



THE EFFECTIVENESS OF LYCRA COMPRESSION GARMENTS ON THE UPPER LIMB IN PATIENTS WITH STROKE

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Declaration

I, Carene Chanel Naubereit, declare that this research report is my own work. It is being submitted for the degree of Masters of Science in Occupational Therapy at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

(Signature of candidate)

On this _____ (day) of _____ 20 _____ in

Dedication

In Memory of my grandfather and aunt

Alziro Henriques

31/12/1955 – 17/04/2008

Sandra Almeida

09/09/1956 – 19/09/2010

Your fighting spirits inspired me to never give up on my dreams

Abstract

Introduction: Lycra compression garments have been documented as beneficial in affecting spasticity in children with cerebral palsy but there is little research on the use of Lycra compression garments in adults with neurological conditions. Thus, the purpose of this study was to explore the effectiveness of Lycra compression garments on motor function and functional use of the upper limb, in patients with stroke.

Methods: A randomised control design with a control or intervention group was used. Both groups received routine upper limb rehabilitation while the experimental group also received a custom Lycra compression garment worn for a minimum of six hours a day.

Results: Change between an initial assessment and assessment at six weeks, was measured on the Fugl-Meyer Assessment of Motor Recovery (FMA) and The Disabilities of the Arm, Shoulder and Hand Outcome Measure (DASH). While both groups had significant improvement in upper limb movement, statistically significant differences for change in total motor function, wrist and hand movement and coordination were found when the experimental group and the control group were compared. Small differences in measurements of pain, passive range of motion, sensation and functional use of the upper limb were found between the two groups.

Conclusion: Results indicate that Lycra compression garments may be beneficial in facilitating the return of movement in the upper limb in individuals with stroke.

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To my editor, Safiya Lambat, thank you for the time taken away from your family to fine tune last minute details

My beautiful daughter - your physical limitations challenged me to think outside the box, inspired my thinking and ultimately determined my topic.

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Definition of Terms

Compression garments: Compression garments often have interchangeable terms depending on the research. These compression garments consists of Lycra sewn together to conform tightly to the patient, the design will vary depending on the specific needs of the patient. These garments are often referred to as Dynamic Lycra splints, second skin Lycra splints (Corn, et al., 2003), Lycra garments (Gracies , et al., 1997) and dynamic Lycra orthosis (Watson, et al., 2007) are used interchangeably.

Deep pressure: Deep pressure refers to input provided to the cutaneous skin receptors through the use of compression thus providing the body with proprioceptive input and awareness of the area where compression is applied (Hylton & Allen, 1997; Kerem, et al., 2001; Elliott, et al., 2011).

Functional use of the upper limb: This is defined as the ability of the upper limb or upper limbs to perform goal directed movement within functional and meaning tasks and activities (Jaraczewska & Long, 2006).

Lycra: Lycra is a material made up of elastic polyurethane fibres. It provides a close fit and conforms comfortable to the skin. This material has a specific stretch property allowing for freedom of movement (LYCRA, 2017).

Proprioceptive sensory input: Proprioception is a complex sensory system, and tactile stimulation alone done not constitute significant enough to provoke the proprioceptive system. Various inputs however such as active and passive movement, vibration and compression to stimulate cutaneous skin receptors as well as Golgi tendon organs and muscle spindles provoke the proprioceptive system (Findlater & Dukelow, 2016).

Stroke: Cerebrovascular accident also known more commonly as stroke. Is defined as a disruption in blood flow to the brain causing destruction to the brain tissue as a result of lack of oxygen supply (Fuller & Manford, 2010).

Upper limb movement: Movement of the upper limb describes the ability of the limb to actively and selectively initiate movement. This is non purposeful movement or movement that is not required in a functional task or activity (Bobath, 1990; Chan, et al., 2006; Pollock, et al., 2014).

Abbreviations

FMA: Fugl – Meyer Assessment

DASH: Disabilities of Arm, Shoulder and Hand Outcome

CP: Cerebral Palsy

CNS: Central nervous system

NDT: Neurodevelopmental Theory

TOT: Task Orientated Training

RCT: Randomized controlled trial

EMG NMES: Electromyogram Neuromuscular electrical stimulation

AROM: Active range of motion

PROM: Passive range of motion

HERC: Human Ethics Research Committee

Botox: Botulin Toxin

HIV: Human Immunodeficiency Virus

AIDS: Acquired Immune Deficiency Syndrome

BMI: Body Mass Index

CHAPTER 1: INTRODUCTION

1.1 Introduction

Stroke refers to damage of the brain as a result of irregularities in blood circulation. A stroke occurs in 2 per 1000 people, this increases from the age of 45 years to 30 per 1000 over 80 years of age (Fuller & Manford, 2010). The most common impairment noted following a stroke is that of hemiplegia or hemiparesis on the contralateral side to that of the stroke. Most individuals however do not regain function of the upper extremity following a stroke, with only 14% experiencing full recovery and 30% experiencing partial recovery of the upper extremity (Radomski & Trombly Latham, 2008).

Occupational therapists treat the associated impairments of the upper limb through maintaining joint range and facilitating active movement in the upper limb, so as to encourage bilateral hand use in functional tasks (Davies , 2000). Oedema may arise in individuals who have suffered from a stroke. This is traditionally treated by occupational therapists through the use of compression garments. Compression garments are also used in the treatment of lymphedema, (Brennan & Miller, 1998) and in scar management by reducing hypertrophic scars following a burn or injury to the dermis (Puzey, 2001).

Lycra compression garments have been used in the treatment of children with Cerebral Palsy (CP). These garments provide a low load stretch force which has been demonstrated to improve the quality of movement in the upper limb (Elliott, et al., 2011), and also showed functional improvements in the upper limb of the children wearing the Lycra compression garments (Hylton & Allen, 1997) (Knox, 2003). These garments vary according to the child's needs and include, but are not limited to, full body suits, vests, ski-pants, sleeves and gauntlets. Compression garments are now also being issued in adult patients with hemiplegia and these garments are viewed to be beneficial, however, to date, no clinical trial has been conducted in order to determine their efficacy (Gracies , et al., 2000).

It has been reported that Lycra compression garments improve awareness and reduce visual neglect of the affected upper limb in individuals with a stroke. They do so by providing the sensory inputs such as deep pressure, light touch, as well as by providing a constant visual stimulus of the affected limb (Gracies , et al., 2000). The continuous deep pressure and slight biomechanical support provided by the Lycra compression garments is an additional reason for their benefit (Hylton & Allen, 1997).

The deep pressure and proprioceptive sensory input provided from the wearing of the Lycra compression garments are associated with cortical and cerebellar connections which play a significant role in motor learning and motor adaptation (Cooper & Abrams, 2006). Proprioception provides an individual with awareness of the position their limbs during active and passive movements, which is important when learning new skills and movements (Stillman, 2002; Aman, et al., 2015). Stillman (2002) however cautioned that it cannot be confirmed whether motor reactions are as a result of proprioceptive input itself (Stillman, 2002). Lycra compression garments may prove to be effective in the treatment of upper limb movement in adults following neurological injury such as stroke.

1.2 Statement of the problem

In current literature there is a lack of reliable and rigorous studies which investigate the effectiveness of Lycra compression garments in adults with a stroke and other neurological conditions. As early as 2001 it was noted in Barnes review on the medical management of spasticity, that Lycra compression garments could be valuable in affecting spasticity (Barnes, 2001). However most of the literature on the subject is on the use of Lycra compression garments in children with CP where benefits have been noted in their ability to perform functional movement (Hylton & Allen, 1997; Nicholson, et al., 2001; Corn, et al., 2003; Knox, 2003).

