstation and vice versa) (table 3.2), ensuring a 1:1 ratio of upper to lower extremity activities. This was to allow for adequate concentration, specificity of activity choice and distribution of equal activity duration for the upper and lower extremities in a structured manner. The activities in the workstations are summarised in the table below:

Table 3-4: Circuit class therapy task specific activities for the intervention

Stations/Description	Prescribed tasks
Workstation 1 ***Tasks for warm-up specific for upper extremity***	
	Active flexion- extension of shoulder, elbow and wrist joints
	Abduction-adduction of shoulder joint
	Upper extremity weight bearing on physiotherapy ball
	Push-ups on physiotherapy ball or using chair armrest
Workstation 2 ***Tasks for warm-up specific for lower extremity***	
	Stretching the lower extremity (flexion/extension of the limb in supine or sitting position)
	Marching on spot
	Shuttle walking (on a 20-meter length floor of the gymnasium)
	Jogging on spot (a form progression specific for participants who can afford it)
Workstation 3 ***Tasks to achieve reaching, gripping and transferring light objects***	
	Sitting with arm supported on high plinth at 90 degrees shoulder flexion
	Active protraction to push small objects (light ball) off edge of plinth to target the wall
	Sitting same way to push weighted object (a heavier ball)
	Active horizontal abduction and adduction to reach object (cup) on the wall
	Use of protracted shoulder to open a door with patient standing three feet away from the door
	Wrist flexion/extension in gravity counterbalance (provide a target to aim for)
	Radial and ulnar deviation (in gravity counterbalance) with a target to push (cup)
	Picking light objects from table to the wall and back
Workstation 4 ***Tasks to achieve lower extremity flexibility and function***	
	Timed shuttle walk/Initiation of minimal Shuttle jogging (50% of time allotted for this station)
	Sit to stand from high chair with armrest (placing affected leg behind the intact)
	Stationary bike riding
	Squatting activity using the wall bars
Workstation 5 ***Task to achieve upper extremity strength/control***	
	Active shoulder flexion, extension and abduction with weight of varying sizes (dumbbells)
	Active shoulder flexion, extension and abduction with resistant band to reach a target on the wall (cup)
	Active shoulder abduction with weights of varying sizes (dumbbells), to reach a target on the wall
	Active elbow flexion/extension with a resistance band. Also, substitute with varying weights
	Active wrist flexion/extension, ulnar/radial deviations with a resistance band. Can be substituted later with weights of varying sizes
	Finger to nose movement
	Rapid hand alternating movements

Table 3-5: Circuit class therapy task specific activities for the intervention

Stations/Description	Prescribed tasks
Workstation Six ***Task to achieve balance/coordination while walking***	
	Sit to stand from lower chair without armrest (affected leg behind a distant placed intact leg)
	Standing on foam eye closed (safety is key in this activity)
	Carrying object while on shuttle walking (a tray with cup of water)
	Walk up and down stairs (patient walk backwards while coming down stairs)
	Sudden stops and turns while walking
	Obstacle crossing while walking
	Figure 8 walking
Workstation Seven ***Task to achieve improved grip, precision and dexterity with upper extremity***	
	Draw a line on the whiteboard
	Rolling a dumbbell forwards and backwards on a flat surface (table)
	Open and close a window
	Take lids off bottles
	Bring object from table to mouth, vary the size and weight of objects
	Pour water from jug to cup
	Mix water with spoon of various sizes
	Take money in and out of a purse
	Fold paper and place in an envelope
	Trace pattern of different figures on white board
Workstation 8 ***Task to achieve lower extremity strength/control of gait***	
	Walking different step length of parallel line
	Obstacle crossing while walking with a tray of cups filled with water
	Walking backwards and sideways
	Heel lift in standing without and with carrying an object
	Walk on toes short distance forward and backwards
Workstation 9 ***Task to achieve advanced motor task with upper extremity***	
	Rolling pin pushing forward and backwards
	Reach, grasp and move objects to and from different heights
	Wipe over windows
	Wash, wring and peg clothing on lining rope
	Paint sketched objects on cardboard paper
	Use keyboards to type
	Cut customised foams using knives of varying sizes
	Put-on common clothing and footwears

Table 3-6: Circuit class therapy task specific activities for the interventioncontinued

Stations/Description	**Prescribed tasks**
Workstation 10 ***Tasks to achieve improved outdoor activities with lower extremity***	
	Walking while picking objects from the floor
	Walking through closely packed obstacles
	Walking through tight space
	Jumping on foam eyes closed
	Walking on joined foams
	Reverse walking on straight line
	Treadmill walking/jogging
	Speed stair climbing
	Outdoor walking
NOTE:	
1. Tasks within stations are not necessarily convenient and possible for all participants, choice is, therefore, individualized	
2. Tasks in stations vary because it is not necessary for participants to undergo all activities and also to allow room for wide range of opportunities and choices	
3. Progression might be based on activities not initially possible within stations or based on modifications considered necessary by the physiotherapist	
4. Tasks are performed as structured in the model based on durations allotted for each group	

Adapted from circuit class therapy intervention manual version 1.0 (English & Hillier, 2012)

The researcher and two trained research assistants implemented the CCT training programme in this pilot study following an adapted training schedule (English & Hillier, 2012) and based on the activities in the 10 workstations. Progression was based on activities not initially possible (for the participant) within stations or based on modifications considered appropriate to induce benefit by the physiotherapist. Assessments of the impact of the CCT included body structure and function, activity and participation using all the instruments described under study instrumentation. All assessments and training were conducted by experienced/trained Research Assistants (RAs). The outcome of the pilot feasibility test is presented in appendix 5.

3.6.2 Main Study Phase

3.6.2.1 Intervention

The intervention groups were the three intensities (durations) of CCT namely 120, 90, and 60minutes, tagged groups A, B and C respectively. The 10 workstations used at the pilot study were retained in the circuit, arranged and progressed in complexity. The intervention was an 8-week, 3-times weekly training programme, with a total of 24 sessions. Activities were individualised allowing each participant to perform at a select level/pace based on his/her ability, and progressed steadily within the allotted time depending on their training group. The one minute change period allowed during the pilot was abolished at this stage of the study. This was because of the heterogeneity of the participants, while some participants found one minute adequate enough to change over some found it inadequate.

The upper extremity task-orientated CCT activities included activities targeting improvement of both gross and fine motor skills, grasp and reach, sensory function, and proximal control, while tasks for the lower extremity were targeted at balance, strength, cardiovascular endurance, retraining of gait mobility and community-based ambulatory activities. All CCT sessions were conducted by the researcher and two trained physiotherapists, with each treatment session structured at a 3:1 ratio of patients to therapists. The CCT training activities were exactly a replication of what was conducted during the pilot study phase (table 3.2).

All assessments were conducted by only one blinded assessor, unlike the pilot phase where two assessors were involved.This was for two reasons: the first experience from the pilot indicated that one assessor can successfully assess participants with proper planning which was possible because of the level of experience gained during the pilot study; second to ensure consistency and eliminate inter-rater variability. Participants in the intervention groups and control were assessed at baseline (prior to randomisation), outcome and at six-month follow-up using the same tools already tested and trained during the pilot study.

3.6.2.2 Control group (standard physiotherapy)

The standard physiotherapy group, like the intervention groups, was seen for the same number of sessions (24), duration of 60 minutes and three times per week of therapy. Standard physiotherapy used comprised of one-to-one therapist/patient sessions engaging in impairment-centred mobilisation techniques, standing balance (using varying methods) and functional activities for both upper and lower extremities. All the activities for the control group were conducted by regular therapists (who are similar in qualification/experience to therapists implementing the CCT programme) in the Physiotherapy Department of AKTH.

3.7 Data analysis

Data were recorded on Microsoft excel and subsequently exported to Statistical Package for Social Science (SPSS version 22.0). The exported data were then analysed using both descriptive and inferential statistics from which the outcomes of the

study was examined. Data normality was tested using the Shapiro-Wilk test and the homogeneity of variance was tested by Levene's statistic. Effect sizes were determined to assess the magnitude of the variations between the means. The variations in mean values are presented in units of their Standard Deviations using Cohen's R, effect sizes of 0.14-0.35 are considered trivial/small; of 0.36-0.50, as a medium; 0.51-0.69 large and ≥ 0.70, very large.

3.7.1 Descriptive statistics

Participants' performance characteristics in CCT per task and number of sessions attended were statistically described. Socio-demographic characteristics of participants were analysed descriptively in frequencies, percentages, means and standard deviation and presented in tables. Means and standard deviations were also presented to depict baseline, outcome and follow-up scores across study groups.

3.7.2 Inferential statistics

Based on intention to treat analysis a repeated measures MANOVA test was conducted to test for interaction effects of a between-subject factor in terms of groups (120CCT, 90CCT, 60CCT and control groups) and within-subject factor as time (baseline, outcome, follow-up). Univariate ANOVAS were conducted in order to determine the main effect and or interactions with a planned simple contrast. In the case of significant interaction effects in between subject factors, Tukey Honestly Significant Difference (Tukey HSD) post hoc test was performed to determine between group differences and Sidak post hoc was used to test differences in within-subject factor (of baseline,

outcome and follow-up). To determine within-group changes over time simple one-way ANOVAS were conducted for each dependent variable. Similarly, where differences were found Tukey HSD was used for pairwise comparison. All analyses were performed with α-level set at 0.05.

To interpret findings after consideration for the rule of equality in variance-covariance matrices, Wilk's λ statistics was used to interpret output because of the differences in sample sizes across the 4-arms of the study (Tabachnick & Fidell, 2007, Field, 2009). The limitation of the Multivariate Test Analysis (MTA) is the increased vulnerability to type I error (Landau & Everitt, 2004; Leech, Barrett & Morgan, 2005; Field, 2009) for which reason it is argued that the Univariate Test Analysis (UTA) should be reported (Landau & Everitt, 2004; Field, 2013). In reporting UTA assumption of sphericity is the most critical criterion in assessing within-subjects factors in repeated measures analysis because if violated, the F-test used are considered positively biased leading to increased chances for type I error.However, when sphericity is violated correction factors are available to check biases and reduce the potentials for type I error. It has been recommended that when sphericity (ε) is higher than 0.75 the Huynh-Feldt correction factor should be used, but when it's below 0.75 or nothing is known about sphericity the Greenhouse-Geisser correction should be applied (Field, 2009). These factors were favoured in interpreting the findings of this study, as such where sphericity was violated the Huynh-Feldt correction factor was reported and where not, the Greenhouse-Geisser was prioritised.

Post hoc statistics of repeated measures are said to be prone to type I error especially in cases where multiple outcome measures are used along with the repeated measurements, to address this threat of type I error Bonferroni adjustment/correction was used in setting a stringent a priori probability level for the interpretation of post hoc statistical output. The Bonferroni adjustment, involves dividing the set alpha level (commonly, 0.05 α-level) by the number of comparisons that is intended and as three levels of comparison were used in this study, the new alpha level for the interpretation of post hoc outputs becomes 0.017 (Tabachnick & Fidell, 2007; Pallant, 2010). Hence, when an alpha level is ≤ 0.017 the outcome is considered significant and when > 0.017 it is insignificant only in cases of post hoc tests.

3.8 Ethical consideration

This study was conducted in accordance with the Declaration of the Helsinki regarding human experimentation (World Medical Association, 2013). The acquiescence to conduct this study was gained from the Senate Research Grants and Study Leave Committee at the University of the Western Cape (UWC) with ethics number 13/9/33 (appendix 6). Additional ethical approval was obtained from the Human Research Ethics Committee of Aminu Kano Teaching Hospital (Nigeria) ethics number NHREC/21/082008/AKTH/EC/1232 (appendix 7). Accordingly, the following guidelines were followed:

The objectives of this study were explained to all the participants and relevant authorities (appendix 8). All participants signed a written informed consent based on the

protocol approved by both of the ethics committees (appendices 6 and 7). Participants were made to understand that participation is voluntary and declining to participate in this study would not affect impending treatment. Furthermore, participants were informed of their rights to withdraw from the study at any point without any consequences. To accommodate all participants the consent forms and information sheets were made available in both English and Hausa languages. Identification codes using numbers were used on pro forma to ensure anonymity. All information obtained from participants was used for the study only and were handled with utmost confidentiality. All information would be kept for a maximum of five years following which it would be destroyed. Arrangements were made for further consultation with participants to take care of any perceived risk experienced during and after the study, however, participants that needed medical advice or reported any negative effect from the study were scheduled to be referred to appropriate personnel for assistance/management. The findings of the study would be made available to all the relevant stakeholders through publication and other relevant available means including conferences, workshops and seminars.

3.9 Summary of this chapter

This chapter focused on the methods employed in the conduct of this study. This study was a randomized controlled trial with blinded outcome assessment. The study had four arms; three arms (120CCT, 90CCT and 60CCT) served as the intervention groups and the fourth was the control (standard physiotherapy). Based on the main objective of this study, which is the determination of the effectiveness of augmented duration of a

structured CCT model in the rehabilitation of stroke, the primary outcome measure of this study was walking distance (as measured by 6MWT). Batteries of other assessments were conducted with specific reference to capture improvement across the three WHO-ICF domains including body/function, activity limitation and participation restriction. The training sessions lasted 8weeks with participants assessed at baseline, outcome, and six-month follow-up. The trial was registered and ethical considerations were firmly adhered to, based on the Declaration of Helsinki. Analysis performed to assess change following the 8-weeks of training involved both descriptive and inferential statistics.

4 CHAPTER FOUR: RESULTS

"Not everything that can be counted counts and not everything that counts can be counted" **Albert Einstein**.

4.1 Introduction

This study was designed to investigate the effectiveness of augmented durations of a structured circuit classtherapy model in stroke rehabilitation. The chapter presents the findings of the study, arranged in sections aimed at addressing the four objectives of the study. There are three broad sections in this chapter, comprising of section A, B and C. Section A presents socio-demographic characteristics and baseline profiles of participants in all the four arms of the study, features of the training programme (such as recruitment of participant and their flow from baseline to follow-up in the four arms of this study, adherence to therapy sessions and frequency of repetitions in CCT activities). Section B presents the study post training findings, dedicated to the three research questions in this study (see chapter one), as such it is divided into three parts B-I, B-II and B-III. B-I was centred on the effectiveness of varied durations CCT and control of the components of body structure/function, B-II was on the effectiveness of durations of CCT with respect to activity limitation and finally B-III focused on the effectivenessof varied durations of CCT on participation restriction after stroke. Section C describes the acceptability of the varying durations of CCT used in this study.

4.2 SECTION A: Features of training programme, Socio-demographic characteristics and Baseline Profiles of participants

4.2.1 Socio-demographic features of the participants

This section describes the participants' socio-demographic features; the section is divided into three subsections. The first describes participants' age, gender, ethnicity and marital status, the second summarises their level of education and employment status and finally the third presents their physical and stroke characteristics. All the results in this section were collected at baseline prior to randomization. The results are presented in descriptive statistics of mean, standard deviations, frequencies and percentages as appropriate for specific variables.

4.2.1.1 Age, gender, tribe and marital status

This section presents results of three socio-demographic features i.e. age, tribe and marital status (table 4.1). The mean age of the sampled participants was 50.5 (10.3) years, the median and mode age of the participants were both 50 years and there was no statistically significant group differences in age among participants ($F_{3, 87} = 1.166, p = 0.327$). Of the 91 stroke survivors who participated in this study, 51 (56%) of them were female, gender distribution across groups was not statistically significant ($\chi^2_{(3)} = 7.10, p = 0.069$). In ethnicity, Hausa-speaking stroke survivors accounted for the bulk of the participants in this study, with about 71% of participants coming from this ethnic group (table 4.1), followed by other minority tribes (16.5%), the remaining ethnic categories were either Yoruba or Igbo (accounting for 7% and 4% respectively). The dominance of the Hausa ethnic group is relatively similar in all the four arms of this

study indicating no significant difference in ethnic distribution among the groups *($\chi^2_{(9)}$ = 3.01, p = 0.964)*. The pattern of ethnic structure in this study mirrored the exact ethnic distributions in the study setting. Participants' marital status suggested that 82.4% were married, with over 60% being married in each group and of particular reference is group C in which 100% of the participants in the group are married. The skewness in marital status is reflected as a marginal statistical significance among the groups *($\chi^2_{(9)}$ = 17.54, p = 0.041)*.

Table 4-1: Age, Gender, Ethnicity and Marital status of participants: results are in mean (standard deviation) unless where indicated

Variables	Participants study group			Group D, Control (n=23)	Total	Prob.
	Group A, 120CCT (n=23)	Group B, 90CCT (n=24)	Group C, 60CCT(n=21)			
Age in years	47.7 (8.1)	50.7 (10.7)	53.5 (12.4)	50.5 (9.5)	50.5 (10.3)	0.327
Gender N (%)						
Female	11 (12.1)	18 (19.8)	8 (8.8)	14 (15.4)	51 (56.0)	0.069
Male	12 (13.2)	6 (6.6)	13 (14.3)	9 (9.9)	40 (44.0)	
Ethnicity N (%)						
Hausa	18 (19.8)	16 (17.6)	14 (15.4)	17 (18.7)	65 (71.4)	0.964
Yoruba	2 (2.2)	1 (1.1)	2 (2.2)	2 (2.2)	7 (7.7)	
Igbo	1 (1.1)	1 (1.1)	1 (1.1)	1 (1.1)	4 (4.4)	
Others	2 (2.2)	6 (6.6)	4 (4.4)	3 (3.3)	15 (16.5)	
Marital status N (%)						
Divorced	0 (0.0)	4 (4.4)	0 (0.0)	1 (1.1)	5 (5.5)	0.041
Married	19 (20.9)	15 (16.5)	21 (23.1)	20 (22.0)	75 (82.4)	
Single	3 (3.3)	3 (3.3)	0 (0.0)	0 (0.0)	6 (6.6)	
Widow	1 (1.1)	2 (2.2)	0 (0.0)	2 (2.2)	5 (5.5)	

N (%) = frequency (percentage), CCT = Circuit Class Therapy

4.2.1.2 Level of education and employment characteristics

This section presents participants' educational level and employment characteristics (table 4.2). Study participants were largely from low level of education, with a little above 40% having only a primary school education and about 24% having no any form of education, this was consistent across the study groups with no statistically significant group differences in level of education ($\chi^2_{(9)} = 7.18, p = 0.619$). In employment characteristics, most participants have elementary employment status (39.6%), completely unemployed (22.0%) or participated in craft, craft related or support work service (20.9%). This pattern of employment characteristics was found in all the study groups, no significant group differences were found in employment features of the participants ($\chi^2_{(12)} = 6.77, p = 0.873$).

Table 4-2: Level of education and Employment Characteristics, results are in frequencies and percentages

Variables	Circuit Class Therapy training groups			Group D, Control (n=23)	Total	Prob.
	Group A, 120CCT (n=23)	Group B, 90CCT (n=24)	Group C, 60CCT(n=21)			
Level of education N (%)						
Nil	5 (5.5)	5 (5.5)	5 (5.5)	7 (7.7)	22 (24.2)	0.619
Primary	10 (11.0)	11 (12.1)	6 (6.6)	10 (11.0)	37 (40.7)	
Secondary	2 (2.2)	4 (4.4)	7 (7.7)	3 (3.3)	16 (17.6)	
Tertiary	6 (6.6)	4 (4.4)	3 (3.3)	3 (3.3)	16 (17.6)	
Employment N (%)						
Unemployed	5 (5.5)	5 (5.5)	5 (5.5)	5 (5.5)	20 (22.0)	0.873
Elementary occupation	8 (8.8)	10 (11.0)	6 (6.6)	12 (13.2)	36 (39.6)	
Crafts/related trades	4 (4.4)	5 (5.5)	7 (7.7)	3 (3.3)	19 (20.9)	
Technician/related workers	3 (3.3)	3 (3.3)	2 (2.2)	1 (1.1)	9 (9.9)	
Managers/professionals	3 (3.3)	1 (1.1)	1 (1.1)	2 (2.2)	7 (7.7)	

N (%) = frequency (percentage), CCT = Circuit Class Therapy

4.2.1.3 Physical characteristics and Stroke features

The assessment of physical characteristics of the participants focused on the height, weight and body composition using Body Mass Index (BMI), both categorical and continuous data were used in interpreting the BMI. The categorical data presented the characteristic pattern of the body composition, while continuous data offered a central tendency with which to view the entire body mass index (table 4.3). The stroke features described included the onset of stroke, type of stroke and whether or not the stroke survivors use a walking aid for ambulation (table 4.3).

Participants' physical characteristic indicated that 51.7% were of normal body composition, 31.9% were overweight and a little over 14.0% were obese. There was no statistically significant between-group differences in body composition among participants *($\chi^2_{(9)} = 6.68, p = 0.671$)*. Further, assessment of body composition using continuous data suggested that participants were marginally overweight with an average BMI of 25.5 ± 4.5 kgm^{-2}; findings also showed no statistically significant differences among the groups *($F_{3, 87} = 0.894, p = 0.448$)*. The onset of stroke morbidity indicated that participants were largely chronic stroke survivors with a mean onset at 13.3±10.9 months, participants did not differ significantly in stroke onset *($F_{3, 87} = 0.206, p = 0.892$)* among the groups.

Stroke types were divided into an ischaemic and haemorrhagic stroke, findings suggested that the most common presentation among the participants investigated was ischaemic stroke which constituted 83.50% of all presentations, there were no

significant between-group differences in the distribution of stroke *($\chi^2_{(3)}$ = 0.82, p = 0.843)*. To describe the side of the lesion, the hemispheric division was used, to indicate whether a lesion is to the right or left cerebral hemisphere. Outcomes suggested that the most common presentation was left cerebral hemispheric lesion with 56% of participants. There was, however, no significant differences among the groups on the distribution of lesion location, ($\chi^2_{(3)}$ = 4.39, p = 0.222). The distribution of the use of walking aids among participants has also examined: findings indicated that a quarter of the participants used walking aids (24.4%) and there were no statistically significant differences in the use of walking aids among the groups ($\chi^2_{(3)}$ = 0.40, p = 0.939).

Table 4-3: Physical and stroke characteristics, result are in mean (standard deviation) unless otherwise expressed

Variables	Circuit Class Therapy training groups			Group D, Control (n=23)	Total	Prob.
	Group A, 120CCT (n=23)	Group B, 90CCT (n=24)	Group C, 60CCT(n=21)			
Body Compositions N (%)						
Normal	14 (15.4)	11 (12.1)	13 (14.3)	10 (11.0)	48 (52.7)	0671
Overweight	5 (5.5)	10 (11.0)	5 (5.5)	9 (9.9)	29 (31.9)	
Obese I	4 (4.4)	3 (3.3)	3 (3.3)	3 (3.3)	13 (14.3)	
Obese II	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.1)	1 (1.1)	
Height (m)	1.6 (0.12)	1.6 (0.1)	1.6 (0.1)	1.59 (0.13)	1.66 (0.12)	0.413
Weight (Kg)	60.9 (11.2)	65.7 (10.8)	65.8 (12.7)	66.7 (9.8)	64.8 (11.2)	0.290
Body Mass Index (Kg^{-2})	24.8 (3.8)	25.35 (4.1)	25.0 (4.0)	26.8 (5.6)	25.5 (4.5)	0.448
Stroke type N (%)						
Haemorrhagic	5 (5.5)	3 (3.3)	3 (3.3)	4 (4.4)	15 (16.5)	0.843
Ischaemic	18 (19.8)	21 (23.1)	18 (19.8)	19 (20.9)	76 (83.5)	
Hemispheric side of lesion N (%)						
Left	14 (15.4)	10 (11.0)	15 (16.5)	12 (13.2)	51 (56.0)	0.222
Right	9 (9.9)	14 (15.4)	6 (6.6)	11 (12.1)	40 (44.0)	
Onset of stroke (months)	14.8 (11.5)	12.8 (11.7)	12.9 (10.8)	12.5 (10.5)	13.3 (10.9)	0.892
Use of cane N (%)						
No	18 (19.8)	17 (18.7)	15 (16.5)	17 (18.7)	67 (73.6)	0.939
Yes	5 (5.5)	7 (7.7)	6 (6.6)	6 (6.6)	24 (26.4)	

N (%) = frequency (percentage), CCT = Circuit Class Therapy

4.2.2 Outcome measures baseline profiles

This section presented the baseline characteristics of the participants according to the selected outcome measures. All outcome measures were selected with a deliberate focus to attend to the three categories of WHO-ICF framework, with, the primary outcome measure was mobility characteristic as measured by 6MWT. In presenting these findings the mobility as a sub-context under the ICF category of activity limitation is presented after measures of body structure/function just to maintain the order of the ICF categories. This section is, therefore, sub-divided into three focusing on baseline profiles for body structure/function, activity limitation and participation restriction.

4.2.2.1 Baseline profile for body structure and function

Two tools were selected for the assessment of body structure and function of muscle strength and spasticity (in both upper and lower extremities). To assess muscle strength, Manual Muscle Testing (MMT) was used, while the Modified Tardieu Scale (MTS) was used in the assessment of spasticity.

4.2.2.1.1 Baseline profile for muscle strength (using Manual Muscle Testing, MMT)

In table 4.4 below, the between-group baseline differences in muscle strength arepresented. Findings indicated that there were no significant between-group differences among participants in all the four arms of this study ($p > 0.05$) at baseline. Descriptively the muscle strength measures at baseline across all joints ranged from 1 to 5, although minimum and maximum scores varied from one muscle group to another across study groups. The mean muscle strength in all tested muscle groups suggested

that all muscle groups showed strength $>^2/_5$. Typically, in the upper extremity in wrist extension (used as a recruitment criterion) showed no statistically significant between-group differences *($F_{3, 87} = 0.03, p = 0.994$)*. Other segmental upper extremity muscle strength assessments were all not statistically significant across groups at baseline.

In the lower extremity hip, knee and ankle assessment of muscle strength proved to be not statistically significantly different at baseline in all muscle group measures (table 4.4). While no muscle group was used as a criterion for recruitment in the lower extremity (for MMT measures), a reference with hip flexion as the only measure with a differing median and mode from all the other measures indicated an insignificant between-group difference among participants at baseline *($F_{3, 87} = 0.01, p = 0.999$)*.

Table 4-4: Baseline values of muscle strength (graded 1-5) across study groups: values are mean (standard deviation)

Variables	Circuit Class Therapy training groups			Group D, Control (n=23)	Total (n=91)	$F_{3, 87}$	Prob.
	Group A, 120CCT(n=23)	Group B, 90CCT(n=24)	Group C, 60CCT (n=21)				
Shoulder Flexors	2.43 (0.66)	2.38 (0.58)	2.48 (0.51)	2.43 (0.59)	2.42 (0.56)	0.11	0.952
Shoulder Extensors	2.43 (0.59)	2.42 (0.50)	2.48 (0.68)	2.35 (0.65)	2.40 (0.60)	0.17	0.914
Elbow Flexors	2.43 (0.59)	2.50 (0.51)	2.48 (0.51)	2.35 (0.49)	2.46 (0.53)	0.37	0.773
Elbow Extensors	2.48 (0.67)	2.50 (0.51)	2.38 (0.74)	2.57 (0.73)	2.51 (0.67)	0.29	0.834
Wrist Flexors	2.43 (0.59)	2.46 (0.59)	2.33 (0.66)	2.48 (0.51)	2.44 (0.59)	0.26	0.854
Wrist Extensors	2.30 (0.64)	2.33 (0.48)	2.33 (0.48)	2.35 (0.49)	2.33 (0.52)	0.03	0.994
Hip Flexors	2.52 (0.59)	2.54 (0.59)	2.52 (0.60)	2.52 (0.51)	2.56 (0.57)	0.01	0.999
Hip Extensors	2.35 (0.65)	2.38 (0.77)	2.38 (0.50)	2.35 (0.49)	2.37 (0.62)	0.02	0.997
Knee Flexors	2.39 (0.58)	2.46 (0.51)	2.38 (0.50)	2.48 (0.59)	2.43 (0.52)	0.18	0.913
Knee Extensors	2.35(0.49)	2.33 (0.48)	2.33 (0.48)	2.35 (0.49)	2.36 (0.48)	0.01	0.999
Ankle Dorsi flexors	2.39 (0.50)	2.50 (0.51)	2.43 (0.51)	2.43 (0.51)	2.43 (0.50)	0.19	0.904
Ankle Plantar flexors	2.43 (0 .51)	2.42 (0.50)	2.43 (0.51)	2.43 (0.59)	2.44 (0.52)	0.01	0.999

4.2.2.1.2 Baseline profile for spasticity (using Modified Tardieu Scale, MTS)

In table 4.5 findings in the upper extremity indicated a mean spastic angle for shoulder flexion of*70.02 ± 9.01*; elbow flexion, *53.31 ± 4.25*; wrist flexion, *15.24 ± 4.66*, descriptively there were certain levels of between-group differences in the mean spastic angle for elbow flexion but this did not reach statistical significance *($F_{3, 87}$ = 0.656, p = 0.581)*. In the lower extremity the mean spastic angle for hip extension was *10.04 ± 1.47; 80*,knee extension was *48 ± 5.34* and ankle plantar flexionwas *12.15 ± 3.01*. Knee extension and hip extension, also were both statistically insignificant, *($F_{3, 87}$ = 1.784, p = 0.156, $F_{3, 87}$= 2.176, p = 0.097 respectively)* (table 4.5).