A study completed by Gracies et al in 2000 showed notable changes following the use of Lycra compression garments in upper limb function in adults with a stroke (Gracies , et al., 2000). Furthermore, based on clinical observations, and in the researchers' experience after administering Lycra compression garments to patients with a stroke, changes in functional movement and improved awareness of the upper limb have been observed in this population.

This should therefore be studied in further detail to identify these changes within the South African population.

1.3 Purpose of the study

Treatment modalities currently used in the treatment of the upper-limb by occupational therapists vary (Roy, et al., 2010; Teasell, et al., 2013). Studies are needed to identify the effectiveness of Lycra compression garments as an adjunctive therapy modality in the treatment of individuals with a stroke. Furthermore, the above-mentioned studies found mainly indicated the motor changes in terms of active movement and joint range, and did not report on improvements in functional abilities, which include that of self-care; instrumental activities of daily living; and leisure activities. The purpose of this study will therefore be to identify movement and sensory changes in the upper limb of patients with stroke, which can be attributed to the wearing of Lycra compression garments and if these changes have any beneficial value in terms of improving functional abilities in the upper limb.

1.3 Aim

To evaluate changes in functional domains which include basic self-care tasks, meal preparation, instrumental activities of daily living and leisure activities, as well the change in motor function, sensory function, co-ordination, joint range and pain of the upper limb in patients with stroke when Lycra compression garments are used as an adjunctive therapy technique

1.4 Objectives

- To determine change in the motor function which includes active voluntary movement, co-ordination, and passive range of motion, in the upper limbs of patients with stroke when Lycra compression garments, were and were not used
- To determine change in sensory function, awareness of limb position and pain, in the upper limb of patients with stroke when Lycra compression garments, were and were not used

- To determine change in the ability to perform functional tasks with the use of the upper limb of patients with stroke where Lycra compression garments are used as an adjunctive therapy technique was and was not used
- To evaluate the perception of the patients with stroke in terms of the comfort and ease of use of the Lycra compression garments

1.5 Null hypothesis

Lycra compression garments do not result in change in motor function, functional use of the upper limb or improved sensation and awareness of the upper limb in a patient with a stroke

1.6 Justification for the study

Lycra compression garments have been proven to show positive effects on spasticity and control and co-ordination of the upper limb in children with CP (Hylton & Allen, 1997; Nicholson, et al., 2001; Corn, et al., 2003; Knox, 2003). In the researchers knowledge only two studies have indicated benefits of Lycra compression garments in the adult population with neurological fall out in the upper limb (Gracies , et al., 2000; Watson, et al., 2007).

This study thus aims to add to the limited knowledge of the use and effectiveness of Lycra compression garments in adults with stroke, and to determine if Lycra compression garments are an effective and valuable therapy adjunctive, which can be implemented when treating the upper limb in individuals with a stroke.

1.7 Overview of the report

Chapter 1 Introduction

This chapter introduces the research question with background information on the application of Lycra compression garments in the treatment of neurological conditions. The purpose, aim and objectives of the study are presented as well as the null hypothesis. The justification of the study is included.

Chapter 2 Review of the Literature

This chapter explores the literature around stroke mortality, incidence, and prognosis with a large focus on sensory and motor function of the upper limb. The review explores neuroplasticity in terms of motor and sensory input with particular focus on proprioception and how this impacts neuroplasticity. Assessment tools used in neurorehabilitation for the upper limb has been discussed along with frames of reference and therapy techniques for the upper limb used by occupational therapists. The final component of the literature review deals with how proprioception can be applied to the upper limb to promote motor relearning this is considered in children with cerebral palsy and thereafter in adults with neurological deficits.

Chapter 3 Methodology

This chapter looks at the research design. It describes the research site and the sample used. The selection of the sample is explained describing the inclusion and exclusion criteria. The sample size and number of control versus experimental participants is described. The measurement techniques used, this included the demographic questionnaire, the FMA, the DASH and the Lycra compression garment comfort questionnaire is included. This is followed by the research procedure which includes the manner in which the occupational therapists were trained for the application of the compression garments, who obtained the Lycra compression garments and how the pre-test assessment was completed, the intervention is discussed and then this is concluded by the manner in which the post-test was completed. The data analysis is also included.

Chapter 4 Results

This chapter looks at the results from the demographic questionnaire, Fugl-Meyer assessment and DASH. This is described in terms of the changes within the same group and between the two groups. The results from the comfort questionnaire is then described.

Chapter 5 Discussion

The discussion looks at the demographics, medical context and medical management of the participants in the study with hemiplegia and hemiparesis.

It considers the effect of compression garments on the recovery of the upper limb following a stroke. This is in particular in terms of active selective movement, range of motion, sensation, pain and speed and co-ordination of movement and whether this movement could translated to functional tasks are discussed.

Chapter 6 Conclusion

This chapter summarizes and concluded the findings in the results and states the most important factors discussed.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This review of literature explores individuals with stroke examining the incidence and mortality following a stroke as well as the rate of disability and the challenges faced within the South African context. The motor and sensory consequences of stroke and recovery are briefly reviewed. Neuroplasticity is explored in terms of its effects of motor and somatosensory input as well as the role of proprioception on motor relearning. The assessment tools used to monitor upper limb recovery after stroke, the frames of reference, and techniques used in occupational therapy in the intervention of stroke, and a focus on motor relearning of the upper limb are also considered. Methods of applying proprioceptive input to the affected limb such as kinesiotaping and Lycra compression garments are discussed in terms of children with neurological deficits and thereafter adults with neurological deficits. The information obtained for this review was through various resources, this included Google scholar, Cochrane library, CINHAL, OT Seeker and Clinical Key

2.2 Stroke

Stroke is described as destruction to the brain tissue as a result of an irregularity of the blood supply to the brain. It presents with a sudden onset of focal neurological deficits (Fuller & Manford, 2010), which may include hemiplegia of the arm, leg and/or face, slurred speech, decreased cognitive functioning and decreased levels of arousal (Fuller & Manford, 2010) which may even lead to death (Crepeau, et al., 2003). A stroke is characterised by a decreased supply of blood to a specific area of the brain. The cause of this is variable and dependent on many risk factors. The main identifiable causes of disturbed blood flow include thrombosis, embolism or haemorrhage (Crepeau, et al., 2003). Thrombotic stroke can occur as a result of irregularity of the vessel wall, unusual tendency of the blood to thrombose, stasis of blood flow or small vessel disease (Fuller & Manford, 2010).

The second leading cause of death amongst adults globally is stroke contributing to 10% of deaths worldwide and largely contributing to the number of disabled individuals. In 2005 it was found that globally 16 million individuals had their first incidence of stroke and a further 5.8 million stroke related deaths (Mensah, 2008).

2.2.1 Stroke in the South African Context

2.2.1.1. Mortality, prevalence and aetiology of stroke

In developing countries it has been found that 30% of deaths are related to strokes and individuals with stroke have a higher fatality rate. In individuals that have had a stroke 30% die within the first 3 weeks (Lemogoum, et al., 2005). The South African National Burden of Disease study showed that in 2000 mortalities, stroke was the third most common cause of death in South Africa after HIV and ischemic heart disease. In 2007 stroke accounted for 25 000 deaths in South Africa. The highest mortality was evident in the racial group of black females (125/100 000) and the lowest in the racial group of white males (72/100 000). Individuals over the age of 50 years showed a higher mortality and stroke is also the highest cause of death in this age band (Bryer, et al., 2010).

Currently there is no population based data indicating prevalence of stroke in Sub-Saharan Africa. The Southern Africa Stroke Prevention Initiative (SASPI) has conducted a community based project which has found the prevalence of stroke in rural South Africa to be 300/100 000 overall and 243/100 000 in individuals above the age of 15 (The SASPI Project Team, 2004; Bryer, et al., 2010). However, this data cannot be generalized to the whole South African population and urban populations as they are expected to have a higher prevalence due to the lifestyle factors that are more readily available (Bryer, et al., 2010).