Table 4-5: Baseline values for spasticity (in degrees) among participants in all study groups: values are mean (standard deviation)

Variables	Circuit Class Therapy training groups			Group D	Total	F	Prob.
	Group A, 120CCT(n=23)	Group B, 90CCT(n=24)	Group C, 60CCT (n=21)	Control (n=23)	(n=91)		
Shoulder flexion	69.26 (6.80)	69.71 (9.63)	70.81 (9.30)	71.17 (10.03)	70.02 (9.01)	0.227	0.877
Elbow flexion	52.83 (4.24)	53.00 (4.10)	50.62 (6.22)	51.78 (8.63)	53.31 (4.25)	0.656	0.581
Wrist flexion	14.83 (4.83)	15.13 (4.66)	15.71 (5.01)	16.00 (4.15)	15.24 (4.66)	0.303	0.823
Hip Extension	10.26 (1.66)	9.54 (1.47)	10.29 (1.42)	10.43 (1.24)	10.04 (1.47)	1.784	0.156
Knee Extension	78.26 (5.39)	80.13 (6.27)	81.10 (4.97)	82.17 (4.72)	80.48 (5.34)	2.176	0.097
Ankle Plantar flexion	12.04 (2.92)	11.88 (3.35)	12.48 (2.84)	12.96 (2.98)	12.15 (3.01)	0.591	0.623

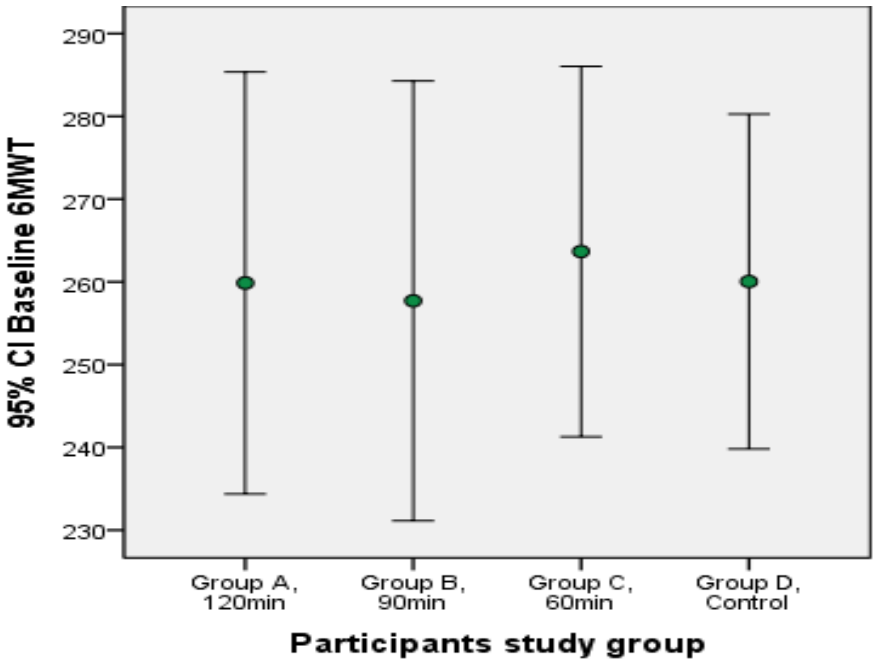
CCT = Circuit Class Therapy, n = frequency of participants in a group

4.2.2.2 Between groups baseline profile for activity limitation among participants

Sixtools were used in order to capture limitations from different perspectives of activityin both upper and lower extremities. Two tools were specific for lower extremity function (Six Minute Walk Test and Ten Meter Walk Test), two for upper extremity function (Action Research Arm Test and Motor Activity Log) and two focused on global activity function (Modified Rankin Scale and Modified Barthel Index).

4.2.2.2.1 Walking distance (assessed by 6MWT) as a primary outcome measure of activity limitation

The primary outcome measure in this study was walking distance as measured by 6MWT. Figure 4.1 shows the baseline values of walking distance among participants in the four groups. Findings indicated no significant between-group differences at baseline ($F_{3, 87} = 0.33$, $p = 857$) (table 4.6).



Between group differences in baseline 6MWT. Error bars represent CI marginal means, results indicated no significant differences, F(3, 87) = 0.38, p = 0.769

Figure 4.1: Between group baseline differences in walking distance (6MWT)

4.2.2.2.2 Secondary outcome measures of activity limitation

Five scales made up the secondary outcome measures for activity limitation in this study (Ten Meter Walk Test, 10MWT; Action Research Arm Test, ARAT; Motor Activity Log, MAL; Modified Rankin Scale, MRS, and Modified Barthel Index, MBI) the tools were used to assess gait speed, upper extremity function and dexterity, task oriented upper extremity function, global disability level and functional ability based on activities of daily living respectively. Results indicated no significant differences between group in all the five measures, gait speed *($F_{3, 87}$ = 0.44, p = 0.728)*, upper extremity function and dexterity *($F_{3, 87}$ = 0.23, p = 0.857)*, amount of use of the upper extremity *($F_{3, 87}$ = 0.13, p = 0.941)*,quality of use of the upper extremity *($F_{3, 87}$ = 0.15, p = 0.923)*, global level of disability *($F_{3, 87}$ = 1.31, p = 0.272)* and functional ability *($F_{3, 87}$ = 073, p = 0.538)*. Table

4.6 (below) presents the summary of the between groups differences at baseline for the five secondary outcome measures.

Table 4-6: Baseline values for measures of activity and mobility function: values are presented in mean (standard deviation)

Variables	Circuit Class Therapy training groups			Group D	Total	F	Prob.
	Group A, 120CCT (n=23)	Group B, 90CCT (n=24)	Group C, 60CCT (n=21)	Control (n=23)	(n=91)		
6MWT (m)	245.70 (63.64)	252.67 (55.01)	259.14 (48.83)	261.04 (46.12)	251.11 (51.24)	0.38	0.769
10MW T (m/s)	0.36 (0.12)	0.36 (0.10)	0.37 (0.10)	0.39 (0.09)	0.37 (0.10)	0.44	0.728
ARAT (0-57)	20.52 (11.62)	21.58 (12.64)	21.95 (10.98)	23.52 (11.79)	20.77 (11.92)	0.23	0.857
MAL							
AOU (0-5)	1.98 (0.77)	2.11 (0.80)	2.08 (0.99)	2.12 (0.81)	2.01 (0.85)	0.13	0.941
QOU (0-5)	2.26 (0.87)	2.42 (0.87)	2.32 (0.83)	2.35 (0.73)	2.34 (0.83)	0.15	0.923
MRS (0-6)	3.65 (0.49)	3.42 (0.50)	3.33 (0.66)	3.39 (0.66)	3.45 (0.54)	1.31	0.272
MBI (0-100)	66.87 (5.05)	66.92 (5.93)	68.67 (4.97)	68.48 (5.59)	67.70 (5.29)	0.73	0.538

6MWT = Six Minute Walk Test, 10MWT = Ten Meter Walk Test,ARAT = Action Research Arm Test, MAL = Motor Activity Log, AOU = Amount of Use, QOU = Quality of Use, MRS = Modified Rankin Scale, Modified Barthel Index = MBI, m = meter, m/s = meter per second.

4.2.2.3 Between groups baseline profile for participation restriction

In this section, each domain of the SS-QOL was assessed and the cumulative total was used to present participation restriction at baseline. The mean SS-QOL score was 160.74 ± 7.65, with a median score was 157, the distribution was multimodal and the average modal score was 153. Table 4.7 shows the baseline mean scores of each domain and the between-group comparisons, this outcome depicted no statistically significant between-group differences ($p > 0.05$) in all

the twelve domain. Similarly, there were no significant between-group differences in the mean SS-QOL at baseline *($F_{3, 87} = 1.61, p = 0.194$)*.

Table 4-7: Baseline values for each of the measures of SS-QOL domains values are presented in mean (standard deviation)

Variables	Circuit Class Therapy training groups			Control (n=23)	Total	F	Prob.
	Group A 120CCT (n=23)	Group B 90CCT (n=24)	Group C 60CCT (n=21)				
Energy (1-15)	7.96 (1.40)	8.38 (1.79)	8.24 (1.87)	8.52 (1.90)	8.15 (1.66)	0.43	0.728
Family roles (1-15)	7.91 (1.38)	8.13 (1.87)	8.43 (2.27)	8.39 (1.64)	8.23 (1.81)	0.41	0.751
Language (1-25)	20.91 (3.58)	20.67 (4.84)	20.95 (2.40)	20.91 (3.83)	20.85 (3.79)	0.03	0.994
Mobility (1-30)	16.96 (1.82)	17.79 (3.48)	18.05 (1.69)	18.22 (2.75)	17.98 (2.55)	1.08	0.361
Mood (1-25)	17.26 (2.51)	18.58 (5.40)	17.81 (3.14)	18.48 (2.84)	18.06 (3.49)	0.65	0.584
Personality (1-15)	8.26 (1.57)	9.17 (2.32)	8.86 (2.08)	9.43 (2.06)	9.21 (2.12)	1.42	0.240
Self-care (1-25)	15.09 (2.47)	16.75 (3.89)	16.67 (4.31)	15.61 (4.56)	16.45 (3.87)	1.01	0.394
Social Roles (1-25)	12.30 (2.31)	13.71 (4.67)	14.43 (5.00)	14.39 (4.59)	14.04 (4.35)	1.23	0.304
Thinking (1-15)	11.52 (2.31)	11.67 (3.00)	11.71 (2.83)	11.74 (2.49)	11.69 (2.60)	0.03	0.993
Upper Extremity function (1-25)	13.22 (3.12)	14.79 (3.50)	14.38 (4.17)	14.65 (4.38)	14.35 (3.81)	0.81	0.488
Vision (1-15)	14.22 (1.54)	14.13 (1.80)	14.14 (1.68)	14.48 (2.13)	14.15 (1.65)	0.19	0.904
Work/productivity (1-15)	6.70 (1.66)	7.63 (2.02)	6.67 (2.13)	7.43 (2.50)	7.58 (2.23)	1.27	0.287
SS-QOL overall score (49 - 45)	152.30 (12.82)	161.38 (19.31)	160.33 (17.65)	162.26 (18.79)	160.74 (7.65)	1.61	0.194

CCT = Circuit Class Therapy, n = frequency, SS-QOL = Stroke Specific Quality of Life

4.2.3 Recruitment/follow-up of participants

The recruitment of participants took place from 7th November 2013 through to 13th June 2014 with all participants recruited from AKTH, Kano State, Nigeria. The intervention period extends from 6th January 2014 to 27th August 2014, and the follow-up began from 7th March 2014 through to 19th February 2015. The total study duration was 14 months, starting from 7th November 2013 and ending 19th February 2015. All participants reported that they do not exceed or fall short of the stipulated duration of the study i.e. two months intervention period and six months follow-up (as detailed in chapter three, section 3.6.2.1).

A total of 91 stroke survivors (representing 25% of the sum total (364) of stroke survivors assessed for eligibility) attending both physiotherapy and medical outpatient clinics of AKTH who met study inclusion criteria were randomized into three CCT groups, 120CCT (n = 23), 90CCT (n = 24), 60CCT (n = 21) and a control (n = 23). All participants completed the eight weeks therapy, with percentage range of drop-out starting from a minimum of 7% in group D (control) to a maximum of 9% in groups A and B (120CCT and 90CCT), suggesting that participants in all the groups attained over 90% attendance rate (table 4.8).

Pattern from baseline to follow-up test period showed that seven participants were lost to the six-months follow-up constituting 8% dropout (four of the participants with two from group A and one each from groups B and D did not turn up for follow-up assessment without any reason, one participant from group B relocated from the Kano

state where the study took place and could not return for follow-up, one participant from group C died from diabetic complications and finally one participant from group D suffered a recurrent stroke). Group wise the loss to follow-up indicated 2(9%) in 120CCT, 2(8%) in 90CCT, 1(5%) in 60CCT and 2(9%) in the control, suggesting that each group had over 90% follow-up rate (see figure 4.1 below).

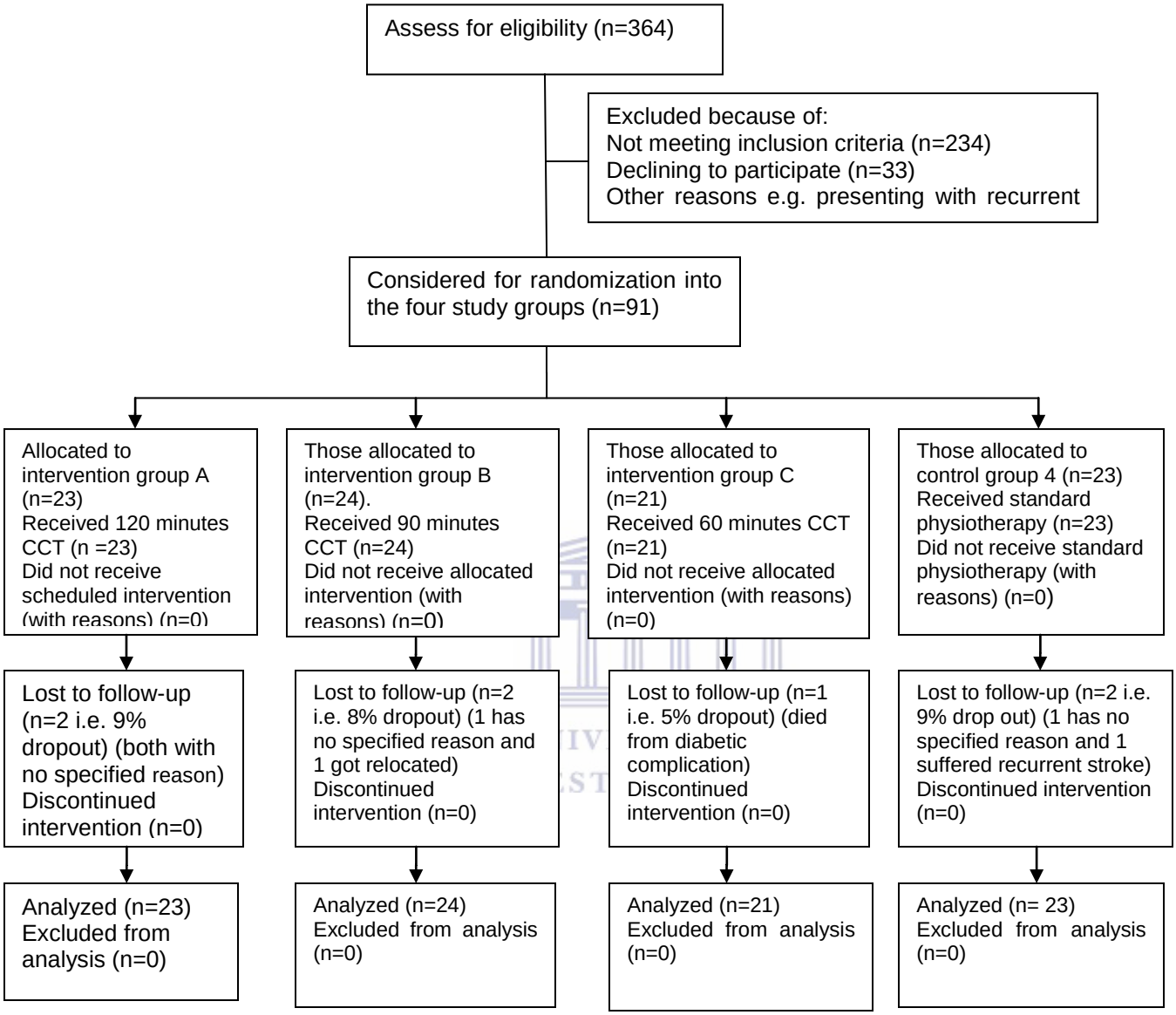


Figure 4.2: Participants' study flow diagram

4.2.4 Adherence to therapy sessions

Participants' adherence to therapy sessions is presented by the frequency of attendance; the outcome is presented in terms of average amount of sessions missed/attended by participants in each group.

Table 4-8: Frequency of attendance and mean time spent during the training programme in the intervention groups and the control

Groups	**Participants' missed training sessions**			**Mean sessions**	**Attendance**	**Meantimespent**
	1-session	2-sessions	3-sessions	**attended**	**frequency rate (%)**	**per participant (min)**
Group A, 120CCT	4	5	11	21.96 (1.11)	91%	2499
Group B,90CCT	3	6	13	21.75 (0.99)	91%	1943
Group C,60CCT	5	7	7	22.14 (1.06)	92%	1329
Control (Standard physiotherapy)	7	7	6	22.30 (1.02)	93%	1301

Table 4.8 illustrates adherence to therapy sessions in each group, participants in all groups had an approximate mean of 22 sessions with ≥ 91% attendance frequency. The table (4.8) also shows the mean time spent by each participant in each group with group A (120CCT) having 2499 minutes at the top and group D at the bottom with 1301 minutes. However, while both group C (60CCT) and D (Control) were on an equal duration of therapy of one-hour per, participants in the 60CCT seem to spend more time in their therapy session than the control. Accordingly, percentage differences in amount of therapy time, therefore, implies that participants in the 120CCT had about 92%, 88%, and 29% higher intensity of therapy time than the control, 60CCT and 90CCT respectively; those in 90CCT are 49% and 46% higher than Control and 60CCT respectively, and 60CCT is 2% higher than the Control in the amount of time spent in therapy. All groups showed over 90% attendance rate for all sessions of therapy (table 4.8) reflecting an overall high adherence to training sessions.

4.1.5 Repetitions per workstation among intervention groups (CCT groups only)

The number of repetitions performed by patients in four of the workstations (aside from the warm-up workstations) in the upper extremity is presented in table 4.9, and similar findings for lower extremity are presented in table 4.10 below.

4.2.4.1 Repetitions per workstation in upper extremity CCT

Table 4.9 shows the mean number of repetitions performed by participants in each group, based on specific activities for the upper extremity CCT tasks. In the upper extremity, activities in the category of Reaching, grasping & transferring light objects

were performed at different rates in all the three groups (120CCT = 30.39, 90CCT = 18.25 and 60CCT = 12.52), with results indicating significant between-group differences *($F_{2, 65}$ = 68.96, p = 0.001)*. The least performed tasks in the upper extremity were the advanced motor tasks which were centered on community based functions such as wiping of windows, washing, wringing and pegging clothing on a lining rope, cut a customised foams using knives of varying sizes and a host of other tasks in this category (see chapter 3 table 3.2). There was significantbetween-group differences in favour of augmented therapy in a number of repetitions in advanced motor tasks ($F_{2, 65}$ = *81.20, p = 0.001*). Post hoc analysis suggested that 120CCT achieved a significantly higher number of repetitions over 90CCT and 60CCT in all tasks, and 90CCT was significantly higher in amounts of repetitions in all tasks over 60CCT *($p < 0.017$)*.The result descriptively suggests that participants in 120CCT had differences in the mean number of repetitions consistently over 200% above 60CCT in a simple task-specific practice of CCT and well over 400% repetitions in more complex tasks such as dual tasks and advanced motors tasks. Similarly, participants in 90CCT had over 100% number of repetitions above those who were in 60CCT in simple tasks and were about 50% better than 60CCT in complex motor tasks (table 4.9).

Table 4-9: Between group differences in average number of repetitions per session of CCT in the upper extremity

Variables	Group A (120CCT)		Group B (90CCT)		Group C (60CCT)		F	Prob.
	Mean(SD)	Range	Mean(SD)	Range	Mean(SD)	Range		
Upper extremity								
Reaching, grasping & transferring light objects (upper extremity)	30.39 (7.36)	18 – 44	18.25 (3.94)	13 – 29	12.52 (3.16)	7 - 19	68.96	0.001
Strength & control e.g. resistance and rapid motor activity (upper extremity)	18.78 (2.94)	12 – 23	10.67 (3.32)	7 – 17	7.48 (2.87)	5 - 16	81.09	0.001
Dual tasking, precision and dexterity functions (upper extremity)	13.96 (2.51)	11 – 19	7.46 (2.36)	4 – 12	3.90 (2.66)	1 - 11	90.47	0.001
Advanced motor tasks e.g. wiping windows, including other outdoor tasks (upper extremity)	8.91 (1.81)	7 – 14	4.04 (1.92)	2 – 8	2.43 (1.36)	1 -5	81.20	0.001

SD = Standard deviation, Prob. = Probability level

4.2.4.2 Repetitions per workstation in lower extremity CCT

In the lower extremity (table 4.10) the outcome suggested a consistently significant higher amount of repetition in favour of augmented therapy time *($p < 0.05$)*. The number of repetitions performed was generally higher in the lower extremity less complex motor tasks. Activities related to flexibility and gait function which typically include sit to stand, shuttle walking, squatting and stepping showed the highest amount of mean repetitions in all the three groups (120CCT = 101.57, 90CCT = 75.00 and 60CCT = 54.05), with results indicating significant between-group differences in this task *($F_{2, 65} = 139.04$, $p = 0.001$)*. Advanced lower extremity motor tasks such as outdoor functions, picking objects from the floor while walking, speed walking/jogging and community ambulation (see chapter three table 3.2) depicted lower mean number of repetitions across the training groups, which also showed significant between-group differences ($F_{2, 65} = 92.50$, $p = 0.001$). A pairwise comparison indicated a significantly higher number of repetitions in all lower extremity motor tasks in the 120CCT group above 90CCT and 60CCT ($p < 0.017$) and significantly better in amounts of repetitions in the 90CCT group over the 60CCT group in all tasks *($p < 0.017$)*.In the lower extremity study finding suggests that participants in 120CCT had a better amount of repetition of ≥ 96% in simple tasks and ≥ 300% in complex lower extremity CCT. Participants in 90CC had between 25 to 75% better number of repetitions in a simple task and ≥ 100% in complex motors tasks above participants in 60CCT.

Table 4-10: Between group differences in average number of repetitions per session of CCT in the upper extremity

Variables	Group A (120CCT)		Group B (90CCT)		Group C (60CCT)		F	Prob.
	Mean(SD)	Range	Mean(SD)	Range	Mean(SD)	Range		
Lower extremity								
Flexibility & gait function e.g. sit to stand, shuttle walking, squatting, stepping (lower extremity)	101.57 (11.93)	79 -121	75.00 (6.51)	66 – 93	54.05 (9.34)	42 – 73	139.04	0.001
Balance & coordination in walking obstacle crossing stops and turns, stairs (lower extremity)	42.35 (7.07)	28 – 53	23.92 (4.05)	16 – 33	16.43 (3.01)	11 – 21	155.72	0.001
Strength & gait control tasks e.g. walking on toes, dual tasking walks, walking backwards (lower extremity)	18.83 (3.74)	11 – 26	10.08 (2.10)	6 – 15	5.76 (2.30)	2 – 10	124.41	0.001
Advanced lower extremity motor tasks e.g. outdoor functions, picking objects from the floor while walking, speed walking/jogging etc.	10.78 (2.37)	7 – 15	5.79 (1.86)	3 – 9	2.71 (1.65)	1 – 6	92.50	0.001

4.3 Section B: Study post intervention findings

This section is organised into three parts, B-I to B-III, with each part dedicated to a WHO-ICF category, according to three of the study research questions (see chapter one). In each section results for changes in specific ICF categories in the upper and lower extremities at three test periods (referred to elsewhere in this chapter as time effect or training effect), involving Test 1 (baseline), Test 2 (outcome) and Test 3 (follow-up) are first presented and immediately followed by the group interaction (also referred as group effect).

4.3.1 Effectiveness of augmented CCT on Body structure and function

The multivariate results suggested that the time effect (baseline to follow-up periods) was significant for changes in both muscle strength and spasticity *Wilks' λ, F(36.00, 286.00) = 58.69, p = 0.001,* with a very large effect size *η2 = 0.88*, indicating a very large training effect on muscle strength among participants. Multivariate tests also indicated significant time by group interaction for both variables (muscle strength and spasticity) *Wilks' λ, F(4.27, 108.00) = 4.27, p = 0.001,* with a small effect size (*η2 = 0.35)*, suggesting minor group effect for muscle strength among participants.

4.3.1.1 Univariate test statistics for separate measurements of muscle strength according to specific muscle groups

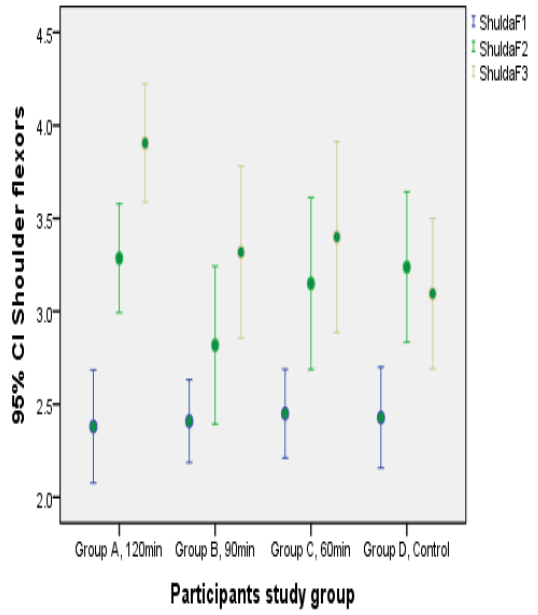
This section presents the univariate test analyses for specific muscle groups across test periods and the time by group interaction based on study groups (120CCT, 90CCT,

60CCT and the control). Both upper and lower extremities were examined for muscle strength.

4.3.1.1.1 Univariate tests for Upper extremity muscle strength (using MMT)

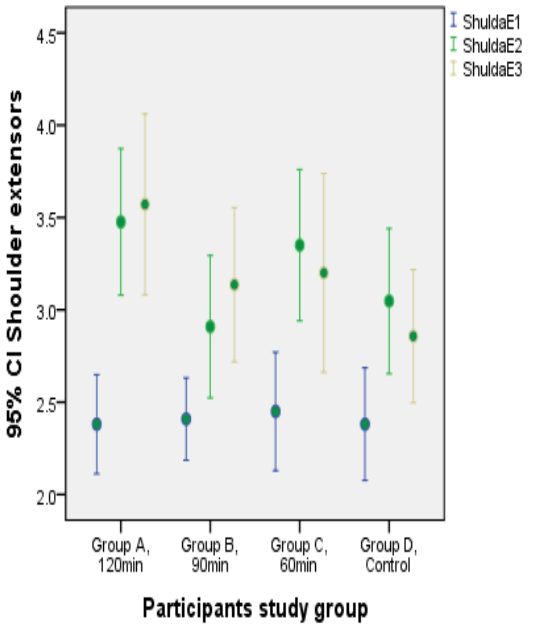
Shoulder flexors and extensors

Univariate test statistics for time effect indicated significant difference on strength of shoulder flexors across the three test periods (baseline to follow-up), $F(1.46, 116.49) = 59.64$, $p = 0.001$, with a medium effect size ($\eta^2 = 0.43$), implying an obvious training effect on the strength of shoulder flexors across the three test periods. Figure 4.9 presents error bars indicating within and between group differences in the strength of shoulder flexors among participants. Similarly, a significant time effect was found in the strength of shoulder extensors, $F(1.88, 150.60) = 69.80$, $p = 0.001$, with a medium effect size, $\eta^2 = 0.47$, which also suggests a visible training effect in shoulder extensors across test period as shown in figure 4.11.



Time by group interactions for MMT shoulder flexors. Error bars represent CI marginal means. Intercation indicated significance, F(4.37, 116.49) = 2.17, p = 0.029. Univariate main effect of time was significant, p < 0.05.

Figure 4.3: Between group differences in MMT shoulder flexors



Time by group interactions for MMT shoulder extensors. Error bars represent CI marginal means. Intercation indicated insignificance, F(5.16, 137.72) = 1.79, p = 0.117. Univariate main effect of time was significant, p < 0.05.