An individual with a stroke can have long lasting disabling effects, and it has been found that in developing countries, 30% of individuals with a stroke have permanent disability (Lemogoum, et al., 2005). In South Africa stroke is the 9th leading cause of disability. In the study completed by SASPI it was found that individuals who have had a stroke in South Africa were considerably more disabled than individuals from Tanzania (Bryer, et al., 2010).

This is believed to be due to many factors common to individuals living in rural South Africa, such as poor availability of rehabilitation services, undiagnosed individuals where there is a minor stroke, unwillingness of individuals attending rehabilitation for fear of losing out on a disability grant, poor access to transport to attend outpatient therapy which is often very far and a delay in acute management of stroke due to hospitals and clinics being far away (Bryer, et al., 2010).

The prevalence of stroke is said to increase due to the numerous risk factors, such as poor lifestyle choices that individuals continue to make, and the growth in the senior population. Furthermore, in South Africa, there are further challenges with managing stroke, particularly in younger HIV positive individuals who are at greater risk due to the complications which can arise from opportunistic infections, poor coagulation due to secondary involvement of the heart, and damage to the blood vessels (Bryer, et al., 2010).

A stroke which results in long term disability requires adequate acute medical management along with physiotherapy and other therapy services (Bryer, et al., 2010). In South Africa acute management has improved drastically as there are more dedicated stroke units and national guidelines (Conner, et al., 2005). Initially only 25 stroke units were available in South Africa. Currently most of the acute government hospitals have facilities for acute and chronic stroke management and thereafter a referral process for patients to receive further stroke preventative care at dedicated clinics in the community has been established. There are a large number of private facilities which specialize in stroke rehabilitation for those individuals that are able to afford private care. Despite the improvements in the availability of services to individuals with a stroke at both a private and public level, only 10-20% of individuals with a stroke have access to stroke units and rehabilitation. Patients who are unable to access these services have poor access to support programmes due to limited financial support of these programs and poor support from medical practitioners and the general population. Furthermore, there is a large gap in the number of neurologists with an interest in stroke in South Africa. This results in patients being treated by physicians or medical officers with little expertise in the field of stroke (Fritz, 2006; Ntamo, et al., 2013).

2.3 Recovery after Stroke

Following a stroke, a common impairment is that of hemiparesis, evident in 80% to 90% of stroke survivors. Numerous other impairments such as impaired sensation, communication disorders, cognitive dysfunction and poor visual perception are also often present. Depending on the side of the lesion often one can often predict certain impairments based on the cortical map. A lesion in the right cerebral hemisphere may result in hemiplegia or hemiparesis in the left upper limb and lower limb, impulsivity, visuospatial neglect of the left side and impaired judgement. In contrast a lesion on the left cerebral hemisphere may result in hemiplegia or hemiparesis in the right upper and lower limb, poor expressive and/or receptive communication and apraxia (Nilsen, et al., 2015).

There is a total of 30% - 66% of individuals with a stroke who experience hemiparesis and never gain any functional use of the affected paretic limb (Kwakkel, et al., 1999; Pandian, et al., 2012). A very small number of 5% - 20% of individuals whom have had a stroke and experience hemiparesis will actually regain full functional use of the affected limb (Kwakkel, et al., 1999). Furthermore, within the first 2 years post stroke it is expected that 25% - 45% of individuals whom have had a stroke will have some degree of movement return to the affected limb, whilst 45% still had poor return of movement four years post stroke (Au-Yeung & Hui-Chan, 2009). It can be predicted that most of the movement in the affected upper limb can be anticipated to return during the first six months post stroke, however this is not to be said that no further recovery occurs after this period. Recovery after six months is slower and at a less significant pace from six months until around two years post stroke (Meldrum, et al., 2004). During recent studies investigating prognostic indicators for movement return, it was concluded that the presence of finger extension and shoulder abduction within the first 72 hours after the stroke has high predictive value for dexterity of the hand after six months (Meyer, 2015).

Following a stroke the brain produces a configuration of distinctive behavioural signs and symptoms. The damage to the upper motor neuron results in poor motor control due to either positive or negative symptoms.

Positive symptoms refer to the presence of irregular behaviours whilst negative symptoms refer to the absence or loss of regular behaviours. Abnormal reflexes or the over-excitability of the stretch reflex causing spasticity and increased tone are examples of positive symptoms whilst paresis, loss of strength and the loss of the control of the descending lower motor neuron are examples of negative symptoms (Shumway-Cook & Woollacott, 2007). Spasticity is common and can significantly affect movement. Of individuals with this symptom, only up to 50% will be candidates for treatment of the spasticity due to the severity of the tone changes present. This is important to recognize as spasticity can result in pain, muscle contractures and muscle shortening (Barnes, 2001). In comparison to spasticity, hypotonicity is also a common impairment which affects movement. It is as a result of a disorganisation of the reflex arch, individuals are unable to initiate active selective movement. The lack of movement due to hypertonicity results in complications such as decreased passive range of motion and joint pain (Fugl-Meyer, et al., 1975). These factors affect the ability of the individual to perform active selective movement of the affected limb which results in individuals having a poor ability to reach, grasp, release and manipulate objects during functional tasks (Meyer, 2015).

Sensory loss following a stroke will contribute to the poor motor control of the affected limbs. Loss of sensation is dependent on factors such as the area and size of the lesion. The somatosensory information arises in the cerebral cortex either via the dorsal column medial lemniscal system or via the anterolateral system. If a lesion occurs in the dorsal column this will result in poor touch discrimination, poor light touch and poor kinaesthetic sense. Lesions in the lateral spinothalamic tract will affect the individual's ability to detect temperature and pain. Furthermore, a lesion in the somatosensory cortex will directly result in a poor ability to discriminate; proprioception, two-point touch, stereognosis and touch localization, in the contralateral part of the body (Shumway-Cook & Woollacott, 2007).

It is not uncommon to find somatosensory deficits in the upper limb following a stroke. There is between 23% - 55% who experience loss of light touch, pain and temperature sense, 19% - 64% who experience loss of proprioception, and up to 89% who lose stereognosis, two point discrimination and the ability to discriminate between dull and sharp. Several cross sectional studies found that in the sub-acute phase of stroke there was a strong association between somatosensory functioning and functioning of the upper limb in terms of pinch grip, bilateral co-ordination and overall motor function. Furthermore loss of somatosensory functioning has been said to result in poorer functioning in activities of daily living and impacts on the satisfaction and performance of activities which individuals viewed as important (Meyer, 2015).

2.3.1 Motor Recovery

Movement is an essential component of human life, it allows individuals to walk, run and reach for objects needed in functional tasks and contributes to all occupational performance areas. Therapists interested in motor control study movement and abnormalities of movement (Shumway-Cook & Woollacott, 2007). Motor training is a form of rehabilitation practices which aims at gaining motor learning, that ultimately results in permanent changes based on experiences or involvement in task specific activities (Mang, et al., 2013). Motor recovery after a stroke is said to occur via two different mechanisms; the first being that of true recovery, which reflects recovery of motor movement and is similar to that of the pre-morbid movement patterns, the second is that of compensatory recovery which reflects motor recovery employing other movement patterns (Zeiler & Krakauer, 2013).

Furthermore, movement occurs through the collaboration of three aspects namely, the individual itself, the task and the environment. The person produces the desired movement for the specific task requirements within certain environmental conditions. There are various constraining variables within each of these domains which can affect movement. Within the individual domain, movement can be restricted by the mechanisms of the body for example, coordinating the muscles through CNS control (Shumway-Cook & Woollacott, 2007).