Figure 4.4: Between group differences in MMT shoulder extensors

In the time by group interaction univariate test, analysis indicated significant group interaction in the strength of shoulder flexors (fig. 4.9), *F(4.57, 116.49) = 2.71, p = 0.029*, with a trivial effect size *(η^2 = 0.09)*, implying that there was no obvious group interaction for shoulder flexors. In shoulder extensors, time by interaction indicated no significant group effect on muscle strength, *F(5.16, 137.72) = 1.79, p = 0.117*, this finding suggested that there were no significant group interactions for shoulder extensors. Further interpretation of these findings for both shoulder flexors and extensors following pairwise comparison (Tukey HSD) at an *a priori set probability level* using Bonferroni adjustment *(p = 0.017)* for time effect, indicated better performances for post-intervention outcome and follow-up test periods in both group of muscles (shoulder flexors and extensors) above the baseline *(p < 0.017)*, no significant

differences were found between post-intervention outcome and follow-up *(p > 0.017)*. In time by group interaction shoulder flexors suggested no significant between-group differences following post hoc test (*p > 0.017*) despite the differences depicted following univariate statistics. However, no post hoc test was performed for shoulder extensors.

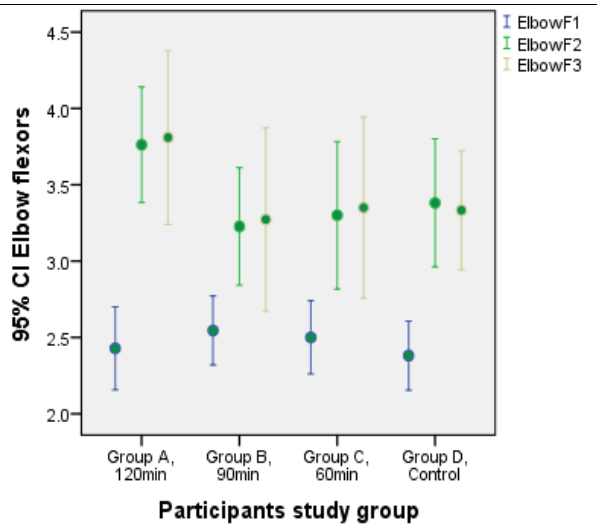
Elbow flexors and extensors

This section presented the univariate tests for elbow flexors and extensors. Study findings regarding elbow flexors indicated a significant time effect, *F(1.92, 153.85) = 51.07, p = 0.001*, with a medium effect size *(η^2 = 0.39)*, which could suggest obvious training effect across the three test periods (fig 4.11). The result also indicated significant time effects for elbow extensors, *F(1.88, 150.60) = 69.80, p = 0.001*, with a medium effect size, *(η^2 = 0.47)*, suggesting improvement in strength of elbow flexors across the three test periods (fig 4.12). Univariate analyses for time by group interaction in elbow flexors (fig 4.11) indicated no significant group interaction, *F(5.77, 153.85) = 1.14, p = 0.344,* however, significant interaction was found in elbow extensors *F(5.65, 150.56) = 2.70, p = 0.018*, with a trivial effect size *(η^2 = 0.09)*, which suggested only a slight group effect for elbow extensors (fig 4.12). Further, investigation of these findings using post hoc test indicated that both post-intervention outcome and follow-up measures were significantly better than the baseline for time effect *(p < 0.017)*, which suggested improved strength across the three test periods. There was no significant difference between post-intervention outcome and follow-up in the time effect *(p > 0.017)*. Post hoc test for the time by group interaction was only conducted for elbow

extensors, the outcome indicated no significant group interaction *(p > 0.017)*, suggesting that group effects were due to chance.

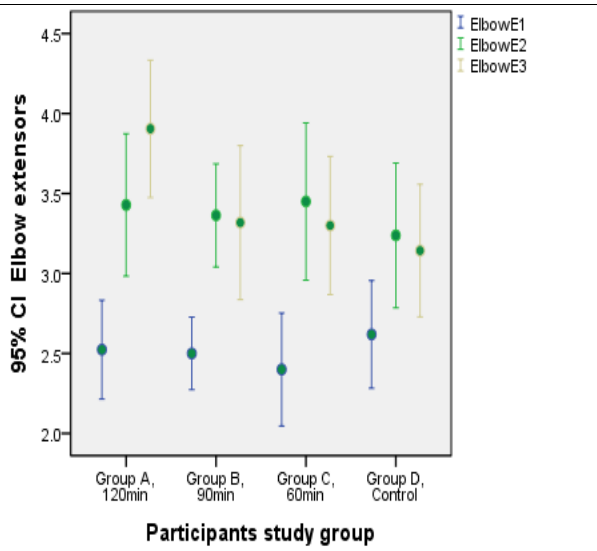
Wrist flexors and extensors

The third segment assessed for muscle strength was the wrist; measurements included both muscle flexors and extensors. Univariate analysis for time effect in wrist flexors indicated significantly improved strength across the three test periods, *F(2.00, 160.00) = 68.95, p = 0.001*, with a medium effect size *(η^2 = 0.46)*. In wrist extensors finding also showed significant time effect, *F(1.88, 150.56) = 45.09*, with a medium effect size (η^2 = 0.36), implying obvious time effect across test periods (baseline to follow-up). Univariate analysis for time by group interaction in elbow flexors indicated significant interaction, *F(6.00, 160.00) = 3.45, p = 0.003*, with a trivial effect size *(η^2 = 0.12)*, implying little or no group effect. Time by group interaction in wrist extensors also indicated a significant difference, *F(5.65, 150.56) = 3.00, p = 0.010*, with a trivial effect size (η^2 = 0.10), signifying a slight if any group effect. Post hoc tests indicated that both post-intervention outcome and follow-ups were significantly better than baseline for time effect *(p < 0.017)*, while there were no significant difference the post-intervention outcome and the follow-up *(p > 0.017)*. However, no significant interactions were found between groups following post hoc test in both wrist flexors and extensors, suggesting that group interactions were due to chance.



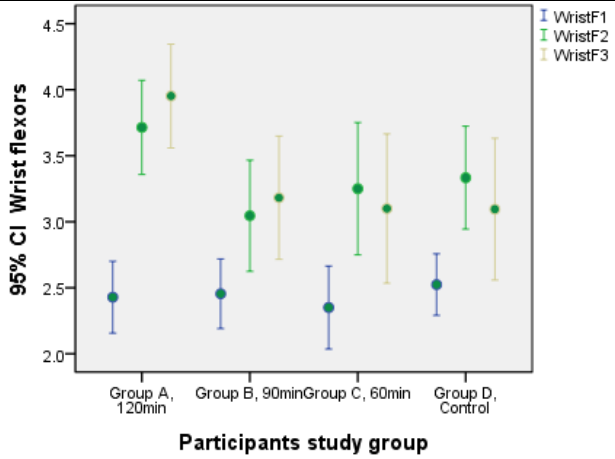
Time by group interactions for MMT Elbow flexors. Error bars represent CI marginal means. Intercation indicated insignificance, F(5.77, 153.85) = 1.14, p = 0.344. Univariate main effect of time was significant, p < 0.05.

Figure 4.5: Between differences in MMT Elbow flexors



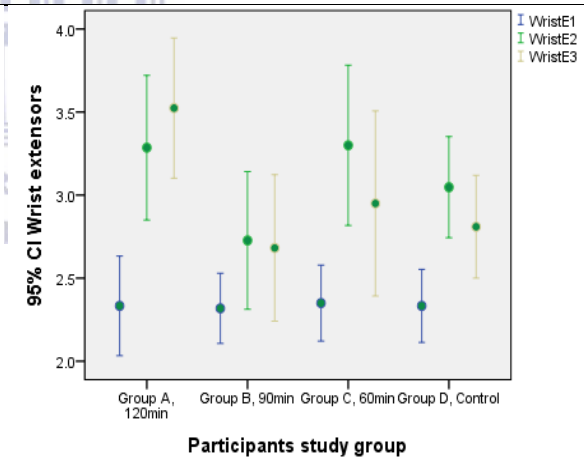
Time by group interactions for MMT Elbow extensors. Error bars represent CI marginal means. Intercation indicated significance, F(5.65, 150.60) = 2.70, p = 0.018. Univariate main effect of time was significant, p < 0.05.

Figure 4.6: Between differences in MMT Elbow extensors



Time by group interactions for MMT Wrist flexors. Error bars represent CI marginal means. Intercation indicated significance, F(6.00, 160.00) = 3.45, p = 0.003. Univariate main effect of time was significant, p < 0.05.

Figure 4.7: Between differences in MMT Wrist flexors



Time by group interactions for MMT Wrist extensors. Error bars represent CI marginal means. Intercation indicated significance, F(5.65, 150.56) = 3.00, p = 0.010. Univariate main effect of time was significant, p < 0.05.

Figure 4.8: Between differences in MMT Wrist extensors

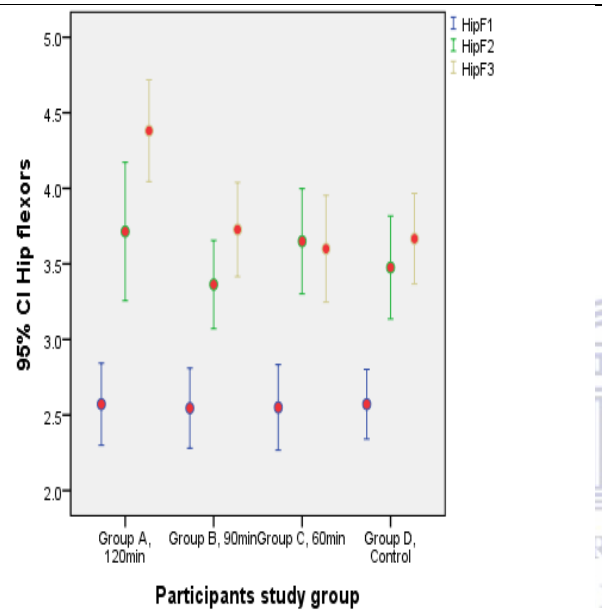
4.3.1.1.2 Univariate test for Lower extremity muscle strength (using MMT)

In this section results of the three lower extremity body parts for muscle strength using univariate tests are presented. Manual Muscle Testing was conducted on the hip, knee and ankle across three test periods (baseline to follow-up).

Hip flexors and extensors

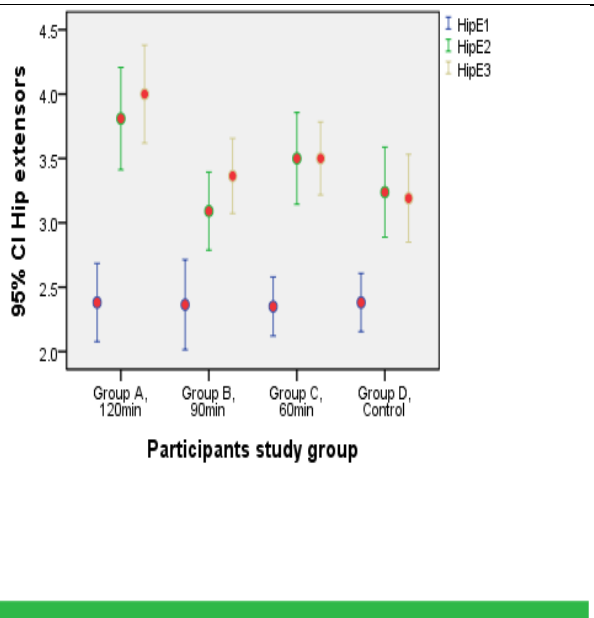
Univariate test results for the time effect on hip flexors indicated a significance, *F(2.00, 169.00) = 133.48, p = 0.001*, with a large effect size, $\eta^2 = 63$. Result also showed significantly improved muscle strength in hip extensors across the three test periods, *F(1.90, 152.01) = 126.15, p = 0.001*, at a large effect size $(\eta^2 = 0.61)$. These outcomes suggest considerably improved muscle strength across the three test periods. Findings regarding time by group interaction in both hip flexors and extensors were found to be significant, *F(6.00, 160.00) = 2.93, p = 0.010 and F(5.70, 152.01) = 3.19, p = 0.007* respectively. However, both measures indicated trivial effect sizes $(\eta^2 = 0.10$ *and* $\eta^2 = 0.11$ *respectively)*. Both of these findings with regards to time by group interaction for hip flexors and extensors point toward a slight group effect on muscle strengths in hip flexors and extensors. Supplementary post hoc statistics for the time effect suggested significantly improved muscle strength across the three test periods (for both hip flexors and extensors), with both post-intervention outcome and follow-up measures being significantly better than the baseline *(p <0.017)*, no significant difference was found between post-intervention outcome and follow-up, implying that the time effect was retained at follow-up. In time by group interaction, no significant between-group differences were found in both hip flexors and extensors *(p < 0.017)*, suggesting that the

group effects found were attributable to chance, which further confirmed the triviality depicted by the small effects sizes earlier presented for both groups of muscle. Figures 4.15 and 4.16 present both the time effect and the time by group interaction of both hip flexor and extensor group of muscles.



Univariate test for time by group interactions, MMT Hip flexors. Results illustrated error bars CI marginal means. Intercation was significance, F(6.00, 160.00) = 2.93, p = 0.010. Simple main effect of time was significant, p < 0.05.

Figure 4.9: Between differences in MMT Hip flexors



Univariate test for time by group interactions, MMT Hip extensors. Results illustrated error bars CI marginal means. Interaction was significance, F(5.70, 152.01) = 3.19, p = 0.007. Simple main effect of time was significant, p < 0.05.

Figure 4.10: Between differences in MMT Hip extensors

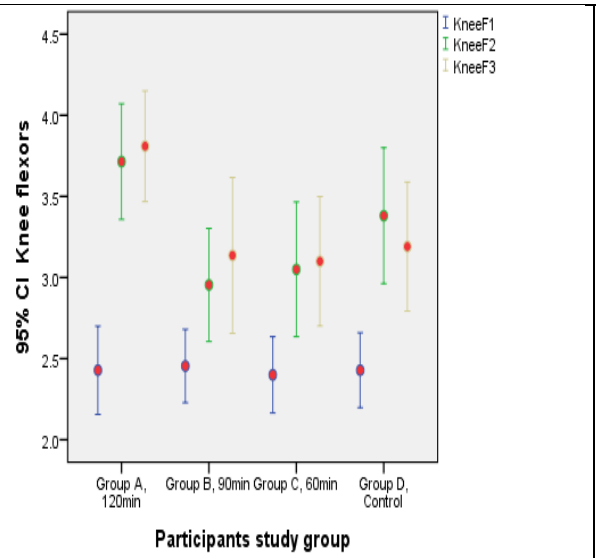
Knee flexors and extensors

Knee flexors and extensors were assessed for muscle strength across the three test periods using MMT. Univariate test statistics indicated a significant time effect for knee flexors, *F(2.00, 160.00) = 87, p = 0.001*, with a large effect size, $\eta^2 = 0.52$, suggesting clear evidence of improved muscle strength across the three test periods. Findings for time effect in knee extensors also depicted significance, *F(1.95, 155.91) = 145.99, p = 0.001*, with a large effect size, $\eta^2 = 0.65$, implying substantial time effect on muscle strength in knee extensors. Results for time by group interaction also depicted significant group interaction in both knee flexors and extensors *(F(6.00, 160.00) = 3.83, p = 0.001 and F(5.85, 155.91) = 3.02, p = 0.009 respectively)*. However, both measures showed only trivial effect sizes *($\eta^2 = 0.13$ and $\eta^2 = 0.10$ respectively)* (figures 17 and 18) in time by group interaction. These results suggest that group effect on knee flexors and extensors is essentially minimal. Further evaluation of findings through pairwise comparison indicated that post-intervention outcome and follow-up assessments were significantly better than the baseline *($p < 0.017$)* in both knee flexors and extensors particularly in the time effect. In contrast between groups' differences in knee flexors and extensors do not reach significance following pairwise comparison *($p > 0.017$)*, suggesting that there was no group effects in muscle strength for knee flexors and extensors.

Ankle dorsiflexors and plantar flexors

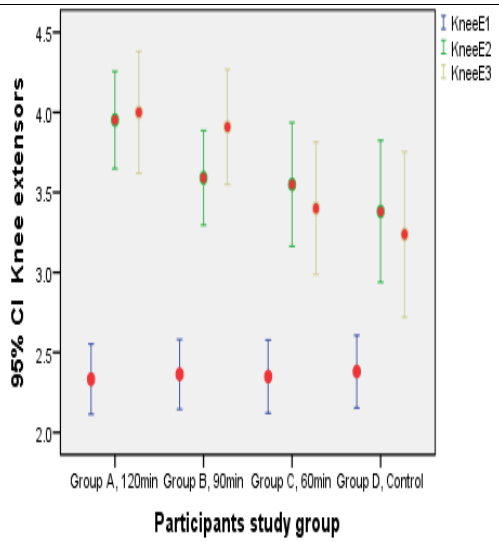
This section presents the univariate analyses for muscle strength in ankle dorsiflexors and plantar flexors for both the time effect and time by group interaction. Findings

suggested significant time effect (figure 19) in ankle dorsiflexors, *F(1.99, 159.36) = 56.21, p = 0.001*, at a medium effect size of $\eta^2 = 0.41$, this finding suggested obvious change across the test periods. In ankle plantar flexors (fig. 20) the univariate test indicated a significant time effect, *F(2.00, 160.00) = 79.07*, with a medium effect size, $\eta^2 = 0.50$, which suggested substantial improvement in muscle strength across the three test periods. In time by group interaction significant interaction was found in ankle dorsiflexors, *F(5.98, 159.36) = 4.22, p = 0.001*, with a trivial effect size, $\eta^2 = 0.19$, indicating minor group effect. Univariate test in time by group interaction for ankle plantar flexors failed to reach significance, *F(5.99, 159.68) = 1.92, p = 0.072*, with a considerably trivial effect size, $\eta^2 = 0.07$, suggesting no any possible group effects. Pairwise comparison of the time effect for both ankle dorsiflexors and plantar flexors indicated a significant improvement in post-intervention outcome and follow-up measures over baseline *(p < 0.017)*, with an insignificant difference between post-intervention outcome and follow-up *(p > 0.017)*. To determine between group differences, pairwise comparison for the time by group interaction in ankle dorsiflexors' did not reach significance *(p < 0.017)*. A pairwise comparison was not conducted for ankle plantar flexors, as the univariate test was insignificant *(p > 0.5)*.



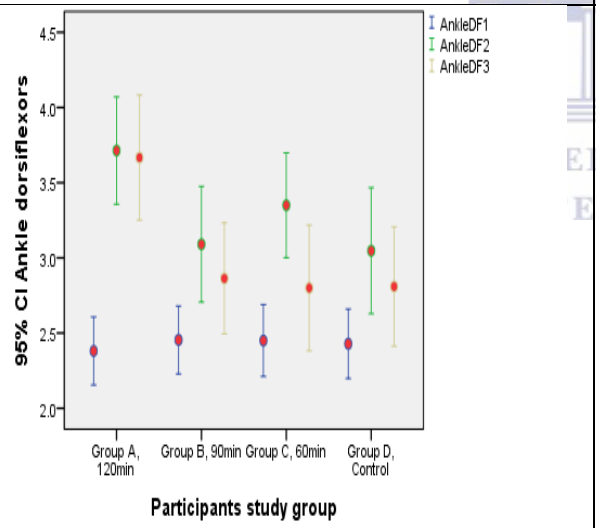
Univariate test for time by group interactions, MMT Knee flexors. Results illustrated error bars CI marginal means. Interaction was significance, F(6.00, 160.00) = 3.83, p = 0.001. Simple main effect of time was significant, p < 0.05.

Figure 4.11: Between differences in MMT Knee flexors



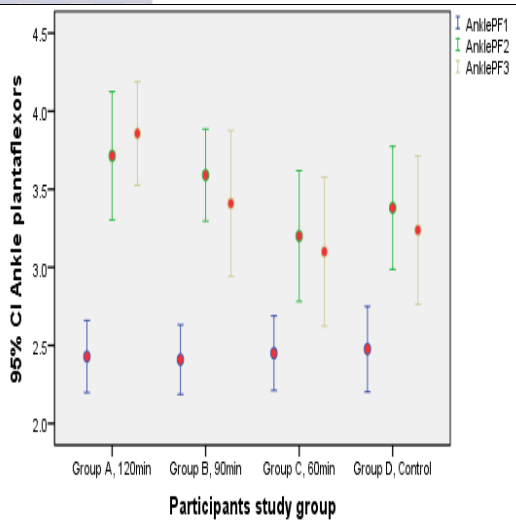
Univariate test for time by group interactions, MMT Knee extensors. Results illustrated error bars CI marginal means. Interaction was significance, F(5.85, 155.91) = 3.02, p = 0.009. Simple main effect of time was significant, p < 0.05.

Figure 4.12: Figure 4.13: Between differences in MMT Knee extensors



Univariate test for time by group interactions, MMT Ankle dorsiflexors. Results illustrated error bars CI marginal means. Interaction was significant, F(5.98, 159.36) = 4.22, p = 0.001. Simple main effect of time was significant, p < 0.05.

Figure 4.14: Between differences in MMT Ankle Dorsiflexors



Univariate test for time by group interactions, MMT Ankle Plantaflexors. Results illustrated error bars CI marginal means. Interaction was insignificant, F(5.99, 159.98) = 1.98, p = 0.072. Simple main effect of time was significant, p < 0.05.

Figure 4.15: Between differences in MMT Ankle plantarflexors

4.3.1.2 Univariate test statistics for separate measures of spasticity according to specific joint positions

This section presents the result of changes in muscle spasticity in the upper and lower extremity joint positions at three test periods and the time by group interaction. Results for the upper and lower extremity are presented in the following sections:

4.3.1.2.1 Upper extremity spasticity

In this section, the results for three measures conducted for upper extremity flexor spasticity (shoulder flexion, elbow flexion and wrist flexion) are presented. The angle of catch in degrees was reported for each of the measures in table 4.11. Results indicated a significant time effect for shoulder spasticity, $F(1.45, 115.65) = 432.52, p = 0.001$, with a very large effect size, $\eta^2 = 0.84$, implying substantially improved spastic angle across the three test periods. For time by group interaction result indicated significant group effect in shoulder spastic angle, $F(4.34, 115.65) = 34.69, p = 0.001$, with a large effect size, $\eta^2 = 0.57$ suggesting marked group interaction in shoulder spastic angle.

Table 4.11 also shows results for time effect in elbow spastic angle which indicated no significant time effect, $F(1.10, 88.21) = 2.16, p = 0.143$, with a poor effect size, $\eta^2 = 0.03$, this finding suggests that there is an obvious improvement in elbow spastic angle across the three test periods. However, univariate test indicated significant time by group interaction in elbow spastic angle, $F(5.91, 157.71) = 4.12, p = 0.007$, with a trivial effect size, $\eta^2 = 0.13$. This finding suggests a minor group effect despite the absence of obvious time effect in elbow spastic angle.

In the wrist (table 4.11) analysis indicated significance for a time effect, *F(1.97, 157.71) = 642.83, p = 0.001,* with a very large effect size,η^2 *= 0.89,* implying a very large improved wrist spastic angle across study test periods. Univariate test for time by group interaction depicted significant interaction, *F(5.91,157.71) = 41.93, p = 0.001,* with a large effect size,η^2 *= 0.61,* this finding suggest a substantial group effect in wrist spastic angle following 8-week training sessions.

Post hoc analyses to determine where differences are found was conducted for shoulder and wrist spastic angles with regards to time effect, noting that univariate tests indicated no significant difference for time effect on elbow spastic angle. Results for time effect indicated better shoulder spastic angle among participants in both post-intervention outcome and follow-up test periods above the baseline and there was no significant difference between the two (post-intervention outcome and follow-up), suggesting that the progress recorded at post-intervention was retained at follow-up. In the wrist, results also indicated improved post-intervention outcome and follow-up over baseline, however, the post-intervention outcome was found to be significantly better than the follow-up in wrist spastic angle, suggesting that there was a decline in wrist spastic angle at follow-up. Post hoc tests for the time by group interaction were conducted for the three spastic angles (shoulder, elbow and wrist). Findings indicated no significant between-group differences in shoulder and wrist spastic angles, however, 120CCT was found to be significantly better than 60CCT and the control in elbow spastic angle following pairwise comparison.

Table 4-11: Univariate test for time effect and time by group interaction in upper extremity spasticity, results are in means (standard deviations)

Variables	Group A 120CCT (n=23)	Group B 90CCT (n=24)	Group C 60CCT (n=21)	Control (n=23)	Total (n=91)	F_T	$Prob_T$	η^2_T	F_{TG}	$Prob_{TG}$	η^2_{TG}
Shoulder flexion (degrees)											
Baseline	69.14 (6.60)	68.68 (9.38)	70.95 (9.52)	71.43 (10.43)	70.02 (9.01)	432.52	0.001	0.84	34.69	0.001	0.57
Outcome	86.95 (9.73)	81.73 (10.50)	78.60 (9.03)	76.24 (9.84)	80.92 (10.44)						
Follow-up	86.57 (11.39)	81.73 (10.61)	77.55 (9.96)	75.29 (10.02)	80.33 (11.20)						
Elbow flexion (degrees)											
Baseline	53.14 (4.25)	52.95 (4.26)	50.60 (4.42)	53.29 (4.31)	53.31 (4.25)	2.16	0.143	0.03	4.12	0.007	0.13
Outcome	56.29 (6.27)	53.18 (4.93)	53.90 (6.38)	49.86 (4.98)	52.51 (6.11)						
Follow-up	56.19 (5.84)	52.64 (5.25)	49.80 (6.21)	49.19 (5.36)	51.99 (6.22)						
Wrist flexion (degrees)											
Baseline	14.81 (4.98)	14.64 (4.55)	15.70 (5.14)	15.86 (4.17)	15.24 (4.66)	642.83	0.001	0.89	41.93	0.001	0.61
Outcome	26.24 (6.33)	23.18 (4.93)	20.60 (6.38)	19.86 (4.98)	22.50 (6.12)						
Follow-up	26.10 (5.92)	22.64 (5.25)	19.80 (6.21)	19.19 (5.36)	21.96 (6.22)						

CCT = Circuit Class Therapy, F_T = F value for time effect, $Prob_T$ = Observed probability for time effect, η_T^2 = Effect size for time effect, F_{TG} = F value for time by group interaction, $Prob_{TG}$ = Observed probability for time by group interaction, η_{TG}^2 = Effect size for time by group interaction.

4.3.1.2.2 Lower extremity spasticity

In the lower extremity, the extensor pattern was assessed for spasticity in the hip, knee and ankle (table 4.12). Univariate test statistics for the time effect on the hip spastic angle (in degrees) indicated significant improvement, *F(1.51, 121.10) = 613.31, p = 0.001,* with a very large effect size*, $\eta^2 = 0.89$*, suggesting a better angle of catch across the three test periods and an obvious training effect. For time by group interaction, a significant interaction was found in hip spastic angle, *F(4.54, 121.10) = 11.78, p = 0.001,* with a small effect size*, $\eta^2 = 0.31$*,implying a perceptible between group effect in hip spastic angle.

The analysis on knee spastic angle (in degrees) depicted a significant time effect, *F(1.55, 123.59) = 860.88, p = 0.001,* with a very large effect size*, $\eta^2 = 0.92$,* signifying a very large improvement in knee extensor spasticity across the three assessment periods and impact of training. Time by group interaction in knee spastic angle was also significant, *F(4.64, 123.59) = 25.72, p = 0.001,* with a medium effect size*, $\eta^2 = 0.49$*, indicating evidence of between-group differences in knee spastic angle.

Findings for time effect on ankle plantar flexion angle of catch depicted significant time effect, *F(1.78, 142.04) = 781. 36, p = 0.001,* with a very large effect size*, $\eta^2 = 0.91$,* which denotes improvement across the three test periods. Study outcome for time by group interaction indicated significant group interaction, *F(5.33, 142.04) = 23.62, p = 0.001*, with a medium effect size*, $\eta^2 = 0.47$,* suggesting anobvious group effect in ankle plantar flexion.

Pairwise comparison of both time effect and time by group interaction in lower extremity spasticity indicated that both post-intervention outcome and follow-up performances were better than the baseline in all the three angles assessed (hip, knee and ankle). However, the post-intervention outcome for the angle of catch of ankle plantar flexion was better than the follow-up. The time by group interaction indicated that 120CCT was better than the control in the hip spastic angle and was better than 60CCT and control in the knee spastic angle. No significant group effect was found for ankle plantar flexion.

Table 4-12: Univariate test for time effect and time by group interaction in lower extremity spasticity, results are in means (standard deviations)

Variables	120CCT (n=23)	90CCT (n=24)	60CCT (n=21)	Control (n=23)	Total (n=91)	F_T	$Prob_T$	η^2_T	F_{TG}	$Prob_{TG}$	η^2_{TG}
Hip extension (degrees)											
Baseline	10.10 (1.64)	9.55 (1.53)	10.20 (1.40)	10.33 (1.24)	10.04 (1.47)	613.31	0.001	0.89	11.78	0.001	0.31
Outcome	22.05 (3.58)	20.14 (3.68)	18.90 (2.73)	16.76 (3.56)	19.48 (3.88)						
Follow-up	22.14 (3.68)	19.55 (4.94)	18.75 (4.04)	16.00 (4.76)	19.12 (4.85)						
Knee extension (degrees)											
Baseline	78.76 (5.37)	80.00 (5.86)	80.85 (4.97)	82.33 (4.79)	80.48 (5.34)	860.88	0.001	0.92	25.72	0.001	0.49
Outcome	105.62 (6.26)	100.05 (4.85)	97.15 (6.25)	94.38 (6.20)	99.33 (7.15)						
Follow-up	107.62 (7.00)	100.91 (5.71)	97.40 (6.89)	94.86 (8.63)	100.24 (8.49)						
Ankle plantar flexion (degrees)											
Baseline	11.71 (2.83)	11.82 (3.42)	12.35 (2.85)	12.76 (2.98)	12.15 (3.01)	781.36	0.001	0.91	23.62	0.001	0.47
Outcome	21.05 (3.58)	19.14 (3.68)	17.90 (2.73)	17.38 (3.37)	18.88 (3.60)						
Follow-up	20.95 (4.49)	18.64 (3.39)	17.30 (2.81)	16.52 (3.40)	18.37 (3.90)						

CCT = Circuit Class Therapy, F_T = F value for main time effect, $Prob_T$ = Observed probability for main time effect, η^2_T = Effect size for main time effect, F_{TG} = F value for time by group interaction, $Prob_{TG}$ = Observed probability for time by group interaction, η^2_{TG} = Effect size for time by group interaction.

4.3.1.2.3 Result of within-group differences for body structure/function

In within group differences from baseline through to follow-up 120CCT and 90CCT groups indicated better performances in the post-intervention outcome and follow-up measures over the baseline, with both groups suggesting improved performances in body structure/function following CCT. Additionally, 120CCT and 90CCT showed improved performances in certain measures during follow-up despite cessation of therapy. In 60CCT post-intervention outcome and follow-up measures were also significantly better than the baseline in all measures aside from elbow flexor spasticity; however, there appears to be a certain level of decline particularly in spasticity measures (MTS) during the follow-up phase. In the control, group differences were similar to the CCT groups with post-intervention outcome and follow-up being significantly better than the baseline, but most gains seemed to be better in the lower extremities and decline was observable during follow-up and similarly in the upper extremity. Results for the within group differences in body structure/function are presented in appendix 17

4.3.1.2.4 Summary of findings on effectiveness of augmented structured CCT model and the control on body structure/function

The outcome of this study on body structure/function indicated statistically significant ($p < 0.05$) time effects and time by group interactions among participants, with relatively large to very large effect sizes for time effects and small to medium effect sizes for the time by group interactions. In measures of muscle strength (for both upper and lower) a statistically significant group effect was found only in ankle dorsiflexors, in which

participants in 120CCT improved significantly above participants in the control group. In spasticity measures (for both upper and lower), three measures depicted significant between groups differences, elbow flexion, hip extension and knee extension. In elbow flexion, participants in 120CCT demonstrated statistically significantly improved spasticity above 60CCT and the control groups (owing to the increased angle of catch), in hip extension 120CCT was significantly better than the control and in the knee extension, the 120CCT demonstrated significantly better performances above 60CCT and the control.

4.3.2 Section BII: Effectiveness of augmented CCT interventions and the control on Activity limitation post stroke

This section presents findings on the effectiveness of augmented CCT groups and the control in the management of activity limitation post stroke.

Results for multivariate test statistics indicated significant time effects on measures of activity limitation, *Wilks' λF(14, 308)= 99.94, p =0.001, η2 = 0.98,* the result presented a very large effect size, suggesting a substantial change in activity limitation across the three test periods and a very large training effect. Findings for time by group interaction indicated a significant group effect, *Wilk's λF(42, 725.78) = 9.25, p =0.001, η2 = 0.29.* The multivariate result for the time by group interaction indicated a small effect size. To detect specific test effects, results for univariate tests are presented in three sub-sections according to the divisions of activity limitations presented earlier in this section.

4.3.2.1 Univariate test statistics for time effect and time by group interaction in separate measures of activity limitation

This section presents results of the univariate analyses for activity limitations. The results are categorised into three subsections representing upper extremity, lower extremity and global activity functions of stroke survivors.

4.3.2.1.1 Upper extremity functions and activity limitations

Two scales were used to assess activity limitations in the upper extremity, ARAT which objectively assesses the upper extremity function and dexterity, and the MAL which subjectively assesses real-world upper extremity motor function.

In the upper extremity function and dexterity, univariate test statistics for time effect (table 4.13) indicated significant improvement across the three test periods, $F(1.22, 97.32) = 102.98$, $p = 0.001$, $\eta^2 = 0.56$. The result presented a large effect size for time effect, suggesting obvious improvement in upper extremity function across the three test periods. For time by group interaction (table 4.13) study findings also showed significant group effect on upper extremity function, $F(3.65, 97.32) = 16.40$, $p = 0.001$, $\eta^2 = 0.38$, the group effect presented a medium effect size, suggesting a visible group interaction in upper extremity function and dexterity.

Post hoc test for time effect indicated better upper extremity function and dexterity in the post-intervention outcome and follow-up test periods over baseline ($p < 0.017$). Post hoc test for the time by group interaction in upper extremity function using ARAT indicated no significant between-groupdifferences, suggesting that augmented CCT and the

control do not differ in upper extremity function and dexterity objectively ($p > 0.017$). The medium effect size, however, contradicts the post hoc findings, which may be due to type II error (failing to detect a trueexisting effect).

In the assessment of real world upper extremity motor function, the two subscales of the MAL (AOU and QOU) were reported. Findings for time effect in AOU indicated a significant improvement in the amount of use of the upper extremity, $F(1.82, 146.92) = 224.74$, $p = 0.001$, $\eta^2 = 0.74$, with a very large effect size, implying a considerable improvement across the three test periods. Univariate test for time by group interaction in AOU indicated significant group effect, $F(5.51, 146.92) = 42.82$, $p = 0.001$, with a large effect size $\eta^2 = 0.62$, suggesting an obvious group effect in AOU. Post hoc test indicated that 120CCT was significantly different over 60CCT and the control, as 90CCT was found to be significant over the control in this measure. No significant differences were found between 120CCT versus 90CCT or 90CCT versus 60CCT.

Findings on QOU indicated significant time effect following training, $F(1.79, 142.82) = 167.48$, $p = 0.001$, with a large effect size, $\eta^2 = 0.68$, this result suggested a major perceived improvement in the quality of use of the upper extremity across the three test periods. Univariate test for time by group interaction in QOU indicated significant group interaction, $F(5.36, 142.82) = 31.86$, $p = 0.001$, with a large effect size, $\eta^2 = 0.54$, which suggests a palpable group effect. Post hoc test for time effect in QOU indicated better perceived QOU in the post-intervention outcome and follow-up test periods over the baseline ($p < 0.017$), no significant differences were found between post-intervention

outcome and follow-up test periods ($p > 0.017$). For time by group interaction, post hoc test indicated 120CCT was significantly better than 60CCT and the control in AOU and significantly better than control in QOU ($p < 0.017$). No significant differences were found in other pairwise comparisons for QOU time by group interaction ($p > 0.017$).

Table 4-13: Univariate test for time effect and time by group interaction in upper extremity function and real life upper extremity motor function, results are means (standard deviation)

Variables	120CCT (n=23)	90CCT (n=24)	60CCT (n=21)	Control (n=23)	Total (n=91)	F_T	$Prob_T$	η^2_T	F_{TG}	$Prob_{TG}$	η^2_{TG}
Action Research Arm Test (ARAT)											
Baseline	20.52 (9.48)	21.18 (11.47)	22.15 (12.48)	23.29 (13.22)	21.77 (11.57)	102.98	0.001	0.56	16.40	0.001	0.38
Outcome	40.52(17.14)	31.14 (18.13)	30.40 (18.99)	26.67 (14.18)	32.19 (17.65)						
Follow-up	43.24(19.29)	32.18 (18.69)	30.75 (19.41)	23.52 (13.07)	32.44 (18.86)						
Motor Activity Log (Amount of Use)											
Baseline	2.02 (0.80)	2.10 (0.75)	2.08 (1.02)	2.09 (0.80)	2.07 (0.83)	224.74	0.001	0.74	42.82	0.001	0.62
Outcome	3.52 (0.60)	3.05 (0.59)	2.84 (0.98)	2.24 (0.91)	2.92 (0.90)						
Follow-up	4.16 (0.77)	3.79 (0.81)	2.57 (1.00)	2.18 (0.84)	3.19 (1.18)						
Motor Activity Log (Quality of Use)											
Baseline	2.20 (0.81)	2.38 (0.89)	2.31 (0.83)	2.32 (0.74)	2.30 (0.81)	167.48	0.001	0.68	31.86	0.001	0.54
Outcome	3.55 (0.90)	3.22 (0.74)	3.02 (1.02)	2.68 (0.73)	3.12 (0.89)						
Follow-up	4.37 (0.55)	3.43 (0.76)	2.77 (1.03)	2.45 (0.94	3.26 (1.10)						

CCT = Circuit Class Therapy, F_T = F value for main time effect, $Prob_T$ = Observed probability for main time effect, η^2_T = Effect size for main time effect, F_{TG} = F value for time by group interaction, $Prob_{TG}$ = Observed probability for time by group interaction, η^2_{TG} = Effect size for time by group interaction. Interaction were

4.3.2.1.2 Lower extremity functions and activity limitations

Activity limitation at the level of the lower extremity was assessed using two scales the Six-Minute Walk Test (6MWT) for walking distance (m) and Ten Meter Walk Test (10MWT) for gait speed (ms^{-1}) during ambulation.

Univariate test statistics (table 4.14) to determine time effect on participants' walking distance across the three test periods indicated a significant time effect, *F(1.52, 121.26) = 151.75, p = 0.001,* with a large effect size, *η2 = 0.66*, which suggests a considerable improvement in walking distance across the three test periods. Findings for the time by group interaction (table 4.14) also revealed significant group effect for walking distance, *F(4.55, 121.26) = 23.83, p = 0.001,* with a medium effect size, *η2 = 0.47*, suggesting obvious between group interaction in walking distance among study groups.

Pairwise comparison for time effect indicated significantly better performances in the post-intervention outcome and follow-up test periods over baseline *(p < 0.017)*in walking distance. In time by group interaction pairwise comparison for walking distance depicted a significantly better performance in 120CCT above control *(p < 0.017)*, no distinctions were found in other pairwise comparisons for walking distance *(p > 0.017)*.

Univariate test statistics for time effect on gait speed among participants (table 4.14) suggested a significant time effect in participants' performances, *F(1.77, 141.47) = 421.76, p = 0.001,* with a very large effect size, $\eta^2 = 0.84$, implying a massive change in gait across the three test periods. Findings for the time by group interaction in gait

speed (table 4.17) also indicated significant group effect, *F(5.17, 141.47) = 49.24, p =0.001,* with a large effect size*, η^2 = 0.65,* suggesting a considerable group effecton gait speed.

Pairwise comparison for time effect in gait speed depicted significantly better post-intervention outcome and follow-up test periods above baseline *(p < 0.017)*. In time by group interaction significantly improved gait speed was found in 120CCT over 60CCT and the control, and 90CCT was better than the control *(p < 0.017).*

Table 4-14: Univariate test for time effect and time by group interaction in walking distance and gait speed, results are means (standard deviation)

Variables	120CCT (n=23)	90CCT (n=24)	60CCT (n=21)	Control (n=23)	Total (n=91)	F_T	$Prob_T$	η^2_T	F_{TG}	$Prob_{TG}$	η^2_{TG}
Walking distance (meter)											
Baseline	250.67 (53.44)	253.77 (59.68)	259.20 (46.85)	259.57 (43.11)	255.74 (50.53)	151.75	0.001	0.66	23.83	0.001	0.47
Outcome	343.33 (64.50)	313.05 (70.08)	293.30 (44.45)	280.43 (47.72)	307.76 (61.75)						
Follow-up	374.00 (58.59)	327.55 (77.46)	287.75 (44.03)	269.86 (41.88)	315.26 (69.49)						
Gait speed (m/s)											
Baseline	0.36 (0.11)	0.37 (0.09)	0.37 (0.11)	0.38 (0.10)	0.37 (0.10)	421.76	0.001	0.84	49.24	0.001	0.65
Outcome	0.65 (0.11)	0.59 (0.12)	0.50 (0.12)	0.44 (0.11)	0.55 (0.14)						
Follow-up	0.70 (0.10)	0.63 (0.09)	0.49 (0.12)	0.42 (0.11)	0.56 (0.15)						

CCT = Circuit Class Therapy, F_T = F value for main time effect, $Prob_T$ = Observed probability for main time effect, η_T^2 = Effect size for main time effect, F_{TG} = F value for time by group interaction, $Prob_{TG}$ = Observed probability for time by group interaction, η_{TG}^2 = Effect size for time by group interaction. Interaction were computed using 0.05 alpha

4.3.2.1.3 Global activity function and activity limitations

Participants' global activity function was assessed using two tools, Modified Rankin Scale (which assesses global functional disability (GFD)) and the Barthel Index (which assesses functional ability or Activities of Daily living).

Using univariate test statistics for time effect on GFD (table 4.15), findings indicated a significant effect, *F(1.95, 156.32) = 362.56, p =0.001,* with a very large effect size, *η2 = 0.82,* which implies marked change in GFD across the three test periods. For time by group interaction significant group effect was depicted among participants in GFD, *F(5.86, 156.32) = 2.46, p = 0.028,* with a trivial effect size, *η2 = 0.084,* suggesting no obvious between group interaction. Post hoc findings for time effect indicated improved post-intervention outcome and follow-up test periods over baseline and also an improved outcome test period over the follow-up *(p < 0.017)*, suggesting consistency in time effect. In the time by group interaction, study findings suggested no significant group effect between the augmented CCT groups and the control *(p > 0.017)*.

Assessment of participants' performances in ADL indicated a significant time effect, *F(1.72, 137.90) = 668.91, p = 0.001*, with a very large effect size, *η2 = 0.89,* suggesting substantial improvement in ADL across the three test periods. Univariate test for the time by group interaction in ADL depicted significant groupeffect, *F(5.17, 137.90) = 12.21, p =0.001,* with a small effect size*, η2 = 0.31,* implying obvious group effect in ADL. Post hoc test for the time effect suggested improved ADL in the post-intervention outcome and follow-up above baseline and of follow-up over the post-intervention

outcome *(p < 0.017)*. Findings on post hoc test for the time by group interaction indicated that 120CCT was significantly better than 60CCT and the control in ADL *(p < 0.017)*.

Table 4-15: Univariate test for time effect and time by group interaction in global disability level and functional ability (ADL), results are means (standard deviation)

Variables	120CCT (n=23)	90CCT (n=24)	60CCT (n=21)	Control (n=23)	Total (n=91)	F_T	$Prob_T$	η^2_T	F_{TG}	$Prob_{TG}$	η^2_{TG}
4.3.2.1.4 Modified Rankin Scale (MRS)											
Baseline	3.62 (0.50)	3.45 (0.51)	3.40 (0.50)	3.38 (0.59)	3.46 (0.53)	362.56	0.001	0.82	2.46	0.028	0.08
Outcome	2.14 (0.73)	2.14 (0.64)	2.20 (0.70)	2.10 (0.62)	2.14 (0.66)						
Follow-up	1.43 (0.51)	1.59 (0.67)	1.85 (0.49)	1.81 (0.40)	1.67 (0.55)						
Modified Barthel Index (MBI)											
Baseline	67.29 (4.71)	66.95 (5.49)	68.40 (5.55)	68.33 (5.59)	67.73 (5.29)	668.91	0.001	0.89	12.21	0.001	0.31
Outcome	86.19 (6.10)	82.95 (4.41)	81.30 (6.11)	78.10 (5.18)	82.15 (6.13)						
Follow-up	96.67 (3.69)	91.23 (5.23)	88.30 (5.89)	83.71 (8.68)	90.01 (7.66)						

CCT = Circuit Class Therapy, F_T = F value for main time effect, $Prob_T$ = Observed probability for main time effect, η_T^2 = Effect size for main time effect, F_{TG} = F value for time by group interaction, $Prob_{TG}$ = Observed probability for time by group interaction, η_{TG}^2 = Effect size for time by group interaction. Interaction were computed using 0.05 alpha

4.3.2.1.5 Result of within-group differences in activity limitation

To determine within group differences in measures of activity limitation among stroke survivors in this study participants' performances in each group was subjected to a simple one-way ANOVA, where significant differences were found and post hoc tests were conducted to ascertain where the differences lay. In 120CCT significant within-group differences were found in all the seven measures of activity limitation with better post-intervention and follow-up performances above baseline in all measures, this group (120CCT) also showed steady improvement during follow-up in four measures (AOU, QOU, MRS and MBI). In the 90CCT study, findings suggested significant within group differences in all the seven measures of activity limitation. Post hoc test in this group (90CCT) however, showed evidence of significant within group differences in six measures (AOU, QOU, 6MWT, 10MWT, MRS and MBI) among which three (AOU, MRS and MBI) presented steady improvement during follow-up. In 60CCT results indicated significant within group differences in four (6MWT, 10MWT, MRS and MBI) measures of activity limitation, no significant improvement was found in any measure of upper extremity function. Post hoc test indicated better performances for post-intervention and follow-up tests in three measures (10MWT, MRS and MBI), and a steady improvement in functional ability (MBI). In the control group significant within differences were only found in global activity function measures of the global level of disability and functional ability. Findings indicated improvement in both measures of global activity function (MRS and MBI) in post-intervention and follow-up test periods above baseline, with a steady improvement in functional ability during follow-up. Results for the within group differences in activity limitation are presented in appendix 18.

4.3.2.1.6 Summary of time effect and time by group interaction in measures of activity limitation

This section presented the findings of this study on measures of activity limitations. In total, six measures were used to assess activity limitation. Using multivariate test the result showed significant time effects in all the measured variables, with a large effect size. Similarly, result for time by group based on multivariate test depicted a significant group effect, however, with a small effect size. Separate univariate tests in each measure of activity limitation equally depicted significant time effect in all measures with effect sizes ranging from large to very large, suggesting improvement ?considerable time effect in all measures. Results for time by group interaction indicated significant group effect in all the measures of activity limitation, with effect sizes ranging from medium to large except in MRS (global functional disability) where the effect size for group effect was trivial.

The result indicated that 120CCT produced significantly higher scores than the control in five tests (AOU, QOU, 6MWT, 10MWT and MBI) and better than 60CCT in three (AOU, 10MWT and MBI) of activity limitations; 90CCT was better than the control in two (10MWT and MBI) measures of activity limitation.

4.3.3 Section BIII: Effectiveness of augmented CCT and the control on Participation restriction post stroke

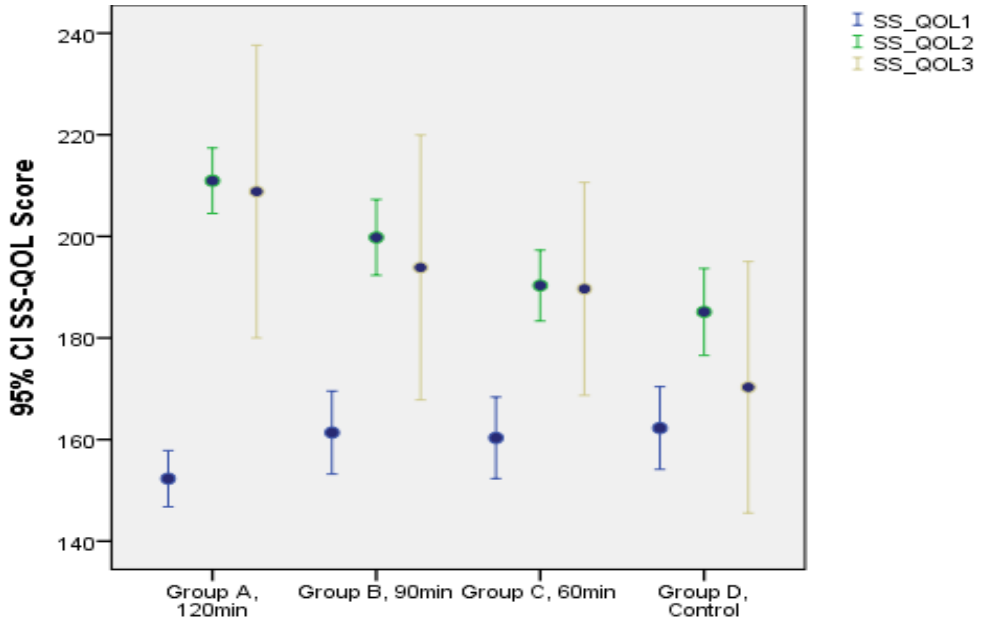
This section focused on the result of the comparative effectiveness of CCT groups and the control in the management of participation restriction post stroke. Results from both

the 49 items comprising all of the 12 subscales and the 26 items spanning the eight subscales of the SS-QOL were reported for multivariate test statistics. For univariate components of the analyses, the 49 items SS-QOL results table is presented in appendix 19, while the univariate test for the 26 items participation component of the SS-QOL is presented in this chapter.

4.3.3.1 Multivariate tests for SS-QOL and SS-QOL participation scale

Multivariate tests for the 49 items SS-QOL scale indicated a significant time effect for change in SS-QOL across the three test periods, *Wilks' λ F(26, 55) = 243.56, p = 0.001,* with a very large effect size, $\eta^2 = 99$. Similarly, the time by group interaction depicted a significant group effect, *Wilks' λ F(78, 161) = 5.63, p = 0.001* on SS-QOL with a very large effect size, $\eta^2 = 73$. These findings (fig. 4.21) generally indicated evidence of training effect and evidence of group effect on participation post stroke.

In the 26 items SS-QOLp subscale multivariate test indicated significant time effect, *Wilks' λ F(16, 65) = 204.00, p = 0.001,* with a very large effect size, $\eta^2 = 98.$ For time by group interaction a significant group effect found, *Wilks' λ F(48, 194) = 5.63, p = 0.001,* with a large effect size, $\eta^2 = 62.$



Time effect for SS-QOL score was significant, F(26,55) = 245.56, p = 0.0001, p/et = 0.99. Error bars represent marginal means. Time by group interaction was significant, Wilks, lamda, F(78, 161) = 5.63, p = 0.001, p/et = 0.73

Figure 4.16: Between group differences in SS-QOL total post intervention

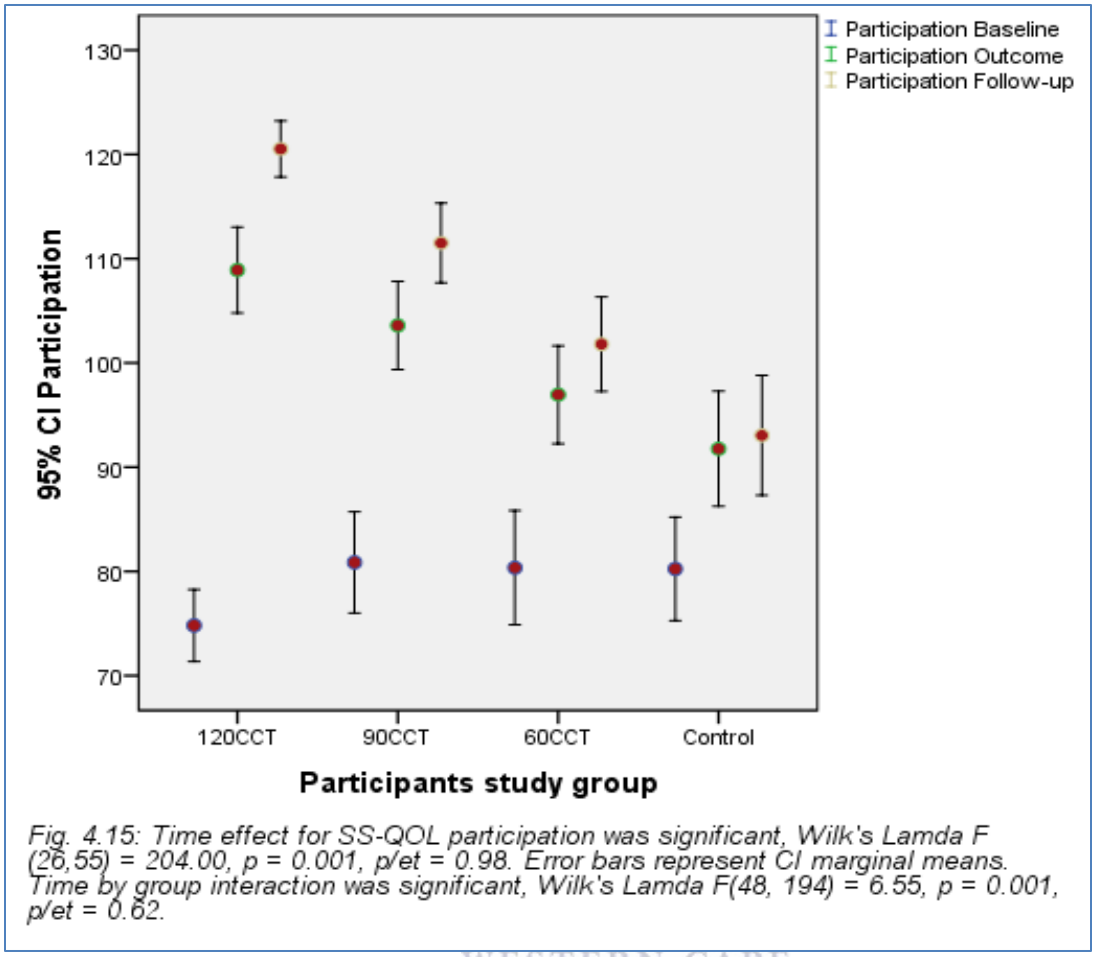


Fig. 4.15: Time effect for SS-QOL participation was significant, Wilk's Lamda F (26,55) = 204.00, p = 0.001, p/et = 0.98. Error bars represent CI marginal means. Time by group interaction was significant, Wilk's Lamda F(48, 194) = 6.55, p = 0.001, p/et = 0.62.

Figure 4.17: Between group differences in SS-QOL participation

4.3.3.2 Univariate tests for the eight subscales of the 26 items SS-QOLpsubscale

This section presented the results of the univariate tests involving the eight sub-scales (family roles, language, mobility, self-care, social roles, thinking, upper extremity function and work/productivity) and the total SS-QOLp score (tables 4.16a and b). Results in all the eight subscales of the 26 items SS-QOLp plus the total SS-QOLp score indicated significant time effect ($p < 0.05$). The magnitude of change (effect) across the three test periods however, varied among the subscales, six subscales (family roles, mobility, self-care, social roles, upper extremity function and work/productivity) and the total SS-QOLp score depicted very large effect sizes ($\eta^2 \geq$

0.70), one subscale (thinking) presented a medium effect size (η^2= *0.47*) and one subscale (language) showed a small effect size (η^2= *0.29*).

For time by group interaction, results indicated significant group effect in six subscales (family roles, mobility, self-care, social roles, upper extremity function and work/productivity) and the total SS-QOLp score ($p < 0.05$), while two subscales (language and thinking) did not show significant difference ($p > 0.05$). However, the effect sizes for the group interaction depicted a very large effect size (η^2= *0.80*), two subscales (social roles and upper extremity function) showed large effect sizes (η^2= *0.51* andη^2= *0.59* respectively), three subscales (mobility, self-care and work/productivity) indicated medium effect sizes (η^2= *0.50,* η^2= *0.43* and η^2= *0.44* respectively) and a subscale (family roles) revealed a small effect size (η^2= *0.29*).

Pairwise comparison of the eight subscales of the SS-QOLp scale and the total SS-QOLp score was conducted for both time effect and time by group interaction. In six subscales (mobility, self-care, social roles, thinking, upper extremity function and work/productivity) and the total SS-QOLp score, there was significantly better participation for both post-intervention outcome and follow-up above baseline and a significantly better follow-up over the post-intervention outcome ($p < 0.017$). The two other subscales (family roles and language) indicated only a significantly better post-intervention outcome and follow-up above baseline ($p < 0.017$). These results generally suggested long-term training effect on participation in stroke survivors, particularly with several domains improving at follow-up over the immediate post-intervention outcome.