Movement can also be affected by the individual's perception of movement for example knowing where their body is in space, which is needed to produce a coordinated movement. Movement produced by the individual can also be constrained by the individual's cognitive function, referring mainly to the individual's intent to move (Shumway-Cook & Woollacott, 2007).

In addition to the constraints from the individual, the task itself possesses its own constraints. As individuals, we participate in a variety of functional tasks, individuals are required to have an understanding how to use movement within various functional tasks. Following dysfunction to the CNS, the individual should be able to grasp a concept of how to engage in movement patterns which meet the demands of various tasks. In addition to engaging in a number of tasks, these are performed in a variety of environments. Movement can be constrained by factors in the environment such as space, shape, size, weight, and height which can affect how the task is performed (Shumway-Cook & Woollacott, 2007).

Both motor and sensory recovery are reliant on neuroplasticity. Furthermore the process of neuroplasticity, following a neurological lesion, contributes to learning and memory, and is key in the development of functional recovery (Hummel & Cohen, 2005)

2.4 Neural plasticity and the effect of sensory input on motor recovery

Neural plasticity comprises of: reinforcement of current neural pathways and development of new neural connections, which is fundamentally the backbone of learnt behaviour. A process known as pruning of the neural pathways, occurs to support the development of the preferential and skill pathways (Mang, et al., 2013). There is a significant plastic ability of the brain to reorganise in both the somatosensory and motor cortices. It has been noted that following a brain lesion, there are changes to the cortex when there is input at the somatosensory area, which impacts on the motor output. This supports and aids motor learning, functional reorganization, and skill attainment (Hummel & Cohen, 2005).

Modulation of somatosensory input at a specific area of the body thus can impact on the plastic changes in the cortex where that body part is represented. Furthermore it was found that with the application of somatosensory input and stimulation of the cortex there is positive effects on motor control in a paretic lower limb (Hummel & Cohen, 2005). The aforementioned supports the notion that the somatosensory input provided through deep proprioceptive input from a compression garment, can facilitate plastic changes which promote the development of motor control and skill attainment of a paretic limb.

2.4.1 Proprioceptive Input

Somatosensory functioning can be described as exteroceptive, proprioceptive and higher cortical somatosensory functions, each of these comprises of different sensory modalities. Exteroception refers to the individuals' ability to sense light touch, pressure, pin prick and temperature sensations. Proprioception refers to the ability to identify the position of the body, the sense of movement and detect vibration. Higher cortical somatosensation allows individuals to discriminate between sharp and dull stimuli, between objects known as stereognosis, between numbers when written on the skin known as graphesthesia and discriminate if there is one or two stimulus present (Meyer, 2015).

Current research has indicated that sensory input plays various roles in movement control. Reflexive movement is organized within the spinal cord and the sensory inputs serve as a stimulus for these reflexive movements to occur. Furthermore sensory input contributes to the modulation of how movement is produced, this is as a result of excitability of the central pattern generators found in the spinal cord. Similarly sensory inputs can modulate the movement generated from directives at higher cortical levels. The reason that sensory information can act as a modulator both at a cortical and spinal cord level is due to the fact that sensory receptors unite onto motor neurons. Furthermore sensory information in movement control is accomplished through the ascending pathways, these play a role in the control of complex movements (Shumway-Cook & Woollacott, 2007).

The various sensory receptors located in the muscles joints and skin which modulate movement is described below. The sensory receptors include muscle spindles, Golgi tendon organs, joint receptors, and cutaneous receptors (Shumway-Cook & Woollacott, 2007; Meyer, 2015).

The muscle spindle is encapsulated, it is spindle shaped and located in the muscle belly of skeletal muscle. This complex sensory receptor consists of; small muscle fibres, which are specialized, called intrafusal fibres, sensory neuron endings called Ia and II afferents, and gamma motor neuron endings. The muscle spindle detects changes in the length of the muscle, as well as produces the monosynaptic reflex which regulates muscle length during movement. The stretch reflex loop occurs when the muscle is stretched, causing an excitation of the muscle spindle, specifically the Ia afferents. This produces one of two responses; Ia afferent excitation, or the monosynaptic stretch reflex. The spindle stretch reflex is activated by excitation from the monosynaptic Ia afferent neurons, onto the alpha motor neurons. This activates the muscle where the motor neuron is placed as well as the synergistic muscles (Shumway-Cook & Woollacott, 2007).

The Golgi tendon organs protect the muscle from injury, and modulate the output of the muscle so that it can avoid fatigue. It is a spindle shaped receptor located in the muscular tendon junction, and it connects to 15 – 20 muscle fibres. Afferent information from the Golgi tendon organ is projected to the nervous system through Ib afferents. There are no efferent receptors located in Golgi tendon organs and thus it is not subjected to modulation from the CNS. The Golgi tendon organ can be defined as, an inhibitory disynaptic reflex whereby it inhibits its own muscle and excites the antagonistic muscle (Shumway-Cook & Woollacott, 2007).

There are a variety of joint receptors found in the joints this includes; Ruffini-type receptors, to paciniform endings. It seems that these joint receptors are sensitive to extreme joint angles, providing a warning signal when the joint is in extreme ranges. The afferent fibres in the joints ascends to the cerebral cortex and provides individuals with a sense of our position in space (Shumway-Cook & Woollacott, 2007).

Several cutaneous skin receptors such as mechanoreceptors, thermoreceptors, and nociceptors detect if there is potential damage to the surface of the skin. Within the CNS, lower levels of hierarchy take the information from the cutaneous receptors to give rise to reflexive movement. Additionally, information from the cutaneous receptors ascends to the cortex providing information about the position of the body, so that one can orientate themselves appropriately to their environment (Shumway-Cook & Woollacott, 2007).

This supports the definition that proprioception is the mindful awareness of the position, active motion, passive motion, and sense of the weight of the limbs. However, proprioception has an unconscious component, and these proprioceptive signals are used for the reflexive control of muscle tone and the control of posture. It can therefore be said that the signals provided from proprioceptive mechanoreceptors in muscles, tendons, joints and the skin are essential for the production and co-ordination of movement (Abbruzzese, et al., 2014; Aman, et al., 2015). Proprioception is therefore very closely associated to movement (Aman, et al., 2015), and loss of proprioception can cause a loss of control of muscle tone, disturbance in postural reflexes, and an impairment in spatial, and temporal orientation of voluntary movement. These are commonly observed in conditions such as stroke Parkinson's disease, focal dystonia and other neuromuscular injuries (Aman, et al., 2015).

The link between proprioception and movement has been explored, and proprioceptive training has shown to be beneficial in movement disorders (Abbruzzese, et al., 2014). Proprioceptive training refers to an intervention focused on training the unconscious and conscious aspects of proprioception. It is an intervention program which involves the use of somatosensory signals via proprioceptive and tactile inputs, whilst excluding other sensory inputs such as vision. It is challenging to conclude the effectiveness of a proprioception training program, as one cannot simply isolate sensory function from motor function. However evidence does show that proprioceptive training promotes cortical reorganization, supporting the idea of motor function improvements are as a result of proprioceptive training (Aman, et al., 2015).

Motor learning is a highly multisensory process and it is impossible to determine whether improvements in motor function is attributed purely to proprioceptive or visual input, or whether changes are attributed to multisensory or sensorimotor integration (Stillman, 2002; Aman, et al., 2015).

Applying focal vibration is one technique used in neurorehabilitation which provides proprioceptive input that is said to stimulate motor control during functional activities. There is no specific study which investigated the effect that vibration had on the upper limb.

A study with patients with Parkinson's disease, gait had improved and this was accredited to the improved proprioceptive feedback (Abbruzzese, et al., 2014). Evidence from other studies on individuals with other neurological conditions suggests that addressing proprioception in stroke may affect sensorimotor function in stroke (Findlater & Dukelow, 2016). The use of compression garments on proprioceptive training has not been reported in the literature, although change in proprioception was reported by Gracies, et al., (2000) after the use of compression garments in the intervention of patients with stroke (Gracies , et al., 2000).

2.5 Measures to assess recovery after stroke

2.5.1 Impairment based measures

In a study outcome measures and assessments are vital in tracking recovery after stroke, to determine the effectiveness of the intervention (Gladstone, et al., 2002). The Fugl-Meyer Assessment (FMA) is considered to be one of the most inclusive assessment measures of motor impairment after a stroke, and has been reported as the "gold standard" for assessment of upper limb function. The assessment is highly recommended in the use of clinical traits in stroke rehabilitation (Gladstone, et al., 2002). However despite this the FMA is an observation based assessment and is unable to detect fine changes in movement. This is due to the fact that the FMA is designed to measure gross motor movement in the limbs. A scale such as the Motor Status Score would be more appropriate to measure isolated and advanced movements which are more specific to functional tasks (Heart and Stroke Foundation: Canadian Partnership for Stroke Recovery, 2015).

Furthermore, the Fugl-Meyer assessment provides mainly information about the motor recovery of the upper limb, especially in those individuals with mild upper limb impairment, and would be useful alongside other assessment measures such as the Chedoke-McMaster Disability Inventory or the Chedoke Arm and Hand Activity Inventory (Gladstone, et al., 2002).

Assessments of the upper limb are categorised in terms of motor recovery and/or functional abilities of the upper limb. The common measures which measure upper limb function include the Action Research Arm Test, Wolf Motor Function test, and Frenchay Arm Test. On the other hand the Box and Block test and Nine Hole Peg Test measure motor performance.

The Motor Assessment Scale is a combined test looking at both components of function and motor performance (Heart and Stroke Foundation: Canadian Partnership for Stroke Recovery, 2015).

The Action Research Arm test reviews the individual's ability to use the upper limb whilst manipulating a variety of objects, it is a measure of activity limitations as a result of reduced motor function (Heart and Stroke Foundation: Canadian Partnership for Stroke Recovery, 2015). The Wolf Motor Function test measures the quality of upper limb movement when performed in a variety of timed functional tasks (Morris, et al., 2001; Heart and Stroke Foundation: Canadian Partnership for Stroke Recovery, 2015). The Frenchay Arm Test much like The Action Research Arm Test, and the Wolf Motor Function Test as it assesses upper limb function in relation to performance in functional tasks, and activities of daily living, however this test looks specifically at dextrous movement in the wrist and hand (Heart and Stroke Foundation: Canadian Partnership for Stroke Recovery, 2015).

Much like the FMA the Box and Block test is a common measure used to identify gross motor function of the affected upper limb, this serves as a quick screening tool (Heart and Stroke Foundation: Canadian Partnership for Stroke Recovery, 2015). The Nine Hole Peg test is a test which measures dexterity and co-ordination of the fine motor movements in the hand, it is not a measure of function in the hand (Heart and Stroke Foundation: Canadian Partnership for Stroke Recovery, 2015).

The Motor Assessment Scale is an outcome measure developed by Carr and Shepard to easily evaluate components of both movement and motor function post stroke (Dean & Mackey, 1992).

2.5.2 Occupational Performance based measures

Additionally, to the various upper limb assessments described there are a variety of outcome measures assessing various components affected following a stroke. In terms of assessment of functional performance the Functional Independence Measure, the Assessment of instrumental activities of daily living (Chan, et al., 2006) and the Bartel Index are most commonly used (Langhammer & Stanghelle, 2011)

The Disabilities of the Arm, Shoulder and Hand (DASH) and Stroke Impact Scale are objective self-score measures which provide the clinician insight into the perceived difficulties which the client is experiencing in relation to function of the upper limb (Heart and Stroke Foundation: Canadian Partnership for Stroke Recovery, 2015; Heart and Stroke Foundation: Canadian Partnership for Stroke Recovery, 2015). Despite the valuable information that is provided during analysis of the DASH, there is limited research exploring how acceptable this measure is for patients and thus it was concluded that this is a measure which should be used in cases where the impairment of the upper limb is mild in nature (Heart and Stroke Foundation: Canadian Partnership for Stroke Recovery, 2015). The Stroke Impact Scale on the other hand is a more general measure reviewing performance in all aspects such as communication, memory, hand function, and performance in ADL's this test should be interpreted with caution as some of the components are basic and do not reflect the true impact of the limitations in function following a stroke (Heart and Stroke Foundation: Canadian Partnership for Stroke Recovery, 2015).

2.6 Occupational therapy for motor and sensory recovery after stroke

Rehabilitation intervention models and frames of reference used in occupational therapy include; neurodevelopmental therapy (NDT) (Bobath, 1990), motor relearning (Carr & Shepherd, 2006), and task orientated training (TOT) (Kim, et al., 2016), all incorporate the paradigm that sensation is fundamental to motor function (Levin & Panturin, 2011; Findlater & Dukelow, 2016).

The effectiveness of the treatment of the sensory components in these interventions have not been tested (Hughes, et al., 2015; Meyer, 2015; Findlater & Dukelow, 2016). Many studies in the clinical field report on sensory recovery and in particular describe techniques for proprioceptive intervention after stroke, compared to the numerous studies dealing with motor recovery (Meyer, et al., 2014; Hughes, et al., 2015).

2.6.1 Frames of reference used in occupational therapy for intervention of the upper limb in stroke

2.6.1.1 Neurodevelopmental Therapy

Neurodevelopmental therapy (NDT) frame of reference describes therapy using a 'neurodevelopmental technique', the aim of which is to reduce the tone in the affected upper limb through various positioning or handling techniques using various key points (Bobath, 1990; Luke, et al., 2004). Normal movement patterns are facilitated through specific handling techniques (Luke, et al., 2004; Pollock, et al., 2014). The NDT approach is an approach which has evolved and in recent years has been described more as a problem solving approach when assessing and treating individuals with dysfunction in movement and postural control. It encourages optimal active participation from the individual to achieve an optimal level of functioning (Luke, et al., 2004; Pollock, et al., 2014). These handling techniques are described as a method of applying proprioceptive input to encourage an active response, as the individual gains movement this facilitation is modified and is progressively withdrawn (Luke, et al., 2004).

Neurodevelopmental therapy has been challenged over the recent years and it is debateable what constitutes as true Bobath practice as described by the Bobath's (Pollock, et al., 2014). Based on the Cochrane review done by Pollock et al (2014) it was concluded that there is low quality evidence, which is also out of date, related to the effectiveness of the NDT approach for adult stroke patients (Luke, et al., 2004; Pollock, et al., 2014).

2.6.1.2 Motor relearning

The motor relearning program was developed in the 1980's, by two physiotherapists Roberta Carr and Janet Shepard (Chan, et al., 2006; Pandian, et al., 2012). The frame of reference is based on the core principle that sensory information is essential for motor function (Findlater & Dukelow, 2016). The main focus of this approach was at relearning specific movements, encouraged and facilitated by the use of activities which are task specific. Using the limb in an activity which is task specific assists in regaining the movement loss, additionally these are tasks should be performed not only in a task specific manner, but also in a manner which is specific to the environment in which that task would naturally be performed (Chan, et al., 2006; Pandian, et al., 2012).