Pairwise comparison for the time by group interaction was performed for six subscales (that were found to be significant following univariate test) and the total SS-QOLp score. Significant group interaction was found in two subscales (mobility and work/productivity) and the total SS-QOLp score ($p < 0.017$). The result indicated that participants in 120CCT were significantly better than the control in mobility, work/productivity and in the total participation score, additionally, participants in this category performed significantly better than those in 60CCT in work/productivity ($p < 0.017$). Similarly, participants in 90CCT showed significantly better performances than their counterpart in 60CCT in work/productivity and a better performance in total SS-QOLp than those in the control group ($p < 0.017$).The remaining four subscales of the SS-QOLp scale(family roles, self-care, social roles and upper extremity function) did not depict between group differences following pairwise comparison

Table 4-16: Univariate test for time effect and time by group interaction in four SS-QOL subscales for participation

Variable	120CC	90CCT	60CCT	Control	Total	F_T	$Prob_T$	η^2_T	F_{TG}	$Prob_{TG}$	η^2_{TG}
Family Roles											
Baseline	2.62 (0.50)	2.91 (0.68)	2.80 (0.77)	2.90 (0.62)	2.81 (0.65)	198.00	0.001	0.71	9.55	0.001	0.26
Outcome	4.10 (0.62)	3.91 (0.75)	3.70 (0.66)	3.48 (0.75)	3.80 (0.72)						
Follow-up	4.38 (0.59)	4.14 (0.83)	3.75 (0.72)	3.43 (0.68)	3.93 (0.79)						
Language											
Baseline	12.43 (2.16)	12.50 (2.99)	12.60 (1.60)	12.29 (2.33)	12.45 (2.30)	32.13	0.001	0.29	0.70	0.587	0.026
Outcome	13.29 (1.71)	13.32 (2.68)	13.05 (1.47)	13.19 (1.89)	13.21 (1.97)						
Follow-up	13.52 (1.60)	13.45 (2.58)	13.15 (1.39)	13.10 (2.14)	13.31 (1.97)						
Mobility											
Baseline	14.05 (1.60)	14.82 (2.95)	15.10 (1.65)	15.14 (2.39)	14.77 (2.24)	360.22	0.001	0.82	26.65	0.001	0.50
Outcome	21.00 (1.97)	18.95 (3.06)	18.90 (1.94)	17.43 (2.71)	19.07 (2.75)						
Follow-up	23.33 (1.91)	20.50 (3.16)	19.10 (2.27)	17.38 (3.09)	20.10 (3.42)						
Self-care											
Baseline	14.95 (2.50)	16.45 (3.94)	16.50 (4.35)	15.76 (4.58)	15.92 (3.90)	359.21	0.001	0.82	19.89	0.001	0.43
Outcome	21.19 (2.79)	20.77 (2.74)	18.95 (3.87)	17.62 (4.40)	19.65 (3.74)						
Follow-up	23.29 (2.12)	21.91 (2.76)	21.00 (3.93)	18.52 (4.01)	21.19 (3.67)						

Table 4-17: Univariate test for time effect and time by group interaction in participation and other four SS-QOL subscales of participation

Variable	120CC	90CCT	60CCT	Control	Total	F_T	$Prob_T$	η^2_T	F_{TG}	$Prob_{TG}$	η^2_{TG}
Social roles											
Baseline	7.29 (1.38)	8.32 (2.87)	8.60 (3.10)	8.38 (2.67)	8.14 (2.59)	418.07	0.001	0.84	27.83	0.001	0.51
Outcome	11.62 (1.43)	11.64 (2.54)	10.55 (2.48)	9.76 (2.91)	10.90 (2.49)						
Follow-up	13.38 (1.20)	12.64 (2.19)	11.75 (2.31)	9.86 (2.82)	11.92 (2.54)						
Thinking											
Baseline	3.86 (0.73)	3.95 (1.05)	3.90 (0.91)	3.95 (0.86)	3.92 (0.88)	70.62	0.001	0.47	1.07	0.377	0.039
Outcome	4.67 (0.48)	4.64 (0.49)	4.40 (0.60)	4.43 (0.60)	4.54 (0.55)						
Follow-up	4.86 (0.36)	4.86 (0.35)	4.65 (0.49)	4.52 (0.60)	4.73 (0.47)						
Upper Extremity Function											
Baseline	13.05 (3.07)	14.32 (3.24)	14.25 (4.23)	14.33 (4.44)	13.99 (3.75)	483.63	0.001	0.86	30.01	0.001	0.59
Outcome	20.57 (3.72)	19.09 (3.50)	17.85 (4.30)	16.24 (4.12	18.45 (4.16)						
Follow-up	23.43 (2.29)	21.27 (3.55)	18.85 (4.12)	16.67 (4.34)	20.08 (4.40)						
Work/Productivity											
Baseline	6.57 (1.69)	7.59 (2.09)	6.60 (2.16)	7.48 (2.54)	7.07 (2.16)	283.10	0.001	0.78	20.58	0.001	0.44
Outcome	12.48 (2.40)	11.27 (2.10)	9.55 (1.76)	9.62 (2.20)	10.75 (2.42)						
Follow-up	14.33 (1.68)	12.73 (2.23)	9.55 (2.09)	9.57 (2.56)	11.58 (2.97)						
SS-QOL Participation Scale											
Baseline	74.81 (7.58)	80.86 (10.95)	80.35 (11.69)	80.24 (10.91)	79.07 (10.51)	1668.11	0.001	0.95	103.31	0.001	0.80
Outcome	108.90 (9.06)	103.59 (9.54)	96.95 (10.02)	91.76 (12.12)	100.38 (12.00)						
Follow-up	120.52 (5.90)	111.50 (8.61)	101.80 (9.70)	93.05 (12.63)	106.83 (13.95)						

4.3.3.3 Summary of effectiveness of augmented CCT and the Control on participation restriction post stroke

The section reported the effectiveness of augmented CCT and the control on participation restriction post stroke. The results presented are based on both multivariate and univariate test statistics. Participation was assessed using SS-QOL a 49 item scale with 12 subscales, however, only 26 items spanning through eight subscales of the SS-QOL represent participation. The results of this study, therefore, presented the multivariate tests result for the 49 items main SS-QOL scale and the 26 items SS-QOL participation scale (SS-QOLp). Multivariate tests for both the 49 items scale SS-QOL and the 26 items SS-QOLp indicated significant time effects and group interaction. Study findings generally suggested substantial training effect and group effect in favour of augmented CCT in participation post stroke.

4.4 Acceptability of the durations of circuit of class therapy

Participants in each CCT training groups were asked to rate their acceptance of the training they received on a six-point acceptability scale. Findings are presented in table 4.17 below:

Participants' responses to acceptability of therapy suggested statistically significant between-group differences in overall acceptance of the demand of treatment, $F(2, 65) = 3.25, p = 0.045$ and total acceptability score, $F(2, 65) = 8.08, p = 0.001$. However, no significant between-group difference was found on participants' views on ethical consideration in each of the duration of therapy, effectiveness of treatment, the perception of negative effects, recommending therapy and how motivating the therapy seemed to participants.

Post hoc analysis on acceptability of durations of therapy

Overall acceptance of treatment demand and total acceptability score were subjected to post hoc test. The result indicated that participants in group C (60min CCT) showed significantly better overall acceptance of treatment demand over participants in group A (120min CCT). However, no significant difference was found between groups B and C (90min and 60min CCT respectively) on the acceptability of treatment demand. In total acceptability score, participants in group C (60min CCT) indicated significantly better all-encompassing acceptance of their group over participants in groups A and B (120min and 90min CCT respectively).

Table 4-18: Between-group differences in acceptability of duration of CCT

Variables		Mean	SD	Df	F	Prob.
Overall how acceptable do you find the demand for treatment to be?	120CCT	5.70	0.70	2	3.25*	0.045
	90CCT	5.92	0.72	65		
	60CCT	6.24	0.70			
	Total	5.94	0.73			
How ethical do find this treatment to be?	120CCT	6.13	0.63	2	1.75	0.182
	90CCT	6.00	0.59	65		
	60CCT	6.33	0.58			
	Total	6.15	0.61			
How effective do you find this treatment?	120CCT	6.22	0.52	2	2.51	0.089
	90CCT	6.25	0.61	65		
	60CCT	6.57	0.60			
	Total	6.34	0.59			
How likely can you describe experiencing any negative side effect during this treatment?	120CCT	6.13	0.55	2	1.97	0.148
	90CCT	6.33	0.48	65		
	60CCT	6.43	0.51			
	Total	6.29	0.52			
How possible is it for you to recommend this therapy to other persons like you?	120CCT	6.43	0.51	2	1.23	0.298
	90CCT	6.58	0.50	65		
	60CCT	6.67	0.48			
	Total	6.59	0.50			
How motivating have you found this treatment to be?	120CCT	6.78	0.42	2	.02	0.976
	90CCT	6.79	0.41	65		
	60CCT	6.81	0.40			
	Total	6.79	0.41			
Total Score for acceptability	120CCT	37.39	1.12	2	8.08*	0.001
	90CCT	37.88	1.83	65		
	60CCT	39.05	1.07			
	Total	38.07	1.54			

SD= Standard deviation, * significant at 0.05 alpha level

4.5 Summary of this chapter

This study investigated the relative effectiveness of three varied durations of CCT (120CCT, 90CCT and 60CCT) and a control (standard physiotherapy) in the

management of stroke-related deficits categorised into three, based on the WHO-ICF framework (body structure/function, activity limitation and participation restriction). A total of 91 stroke survivors randomised into the three CCT groups and the control participated in this study. Participants were made-up of 56% females and 44% males of 50.5±10.3 years mean age and they largely presented with ischaemic stroke (83.5%). Participants indicated no between differences at baseline for all of the outcome measures.

Results for body structure/function focused on muscle strength and spasticity, findings indicated a positive training effect for all measures for both muscle strength and spasticity with impact largely in the lower extremity measures. Measurements for muscle strength essentially indicated no group effect except in one measure of the lower extremity. Spasticity measures, however, depicted significant group effects in favour of augmented CCT, particularly in the lower extremity measures. Findings with regard to activity limitation showed substantial training effect for all measures and largely tailored towards lower extremity function and global activity function of the stroke survivors. Group interaction in activity limitation considerably favoured augmented CCT for one of the measures of upper extremity function and all other measures for lower extremity function and global activity function Participation restriction results indicated a very large training effect on participation in all the eight subscales aside from language, however, only subscales (mobility and work/productivity) plus the total depicted a significant group effect which was in favour of augmented CCT. In acceptability of the training duration participants in 60CCT indicated significantly better acceptance of their training duration and demand above participants in both 90CCT and 120CCT.

5 CHAPTER FIVE: DISCUSSION

There is not a discovery in science, however revolutionary, however sparkling with insight that does not arise out of what went before. 'If I have seen further than other men,' said ***Isaac Newton****, 'it is because I have stood on the shoulders of giants"* ***Isaac Asimov*** *(1919-1992***)**

5.1 Introduction

This study investigated the effectiveness of augmented durations of circuit class therapy in the rehabilitation of stroke survivors. The argument to stage this study is derived from the hypothesis that additional, dedicated exercise therapy practice has a positive effect on stroke recovery outcomes. This chapter discusses the findings of this study. The chapter is organised into four sections including sociodemographic features and features of the intervention programme of participants in relation to previous studies on augmented exercise training; the primary outcome measure; secondary outcome measures (divided into three subsections according to the ICF categories); and the acceptability findings.

5.2 Sociodemographic characteristics and features of the intervention

5.2.1 Socio-demographic

There are three commonly reported socio-demographic characteristics often expected to confound outcome in stroke studies namely age, gender and time since stroke.

The present finding indicated no age or gender differences in all the four arms of this study, implying that neither of the two variables would have influenced the findings of this study. The mean age of the participants in this study is 50.5 ± 10.3 years; this age is younger to the mean age of participants in most studies on the use of additional intensity

of exercise practice for stroke. In a most recent systematic review (Schneider et al, 2016) nearly 62% of the reviewed study involved stroke survivors who were ≥ 65 years old; two of the studies (Kim, Cho & Lee, 2014; Han, Wang, Meng & Qi, 2013) presented mean ages of 51 and 49 years respectively. It is important to note that both of the two studies having a lower age of participants were conducted in regions under low-income and middle-income countries (like the present study), one in China (Kim et al, 2014) and the other in South Korea (Han et al, 2013). Several epidemiologic studies have reported declining age of stroke onset in low-income and middle-income countries (Yan et al 2016; Thrift & Arabshahi, 2012); consistent with the age of participants in this study.

The distribution of gender across the study groups was not significant; however, there were more female participants (56%) than males. Contrary to the preponderance of females in this study, earlier studies on augmented intensity of exercise in stroke rehabilitation have male dominance (English et al, 2015; Kim et al, 2014; Han et al, 2013). While this study does not particularly investigate the reason for more women than men, there are substantial evidence that women compared to men report more intense, more numerous and more frequent bodily symptoms and in older adults they make greater use of health care services (Redondo-Sendino, Guallar-Castillón, Banegas & Rodríguez-Artalejo, 2006; Barsky, Peekna, Barus, 2001). This will probably account for why there are more women than men in this study.

The mean duration of onset of stroke in this study is 13.3 ± 10.9 months, this duration of time since stroke suggest that participants were largely chronic stroke survivors. Most of the earlier studies on CCT were conducted on stroke survivors who were of < 6 months onset (van de Port et al, 2012; Outermans et al, 2010; English et al, 2007) and so it is

with previous studies on augmented intensity of therapy (English et al, 2015; Han et al, 2013; Cooke et al, 2010b). However, there are few studies on augmented intensity of therapy conducted in patients who were > 6 months since stroke (Kim et al, 2014; Page, Levin, Hermann, Dunning & Levine, 2012). While the most available studies on augmented exercise therapy suggesting improved stroke outcomes were conducted in acute stroke survivors (≤ 6 months onset), improvement of function has also been reported in chronic stroke survivors following task specific training (Rensink et al, 2009; French et al, 2007) and in circuit class therapy (English & Hillier, 2010; Wevers et al, 2009).

5.2.2 Features of the study/intervention

The main features of the study/intervention to be discussed are the numbers of arms in the study, intensity of practice both in amounts of time spent in training and the amounts of repetitions conducted while training.

This study is made up of four arms with three arms dedicated to intervention groups and one dedicated to the control, the decision to have four arms in this study is to allow a wide range of comparison of intensities of CCT, comprising of the commonly used intensities (time of therapy) for a single therapy session such as 60 mins (Mudge et al, 2009; Pang et al, 2005; Blennerhassett & Dite, 2004) and 90 mins (English et al, 2015; van de Port et al, 2012; English et al, 2007), with an added intensity not specifically found in the literature for single session of therapy i.e. 120 minutes. Majority of the earlier study on augmented intensity of therapy were designed with two arms (Kim et al, 2014; Ross et al, 2009; GAPS. 2004), involving one intervention group and a control or with three arms

characterised by two intervention groups and one control (English et al, 2015; Han et al, 2013; Burgar et al, 2011; Cooke et al, 2010b), similar to the design of this study.

The intensity of therapy which is the main focus of this study was structured based on the group of the participants (120CCT, 90CCT, 60CCT or Control), however, due to the incomplete number of sessions the recorded time spent by each group was not as exactly allocated. In particular, the total number of session of 24 sessions in eight weeks were not mate by some participants, however, no participants missed more two sessions throughout the training period; no significant between-group differences were found in attendance/adherence rate. Findings suggest that participants in 120CCT received 92% and 88% more therapy than Control and 60CCT respectively, while participants in 90CCTrecieved 49% and 46% more therapy than the former and latter respectively. This increased intensity of therapy in both 120CCT and 90CCT are more than the amount of therapy input (of 16 hours) to influence a change suggested by Kwakkel et al (2004). A recent meta-analysis found that large increases in the amount of therapy are associated with beneficial effects in stroke survivors and that an extra of 240% of the increase in rehabilitation is required for a significant likelihood that additional rehabilitation would institute improvement in activity (Schneider et al, 2016). This amount of recommended additional therapy time (240%) although not achieved in this study, does not suggest that quality extra intensities below 240% would yield no benefit to stroke survivors. English and Veerbeek (2015) observed that just augmenting physiotherapy time alone without increasing the specific time involved task-specific practice does not seem to be of benefit to stroke survivors. To support this fact findings in this study on amounts of repetitive practice suggest that participants in 120CCT practiced better than those in 60CCT over 200% times in simple tasks and over 400% times in complex tasks above those in

60CCT; this by implication obviously suggests that participants in 120CCT will achieve better amounts of practice than both 60CCT and the Control, even though the amount of practice was not monitored in the control group. This may, therefore, imply that based on amounts of repetitive practice, this study is consistent with the recommended amount of additional therapy of ≥ 240% expected to yield benefits in stroke rehabilitation (Schneider et al, 2016).

5.3 Primary outcome measure

The main outcome measure in this study is walking distance as measured by 6MWT. This study found significantly better performance in walking distance among participants in the 120CCT group over those in the control and no significant difference was found among the intervention group. There are two interpretations to this outcome, the first interpretation suggests that if the content of therapy is the same as established in the intervention groups, augmenting therapy time does not significantly influence walking distance following intervention (because 120CCT is not significant over 90CCT and even 60CCT); the second interpretation suggests that to achieve meaningful improvement in walking distance CCT has to be delivered in a reasonably high intensity of therapy (since 120CCT is particularly significant over Control). This finding suggests that while the content of a training programme to attain a meaningful walking distance after stroke is important the intensity with which the programme is administered is one of the major drivers of the rehabilitation outcome. This finding support previous study on the effectiveness of augmented therapy time on walking ability after stroke. Although walking ability is not synonymous to walking distance, a recent systematic review concluded that the distances achieved during walking by stroke survivors substantially indicate the level of compromised walking ability (Dunn et al, 2015). It is, therefore, appropriate to regard

study findings defining the walking ability in stroke survivors in explaining their walking distance. One meta-analysis (Veerbeek et al, 2011) reported a significant medium homogeneous effect in favour of augmented exercise therapy after pooling data from 14 randomised controlled trials included in their review regarding walking ability. Studies are not generally consistent with findings regarding the effect of augmented intensity of therapy on walking distance/ability. Peurala et al (2009) studied the effect of intensive therapy for walking exercise (in acute stroke survivors), their finding suggested that walking ability improved more with intensive walk training compared with conventional treatment. In a related study Kim et al (2014) reported improved walking function in favour of augmented therapy group in a study investigating community walking among chronic stroke survivors. Blennerhasset and Dite (2004) using circuit class therapy reported improved walking distance in favour of augmented intensity of therapy, in acute stroke survivors. In contrast, a recent study by English et al (2015) found no significant between-group differences in walking distance following four weeks of intervention in acute stroke survivors. The difference in the intensity of practice between the augmented therapy groups and the control in the study of English et al (2015) was found to be about 40% (Schnieder et al, 2016) which can be considered hugely below recommended intensity to institute the needed change. English and Veerbeek (2015) observed that in the CIRCIT trial (English et al, 2015) averagely only one minute was added per session of a therapy session to practice walking. It was also observed that the duration spent by participants standing or walking across walking day is pretty low for all the participants. They, therefore, asserted that in spite of the convincing differences in therapy time, there was only a minimal difference in the dose of walking based exercise practice between the groups. This, therefore, could be responsible for the insignificant difference they found in walking distance. There are several other studies reporting improved walking

ability/distance in favour of augmented intensity of therapy but the findings do not reach statistical significance over the control group (Kuys, Brauer & Ada, 2011; GAPS, 2004; Kwakkel et al, 2002; Partridge et al, 2000). The positive finding on walking distance in this study may be influenced by the younger age of the stroke survivors in this study which is considerably younger than what is found in most western studies (English et al, 2015; Kuys et al, 2011; Kwakkel et al, 2002). This finding could also be attributable to the uniqueness of the technique used in the intervention as it is premised that medical interventions are made up of a set of attributes or results and the attractiveness of any of the intervention to a client/patient lies in the function of these attributes (Hensher, Rose & Greene, 2005; Ryan & Farrar, 2000). The fact that CCT is new in this setting and the attributes of the technique, particularly the group dynamic, reflected an overwhelming acceptance from the participants, which might contribute to the outcome of this study. Similar, other factors that could contribute to the positive findings in this study include: the type of training/intervention (i.e. CCT), number of repetitions and duration of practice (i.e. 120CCT).

5.4 Secondary Outcome measures

This section discusses the secondary outcome measures used in this study. The section is organised into three subsections according to the ICF categories of body structure/function, activity and participation. The last part of this section is on acceptance of the doses of the therapy i.e. the three categories of the intervention. As it is largely identified and emphasised by several systematic reviews and meta-analyses, the main challenge in pooling outcome together for meta-analysis is the heterogeneity of methods used and of particular reference is the superfluity of the outcome measures used (Schneider et al, 2016; Veerbeek et al, 2011, Cooke et al, 2010a, Galvin et al, 2008). This

challenge is also encountered in interpreting the findings of this study, therefore, interpretation of some outcome measures in this study is directed towards the primary aim of the corresponding authors, the purpose with which the outcome measure was developed and how it relates to the outcome measure used in this study.

5.4.1 Body Structure/Function (Impairment)

5.4.1.1 Muscle strength

The outcome of this study for upper extremity suggested that elbow flexors and wrist flexors demonstrated improved muscles strength, while it was the extensors that showed improvement in the shoulder. No significant between-group differences were found, as improvement was evident in all the groups including the control. However, study findings suggested a trend towards improved strength along the flexor pattern in the upper extremity favour of augmented intensity of therapy. This finding is consistent with what was reported by Ross, Harvey and Lannin (2009) who reported improved Summed Manual Muscle Testing in the upper extremity in both intervention group (additional intensity) and the control, with no clear evidence of benefit from extra hand therapy. Similarly, Rodgers et al (2003) found no significant difference extra therapy group and the control in upper extremity impairment as assessed using Motricity Index at both three and six months post intervention. Lincoln, Parry and Vass (1999) assessed upper extremity impairment using Rivermead Motor Assessment scale, their finding also corroborates the present finding suggesting no significant different between additional therapy and the control. In contrast to this finding Donaldson et al (2009) in a pilot study reported improvement in hand grip force, pinch grip force, isometric elbow flexion force and isometric elbow extension force in favour of extra therapy time. It is, however, important to emphasise that the study is an exploratory designed pilot study with inadequate

sample size and no inferential statistics was conducted to allow for generalizability of findings.

In the lower extremity findings indicated improved muscle strength in both flexors and extensors of the hip and knee joints, while only dorsiflexors showed improvement in the ankle. The outcome indicated a trend towards improved muscle strength in favour of the augmented therapy groups and in particular the 120CCT and 90CCT, however, the outcome fails to reach significance. This finding appears to be consistent with the report of the Glasgow Augmented Physiotherapy Study group (GAPS, 2004) who found no significant different between additional therapy group and the control in lower extremity impairment of muscle strength using Motricity Index. Contrary to the finding of this study and particularly regarding knee complex, Cooke et al (2010b) reported significantly improved knee peak torque in favour of the augmented therapy group. Two major differences between their finding and the present study are that although, muscle strength was measured in both studies they applied a more objective technique in assessing muscle torque (dynamometer) and as such their finding may prove more accurate in determining the exact force exerted in each of the groups (intervention and control) and secondly, they assessed the peak force exerted by the knee, which cannot be achieved using Manual Muscle Testing as used in this study. Owing to the result of Cooke et al (2010b) on improved muscle strength following augmented intensity of therapy, it may be assumed that using objective measures may probably yield a more positive outcome in favour of augmented therapy time. Evidence have shown that performance in 6MWT distance could be an indicator of lower extremity muscle strength, and strengthening the lower extremity could as well enhance gait capacity in stroke survivors (Pradon, Roche, Enette & Zory, 2013); lower extremity muscle strength has

also been found to be significantly related to improved gait speed (Purser, Peiper, Poole & Morey, 2003). The outcome of this study suggesting a trend towards improved muscle strength based on augmented CCT could possibly be as a result of the better and improved 6MWT in the augmented CCT group over the control.

5.4.1.2 Spasticity

The outcome of this study indicated significantly improved ROM following declining spasticity in the shoulder, elbow and wrist joints with moderate effect sizes for shoulder and wrist joints (0.57 and 0.61 respectively) and a small effect size for the elbow joint (0.13) in favour of augmented therapy time, however, pairwise comparison for shoulder and wrist joint did not indicate where the differences lie despite having moderate effect sizes. However, in the elbow joint 120CCT indicated better improvement in spasticity above 60CCT and the Control. This finding is not a surprise as in the should both 60CCT and the Control exhibited improved spasticity, they showed a minimal decline in the wrist and a huge decline in the wrist joint particularly during the six-month follow-up. Although, all the three groups showed declining ROM in the elbow joint the rate of decline was more obvious in 60CCT and the Control. This finding clearly indicates that augmented therapy time could positively influence upper extremity spasticity. This finding is consistent with the result of Burgar et al (2011) who conducted an upper-extremity robotic-assisted therapy in acute stroke survivors and found a significant decrease in spasticity of the upper extremity at six-month follow-up in favour of the extra intensity group. An earlier study (Fazekas, Horvath, Troznai & Toth, 2007) using robotic-mediated therapy in patient with spastic hemiparesis found that the Modified Ashworth score of shoulder adductors and elbow flexors indicated a statistically significant change only in the additional therapy group with robotic; thereby, corroborating the present findings. In

contrast, Lincoln et al (1999) assessed upper extremity spasticity using Modified Ashworth Scale to determine changes in hypertonia between additional therapy group and a Control their finding suggested no significant difference between the two groups. Rodgers et al (2003) similarly reported no significant difference between additional intensity group and the control in upper extremity impairment using Motricity Index as a measure. It is, however, noteworthy that the study of Lincoln et al (1999) is confounded by the heterogeneity of subjects with many of the participants completely no sign of motor recovery, a situation which was sustained or even become worse at the end of the study. In the study Rodgers et al (2003), the authors ascribed the lack of improved better outcome in the additional therapy group to the fact that all the patients included in their study received a remarkable baseline stroke unit care and have, therefore, achieved remarkable motor recovery such that the benefits of additional therapy may not be obvious in the sampled participants. As such it is possible that the finding of this regarding decreased hypertonicity in favour of the additional therapy group is plausible.

Study findings on lower extremity spasticity indicated significantly improved ROM following decreased spasticity for hip, knee and ankle extensor patterns in favour of extra intensity. The outcome suggests that 120CCT was better than the Control in hip spastic angle and better than both 60CCT and the Control in knee spastic angle. However, no significant difference was found between the groups in ankle spastic angle despite showing a medium effect size (0.47). The result clearly points to the effectiveness of augmented duration of CCT in reducing spasticity in the lower extremity after stroke. The implication of reduced spasticity in the lower extremity is improved functional recovery which is expectedly going to enhance ambulation and promote activities of daily living (Francisco & McGuire, 2012; Kaji et al, 2010). This study finding is consistent with the

study of Farina et al (2008) who reported that an intensive therapy, given in the form of prolonged stretching of spastic muscles, obtained by means of casting after BTA injection gives a longer-lasting therapeutic benefit compared to BTA injection alone, as assessed by the Modified Ashworth Scale. The authors reported that at four months follow-up the extra intensity group showed further improvement with the control group returned to the baseline; suggesting an obvious dose-response relationship. In a recent study, Pimentel, Alencar, Rodrigues, de Sousa & Teles (2014) reported a dose effect in a study combining the use of botulinum toxin type A for a spastic foot in post-stroke patients. The authors reported that while both groups showed improvement in time walking 10 meters and Functional Independent Measure (mFIM), with no significant differences between the groups, the higher-dose group exhibited a significant improvement in spasticity over the lower dose group. Despite the effectiveness of task specific training is the management of neuromuscular challenges in stroke little has been done in evaluating the effectiveness of this approach in the management of spasticity after stroke. This is obvious has comparative only comparative studies are said to be available on the effectiveness of one approach over another (Fracisco & McGuire, 2012); in particular available studies on spasticity and exercise largely focused on whether subjecting patients with spasticity will lead to worsening of the situation (Badics, Wittmann, Rupp, Stabauer & Zifko, 2002).

Measurements of impairment centred characteristics such as muscle strength and spasticity have not received enough attention from studies evaluating the effectiveness of CCT and studies on augmentation of the intensity of therapy.