Chan et al conducted a RCT investigating the use of motor relearning programme in comparison to traditional therapy methods for improving physical abilities and function in specific tasks. Overall it was found that the motor relearning approach had good outcomes for performance in self-care and general physical abilities, especially in terms of upper limb function where motor relearning approach was in fact found to be more effective than the NDT approach (Chan, et al., 2006; Langhammer & Stanghelle, 2011; Pandian, et al., 2012).

2.6.1.3 Task orientated training

Task orientated training (TOT) (Kim, et al., 2016) also referred to as functional task training (Pollock, et al., 2014) it is a rehabilitation frame of reference which is based on the fundamental principles of motor relearning and neuroplasticity (Pollock, et al., 2014; Kim, et al., 2016). It is dependent on adaptations to the environment, specific analysis of tasks, repetition in a variety of situations and specific feedback. Task orientated training relies on the concept that motor relearning (Pandian, et al., 2012; Kim, et al., 2016) is enhanced through the improvement of sensory mechanisms, by requiring continuous movement which is specific to a task thereby enhancing the individual's perception of the movement and thus providing sensory feedback (Kim, et al., 2016).

This intervention requires the individual to maximally participate in specific tasks. Task orientated training has been found to play a significant role in the activation of wrist and finger extensors in individuals with a stroke, this is important for grasp and release and ultimately plays a large role in functional use of the affected hand (Kim, et al., 2016). A randomised control trial (RCT) conducted by Kim et al (2016) where they explored TOT alone, versus TOT alongside EMG neuromuscular electrical stimulation (EMG-NMES). It was concluded that EMG-NMES alongside TOT had better outcomes than TOT alone (Kim, et al., 2016). However based on a Cochrane review for upper limb interventions there is currently no strong evidence to support TOT this was specific for reach-to-grasp exercises which is common practice in TOT (Pollock, et al., 2014).

2.6.2 Occupation based therapy

The frames of reference used by occupational therapists over time as they were developed, become more occupation based with motor relearning and TOT requiring active involvement in tasks as part of intervention. This occupation based therapy subscribes to the philosophy of occupational therapy. Performance of occupations and daily activities similar to that of those which an individual will typically perform facilitates improvement in these areas and incorporates both motor and sensory input related to meaningful purposeful functional performance (Kim, et al., 2016).

This therapy is based on three main concepts which include; comprehensive assessment using interview and observation in the most natural context for the individual to understand their occupational performance, treatment in their most natural context, and setting of goals which encourage the most functional participation rather than reducing the impairments (Tomori, et al., 2015). Although this suggests that outcomes should be measured in terms of performance in occupation rather than impairment based assessments, occupation based therapy has been viewed as controversial in a medical model. There is still a to focus on reducing secondary impairments and improving motor and cognitive impairments in subacute stroke, but very little emphasis on remediation of proprioception and the integration of motor and sensory recovery (Tomori, et al., 2015).

Tomori et al (2015) found that both occupation-based therapy versus impairment based therapy were effective in improving physical abilities and independence in activities of daily living in stroke and that there was no comparable difference between these two types of therapy approaches (Tomori, et al., 2015). Thus since evidence for neither occupation based nor impairment based therapy is not stronger it is important therefore to include assessments and interventions that consider occupational performance and individual impairments in stroke.

2.6.3 Occupational Therapy techniques used for specific impairments of the upper limb after stroke

A number of adjunctive techniques are used in conjunction with the occupation and impairment based intervention to facilitate the motor recovery of specific impairments of the upper limb after stroke.

These include mirror therapy, constraint induced movement therapy, bilateral arm therapy, neuromuscular electrical stimulation, repetitive task training, virtual reality and robotics as well as strength training and position and stretching.

Techniques which specifically target proprioception and sensory recovery have been introduced and researched in relation to stroke. These techniques include kinesiotaping and sensory dynamic orthoses or compression garments.

2.6.3.1 Kinesiotaping

Kinesiotaping has also been proposed to promote increased proprioceptive input to facilitate motor control, however despite reduced pain and some changes in the modulation of sensory function there was no improvement in motor function as a result of the application of kinesiotaping (Abbruzzese, et al., 2014). In normal healthy adults a study conducted on kinesiotaping showed that it assisted in reducing spasticity which is said to be due to the proprioceptive input, it also released atypical muscle tension. In individuals who had suffered from a stroke kinesiotaping applied to gluteus muscles yielded improved hip extension which again is said to be due to the cutaneous stimulus provided on the skin surface (Tamburella, et al., 2014).

2.6.3.2. Sensory Dynamic Orthoses - Compression Garments

The use of Lycra compression garments in burns and oedema management is highly recognised and researched; however there is a recent trend towards the use of compression garments as sensory dynamic orthoses in both adults and children with neurological deficits (Watson, et al., 2007). There are a variety of compression garments currently being used in the neurological population, which include whole body suits such as the Upsuit, SPIO brace and Theratogs, shorts, gauntlets and vests (Hylton & Allen, 1997; Knox, 2003; Footer , 2006). These are custom made and measured to the wearer so as to provide a tight fitting garment therefore providing a deep pressure input (Knox, 2003).

Lycra garments are used as dynamic splints for adults (Gracies , et al., 2000) or children (Blair, et al., 1995) with neurological conditions. The reasons for using these garments as dynamic splints are that they differ from kinesiotaping in that they provide both proprioceptive input through cutaneous skin receptors but also a deep pressure to the internal soft tissue (Hylton & Allen, 1997; Kerem, et al., 2001). This deep pressure provides meaningful information to the somatosensory system about the position of the limb which provided better awareness of the body enabling the body to direct more controlled motor actions (Hylton & Allen, 1997; Elliott, et al., 2011). This has reportedly resulted in outcomes which include; affecting the tone changes in the limbs and trunk, the reduction of soft tissue contractures, improving postural alignment, and providing proximal stability and facilitating lower and upper limb movements (Gracies , et al., 2000; Rennie, et al., 2000; Nicholson, et al., 2001).

2.7 Therapeutic use of compression garments

2.7.1 Children with cerebral palsy

In children with cerebral palsy, full body compression garments were used in those individuals with athetosis, ataxia and spasticity, improvements in proximal stability as well as more controlled movements were evident. Those children with hypotonia on the other hand there were improvements noted in fine motor skills and sitting balance (Knox, 2003).

There are also reports of full body compression garments assisting in improving sensory attentiveness, increasing muscle readiness, improving dynamic standing balance through increase in the base of support and improving posture (Hylton & Allen, 1997; Footer , 2006).

Despite the aforementioned benefits there were notable barriers in the use of full body compression garments. These included; poor compliance in wearing the garments, effortful application of the garments, irritability caused by the heat and friction of the garment, difficulty with toileting, including a reported increase in bowel and bladder movements (Knox, 2003), garments are also costly and do not accommodate for the growth of the child (Footer , 2006).

The application of Lycra garments on the upper limb has however become increasingly popular in children with cerebral palsy. When considering the upper limb in children with cerebral palsy the degree of deficit in the upper limb function of the child, can range from weakness, decreased speed of movements, sensory dysfunction, contractures and limited joint range, poor control of movements, and instability at the joints which is related to either hypotonia or spasticity (Nicholson, et al., 2001; Elliott, et al., 2011). Ultimately this impairs voluntary and functional use of the upper limb which has a significant impact on the child's ability to engage in basic daily functional tasks.

Traditionally splinting is a technique used by occupational therapists to manage spasticity, improve range and functional movement in children with cerebral palsy. Splints provide supportive positioning, prevent joint deformities and contractures, promote function of the hand and maintain muscle length (Corn, et al., 2003; Elliott, et al., 2011). Compression or pressure garments which are also referred to as Dynamic Lycra splints were developed in response to problems with compliance to hard splints. They were developed to provide an alternative to traditional splinting methods (Corn, et al., 2003) with the premise that they may alter spasticity through the provision of neutral heat and by creating a low intensity sustained stretch (Elliott, et al., 2011). This was based on the use of Johnstone air pressure splints initially designed as emergency splints for fractures. The use of these splints was incorporated into the treatment of neurological patients with spasticity, as these splints are inflated through air from the lungs, providing neutral warmth over the area applied (Kerem, et al., 2001).

The mechanism for the application of Lycra compression garments, is primarily the same, which is to provide proprioceptive and cutaneous input through the application of deep pressure and warmth. This stimulates the thermal and tactile receptors to adapt to the stimulus, by lessening the excitability of the intermediate and motor neurons. This mechanism is said to reduce spasticity in the upper limb and individuals using this for 30 minutes prior to therapy has shown evidence of increased sensory awareness and reduced spasticity and of the upper limb (Kerem, et al., 2001).

Compression garments have since become a therapeutic tool and Elliot et al concluded that after the use of Lycra arm splints for three months children with cerebral palsy displayed more accurate and effective movements and a decrease in jerky movements (Elliott, et al., 2011) however Corn et al concluded that there was no difference in the quality of movement and had no effect of upper limb function. In fact there was evidence in decline in function associated the use of the upper limb compression garments, however they highlighted that the population which may benefit from compression garments are still to be determined (Corn, et al., 2003). The general consensus is that these garments are beneficial however there is conflicting observations noted (Nicholson, et al., 2001; Corn, et al., 2003). Furthermore the studies found on the matter are based on small case studies and thus cannot be generalized to the larger population (Nicholson, et al., 2001; Corn, et al., 2003; Elliott, et al., 2011).

2.7.2 Use of compression garments with adults with neurological impairments

The use of upper limb compression garments in the adult neurologically impaired population is currently under researched, but this technique is becoming popular in rehabilitation centres in Australia (Gracies , et al., 1997; Gracies , et al., 2000).

The use of compression garments was intended to provide sensory input with continuous proprioceptive input and feedback to the area applied through stimulation of cutaneous receptors and provides continuous proprioceptive input (Watson, et al., 2007).

The idea of continuous proprioceptive input and increased sensory awareness of the upper limb, is suggested to be the main reason for the effectiveness of the compression garments in a neurological adult population. There is currently speculation regarding the mechanism of compression garments however which include the low load prolonged stretch provided by the garments has an effect on shortened muscles, provides an external support, provides an external motivation to the wearer, increases visual awareness of the affected limb and thus prevents learnt non-use (Hylton & Allen, 1997; Gracies , et al., 2000; Kerem, et al., 2001; Nicholson, et al., 2001; Footer , 2006; Watson, et al., 2007 ; Elliott, et al., 2011).

Gracies et al (1997) researched the effects of compression garments on the upper limb in normal subjects and found that the compression garments which are fabricated to promote supination had an instantaneous result on facilitating forearm supination within normal subjects. It was concluded that compression garments may in fact be suitable for facilitating motor and sensory recovery during the acute stages in adults with neurological conditions (Gracies , et al., 1997).

Gracies, et al., (2000) then reported on the use of compression garments applied to the upper limb of patients with stroke. This was a cross over design of 16 patients carried out over two days. The study was well controlled and the researcher used this design to account for differences in learning between the two assessment dates. The results were promising and showed that even after a small period of three hours of the compression garment being worn not only did the participants tolerate the garment well but also demonstrated a variety of benefits including improved sensation and proprioception, improved awareness of the hemiplegic limb and reduced visual neglect (Gracies , et al., 2000) Other changes and benefits noted were a reduction in spasticity in the wrist and finger flexors and improved wrist positioning although there was reduced the ability to flex the fingers actively. Participants also had an increased active range of motion (AROM), reduced the experience of pain, increased the passive range of motion (PROM) at the shoulder and reduced swelling where swelling was evident (Gracies , et al., 2000). The application of compression garments was more acceptable to patient without the uncomfortable fitting that traditional splints provided (Gracies , et al., 1997).

2.7.3 Criteria for compression garments used therapeutically

Compression garments are constructed from a variety of materials depending on the supplier however most blends contain nylon yarn with various ratios of elastane filaments (Leung, et al., 2010). These are traditionally custom made according to the measurements of the patient, and the desired compression is typically decided by the therapist depending on the needs of the patient (Leung, et al., 2010).

The recommended compression applied to the skin by the compression garment ranges from 5mmHg to 40mmHg (Leung, et al., 2010), however the general consensus is to apply a pressure of 25mmHg (Puzey, 2001). This pressure is determined through the use of a reduction factor which varies from a reduction of 5-20% of the measurement, this occurs most frequently in intervals of 5% with a 20% reduction factor most commonly used (Kwakkel, et al., 1999; Leung, et al., 2010). The reduction factor is mainly dependent on the tensile property of the fabric being used. Leung et al described three fabric types commonly used in the fabrication of compression garments, and highlighted the differences in pressure obtained on each fabric with the above reduction factors. They highlighted that the application of a double layer of two types of fabric would provide a more effective and desired pressure than that of the traditionally applied single layer (Leung, et al., 2010).

A study conducted by Macintyre et al noted that factors which affect the pressure of the compression garment with use and wear of a compression garment over a two week period. The tension of the compression garment significantly decreases over a 14 day period and this was noted especially in garments with a higher reduction factor. However it was also noted that washing the garment and allowing it to rest for a period provided the garment with the opportunity to regain their tension. Therefore it was concluded that it would be most beneficial for compression garments to undergo a pre-stretch and pre-wash program prior to commencing the use of the garment (Kwakkel, et al., 1999). Compression garments should furthermore be replaced after a period of six – eight weeks (Puzey, 2001).

2.8 Summary

In the above literature stroke is one of the leading causes of disability with impairments ranging from a disruption in movement and sensation to communication disorders, cognitive fall out and visual perceptual disturbances (Nilsen, et al., 2015), hemiplegia and hemiparesis is a common impairment following a stroke which affects participation in all activities of daily living (Meyer, 2015; Nilsen, et al., 2015).

There is a strong association of sensory input in order to produce smooth, controlled and purposeful movement as well as for participation within functional tasks (Shumway-Cook & Woollacott, 2007). Whilst sensation play a large role in movement there are various other factors which affect movement this can be factors within the individual itself, factors in the environment or components of the task (Shumway-Cook & Woollacott, 2007). Despite the various constraints that these factors can play on movement (Shumway-Cook & Woollacott, 2007), neuroplasticity allows for motor relearning. Furthermore there is strong evidence which has shown that input at the somatosensory cortex facilitates cortical re-organization and motor relearning of the affected limb (Hummel & Cohen, 2005). This is the premise for which this study is based on is that the proprioceptive and neutral warmth input provided from the compression garment can facilitate neuroplastic changes in the cortex and thus facilitating the development of motor control following a stroke.

Sensory input contributes to the modulation of how movement is produced, this is due to the fact that sensory receptors are united onto motor neurons (Shumway-Cook & Woollacott, 2007). Due to the complex nature of motor relearning, which is multisensorial, it is often difficult to determine if motor function is purely associated with proprioceptive input (Stillman, 2002; Aman, et al., 2015).

Occupational therapists use a variety of frames of reference to improve motor function after a stroke this may include a neurodevelopmental approach, motor relearning approach or task orientated approach (Bobath, 1990; Kim, et al., 2016; Carr & Shepherd, 2006).

These approaches are all based on the notion that sensory input is an input component for motor output (Luke, et al., 2004), furthermore the task orientated approach specifically states that motor relearning is in fact enhanced through the improvement of the sensory system (Pandian, et al., 2012; Kim, et al., 2016). Within these frames of references specific techniques are adopted to further enhance motor relearning of the upper limb. Some of these techniques which apply proprioceptive input include kinesiotaping as well as sensory dynamic orthosis or compression garments.