5.4.2 Activity

5.4.2.1 Gait speed (10MWT)

The outcome of this study indicates that 8-weeks of structured CCT model of additional intensity and control indicated improved performance in gait speed in favour of additional therapy with a large effect size (0.65). The result indicated that participants in 120CCT are better than those in 60CCT and the Control and those in 90CCT also performed better than the Control in gait speed. Study findings further suggested that the improved gait speed was sustained 6-months post intervention and it is only the participants in 120CCT that nearly achieved the recommended gait speed community walking by attaining 0.70m/s just 0.1m/s below the recommended gait speed. This finding is supported by a meta-analysis which reported a homogeneous small but significant Summary Effect Size (SES) for comfortable walking after pooling result from eight studies (Veerbeek, et al, 2011). Finding from the same study, however, found a homogeneous borderline SES in maximum walking speed; both findings were in favour of increasing dose of exercise therapy. Earlier meta-analyses also reported improved walking speed in favour of augmented exercise therapy is stroke survivors (Kwakkel et al, 2004; Galvin et al, 2008). However, Cooke et al (2010b) reported a finding regarding the influence of exercise dose on walking after stroke, suggesting no significant difference between augmented intensity and the Control. Two factors might have contributed to the positive outcome seen in this study. Firstly, the age of the participants in this study still remains within the active category of the society, age has been found to be a confounding variable to stroke rehabilitation outcome (Bagg, Pombo & Hopman, 2002) and it has also been recognised as influencing the outcome in augmented exercise studies (Lincoln et al, 1999). Secondly, the average onset of morbidity of the participants in this study is ≈ 13 months, Veerbeek et al (2011) found that the influence of augmented therapy time for

below 6-months of onset was insignificant for a host of variables such as walking capacity, activities of daily living and arm function aside from gait speed. This by implication will suggest that stroke survivors that may likely benefit from augmented exercise therapy time are those beyond 6-months of onset. This argument has also been supported by English et al (2015) who found no significant difference in walking between augmented exercise therapy group and the Control in a sample involving stroke survivors who were just 28 post stroke at baseline.

5.4.2.2 Upper extremity function and dexterity

The complications of upper extremity after stroke are common findings and are often associated with disturbing debilities. The recovery of function in the upper extremity is largely slower than the lower extremity (Desrosiers et al, 2003; Kwakkel et al, 1999), causing an enormous challenge in stroke rehabilitation. This has led to the development of various rehabilitation options among which is augmenting the duration of exercise therapy (Dobkin, 2004). Findings of this study using two different tools to measure upper extremity function and dexterity indicated significant group interaction in favour of the augmented duration of CCT. Using Action Research Arm Test (ARAT) to measure upper extremity function and dexterity indicated significant between-group differences in favour of the extra CCT groups with a medium effect size (0.38), however, the pairwise comparison failed to identify where the difference lie. In the assessment of function using Motor Activity Log (MAL) with its two subscales (Amount of Use [AOU] and Quality of Use [QOU]), the outcome suggested significant group interaction AOU in favour of augmented CCT, with participants in 120CCT group performing better than those in 60CCT and the Control as well as 90CCT participants being better than the Control; and there is also a significant group effect in QOU in favour of the extra CCT groups, with participants in

120CCT doing better than those in the Control. Study findings on the effect of additional therapy on upper extremity function are heterogeneous, evidence from available meta-analyses equally presented conflicting findings. Cooke et al (2010a) in a meta-analysis involving studies of same types of exercise-based therapy reported findings for studies based on single effect sizes suggesting a trend for improved recovery following an extra dose of exercise, which extends to the follow-up period for ARAT measures of the upper extremity function. However, due to the heterogeneity of data from the studies included in their study, they could not report findings for pooled results on upper extremity function. The MAL assesses stroke survivorson how they use of their upper extremity in the real world. The involvement of this measure is to allow stroke survivors to express changes as they witnessed in the real world. Surprisingly, none of the studies included in the available meta-analyses used MAL to assess real-world upper extremity function. However, two separate RCTs published in 2006 (Wolf et al, 2006; Taub et al, 2006) who both involved augmented exercise therapy reported. Taub et al (2006) conducted a placebo-controlled trial of constraint-induced movement therapy plus augmented exercise therapy for upper extremity in stroke survivors, findings from their suggested significantly improved function in favour of the additional exercise therapy group over the placebo, gains were in the intervention were sustained in four weeks follow-up and participants were found to have improved more at 2-years follow-up. Similar findings were reported by Wolf et al (2006) who found improved AOU and QOU in the intervention group over the usual care among stroke who were 3 to 9 months post-stroke in a large RCT referred to as the EXCITE study. Accordingly, based on this two reported findings stroke survivors are expected to improve in real-world upper extremity function following appropriate intervention and dose of practice as seen in this study. A meta-analysis (Galvin et al, 2009) reported conflicting finding regarding the effect of additional exercise therapy and

upper extremity function. Galvin et al (2008) found no significant SES using ARAT measure to assess upper extremity function post stroke based on pooled data from five different studies. It is, important to note that the involved were grossly heterogeneous in methods, such as the onset of the stroke of the included stroke survivors, duration of treatment and most importantly in the definition of what constitutes additional therapy. Findings in this study on upper extremity function are strengthened by the diversity injected in the assessment of function, which involve both stringent objective assessment and subjective approach, which gives participants the opportunity to express gains or otherwise based on the self-assessment.

5.4.2.3 Disability and Activities of Daily Living

Disability is the major consequence of stroke and at the early onset of stroke, the most important concern is the ability to carry out basic Activities of Daily Living (ADL). It is for this reason that researchers focus on both the level of disability and ADL following a rehabilitation programme. The most commonly used clinimetric instruments for measuring disability post-stroke are the modified Rankin Scale (mRS) and the Barthel Index (BI) (Cioncoloni et al, 2012). The outcome of this study using Modified Rankin Scale to assess between-group level of disability suggested significant group in favour of additional therapy with a trivial effect size (0.08), a pairwise comparison could not dictate where the difference lie. In basic ADL, study outcome indicated significant group effect in favour of augmented CCT, with participants in 120CCT doing better in basic ADL than those in 60CCT and the Control. This finding implies that augmented CCT is effective not just at the level of differing form of activity but also both at the same type of activity in enhancing basic ADL. This finding is consistent with the outcome of one meta-analysis who reported that basic ADL as assessed by Barthel Index is positively influenced by

additional therapy post-stroke (Galvin et al, 2008). A contrasting finding (also using Barthel Index) was, however, reported by Kwakkel et al (2004) that there is homogeneous nonsignificant SES for additional therapy in basic ADL, they further affirmed this outcome in an updated meta-analysis (Veerbeek et al, 2011). Although, both studies also reported a small but significant heterogeneous SES in favour of augmented exercise therapy in ADL and a homogeneous significant SES in extended ADL in favour of additional exercise therapy (as measured by Nottingham extended ADL scale). Obviously, from these previous findings, it can be adjudged that both basic and extended ADL showed a trend towards improvement following augmented intensity. One factor that can possibly explain the contrasting finding in this study and the pooled results reported in the two meta-analyses (Veerbeek et al, 2011; Kwakkel et al, 2004) is that both meta-analyses focused on studies conducted on stroke survivors in the first six months post-stroke. The outcome exhibited in this study on better and improved ADL in favour of augmented CCT may not be unconnected to the improved functions in the upper and lower extremities demonstrated by the augmented CCT groups. Studies have reported the positive influence of improved upper extremity (Kim, 2016; Park, Chang, Kim & An, 2015) and lower extremity functions (Fujita et al, 2015; Batista et al, 2014) on enhanced ADL among stroke survivors.

5.4.3 Participation

Participation is the most complex category of the ICF and a highly targeted aim of any comprehensive stroke rehabilitation programme (Silva et al, 2013; Silva et al, 2015). To the researcher's knowledge, no study has included participation measure in investigating the effectiveness of augmented exercise therapy to date. In fact, Veerbeek et al (2011) identified this gap in a meta-analysis and recommended the inclusion of participation

measures in the evaluation of the effectiveness of additional therapy. The outcome of this study on participation is based on the eight domains (family roles, language, mobility, self-care, social roles, thinking, upper extremity function and work/productivity) defining participation on Stroke Specific Quality of Life (SSQOL), result showed significant between-group differences in six domains (family roles, mobility, self-care, social roles, upper extremity function and work/productivity) and the overall participation score in favour of augmented CCT. Of the six domains participants in 120CCT performed significantly better than both 60CCT and the Control in work/productivity, they, however, only performed better than the control in mobility and overall participation. The implication of this finding is that for overall participation, augmented CCT is not significantly better for the same type of training programme, but significant for a different type of training programme (standard physiotherapy). The finding suggested that the difference found was sustained six months post-training. The convincing finding favouring augmented CCT over the Control may largely be due to the characteristic feature of the CCT, such as the group dynamics which seem to have a motivating effect in encouraging patients to push harder as well as develop an attitude towards competitiveness to be able to accomplish as many tasks as possible. Koh, Barr and George (2014) found motivation to be a key factor influencing participation among stroke survivors living in the community post-hospital discharge. The improved and better participation among participants in the augmented CCT group can also possibly be due to improvement in functional capacity following the intervention. As a measure of functional capacity 6MWT has been found to correlate positively with hand function, strength, mobility ADL/IADL and participation post stroke (Almkvist-Muren, Hütler & Hoope, 2008). Similarly, Bijleveld et al (2013) reported that gait speed and walking distance are equally identified as better predictors of community walking; and community walking is a major factor for remarkable participation

after stroke. Furthermore, Alzahrani, Dean and Ada(2011) reported in a summary of their findings on this subject that if walking performance (6MWT) is poor after stroke activities at home and in the community will be limited so that people will become housebound and isolated from the society, the implication of which is reduced participation.

5.5 Acceptability

Successful implementation of a clinical trial requires the opinion of the user “buy-in” of the clinical content, positive/negative experience, ethical compliance and effectiveness. A key factor in determining whether or not a clinical finding can be translated into clinical practice is to assess its acceptability. Acceptability is a measure of feasibility in this study, that is to say, acceptance of the intervention by participants would guarantee an evidence that the intervention can be translated into clinical practice. In this study, acceptability was monitored both directly by allowing the participants to express their level of acceptance of the intervention through administering Treatment Acceptability Questionnaire (TAQ) (Hunsley, 1992) and through taking the record of the withdrawal or drop-out rate from each group and the study on overall (Mehrholz, Hädrich, Platz, Kugler & Pohl, 2012). No drop-out was recorded during the eight weeks training period; however, the loss to follow-up rate was 8%. The 100% adherence rate (absence of drop-out) suggests enormous acceptance of the intervention irrespective of the intensity. Kwakkel et al (2004) asserted that it is not usually feasible to administer > 2 hours therapy each for every patient or clinical setting due to poor tolerance of some patients to an extended session of therapy and availability of personnel. The present study is not in excess of 2-hours, which is probably why all participants, particularly in the 120CCT group tolerated the eight weeks therapy sessions. However, using TAQ to measure tolerance added more information regarding tolerance to each intensity of practice. There

is a marginal between-group significant difference in acceptance among the intervention groups in favour of low intensity of CCT; with participants in 60CCT showing better acceptance of their therapy than both 90CCT and 120CCT. This suggests that lower intensity of therapy are better tolerated by stroke survivors, while this is conceivable it is, however, important emphasise that intensity of practice is an important component influencing the outcome of a rehabilitation programme in stroke (Schneider et al, 2016; Veerbeek et al, 2011, Cooke et al, 2010a), but such intensity must be tolerable and acceptable to the patient (Kwakkel et al, 2004).

5.6 Limitation of the study

There some limitations that may affect the generalizability of the findings of this study trial, such as listed below:

- This study is a moderately powered study. A highly powered study might yield a different outcome. However, because the population size was statistically determined, it is hoped that the outcome would enjoy a certain level of generalizability within the limit of the criteria of this study.
- Participants in this study are chronic stroke survivors; the present findings may not be suitable for acute stroke survivors.
- The procedure used to track the intensity of training such as time spent practising and numbers of repetitions are not based on contemporary sophisticated recommended approaches, such as the use of videos. However, it is believed that having this information would add to the quality of the findings generated in this study.
- A key recommendation in clinical trials is to document information on adverse reactions such as fall rate during an intervention. Unfortunately, this data was not

obtained in this study. Although, such data would have contributed to the fidelity of the implementation of the training programme, the absence of this information does not affect the findings of this study.

- A battery of outcome measures was used to obtain patients' response to the training programme, however, most these outcomes measures were used as secondary outcome measures, as such; they may be prone to extraneous variables. This, therefore, suggests that all findings generated in the secondary outcome measures must be interpreted with caution.
- The interpretation of findings based on previous relevant related studies was difficult particularly in two categories of the ICF, i.e. the body structure/function and the participation. This is probably so, because to the best of the researcher's knowledge this is the first study to comprehensively use the ICF framework for the selection outcomes measures for the assessment of findings in an augmented intensity of therapy research.

5.7 Summary of this chapter

The present chapter discussed the findings of this study by relating findings to relevant related literature. The intensity of the CCT training programme was found to conform to the recommendation of previous meta-analyses on augmented therapy time. It was obvious for the literature that perspective in interpreting the findings of this study can be classified into two: effectiveness of higher intensity of CCT over the lower intensity of CCT and effectiveness of augmented CCT over the lower intensity of standard physiotherapy. The implication of these two interpretations is that comparison can be made within the same type of therapy to determine the true effect of augmenting therapy time and different type of therapy, in which both intensity and therapy. Data for

interpreting impairment and participation related measures following increased intensity are scarce, therefore, evidence supporting or contrasting finding were searched from other sources. Walking speed, walking distance and other gait related measures are the most highly researched measures in augmented exercise therapy studies.

6 CHAPTER SIX: SUMMARY, CONCLUSION, CLINICAL IMPLICATION, AND RECOMMENDATIONS

Research is an infinite journey, where one thinks it ends a new dream begins. (Isa Lawal, 2016)

6.1 Introduction

This study investigated the effectiveness of augmented duration of circuit class therapy in the rehabilitation of stroke survivors. This chapter presents abrief summary of the study; the conclusion of the major findings and achievements of this study. It describes the extent to which each of the study research question and the objective was accomplished. Finally, the contributions of the study findings to clinical practice and recommendations for future studies are presented.

6.2 Summary

This study investigated the effectiveness of structured augmented CCT model in the rehabilitation of stroke survivors. In practice the principle for the administration of CCT is premised on two theories, including; first to increase the amount of active repetitive practice and second is to enhance cost-effective rehabilitation. However, the intensity with which gain can be attained still needs to be investigated. The present study investigated three different intensities of CCT and standard physiotherapy in the rehabilitation of stroke survivors. Using a battery of ICF compliant outcome measures participants were assessed at baseline (prior to the intervention), post intervention and at six months follow-up. Assessment conducted include muscle strength and spasticity (body structure/function), walking distance, gait speed, real world upper extremity function, upper extremity function and dexterity, basic ADL, global disability level (activity

limitation), community participation (participation restriction) and acceptability of allocated intensity of practice.

Study findings demonstrated that irrespective of the ICF category there is a general trend towards a dose-response relationship, implying improving outcome at higher intensities of CCT. However, statistically significant improvements are found at the ICF category of activity and are more likely at the lower extremity than the upper extremity.

6.3 Conclusion

There was an obvious trend in the effectiveness of augmented duration of circuit class therapy in the rehabilitation of body structural/functional limitations (impairment), activity limitation and participation restriction in chronic stroke survivors. Comparison within the intervention groups (the same type of therapy) suggests that high-intensity CCT (120CCT) is better than the low-intensity CCT (60CCT) in real world upper extremity function (assessed by MAL), gait speed (assessed by 10MWT) and basic ADL (assessed by MBI). Augmented CCT seems to be potentially more effective in many variables against standard physiotherapy, these include walking distance (as measured by 6MWT), spasticity particularly of the hip and knee extensors (measured by MTS), real world upper extremity function (measured by MAL),basic ADL (measured by MBI) and participation (measured by SSQOL). In the three ICF categories the activity category depicted a greater response to augmented CCT(when the same type or different type of training programmes are involved) and the less responsive is the body structure/function component. The greater effectiveness is not surprising given the nature of CCT is primarily task-specific practice which by definition is aimed at real world activity practice.

The results indicated better responses in the lower extremity functions than the upper extremity, although both extremities indicated a trend for a dose-response to CCT.

6.4 Conclusions based on research questions and objectives

In this section each research question was followed by its targeted objective and the conclusion of the study finding of the research question/the objective is given.

Q1: What is the effect of a structured CCT model on body structure/function (impairment) in stroke survivors?

> ***Obj1:*** *To determine the effect of varying durations (intensity) of CCT on body function/structure following CCT in stroke survivors.*

Findings on upper extremity muscle strength indicated improved muscle strength in all groups of muscles tested, evident by the effect of time, which suggested better muscle strength across the three test periods (baseline, post intervention and 6-month follow-up). There was evidence of group effect at the multivariate level of testing, but the univariate analyses of individual muscle groups showed no significant group differences in upper extremity muscle strength as measured by Manual Muscle testing. This outcome identified improvement across the three test periods, but could not find differences between groups, implying that there were no significant differences between augmented CCT groups and the control in upper extremity muscle strength. It is not possible to differentiate between the effect of time (spontaneous recovery) versus a training effect from any of the four arms (three interventions or standard physiotherapy).

Conclusion*: There is improved upper extremity muscle strength using CCT and there is a trend towards dose-response relationship going by the multivariate analysis.*

In the lower extremity participants showed evidence of improved muscle strength in all groups of muscles across the three test periods, suggesting either a time effect or a training effect as improvement was seemingly more pronounced descriptively in 120CCT in all the groups of muscles, while a certain level of decline was noticeable in few groups of muscles in the remaining study groups. There is a significant time by group effect at multivariate level, no significant group effects were found at the univariate level for individual muscle groups. These findings suggest that augmented duration of therapy does not differ significantly from the control in influencing lower extremity muscle strength.

Conclusion: *There is mixed evidence for improved lower extremity muscle strength following the training and a trend towards a dose-response in lower extremity muscles strength.*

Findings regarding spasticity in the upper extremity indicated significantly improved spastic angle in the shoulder and wrist across the three test periods using the MTS. Outcomes indicated a declining effect at 6-months follow-up for the wrist joint. Time by group interaction univariate tests indicated significant differences in all the three joints (shoulder, elbow and wrist), however, a between-group effect was only found in the elbow joint, with 120CCT being better than 60CCT and the control.

Conclusion: *There is evidence for widening spastic angles following training and a dose-response for improved spasticity following augmented CCT.*

Improvement was found both for the same type of training programme (high-intensity versus low-intensity CCT) and different training programme (high-intensity CCT versus standard physiotherapy).

To assess spasticity in the lower extremity the extensor pattern was used in three joints (hip, knee and ankle) of the lower extremity. Study outcomes based on univariate tests indicated a significant effect of time and time by group interaction in all the three measures. Improvement followed through across the three test period for all the joints except the ankle where there was a better post-intervention outcome over follow-up in ankle spastic angle, signifying a waning of effect. For time by group interaction 120CCT was better than the control in the hip spastic angle and better than 60CCT and the control in knee spastic angle.

Conclusion: *There is indication of a training effect for lower extremity spasticity. Higher augmented CCT was effective over lower dose CCT in the knee and also better than the control for the hip and knee. Augmented CCT seems to better influence lower extremity spasticity than the upper extremity.*

Q2: What is the effect of a structured CCT model on activity limitations (functional activities) experienced by stroke survivors?

> ***Obj2:*** *To determine the effect of varying durations of CCT on activity following CCT in stroke survivors.*

Results of measures of activity limitation indicated a statistically significant main effect of time in all measures with very large effect sizes in all the measures. The main effect of time suggested significantly better performances at both outcome and follow-up for all

measured variables. Additionally, MBI (activities of daily living) indicated significantly improved follow-up over outcome for the main effect of time. In time by group interactions, six measures (ARAT, 10MWT, MBI, 6MWT, AOU and QOU) indicated a significant interaction with effect sizes ranging from small (MBI) to very large (10MWT). In between group differences, 120CCT showed a significantly improved real world upper extremity function (AOU and QOU) above 60CCT and the control, while 90CCT showed better performance in AOU over the control; implying better performances in high-intensity CCT over low-intensity CCT and the control. In lower extremity functions of gait and walk distance, 120CCT demonstrated significantly improved gait speed (10MWT) over 60CCT and the control, while 90CCT showed better performance in gait speed over the control. Findings on walking distance only indicated better performance of 120CCT over the control. Participants in 120CCT also showed better performances in activities of daily living (MBI) over 60CCT and the control, while 90CCT was better than the control.

Conclusion: *Participants showed improved performances in function following augmented CCT in both upper and lower extremities. Findings generally suggest a dose-response effect for activity. High and moderate intensity CCTs (120CCT and 90CCT respectively) were more effective in activity-related variables than both low-intensity CCT (60CCT) and the control. The findings summarily support the dose-response hypothesis on augmented exercise practice and activity-related outcomes post stroke.*

Q3: What is the effect of the structured CCT model in influencing participation restrictions suffered by stroke survivors?

> ***Obj3****: To determine the effect of varying duration of CCT on participation following CCT in stroke survivors.*

Participation restriction (SSQOL) findings indicated statistically significant main effects of time in all the eight participation domains of SSQOL and their total score. Between groups differences following simple contrast indicated significant differences in six domains (family roles, mobility, self-care, social role, upper extremity function and work/productivity) plus the total SSQOL score. Differences in the main effect of time suggested consistently improved outcome and follow-up measures over the baseline in all the domains of SSQOL and the overall score. Participants in 120CCT showed better performances than the control in mobility, work productivity and total SSQOL participation; the participants in 120CCT were likewisey, better than those in 60CCT in work productivity. Participants in 90CCT exhibited better performances in work/productivity and overall SSQOL than participants in the control. Differences within group indicated that consistently better outcome and follow-up measures over baseline in most measures at varying degrees, with 120CCT and 90CCT indicating differences in most measures. It is also worth noting that within group difference in the control group showed improved overall SSQOL of outcome over baseline, suggesting that improvement is not restricted to the intervention groups with regards to participation restriction.

Conclusion: *Additional CCT is effective in improving participation post-stroke. A dose-response effect exists in the enhancement of participation among stroke survivors using CCT.*

6.5 Contributions and clinical implication of the study

This section highlights what may be considered contributions this study has addressed and the clinical implication of the study findings.

6.5.1 Contributions of the study

The following are the contributory features of this study:

- To the researcher's knowledge, this is the first study on augmented intensity of exercise in stroke survivors that judiciously incorporates the three ICF categories in the assessment of outcome as a framework. No previous study to the researcher's knowledge has from the outset planned to examine participation following augmented intensity of exercise therapy as affirmed by a systematic review (Veerbeek et al, 2011).
- To the researcher's knowledge, this is the first study to investigate the effectiveness of an augmented exercise therapy approach in which both the same type and different types of training (content of training) were both examined using varying intensities of therapy.
- To the researcher's knowledge this the first study involving Circuit Class Therapy where the same type of therapy is being tested (i.e. high, moderate and low dose of CCT).
- This study was able to capture two pieces of important fidelity data: the repetitive practice and time spent through the training sessions.

6.5.2 Clinical implications of the study

It is expected that the findings of this study will:

- Aid in the selection of an effective dose for circuit class therapy in clinical practice.
- Provide further evidence that chronic stroke survivors do have a remarkable chance to improve in function using appropriate therapeutic approach and required dose to stimulate a change.

- Indicate that focused exercise therapeutic interventions such as Circuit Class Therapy are effective at the level of impairment, activity and participation and they should form the basis for contemporary stroke rehabilitation plans.
- Suggest that a moderate increase in the intensity of focused exercise therapy training for stroke rehabilitation in the clinic will bring a greater change than conventional treatment and as such should be encouraged.
- Aid the adoption of Circuit Class Therapy in low-income to middle-income countries and particular the feature of reduced therapist to patient ratio, which will highly benefit patient care in this region due to low level of staffing.

6.6 Recommendations

Based on the findings and observations made during the conduct of this study the following are made:

- The use of circuit class therapy is still new in many settings, it is important to develop a training guide to assist clinicians in the implementation of this approach.
- Several studies have recommended the need to investigate the cost-effectiveness of circuit class therapy, to add to such voices, it is recommended that the cost-effectiveness should be tested in both high-income and low to middle-income countries as the economic challenges in these regions are different.
- This study is moderately powered, it is, therefore, recommended that a higher powered study should be conducted to further confirm the findings of this study
- Participants in this study are chronic stroke survivors; it is, therefore, recommended that acute stroke survivors should be investigated using similar research procedure.

- The study design is characteristically quantitative, getting to have feedbacks from patients following treatment with regards to how exhaustive is the additional therapy and how negative or positive they perceive the treatment through a qualitative research would add credence to both the use of circuit class therapy and the appropriate time for practice.

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8 APPENDICES

APPENDIX 1

Protocol

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STUDY PROTOCOL Open

Effectiveness of a structured circuit class therapy model in stroke rehabilitation: a protocol for a randomised controlled trial

Isa U. Lawal[1,4*], Susan L. Hillier[2†], Talhatu K. Hamzat[3†] and Anthea Rhoda[1†]

Abstract

Background: Currently, the key advocacy in neuroscientific studies for stroke rehabilitation is that therapy should be directed towards task specificity performed with multiple repetitions. Circuit Class Therapy (CCT) is well suited to accomplish multiple task-specific activities. However, while repetitive task practice is achievable with circuit class therapy, in stroke survivors repetitive activities may be affected by poor neurologic inputs to motor units, resulting in decreases in discharging rates which consequently may reduce the efficiency of muscular contraction. To accomplish multiple repetitions, stroke survivors may require augmented duration of practice. To date, no study has examined the effect of augmented duration of CCT in stroke rehabilitation, and specifically what duration of CCT is more effective in influencing functional capacity among stroke survivors.

Methods/design: Using a randomised controlled trial with blinded outcome assessment, this study is aimed at determining the effectiveness of structured augmented CCT in stroke rehabilitation. Sixty-eight stroke survivors (to be recruited from a tertiary health institution in Kano, Northwest, Nigeria) will be randomised into one of four groups: three intervention groups of differing CCT durations namely: 60 min, 90 min, and 120minuntes respectively, and a control group. Participants will take part in an 8-week structured intensive CCT intervention. Participants will be assessed at baseline, post-intervention, and six-month follow-up for the effectiveness of the varied durations of therapy, using standardised tools. Based on the WHO-ICF model, the outcomes are body structure/function, activity limitation, and participation restriction measures.

Discussion: It is expected that the outcome of this study will clarify whether increasing CCT duration leads to better recovery of motor function in stroke survivors.

Trial registration: Pan African Clinical Trial Registry (PACTR): PACTR201311000701191

Keywords: Stroke, ICF model, Circuit class therapy, Exercise intensity, Neuro-rehabilitation

APPENDIX 2
Protocol registration

SOUTH AFRICAN COCHRANE CENTRE

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Francie van Zijl Drive, Parow Valley, Cape Town
Tel: +27 21 938 0438; Fax: +27 21 938 0836
E-mail: cochrane@mrc.ac.za

28 November 2013

To Whom It May Concern:

RE: Effectiveness of a structured circuit class therapy model in stroke rehabilitation: a single blind randomized controlled trial.

As project manager for the Pan African Clinical Trial Registry (www.pactr.org) database, it is my pleasure to inform you that your application to our registry has been accepted. Your unique identification number for the registry is **PACTR201311000701191.**
Please be advised that you are responsible for updating your trial, or for informing us of changes to your trial.
Additionally, please provide us with copies of your ethical clearance letters as we must have these on file (via email, post or fax) at your earliest convenience if you have not already done so.
Please do not hesitate to contact us at +27 21 938 0835 or email epienaar@mrc.ac.za should you have any questions.

Yours faithfully,
Elizabeth D Pienaar
www.pactr.org
Project Manager +270 21380835

PACTR
PAN AFRICAN CLINICAL TRIALS REGISTRY

APPENDIX 3
CONSENT FORM

Participant consent form (English Language)

UNIVERSITY OF THE WESTERN CAPE

Private Bag X 17, Bellville 7535, South Africa

Tel: +27 21-959, Fax: 27 21-959

E-mail: isalawal30@yahoo.com

Title of Research Project: Effectiveness of a structured circuit class therapy model in stroke rehabilitation in Nigeria: a single blind randomized controlled trial

The study has been described to me in language that I understand and I freely and voluntarily agree to participate. My questions about the study have been answered. I understand that my identity will not be disclosed and that I may withdraw from the study without giving a reason at any time and this will not negatively affect me in any way.

Participant's name……..
Participant's signature…….
Witness…….
Date……

Should you have any questions regarding this study or wish to report any problems you have experienced related to the study, please contact the study coordinator:

Study Coordinator's Name: Isa Usman Lawal

University of the Western Cape

Private Bag X17, Belville 7535

Telephone: (021)959-2542

Cell: 0785217666

Email: isalawal30@yahoo.com

APPENDIX 4
STUDY PROFORMA

SECTION I

A. Socio-demographic characteristics of participants

Personal information (Bio-data)

Age _____
Sex _____
Height _____
Weight _____
Marital status
Pre-stroke _____
Post-stroke _____
Educational qualification _____
Occupation
Pre-stroke _____
Post-stroke _____
Tribe _____

B. Stroke specific information

Time since stroke (in months) _____
Type of stroke _____
Hemispheric side of lesion _____
Use of cane/stick Yes_____ No_____

SECTION II (BASELINE CRITERION MEASURES)

Total scores of all the measures will be recorded as follows:

A. Body structure/function measures

1. Modified Tadieu Scale (MTS): has two representative measures
   i. Quality of muscle reaction "R"_____
   ii. Angle of catch "A"_____
2. Manual Muscle Test (MMT): three upper and lower extremity assessments will be conducted in sagittal or frontal planes or both as it is relevant to a specific joint muscle component

Upper extremity	Sagittal	Frontal
Shoulder	_____	_____
Elbow	_____	_____
Wrist	_____	_____
Lower extremity		
Hip	_____	_____
Knee	_____	_____
Ankle	_____	_____

B. Activity Limitation **Score**

1. Modified Rankin Scale (MTS) _____
2. Six-minute walk test (6MWT) _____ in meters
3. 10-meter walk test(10MWT) _____ in m/s
4. Action Research Arm Test (ARAT) _____

5. Motor Activity Log (MAL)
    i. Quality of Movement (QOM) _____
    ii. Amount of Use (AOU) _____
6. Stroke Specific Quality of Life Questionnaire _____

SECTION III (POST INTERVENTION MEASURES)

All the baseline measures will be replicated and recorded in this section. However, acceptability measure will be added in this section as follows:

	Score
Acceptability	_____

SECTION IV (SIX-MONTH FOLLOW-UP MEASURES)

All baseline measures will be replicated here and recorded and no acceptability record.

APPENDIX 5

PILOT STUDY

Introduction

This study is designed to investigate the effectiveness of structured augmented circuit class therapy in the rehabilitation of stroke survivors.

Aim

The aim of the pilot study is to determine the feasibility of conducting this study in the setting and to ascertain the likely challenges that might be encountered during the main study.

Methods

Participants were recruited when they were certified eligible to participate using the study inclusion criteria. A total of 15 participants were recruited to participate in this pilot study with 5 participants were randomised into the three treatment durations (60CCT, 90CCT and 120CCT). All participants were assessed at baseline before the intervention, immediately after the intervention (post intervention) and at follow-up. The training included a 2-week, 3-days per week and 2-week follow-up.

The Circuit Class Therapy (CCT) was conducted using 10 workstations using activities presented in the proposal (here in chapter 3). Each workstation houses task specific activities for either of upper and lower extremity activities, being placed alternately across the circuit (i.e. after every lower extremity workstation follows an upper extremity workstation and vice versa, ensuring a 1:1 ratio of upper to lower extremity activities. This is to allow for adequate concentration, specificity of activity choice and distribution of equal activity duration for the upper and lower extremities in a structured manner. Progression (of the activities) was ensured as participants proceed from one workstation

to the next by the therapists in charge. A minute change period (within the duration of intervention) was be allowed for changing from one workstation to the next. Assessments of the impact of the CCT included body structure and function, activity and participation using all the instruments described in the study proposal. The assessments at this level (pilot study) were monitored by the researcher who guided the Research Assistants (RAs) involved in either data collection or implementation of the CCT training.

Results

Feasibility

Two distinct procedures were used to assess the feasibility of the study at this stage, these included attendance/adherence rate and the use of treatment acceptability questionnaire. Findings indicated that during the two weeks treatment sessions none of the 15 participants missed a single of the therapy sessions and adverse effect was recorded. Additionally, all participants regardless of their group found the training practicable and achievable.

Activity limitation results

Two weeks Circuit Class Therapy depicted a significant difference in mobility in the lower extremityin the three groups (Roy's largest root $F(2,10) = 7.91$, $P = 0.009$). However, no significant difference were found in upper extremity function (Roy's largest root $F(2,10) = 4.05$, $P = 0.063$). The differences in mobility between participants in groups A and C, with group C participants exhibiting better performance in mobility (Post hoc test).

Conclusion: Two weeks CCT programme could potentially increase gait speed and functional capacity when performed for a longer duration per session of treatment, but appears too short to influence change in upper extremity function and ADL. By implication longer session of circuit class therapy potentially increase mobility in the lower extremity

in two weeks but is not enough to influence mobility in the upper extremity within this short term.

Implications: Stroke survivors would need the augmented duration of therapy time to allow for multiple repetitions in circuit class therapy to yield a beneficial effect on mobility function.

APPENDIX 6
ETHICAL APPROVAL (UWC)

UNIVERSITY of the
WESTERN CAPE

OFFICE OF THE DEAN

DEPARTMENT OF RESEARCH DEVELOPMENT

7 November 2013

To Whom It May Concern

I hereby certify that the Senate Research Committee of the University of the Western Cape approved the methodology and ethics of the following research project by: Mr IU Lawal (Physiotherapy).

Research Project: Effectiveness of a structured circuit class therapy model in stroke rehabilitation: a single blind randomized controlled trial.

Registration no:13/9/33

Any amendments, extension or other modifications to the protocol must be submitted to the Ethics Committee for approval.

The Committee must be informed of any serious adverse event and/or termination of the study.

Ms Patricia Josias
Research Ethics Committee Officer
University of the Western Cape

Private Bag X17, Bellville 7535, South Africa
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E: pjosias@uwc.ac.za
www.uwc.ac.za

A place of quality,
a place to grow, from hope
to action through knowledge

APPENDIX 7
ETHICAL APPROVAL (AKTH)

APPENDIX 7

AMINU KANO TEACHING HOSPITAL

P. M. B. 3452, ZARIA ROAD, KANO.

(☎: 07068297399,) www.akth.org.ng, E-mail: enquiries@akth.org.ng, email: (akthkano@yahoo.com)

CHAIRMAN BOARD OF MANAGEMENT	CHIEF MEDICAL DIRECTOR	CHAIRMAN M. A. C.	DIRECTOR OF ADMINISTRATION
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NHREC/21/08/2008/AKTH/EC/1232

AKTH/MAC/SUB/12A/P-3/VI/1332 **4th June, 2014**

Isa Usman Lawal
Department of Physiotherapy
AKTH, Kano

Ufs:

The Head of Department
Physiotherapy
AKTH, Kano

ETHICAL APPROVAL

Refer to the request for approval in respect of your research proposal titled "Effectiveness of A Structured Circuit Class Therapy Model in Stroke Rehabilitation: A Single Blind Randomized Trial", the Committee reviewed the proposal and noted same as a Prospective Study.

In view of above, Ethical approval is given to conduct the research.

However, the approval is subject to periodic reporting of the progress of the study and its completion to the Research Ethical Committee.

Regards

Barrister Bara'atu Aliyu-Datti
Secretary, Research Ethical Committee
For: Chairman

APPENDIX 8

Participant consent form (English Language)

UNIVERSITY OF THE WESTERN CAPE

Private Bag X 17, Bellville 7535, South Africa

Tel: +27 21-959, Fax: 27 21-959

E-mail:isalawal30@yahoo.com

INFORMATION SHEET

Project Title:EFFECTIVENESS OF A STRUCTURED CIRCUIT CLASS THERAPY MODEL INSTROKE REHABILITATION IN NIGERIA: A SINGLE BLIND RANDOMIZED CONTROLLEDTRIAL

What is this study about?

This is a research project being conducted by Isa Usman Lawal at the University of the Western Cape. We are inviting you to participate in this research project because you are a stroke patient and because you are receiving treatment at Aminu Kano Teaching Hospital, Kano, Nigeria. The purpose of this research project is to determine the effectiveness of structured circuit class therapy in the context of increased durations of therapy.

What will I be asked to do if I agree to participate?

You will be asked to participate in a 24 session, three time weekly circuit class therapy, which is a structured progressive exercise training programme, for a period of in the 8-weeks, you programme might be of 60min, 90min or 120min depending on the group you are allocated to. You will be assessed using standard procedures to determine the effectiveness of this procedure at three different times including before the treatment, after 8-weeeks and six-months after completion of the therapy

Would my participation in this study be kept confidential?

We will do our best to keep your personal information confidential. To help protect your confidentiality, all questionnaires are anonymous, you will be identified by code and you will not be personally identified in any publication emerging from this study.

If we write a report or article about this research project, your identity will be protected to the maximum extent possible.

What are the risks of this research?

There are no known risks associated with participating in this form of therapy and as such no risk in participation in this study.

What are the benefits of this research?
The benefits to you include improve cardiovascular endurance, balance, hand function/mobility, gait speed, faster rate of accomplishing task, and improved community participation. Similarly, your participation will aid in appreciating a new concept in increased intensity in this model therapy.

Do I have to be in this research and may I stop participating at any time?
Your participation in this research is completely voluntary. You may choose not to take part at all. If you decide to participate in this research, you may stop participating at any time. If you decide not to participate in this study or if you stop participating at any time, you will not be penalized or lose any benefits to which you otherwise qualify. Similarly, if there arise any unforeseen circumstance where you develop any medical related or unrelated to your primary condition which might affect the present study, your participation will be terminated.

Is any assistance available if I am negatively affected by participating in this study?
You will be referred to the appropriate expert should there be any problem at the course of participating in this study.

What if I have questions?
This research is being conducted by**Isa Usman LAWAL of Department of Physiotherapy**at the University of the Western Cape. If you have any questions about the research study itself, please contact:
Isa Usman LAWAL
Cell number: +27804061776 or +2347033318835
E-mail: isalawal30”yahoo.com

Should you have any questions regarding this study and your rights as a research participant or if you wish to report any problems you have experienced related to the study, please contact:

Head of Department: Professor Anthea Rhoda

Dean of the Faculty of Community and Health Sciences: Professor Jose Frantz

University of the Western Cape

Private Bag X17

Bellville 7535

This research has been approved by the University of the Western Cape's Senate Research Committee and Ethics Committee.

APPENDIX 9

Modified Tardieu Scale

Guide

Quality of movement mobilization

0. No resistance throughout the course of the passive movement
1. Slight resistance throughout the course of passive movement, no clear catch at a precise angle
2. Clear catch at a precise angle, interrupting the passive movement, followed by release
3. Fatigable clonus with less than 10 seconds when maintaining the pressure and appearing at the precise angle
4. Unfatigable clonus with more than 10 seconds when maintaining the pressure and appearing at a precise angle
5. Joint is fixed

V: Measurements take place at three different velocities

a. V1 As slow as possible
b. V2 Speed of limb segment falling under gravity
c. V3 As fast as possible

Y: Angle of catching (muscle reaction)

Assessments

Baseline

Upper limb function

	Flexors	Extensors	Abduction	Adduction
a. Shoulder	_____	_____	_____	_____
b. Elbow	_____	_____	_____	_____
c. Wrist	_____	_____	_____	_____

Lower limb function

	Flexors	Extensors	Abductors	Adductors
a. Hip	_____	_____	_____	_____
b. Knee	_____	_____	_____	_____
c. Ankle	_____	_____	_____	_____

Outcome following 2-month intervention

Upper limb function

	Flexors	Extensors	Abduction	Adduction

d. Shoulder _____ _____ _____ _____
e. Elbow _____ _____ _____ _____
f. Wrist _____ _____ _____ _____

Lower limb function

	Flexors	**Extensors**	**Abductors**	**Adductors**
d. Hip	_____	_____	_____	_____
e. Knee	_____	_____	_____	_____
f. Ankle	_____	_____	_____	_____

Six-month follow-up assessment

Upper limb function

	Flexors	**Extensors**	**Abduction**	**Adduction**
g. Shoulder	_____	_____	_____	_____
h. Elbow	_____	_____	_____	_____
i. Wrist	_____	_____	_____	_____

Lower limb function

	Flexors	**Extensors**	**Abductors**	**Adductors**
g. Hip	_____	_____	_____	_____
h. Knee	_____	_____	_____	_____
i. Ankle	_____	_____	_____	_____

APPENDIX 10

Manual Muscle Testing scale

Baseline assessments

Upper limb function

	Flexors	Extensors	Abduction	Adduction
j. Shoulder	_____	_____	_____	_____
k. Elbow	_____	_____	_____	_____
l. Wrist	_____	_____	_____	_____

Lower limb function

	Flexors	Extensors	Abductors	Adductors
j. Hip	_____	_____	_____	_____
k. Knee	_____	_____	_____	_____
l. Ankle	_____	_____	_____	_____

Outcome following 2-month intervention

Upper limb function

	Flexors	Extensors	Abduction	Adduction
m. Shoulder	_____	_____	_____	_____
n. Elbow	_____	_____	_____	_____
o. Wrist	_____	_____	_____	_____

Lower limb function

	Flexors	Extensors	Abductors	Adductors
m. Hip	_____	_____	_____	_____
n. Knee	_____	_____	_____	_____
o. Ankle	_____	_____	_____	_____

Six-month follow-up assessment

Upper limb function

	Flexors	Extensors	Abduction	Adduction
p. Shoulder	_____	_____	_____	_____
q. Elbow	_____	_____	_____	_____
r. Wrist	_____	_____	_____	_____

Lower limb function

	Flexors	Extensors	Abductors	Adductors

p. Hip	_____	_____	_____	_____
q. Knee	_____	_____	_____	_____
r. Ankle	_____	_____	_____	_____

APPENDIX 11

Modified Rankin Scale (MRS)

MODIFIED	**Patient Code**:	
RANKIN	**Rater Name:**	
SCALE(MRS)	**Date:**	

Score	Description
0	No symptomsatall
1	No significantdisabilitydespitesymptoms;ableto carryoutallusualdutiesandactivities
2	Slightdisability;unableto carryoutallpreviousactivities,butableto lookafterownaffairs withoutassistance
3	Moderatedisability;requiringsomehelp,butableto walk withoutassistance
4	Moderatelyseveredisability;unabletowalk withoutassistanceandunabletoattendtoownbodily needs withoutassistance
5	Severedisability;bedridden,incontinentandrequiringconstantnursingcareandattention
6	Dead

TOTAL (0–6): ___

APPENDIX 12A
MODIFIED BARTHEL INDEX

INDEXI	SCORE	DESCRIPTI
CHAIR/BED TRANSFERS	0	Unable to participate in a transfer. Two attendantsarerequired totransfer the patient with orwithout amechanical device.
	3	Able to participatebutmaximumassistanceof oneotherperson isrequireinallaspectsof the transfer.
	8	The transfer requires the assistanceofoneotherperson. Assistancemay be requiredin anyaspect ofthe transfer.
	12	The presenceof another person is requiredeitherasa confidence measure, or to provide supervision for safety.
	15	Thepatient can safely approach thebed walkingorina wheelchair, lockbrakes, lift footrests,orposition walking aid,move safely to bed, lie down, come toa sitting position onthe sideof thebed, change theposition of the wheelchair, transfer back into it safelyand/or grasp aidand stand. The patient must be independent in all phases of this activity.
AMBULATION	0	Dependent inambulation.
	3	Constant presenceof one ormoreassistant isrequired duringambulation. Assistanceis required withreachingaids and/ortheirmanipulation. One personis requiredto offer assistance.
	8	The patient is independent in ambulation but unable towalk 50 metreswithout help, or supervisionisneeded for confidence or safety in hazardoussituations.
	12	Thepatient must be able to wear braces if required, lockand unlock thesebraces assume standingposition, sit down, andplace thenecessary aidsinto positionfor use. Thepatient must beable to crutches, canes, or a walkarette, andwalk50 metres withouthelp or supervision.
	15	

AMBULATION/ WHEELCHAIR ***(Ifunabletowalk) Onlyuse this item ifthe patientisra ted"0" for Ambulatio n, and then only ifthe patienthas been trained in wheelchair manageme**	0 1 3 4 5	Dependent inwheelchair ambulation. Patient can propel self short distancesonflat surface, but assistance isrequired for all other stepsofwheelchair management. Presenceof oneperson isnecessary and constant assistanceis requiredto manipulate chair totable, bed,etc. Thepatient canpropel selffor areasonableduration over regularly encountered terrain. Minimal assistance may still be requiredin "tight corners" or to negotiate akerb 100mmhigh. Topropel wheelchairindependently,thepatient must beable to go aroundcorners, turnaround, manoeuvre the chair toa table, bed,toilet, etc.The patient must be able topusha chair at least 50metresandnegotiate akerb.

IN	SCORE	DESCRIPTION
STAIR CLIMBING	0 2 5 8 10	Thepatient is unable toclimbstairs. Assistanceis required in all aspectsof chair climbing, including assistance with walkingaids. Thepatient is able to ascend/descend but isunabletocarrywalkingaidsandneeds supervision and assistance. Generally noassistance isrequired. Attimes supervision is requiredfor safety due to morning stiffness,shortnessofbreath, etc. Thepatient is able to go upand down aflight of stairssafely withouthelp or supervision. The patient is able to usehand rails, caneor crutcheswhen needed and is able to carry thesedevices ashe/she ascendsor descends.
TOILET TRANSFERS	0 2 5 8 10	Fully dependent in toileting. Assistance required inall aspectsof toileting. Assistancemay berequired withmanagement of clothing,transferring,or washinghands. Supervisionmay be required for safetywith normal toilet. A commode may be usedatnight but assistance is required for emptying and cleaning.

BOWEL CONTROL	0	Thepatient is bowel incontinent.
	2	Thepatientneedshelp toassume appropriate position,and with bowel movement facilitatory techniques.
	5	Thepatient can assume appropriateposition, but cannotuse facilitatory techniques or clean self without assistance and has frequent accidents. Assistanceis required with incontinence aids such aspad, etc.
	8	The patient may requiresupervision with theuse ofsuppository orenemaand has occasional accidents.
		Thepatient can controlbowelsandhasno accidents, canuse suppository,or take an
BLADDER CONTROL	0	Thepatient is dependent in bladder management, is incontinent,or has indwelling catheter.
	2	Thepatient is incontinent but is able to assist withthe application of aninternalor external device.
	5	Thepatient is generally dry byday,but not atnight and needs some assistance withthe devices.
	8	Thepatient is generally dry byday and night,but may have anoccasional accident or needminimal assistancewithinternalor external devices.
		The patient is able to controlbladder day andnight,and/or is independent with internalor externaldevices.

IND	SCORE	DESCRIPTION
BATHING	0	Total dependencein bathing self.
	1	Assistance is required in all aspectsofbathing, butpatient is able tomake some contribution.
	3	Assistanceis required witheither transfertoshower/bath orwith washing or drying; including inability to complete a task becauseof conditionor disease,etc.
	4	Supervisionis required for safety inadjustingthewater temperature, or in the transfer.

DRESSING	0 2 5 8	Thepatient is dependent inall aspectsof dressing andisunable to participate in the activity. Thepatient is able to participate to some degree, but isdependent inall aspectsof dressing. Assistance is neededin puttingon, and/or removingany clothing. Only minimal assistance is required with fastening clothing such asbuttons,zips, bra,shoes,etc.
P ***E*** ***R*** ***S*** ***O***	0 1 3 4	Thepatient is unabletoattendto personal hygieneandisdependent inall aspects. Assistance is required in all stepsof personal hygiene, butpatient able tomake some contribution. Some assistance is requiredinoneor moresteps of personal hygiene. Patient is able to conducthis/her ownpersonal hygiene but requiresminimal assistancebeforeand/or after theoperation. Thepatient canwash his/her hands andface, combhair, clean teeth and shave. A
FEEDING	0 2 5 8	Dependent inall aspects and needstobefed,nasogastricneedsto beadministered. Canmanipulatean eatingdevice, usually aspoon, but someonemust provide active assistanceduring the meal. Able to feed selfwith supervision.Assistance isrequired with associated tasks suchasputtingmilk/sugar into tea,salt, pepper, spreading butter, turninga plateor other "setup"activities. Independence in feeding withpreparedtray, except may need meat cut, milk

SCORE	INTERPRETATION
00- 20	Total Dependence
21- 60	SevereDependence
61- 90	Moderate Dependence SlightDependence
91- 99	Independence

SCORE	P

Less Than 40 60 60 - 80 More Than 85	Unlikely to gohome - Dependent inMobility -Dependent inSelfCare Pivotal score wherepatientsmovefromdependency to assistedindependence. If living alone will probablyneedanumber of community services tocope.

APPENDIX 12B

BARTHEL INDEX HAUSA

SABUWAR HANYAR AWO TA BARTHEL: GWADA-DA -KANKA

Batu	Maki/Daraja	Bayani
Sauka daga kujera a hau gado	0	Majinyaci ba zai iya sauka daga kujera ya hau gado da kansa ba. Sai ya buqaci taimakon masu jinya aqalla biyu.
	3	Idan majinyaci zai iya yinqurin yin hakan amma tare da taimakawar mutum guda.
	6	Majinyaci Zai iya yi amma da buqatar 'yar taimakawa a wani mataki.
	12	Idan majinyaci zai iya, amma yana buqatar wani a kusa da shi kodai saboda ya sa-ido da yadda zai yi ko kuma dai domin samun qwarin guiwa.
	15	Majinyacin zai iya takawa da qafarsa zuwa gado, ko kuma idan a kujerar- turawa ne zai iya dakatar da ita sannan kuma ya sauko ya hau gado kana kuma ya kwanta da kansa, sannan ya iya tashi zaune a gefen gado, kana kuma ya tashi ya koma kan kujerar -turawar da kansa. Amma ya kasance shi ya yi waxannan abubuwa da kansa.
Kasa motsawa	0	Idan majinyaci ba ya iya motsawa sai an xauke shi.
	3	Idan majinyaci ya kasance sai ya buqaci taimakon mutum xaya ko biyu kafin ya motsa/tafiya.
	8	Idan majinyaci yana iya motsawa amma tare da taimakon abin dogarwa kamar sanda da sauransu, sannan kuma da wani mutum domin taimakawa.
	12	Idan majinyaci zai iya tafiya ba tare da wani taimako ba, amma kuma ba zai iya tafiyar da ta kai mita 50 ba tare da an sa-ido a kansa ba.
	15	Idan majinyaci zai iya xaura takalmi a qafarsa, sannan ya yinqura ya tashi tsaye da kansa sannan kuma ya zauna. Ko kuma idan majinyaci zai iya amfani da sanda ya yi tafiyar da ta kai mita 50 ba

		tare da an taimaka masa ba.
Kasa tafiya sai da kujerar turawa/ ko kuma xauka. **(idan majinyaci ba ya iya tafiya)**	0	Idan majinyaci ba ya tafiya sai a kujerar- turawa.
	1	Idan majinyaci zia iya tura kansa a kujerar -turawa, amma kuma ba zai iya sauran abubuwan da suka shafi kujerar ba sai an taimaka masa.
	3	Idan majinyaci yana buqatar taimako a qoqarin tura kujerar zuwa gado ko kuma teburin cin abinci.
	4	Idan majinyaci zai iya tura kansa a kujerar zuwa dukkan inda yake buqata, kuma xan taimako kaxan yake buqata a wurare masu wahala.
	5	Idan majinyaci zai iya tura kujerar zuwa kowane saqo, tun daga zuwa ban-xaki, teburin cin abinci da sauran wurare, kuma ya kasance zai iya yin haka har ya zuwa mita 50.

Batu	**Maki/Daraja**	**Bayani**
Hawa Bene/Matattakalar Bene	0	Idan majinyacin ba zai iya taka matattakalar bene ba.
	2	Idan majinyacin zai iya amma sai da taimaka masa a kowane mataki na hawa benen.
	5	Idan majinyacin zai iya hawa ko ya sauko amma ba zai iya aamma yana buqatar mai sa-ido da kuma xan taimaka masa.
	8	Idan majinyacin bay a buqatar wani taimako ko kaxan, sai dai mai sa-ido kawai saboda maganin ko-ta-kwana.
	10	Idan majinyacin zai iya takawa ya hau bene kuma ya sauko da kansa ba tare da wani taimako ko sa-ido ba. kuma zai iya hawan da sanda ko wani abin dogarawa idan da buqatar yin haka.

Batu	**Maki/Daraja**	**Bayani**
Zuwa Ban- xaki	0	**I**dan majinyaci ya dogara ga taimakon wani a duk harkokin da suka shafi ban xaki.
	2	Idan majinyaci yana buqatar taimakawa ga harkar

		da ta shafi ban xaki.
	5	Idan majinyaci zai iya buqatar taimako kamar wajen cire da sanya tufafi, ko wanke hannuwa da sauran su.
	8	Idan majinyaci yana buqatar sa-ido ne kawai saboda ko-ta-kwana. Amma kuma yana buqatar taimakawa wajen wanke wuri da gyara shi.
	10	Idan majinyaci zai iya hawa da sauka kan masai, sannan kuma ya iya sanya kayansa bayan y agama kuma yay i tsarki. Idan kuma da dare ne zai iya amfani da roba/fo amma kuma zai iya gyara shi ya wanke da kansa.

Batu	**Maki/Daraja**	**Bayani**
Sanya Tufafi	0	Idan majinyaci ya dogara ga taimako gaba xaya wajen sanya tufafi.
	2	Idan majinyacin zai iya yin wani xan yinquri, amma dai ya dogara ga wani wajen dukkan abin da ya shafi sanya tufafi.
	5	Idan majinyaci yana buqatar a taimaka masa wajen sanya tufafi.
	8	Idan majinyacin xan taimako kaxan kawai yake buqata wajen sanya tufafin kamar valla mavalli ko zif da sauran su.
	10	Idan majinyacin zai iya sanya tufafi masu wahalar sanyawa da kansa.
Batu	**Maki/Daraja**	**Bayani**
Kula da Tsafkar kai	0	Idan majinyacin ba zai iya kula da tsafkar kansa da kansa ba, ya dogara ne ga wani mutum wajen kulawa da shi.
	1	Idan majinyaci yana buqatar taimakawar wani, amma kuma zai iya xan tavuka wani abin.
	3	Idan majinyacin yana buqtara xan taimakawa kaxan wajen kula da tsaftar kansa.
	4	Idan majinyaci yana iya yi wa kansa komai da

		komai da ya shafi tsaftar kansa ba tare da ya nemi wani taimako da yaw aba.
	5	Idan majinyacin zai iya yiwa kansa wanka ko wankin jiki, sannan kuma ya shafa wa kansa mai sannan kuma y ataje wa kansa suma/gashi.sannan kuma majinyaci namiji ya iya amfani da reza ko aska ko kuma wani abin aski yay i kansa aski ko gyaran fuska, majinyaciya mace ta yi wa kanta kwalliiya.

Batu	**Maki/Daraja**	**Bayani**
Cin Abinci	0	Idan majinyacin ya dogara gaba xaya da wani ya ba shi abinci idan ya gama kuma ya gyara shi.
	2	Idan majinyaci zai xan iya gwada amfani da cokali amma kuma yana buqatar taimakawar wani yayin cin abincin.
	5	Idan majinyacin zai iya cin abinci da kansa sai dai kawai a taimaka masa wajen abubuwa masu wahala kamar zuba madara ko sukari cikin shayi ko shafa bota a kan biredi da sauransu.
	8	Idan majinyaci zai iya komai da komai da kansain banda kila bude gwangwani da rufe shi, ko yanka nama da sauransu.
	10	Idan majinyacin zai iya cin abinci da kansa da aka jera a kan tebur ko tabarma, kuma ya iya amfani da wuqa ya yanka nama da sauransu.

APPENDIX 13

Action Research Arm Test

ACTION	**PatientCode**:	
RESEARCH	**RaterName:**	
ARMTEST	**Date:**	

Instructions

Thereare foursubtests:Grasp,Grip,Pinch,and GrossMovement.Itemsineachareorderedsothat:

- Ifthe subjectpassesthefirst, nomoreneedto beadministeredand he scorestopmarksforthatsubtest;
- If the subjectfailsthefirst*and*failsthe second,hescoreszero,andagainnomoretestsneedto be performedinthatsubtest;
- Otherwise he needsto completealltasks withinthesubtest
- **Activity** **Score**

Grasp _____

1.Block,wood,10 cmcube(Ifscore= 3,total= 18andto Grip)Pickup a 10 cmblock _____

2.Block,wood,2.5cmcube(If score= 0, total=0 and go toGrip) Pickup 2.5cmblock _____

3.Block,wood,5 cmcube

4.Block,wood,7.5cmcube _____

5.Ball(Cricket),7.5cmdiameter _____

6.Stone10 x2.5x1 cm _____

Grip _____

1.Pourwaterfromglassto glass(Ifscore= 3, total=12,andgo to Pinch) _____

2.Tube2.25cm(Ifscore= 0, total= 0 and go to Pinch) _____

3.Tube1x16 cm

4.Washer(3.5cmdiameter)overbolt

Pinch

1.Ballbearing,6mm,3rd fingerandthumb(If score= 3, total= 18 and go to Grossmt) _____

2.Marble,1.5cm,indexfingerandthumb(Ifscore= 0, total= 0 and go to Grossmt) _____

3.Ballbearing2nd fingerandthumb

4.Ballbearing1st fingerandthumb

5.Marble3rd fingerandthumb _____

6.Marble2nd fingerandthumb _____

_____

GrossMovement _____

1.Placehandbehindhead(Ifscore= 3,total= 9 and finish)

2.(Ifscore= 0, total=0 and finish

3.Placehandontopofhead

3. Handtomouth

APPENDIX 14

Motor Activity Log

SID Name Date Visit Examiner

Motor Activity Log (UE MAL) Score Sheet
Amount Scale How Well Scale

1. Turn on a light with

if no, why? (use code)

a light switch Comments

2. Open drawer

if no, why? (use code) Comments

3. Remove an item

if no, why? (use code)

of clothing from a drawer Comments

4. Pick up phone

if no, why? (use code) Comments

5. Wipe off a kitchen

if no, why? (use code)

counter or other surface Comments

6. Get out of a car

if no, why? (use code)

(includes only the movement needed to get Comments
body from sitting to standing outside of the car, once the door is open).

7. Open refrigerator

if no, why? (use code) Comments

8. Open a door by

if no, why? (use code)

turning a door knob/ handle Comments

9. Use a TV remote

if no, why? (use code)

control Comments

10. Wash your hands

if no, why? (use code)

(includes lathering and rinsing hands; does not include turning water on and off with a faucet handle). Comments

Codes for recording “no” responses:

1. “I used the unaffected arm entirely.” (assign “0”).

2. “Someone else did it for me.” (assign “0”).

3. “I never do that activity, with or without help from someone else because it is impossible.” For example, combing hair for people who are bald. (assign “N/A” and drop from list of items).
4. “I sometimes do that activity, but did not have the opportunity since the last time I answered these questions.” (carry-over last assigned number for that activity).
5. Non-dominant hand hemiparesis. (only applicable to #24; assign “N/A” and drop from list of items).

Amount Scale How Well Scale

11. Turning water on/off

if no, why? (use code)

with knob/lever on faucet Comments

12. Dry your hands

if no, why? (use code) Comments

13. Put on your socks

if no, why? (use code) Comments

14. Take off your socks

if no, why? (use code) Comments

15. Put on your shoes

if no, why? (use code)

(includes tying shoestrings and fastening straps) Comments

16. Take off your shoes

if no, why? (use code)

(includes untying shoestrings and unfastening straps) Comments

17. Get up from a chair

if no, why? (use code)

with armrests Comments

18. Pull chair away from

if no, why? (use code)

table before sitting down Comments

19. Pull chair toward table

if no, why? (use code)

after sitting down Comments

20. Pick up a glass, bottle,

if no, why? (use code)

drinking cup, or can (does not need to include drinking) Comments

SID Name Date Visit Examiner

Amount Scale How Well Scale

21. Brush your teeth

if no, why? (use code)

(does not include preparation of toothbrush or brushing dentures unless the dentures are brushed while left in the mouth) Comments

22. Put on makeup base,

if no, why? (use code)

lotion, or shaving cream on face Comments

23. Use a key to

if no, why? (use code)

unlock a door Comments

24. Write on paper

if no, why? (use code)

(If hand used to write pre-stroke is more affected, score item; if non-writing hand pre-stroke is more affected, drop item and assign N/A) Comments

25. Carry an object in

if no, why? (use code)

your hand (draping an item over the arm is not acceptable) Comments

26. Use a fork or

if no, why? (use code)

spoon for eating (refers to the action of bringing food to the mouth with fork or spoon) Comments

27. Comb your hair

if no, why? (use code) Comments

28. Pick up a cup

if no, why? (use code)

by a handle Comments

29. Button a shirt
if no, why? (use code) Comments

30. Eat half a sandwich

if no, why? (use code)

or finger foods Comments

APPENDIX 15A

Stroke Specicfic Quality of Life Questionnaire (SS-QOL)

Scoring:eachitemshallbescoredwiththefollowingkey	
Totalhelp-Couldn'tdoitatall-Stronglyagree	1
A lotofhelp-A lotoftrouble-Moderatelyagree	2
Somehelp-Sometrouble-Neitheragreenordisagree	3
A littlehelp-A littletrouble-Moderatelydisagree	4
Nohelpneeded-Notroubleatall-Stronglydisagree	5
Energy	
1.I felt tired most of thetime.	___
2.I had to stop and rest during the day.	___
3.I was toot iredtodowhatIwantedtodo.	___
FamilyRoles	
1.Ididn'tjoininactivitiesjustforfunwithmyfamily.	___
2.IfeltIwasaburdentomyfamily.	___
3.Myphysicalconditioninterferedwithmypersonallife.	___
Language	___
1.Didyouhavetroublespeaking?Forexample,getstuck,stutter,stammer,or	___
2.Didyouhavetroublespeakingclearlyenoughtousethetelephone?	___
3.Didotherpeoplehavetroubleinunderstandingwhatyousaid?	___
4.Didyouhavetrouble findingthewordyouwantedtosay?	___
5.Didyouhavetorepeatyourselfsootherscouldunderstandyou?	___
Mobility	___
1.Didyouhavetroublewalking?(Ifpatientcan'twalk,gotoquestion4andscorequestions2-3as	___
2.Didyouloseyourbalancewhenbendingovertoor reachingforsomething?	___
3.Didyouhavetroubleclimbingstairs?	___
4.Didyouhavetostopandrestmorethanyouwouldlikewhenwalkingor usingawheelchair?	___

5.Didyouhavetroublewithstanding?	
6.Didyouhavetroublegettingoutofachair?	
Mood	
1.Iwasdiscouragedaboutmyfuture.	
2.Iwasn'tinterestedinotherpeopleor activities.	
3.Ifeltwithdrawnfromotherpeople.	
4.Ihadlittleconfidenceinmyself.	
5.Iwasnotinterestedinfood.	
Personality	
1.Iwasirritable.	
2.Iwasinpatientwithothers.	
3.Mypersonalityhaschanged.	
Self-Care	
1.Didyouneedhelppreparingfood?	
2.Ididmyhobbiesandrecreationforshorterperiodsoftimethan Iwouldlike.	
3.Didyouneedhelpgettingdressed?Forexample,puttingonsocksor	
4.Ihadsexlessoftenthan Iwouldlike.	
5.Myphysicalconditioninterferedwithmysociallife.	
Thinking	
1.Itwashardformetoconcentrate.	
2.Ihadtroublerememberingthings.	
3.Ihadtowritethingsdowntorememberthem.	
UpperExtremityFunction	
1.Didyouhavetroublewritingor typing?	
2.Didyouhavetroubleputtingonsocks?	
3.Didyouhavetroublebuttoningbuttons?	
4.Didyouhavetroublezippingazipper?	
5.Didyouhavetroubleopeningajar?	
Vision	
1.Didyouhavetroubleseeingthetelevisionwellenoughtoenjoyashow?	
2.Didyouhavetroublereachingthingsbecauseofpooreyesight?	
3.Didyouhavetroubleseeingthingsofftooneside?	
Work/Productivity	

1.Didyouhavetroubledoingdailyworkaroundthehouse?	
2.Didyouhavetrouble f i n ishingjobsthatyoustarted?	
3.Didyouhavetroubledoingtheworkyouusedtodo?	
TOTAL SCORE	

APPENDIX 16

TREATMENT ACCEPTABILITY QUESTIONNAIRE

Please answer these questions that deal with your reaction/experience to the treatment you received in over the past 8-weeks. Circle the number that best describe your reaction in each of the questions.

1. Overall how acceptable do you find this treatment to be?

VERY UNACCEPTABLE 1 2 3 4 5 6 7 VERY ACCEPTABLE

2. How ethical do find this treatment to be?

VERY UNETHICAL 1 2 3 4 5 6 7 VERY ETHICAL

3. How effective do you find this treatment?

VERY INEFFECTIVE 1 2 3 4 5 6 7 VERY EFFECTIVE

4. How likely can you describe experiencing any negative side effect during this treatment

VERY LIKELY 1 2 3 4 5 6 7 VERY UNLIKELY

5. How possible is it for you to recommend this therapy to other persons like you?

VERY IMPOSSIBLE 1 2 3 4 5 6 7 VERY POSSIBLE

6. How motivating have you find this treatment to be?

VERY UNMOTIVATING 1 2 3 4 5 6 7 VERY MOTIVATING

APPENDIX 17

WITHIN GROUP DIFFERENCES IN BODY STRUCTURE/FUNCTION

Within group differences in Muscle strength and spasticity test periods for 120CCT group

Measures	Test periods			$F_{3, 87}$	Prob.
	Baseline	Outcome	Follow-up		
Muscle strength (MMT)					
Shoulder flexors	2.43 (0.66)	3.22 (0.67)	3.90 (0.70)	25.95	0.001
Shoulder extensors	2.43 (0.59)	3.48 (0.85)	3.57 (1.08)	12.36	0.001
Elbow flexors	2.43 (0.59)	3.61 (0.99)	3.81 (1.25)	13.14	0.001
Elbow extensors	2.43 (0.79)	3.35 (0.89)	3.60 (1.14)	9.39	0.001
Wrist flexors	2.43 (0.59)	3.70 (0.77)	3.95 (0.87)	26.73	0.001
Wrist extensors	2.30 (0.64)	3.30 (0.93)	3.52 (0.93)	13.49	0.001
Hip flexors	2.52 (0.59)	3.65 (0.98)	4.38 (0.74)	31.14	0.001
Hip extensors	2.35 (0.65)	3.78 (0.85)	4.00 (0.84)	29.66	0.000
Knee flexors	2.39 (0.58)	3.61 (0.84)	3.81 (0.75)	24.79	0.001
Knee extensors	2.35 (0.49)	3.96 (0.64)	4.00 (0.84)	45.57	0.001
Ankle dorsiflexors	2.39 (0.50)	3.65 (0.78)	3.67 (0.91)	21.97	0.001
Ankle plantar flexors	2.43 (0.51)	3.70 (0.88)	3.86 (0.73)	26.42	0.001
Spasticity (MTS in degrees)					
Shoulder flexion	69.14 (6.60)	86.95 (9.73)	86.57 (11.39)	25.19	0.001
Elbow flexion	53.14 (4.25)	56.29(6.27)	56.19 (5.84)	2.89	0.063
Wrist flexion	14.81 (4.98)	26.24(6.33)	26.10 (5.92)	30.04	0.001
Hip extension	10.10 (1.64)	22.05(3.57)	22.14 (3.68)	111.71	0.001
Knee extension	78.76 (5.37)	105.62 (6.26)	107.62 (7.00)	161.34	0.001
Ankle extension	11.71 (2.83)	21.05 (3.58)	20.95 (4.49)	45.77	0.001

Results are presented in mean (standard deviation**)**

Within group differences in Muscle strength and spasticity test periods for 90CCT group

Measures	Test periods			$F_{3, 87}$	Prob.
	Baseline	Outcome	Follow-up		
Muscle strength (MMT)					
Shoulder flexors	2.38 (0.58)	2.88 (0.95)	3.32 (1.04)	6.73	0.002
Shoulder extensors	2.42 (0.50)	2.96 (0.86)	3.14 (0.94)	5.31	0.007
Elbow flexors	2.50 (0.51)	3.25 (0.85)	3.27 (1.35)	5.03	0.009
Elbow extensors	2.50 (0.51)	3.33 (0.70)	3.32 (1.09)	8.57	0.001
Wrist flexors	2.46 (0.59)	3.08 (0.93)	3.18 (1.05)	4.75	0.012
Wrist extensors	2.33 (0.48)	3.13 (0.61)	2.91 (0.68)	11.29	0.001
Hip flexors	2.54 (0.59)	3.46 (0.72)	3.73 (0.70)	19.98	0.001
Hip extensors	2.38 (0.77)	3.13 (0.68)	3.36 (0.66)	12.49	0.001
Knee flexors	2.46 (0.51)	3.00 (0.78)	3.14 (1.08)	4.53	0.014
Knee extensors	2.33 (0.48)	3.67 (0.70)	3.91 (0.81)	37.14	0.001
Ankle dorsiflexors	2.50 (0.51)	3.17 (0.87)	2.86 (0.83)	4.72	0.012
Ankle plantar flexors	2.42 (0.50)	3.67 (0.70)	3.41 (1.05)	17.20	0.001
Spasticity (MTS in degrees)					
Shoulder flexion	68.68 (9.38)	81.73 (10.50)	81.73 (10.61)	11.75	0.001
Elbow flexion	52.95 (4.10)	53.18 (4.93)	52.64 (5.25)	0.30	0.744
Wrist flexion	14.64 (4.55)	23.18 (4.93)	22.64 (5.25)	20.91	0.001
Hip extension	9.55 (1.64)	20.14 (3.68)	19.55 (4.94)	65.80	0.001
Knee extension	80.00 (5.86)	100.05 (4.85)	100.91 (5.71)	103.16	0.001
Ankle extension	11.82 (3.42)	19.14 (3.68)	18.64 (3.39)	32.97	0.001

Results are presented in mean (standard deviation**)**

Within group differences in Muscle strength and spasticity test periods for 60CCT group

Measures	Test periods			$F_{3, 87}$	Prob.
	Baseline	Outcome	Follow-up		
Muscle strength (MMT)					
Shoulder flexors	2.48 (0.51)	3.10 (1.00)	3.40 (1.10)	5.63	0.006
Shoulder extensors	2.48 (0.68)	3.33 (0.86)	3.20 (1.15)	5.34	0.007
Elbow flexors	2.48 (0.51)	3.29 (1.01)	3.35 (1.27)	5.19	0.008
Elbow extensors	2.38 (0.74)	3.48 (1.03)	3.30 (0.92)	8.82	0.001
Wrist flexors	2.33 (0.66)	3.24 (1.04)	3.10 (1.21)	5.03	0.010
Wrist extensors	2.33 (0.48)	3.29 (1.01)	2.95 (1.19)	5.57	0.006
Hip flexors	2.52 (0.60)	3.62 (0.74)	3.60 (0.75)	16.67	0.001
Hip extensors	2.38 (0.50)	3.57 (0.81)	3.50 (0.61)	21.86	0.000
Knee flexors	2.38 (0.50)	3.05 (0.87)	3.10 (0.85)	5.85	0.005
Knee extensors	2.33 (0.48)	3.52 (0.81)	3.40 (0.88)	16.14	0.001
Ankle dorsiflexors	2.43 (0.51)	3.33 (0.73)	2.80 (0.89)	8.26	0.001
Ankle plantar flexors	2.43 (0.51)	3.24 (0.89)	3.10 (1.02)	5.68	0.006
Spasticity (MTS in degrees)					
Shoulder flexion	70.95 (9.52)	78.60 (9.03)	77.55 (9.96)	4.28	0.018
Elbow flexion	50.60 (6.38)	53.90 (4.42)	49.80 (6.21)	3.48	0.037
Wrist flexion	15.70 (5.01)	20.60 (6.22)	19.80 (6.21)	4.24	0.019
Hip extension	10.20 (1.24)	16.76 (3.56)	16.00 (4.76)	60.31	0.001
Knee extension	82.33 (4.79)	94.38 (6.20)	94.86 (8.63)	50.23	0.001
Ankle extension	12.35 (2.85)	17.90 (2.73)	17.30 (2.81)	24.30	0.001

Results are presented in mean (standard deviation**)**

Within group difference in Muscle strength and spasticity test periods for Control group

Measures	Test periods			$F_{3, 87}$	Prob.
	Baseline	Outcome	Follow-up		
Muscle strength (MMT)					
Shoulder flexors	2.43 (0.59)	3.22 (0.90)	3.10 (0.89)	6.26	0.003
Shoulder extensors	2.35 (0.65)	3.00 (0.85)	2.86 (0.79)	4.55	0.014
Elbow flexors	2.35 (0.49)	3.43 (0.90)	3.33 (0.86)	13.99	0.001
Elbow extensors	2.57 (0.73)	3.22 (0.95)	3.14 (0.91)	3.86	0.026
Wrist flexors	2.48 (0.51)	3.30 (0.82)	3.10 (1.18)	5.58	0.006
Wrist extensors	2.35 (0.49)	2.74 (0.92)	2.62 (0.97)	1.38	0.258
Hip flexors	2.52 (0.51)	3.43 (0.73)	3.67 (0.66)	20.16	0.001
Hip extensors	2.35 (0.49)	3.26 (0.75)	3.19 (0.75)	13.00	0.000
Knee flexors	2.48 (0.59)	3.39 (0.89)	3.19 (0.87)	8.33	0.001
Knee extensors	2.35 (0.49)	3.39 (0.94)	3.24 (1.14)	9.17	0.001
Ankle dorsiflexors	2.43 (0.51)	3.04 (0.93)	2.81 (0.87)	3.48	0.037
Ankle plantar flexors	2.43 (0.59)	3.35 (0.83)	3.24 (1.04)	8.11	0.001
Spasticity (MTS in degrees)					
Shoulder flexion	71.17 (10.04)	76.48 (9.65)	75.29 (10.02)	1.81	0.172
Elbow flexion	51.78 (8.63)	48.52 (7.51)	49.19 (5.36)	1.26	0.292
Wrist flexion	16.00 (4.15)	19.96 (4.91)	19.19 (5.36)	4.34	0.017
Hip extension	10.43 (1.24)	16.91 (3.52)	16.00 (4.76)	23.62	0.001
Knee extension	82.17 (4.72)	94.74 (6.34)	94.86 (8.63)	26.88	0.001
Ankle extension	12.96 (2.98)	17.57 (3.36)	16.52 (3.40)	12.69	0.001

Results are presented in mean (standard deviation**)**

APPENDIX 18

WITHIN GROUP DIFFERENCES IN ACTIVITY LIMITATION

Within group differences for measures of activity limitation in 120CCT

Test periods	Mean	SD	F	Prob.
Action Research Arm Test				
Baseline	20.52	9.48	13.78*	0.001
Outcome	40.17	17.12		
Follow-up	43.24	19.29		
Total	34.39	18.55		
MAL Amount of Use				
Baseline	1.98	0.79	52.25*	0.001
Outcome	3.48	0.61		
Follow-up	4.16	0.77		
Total	3.18	1.16		
MAL Quality of Use				
Baseline	2.26	0.81	42.88*	0.001
Outcome	3.59	0.88		
Follow-up	4.37	0.55		
Total	3.37	1.15		
Ten Meter Walk Test (m/s)				
Baseline	0.36	0.11	63.34*	0.001
Outcome	0.66	0.11		
Follow-up	0.70	0.10		
Total	0.57	0.18		
Six Minute Walk Test (m)				
Baseline	253.30	52.89	26.43*	0.001
Outcome	347.09	63.02		
Follow-up	374.00	58.59		
Total	323.33	77.58		
Modified Rankin Scale				
Baseline	3.65	0.49	81.01*	0.001
Outcome	2.22	0.74		
Follow-up	1.43	0.51		
Total	2.46	1.09		
Modified Barthel Index				
Baseline	66.87	4.70	214.86*	0.001
Outcome	86.26	5.85		
Follow-up	96.67	3.69		
Total	82.87	13.29		

*The mean difference is considered significant at 0.05 alpha.

Within group differences for measures of activity limitation in 90CCT

Test periods	Mean	SD	F	Prob.
Action Research Arm Test				
Baseline	21.58	11.05	57.80*	0.001
Outcome	32.21	17.76		
Follow-up	32.18	18.69		
Total	28.56	16.67		
MAL Amount of Use				
Baseline	2.11	0.80	3.42*	0.039
Outcome	3.08	0.66		
Follow-up	3.79	0.81		
Total	2.97	1.02		
MAL Quality of Use				
Baseline	2.42	0.87	47.42*	0.001
Outcome	3.26	0.75		
Follow-up	3.42	0.76		
Total	3.03	0.90		
Ten Meter Walk Test (m/s)				
Baseline	0.36	0.10	8.00*	0.001
Outcome	0.59	0.12		
Follow-up	0.63	0.09		
Total	0.52	0.16		
Six Minute Walk Test (m)				
Baseline	251.88	58.07	136.50*	0.001
Outcome	310.67	67.74		
Follow-up	327.55	77.46		
Total	295.81	74.49		
Modified Rankin Scale				
Baseline	3.42	0.50	28.80*	0.001
Outcome	2.13	0.61		
Follow-up	1.59	0.67		
Total	2.40	0.97		
Modified Barthel Index				
Baseline	66.92	5.59	10.79*	0.001
Outcome	83.00	4.42		
Follow-up	91.23	5.23		
Total	80.07	11.32		

*The mean difference is considered significant at 0.05 alpha.

Within group differences for measures of activity limitation in 60CCT

Test periods	Mean	SD	F	Prob.
Action Research Arm Test				
Baseline	21.95	12.20	1.69	0.193
Outcome	29.90	18.65		
Follow-up	30.75	19.41		
Total	27.48	17.21		
MAL Amount of Use				
Baseline	2.08	0.99	3.08	0.054
Outcome	2.82	0.96		
Follow-up	2.57	1.00		
Total	2.49	1.02		
MAL Quality of Use				
Baseline	2.32	0.81	2.90	0.063
Outcome	3.02	1.00		
Follow-up	2.77	1.03		
Total	2.70	0.98		
Ten Meter Walk Test (m/s)				
Baseline	0.37	0.10	9.25	0.001
Outcome	0.51	0.12		
Follow-up	0.49	0.12		
Total	0.45	0.13		
Six Minute Walk Test (m)				
Baseline	262.38	47.94	3.13	0.050
Outcome	296.76	46.14		
Follow-up	287.75	44.03		
Total	282.21	47.68		
Modified Rankin Scale				
Baseline	3.33	0.58	34.62	0.001
Outcome	2.14	0.73		
Follow-up	1.85	0.49		
Total	2.45	0.88		
Modified Barthel Index				
Baseline	68.67	5.54	60.63	0.001
Outcome	81.38	5.97		
Follow-up	88.30	5.89		
Total	79.31	9.98		

*The mean difference is considered significant at 0.05 alpha.

Within group differences for measures of activity limitation in Standard Physiotherapy

Test periods	Mean	SD	F	Prob.
Action Research Arm Test				
Baseline	23.52	12.66	0.43	0.656
Outcome	26.86	13.87		
Follow-up	23.95	12.91		
Total	24.76	13.04		
MAL Amount of Use				
Baseline	2.12	0.81	0.29	0.751
Outcome	2.31	0.95		
Follow-up	2.16	0.83		
Total	2.19	0.85		
MAL Quality of Use				
Baseline	2.35	0.73	1.24	0.296
Outcome	2.72	0.73		
Follow-up	2.48	0.93		
Total	2.51	0.80		
Ten Meter Walk Test (m/s)				
Baseline	0.39	0.10	1.53	0.224
Outcome	0.44	0.11		
Follow-up	0.42	0.10		
Total	0.42	0.10		
Six Minute Walk Test (m)				
Baseline	261.57	47.30	0.77	0.469
Outcome	278.05	47.90		
Follow-up	274.73	46.83		
Total	271.30	47.18		
Modified Rankin Scale				
Baseline	3.39	0.58	51.81	0.001
Outcome	2.14	0.64		
Follow-up	1.82	0.39		
Total	2.46	0.88		
Modified Barthel Index				
Baseline	68.48	5.38	32.22	0.001
Outcome	78.14	5.05		
Follow-up	83.77	8.47		
Total	76.67	9.03		

*The mean difference is considered significant at 0.05 alpha.

APPENDIX 19

RESULT FOR 12 DOMAIN, 49 ITEMS SS-QOL

Univariate test for time effect and time by group interaction in four SS-QOL subscales for participation

Variable	120CC	90CCT	60CCT	Control	Total	F_T	$Prob_T$	η^2_T	F_{TG}	$Prob_{TG}$	η^2_{TG}
Family Roles											
Baseline	2.62 (0.50)	2.91 (0.68)	2.80 (0.77)	2.90 (0.62)	2.81 (0.65)	198.00	0.001	0.71	9.55	0.001	0.26
Outcome	4.10 (0.62)	3.91 (0.75)	3.70 (0.66)	3.48 (0.75)	3.80 (0.72)						
Follow-up	4.38 (0.59)	4.14 (0.83)	3.75 (0.72)	3.43 (0.68)	3.93 (0.79)						
Language											
Baseline	12.43 (2.16)	12.50 (2.99)	12.60 (1.60)	12.29 (2.33)	12.45 (2.30)	32.13	0.001	0.29	0.70	0.587	0.026
Outcome	13.29 (1.71)	13.32 (2.68)	13.05 (1.47)	13.19 (1.89)	13.21 (1.97)						
Follow-up	13.52 (1.60)	13.45 (2.58)	13.15 (1.39)	13.10 (2.14)	13.31 (1.97)						
Mobility											
Baseline	14.05 (1.60)	14.82 (2.95)	15.10 (1.65)	15.14 (2.39)	14.77 (2.24)	360.22	0.001	0.82	26.65	0.001	0.50
Outcome	21.00 (1.97)	18.95 (3.06)	18.90 (1.94)	17.43 (2.71)	19.07 (2.75)						
Follow-up	23.33 (1.91)	20.50 (3.16)	19.10 (2.27)	17.38 (3.09)	20.10 (3.42)						
Self-care											
Baseline	14.95 (2.50)	16.45 (3.94)	16.50 (4.35)	15.76 (4.58)	15.92 (3.90)	359.21	0.001	0.82	19.89	0.001	0.43
Outcome	21.19 (2.79)	20.77 (2.74)	18.95 (3.87)	17.62 (4.40)	19.65 (3.74)						
Follow-up	23.29 (2.12)	21.91 (2.76)	21.00 (3.93)	18.52 (4.01)	21.19 (3.67)						

CCT = Circuit Class Therapy, F_T = F value for main time effect, $Prob_T$ = Observed probability for main time effect, η_T^2 = Effect size for main time effect, F_{TG} = F value for time by group interaction, $Prob_{TG}$ = Observed probability for time by group interaction, η_{TG}^2 = Effect size for time by group interaction.

Univariate test for time effect and time by group interaction in participation and other four SS-QOL subscales of participation

Variable	120CC	90CCT	60CCT	Control	Total	F_T	$Prob_T$	η^2_T	F_{TG}	$Prob_{TG}$	η^2_{TG}
Social roles											
Baseline	7.29 (1.38)	8.32 (2.87)	8.60 (3.10)	8.38 (2.67)	8.14 (2.59)	418.07	0.001	0.84	27.83	0.001	0.51
Outcome	11.62 (1.43)	11.64 (2.54)	10.55 (2.48)	9.76 (2.91)	10.90 (2.49)						
Follow-up	13.38 (1.20)	12.64 (2.19)	11.75 (2.31)	9.86 (2.82)	11.92 (2.54)						
Thinking											
Baseline	3.86 (0.73)	3.95 (1.05)	3.90 (0.91)	3.95 (0.86)	3.92 (0.88)	70.62	0.001	0.47	1.07	0.377	0.039
Outcome	4.67 (0.48)	4.64 (0.49)	4.40 (0.60)	4.43 (0.60)	4.54 (0.55)						
Follow-up	4.86 (0.36)	4.86 (0.35)	4.65 (0.49)	4.52 (0.60)	4.73 (0.47)						
Upper Extremity Function											
Baseline	13.05 (3.07)	14.32 (3.24)	14.25 (4.23)	14.33 (4.44)	13.99 (3.75)	483.63	0.001	0.86	30.01	0.001	0.59
Outcome	20.57 (3.72)	19.09 (3.50)	17.85 (4.30)	16.24 (4.12	18.45 (4.16)						
Follow-up	23.43 (2.29)	21.27 (3.55)	18.85 (4.12)	16.67 (4.34)	20.08 (4.40)						
Work/Productivity											
Baseline	6.57 (1.69)	7.59 (2.09)	6.60 (2.16)	7.48 (2.54)	7.07 (2.16)	283.10	0.001	0.78	20.58	0.001	0.44
Outcome	12.48 (2.40)	11.27 (2.10)	9.55 (1.76)	9.62 (2.20)	10.75 (2.42)						
Follow-up	14.33 (1.68)	12.73 (2.23)	9.55 (2.09)	9.57 (2.56)	11.58 (2.97)						
SS-QOL Participation Scale											
Baseline	74.81 (7.58)	80.86 (10.95)	80.35 (11.69)	80.24 (10.91)	79.07 (10.51)	1668.11	0.001	0.95	103.31	0.001	0.80
Outcome	108.90 (9.06)	103.59 (9.54)	96.95 (10.02)	91.76 (12.12)	100.38 (12.00)						
Follow-up	120.52 (5.90)	111.50 (8.61)	101.80 (9.70)	93.05 (12.63)	106.83 (13.95)						

CCT = Circuit Class Therapy, F_T = F value for main time effect, $Prob_T$ = Observed probability for main time effect, η_T^2 = Effect size for main time effect, F_{TG} = F value for time by group interaction, $Prob_{TG}$ = Observed probability for time by group interaction, η_{TG}^2 = Effect size for time by group interaction.