Whilst compression garments are commonly used in children with cerebral palsy there is an indication for compression garments to be applied to the upper limb.

The application of compression garments in children with cerebral palsy varies and there is a variety of different compression garments available ranging from full body suits to garments specifically placed on the upper limb. The full body suits have been shown to improve sensory awareness, increase muscle activation and improve dynamic standing balance (Hylton & Allen, 1997). Furthermore compression garments on the upper limb in cerebral palsy children altered spasticity through the neutral warmth and prolonged low intensity stretch provided from the garments (Elliott, et al., 2011).

The proprioception and neutral warmth from the compression garments stimulate thermal and tactile receptors so that they can adapt to the provided stimulus by providing a less of an excitability of the intermediate and motor neuron (Kerem, et al., 2001). Currently there is conflicting evidence for the use of compression garments on the upper limb, furthermore the studies completed are not strong evidence as these are not RCT's and have small sample sizes (Nicholson, et al., 2001; Corn, et al., 2003; Elliott, et al., 2011).

Compression garments applied on adults with neurological deficits is a new concept. This technique is aimed at providing continuous proprioceptive sensory input which thus stimulates the cutaneous skin receptors (Watson, et al., 2007). It has been found effective to encourage supination of the upper limb in normal subjects (Gracies , et al., 1997), this study was then extended to participants with hemiplegia. This small cross over study demonstrated positive effects after the use of compression garments.

This included decreased spasticity in the wrist and fingers, better positioning of the wrist, improved active range of motion and passive range of motion, decrease in swelling and pain (Gracies , et al., 2000). These positive outcomes supports the notion that compression garments are a beneficial adjunctive technique in the upper limb in adults with stroke. However this s the only study in the adult population where a compression garment is applied on the upper limb and the small sample size reduces the quality of the study. It is clear based on physiology, neuroplasticity and the various frames of reference used in occupational therapy that sensation is a vital component for motor function. This study will aim to identify if this association can be made, it also aims to add to the lack of literature with regards to the use of compression garments in adults with stroke.

Chapter 3: Methodology

3.1 Research design

A quantitative experimental study was conducted using a randomised control trial (RCT), wherein participants were randomly assigned to either a control or intervention group. This study aims to determine the cause and effect. It looks at the magnitude to which the research has an effect when applying a certain intervention or treatment within a certain circumstance. When observing the effect of the intervention, it becomes difficult to identify the true effect that the intervention may have due to multiple factors which may also be affecting the participant. An RCT sets itself apart from a single data set experimental design through the addition of a control group. This control group receives the same treatment as the experimental group. The experimental group then receives the change in the variable being studied. This aims to reduce the number of variables which could also result in a change (Thomas, 2013).

The control group received treatment which is based on treatment modalities currently in practice in private rehabilitation centres in South Africa. The experimental group received treatment in the same manner as the control group, with the addition of intervention with a custom Lycra compression garment. The purpose of this type of methodology design was to gauge whether or not the custom Lycra compression garment showed any change when compared to a control group (Brink, 2006)

3.2 Research site and sample

The research study took place at two private rehabilitation centres in Gauteng with the physical rehabilitation providers of Rita Henn and partners affiliated with Summit Rehabilitation. Initially the participants were only to be sourced from Netcare rehabilitation hospital in Auckland Park, however due to insufficient participant numbers the study was extended to Care Cure Vereeniging. Majority of the participants from the study were obtained from Netcare rehabilitation hospital whilst only two participants were obtained from Care Cure Vereeniging.

Summit Rehabilitation provides goal directed therapy where functional goals are discussed and set as a multidisciplinary team, for both inpatients and outpatients. Therapists then provide treatment within a multidisciplinary framework in order to work towards achieving the agreed upon goals. Patients who are able to form part of this process are encouraged to set goals with the team.

Netcare Rehabilitation Hospital is the largest of the practices serviced by Summit Rehabilitation. This practice was founded by Rita Henn and partners who now have a total of 7 satellite practices located in both Gauteng and Western Cape. Netcare rehabilitation hospital provides both inpatient and outpatient services to individuals with a newly acquired disability. The inpatient units are divided into orthopaedic, spinal, neurology, paediatrics and general. Patients have access to services such as Botox, Lotomat, Sitlab, upper limb clinic and vocational rehabilitation which is provided either as an inpatient or as an outpatient.

The patients used in this study were all obtained from the neurology unit, as patients in this unit have acquired various neurological deficits ranging from traumatic injuries to medically acquired injuries. The majority of the patients seen in this unit are adults with occasional young adults being admitted. The unit can accommodate forty patients at a time with therapists seeing between six to nine patients a day. There are a total of 8 physiotherapists, 7 occupational therapists and 7 speech therapists treating patients in the neurology unit. Each patient receives one session of physiotherapy and occupational therapy per day, speech therapy is provided daily along with physiotherapy and occupational therapy if it is appropriate. Depending on the patient's ability to tolerate therapy, they may receive an additional treatment session of physiotherapy or occupational therapy per day.

The patients within this unit range from those with traumatic brain injuries to stroke and cancers of the brain. This inpatient unit treats patients for a period of between two to twelve weeks depending on the severity of the client and the funding available to the client. The average length of stay is a period of six weeks for inpatient rehabilitation.

The second practice at which patients were obtained is one of the seven satellite practices of Summit rehabilitation, and was the first satellite practice to branch off from Netcare Rehabilitation Hospital. Summit Rehabilitation Vereeniging services Care Cure Clinic in Vereeniging. This is a subacute facility which has eight rehabilitation beds and ten subacute beds within the medical wing of the facility. There is a psychiatric wing which hosts a total of 20 beds. Within the medical wing there are a variety of patients admitted with conditions ranging stroke, traumatic brain injuries and poly trauma to conditions such as cancer requiring palliative care or renal failure requiring strengthening and dialysis before they can be safely discharged home.

The unit initially consisted of one physiotherapist, one occupational therapist and one speech therapist servicing 13 inpatient beds and occasional outpatients. The facility now has three occupational therapists, three physiotherapists and two speech therapists, these therapists are divided into a team of inpatient therapists and outpatient therapists. The inpatient team consists of two occupational therapists, two physiotherapists and one speech therapist and the outpatient team consists of one occupational therapist, one physiotherapist and one speech therapist. Each therapist see's between six to nine patients daily regardless of whether they are in the inpatient or outpatient team. The occupational therapist and speech therapist of the outpatient team provide further services in the acute hospitals around the Vaal so that rehabilitation begins as soon as possible whilst waiting for authorization for the patient to be transferred to the subacute facility.

There are a variety of specialist services which patients can access at Summit Rehabilitation Vereeniging as both an inpatient and outpatient. This includes services such as unweighing treadmill, Botox, Sitlab, upper limb clinic, driving rehabilitation and vocational rehabilitation.

As with the inpatients at Netcare rehabilitation hospital patient's length of stay is dependent on the funder, the patient's diagnosis and severity. The average length of stay for an individual with a stroke is six weeks however in some cases a length of stay of 12 weeks is also seen if motivated for appropriately.

Outpatient therapy provided at Netcare Rehabilitation hospital and Summit Rehabilitation Vereeniging is dependent on the patient's transportation availability, severity of the client and authorization provided by the funder. Patients with a neurological condition generally receive therapy two to three times per week for a period of three months. Thereafter the frequency of therapy decreases over the next three to six months. Some patients continue therapy for up to two years.

3.2.1 Selection of subjects

Convenience sampling is a method used based on the availability of the required participants. This form of sampling was used as the participants were easily available through the researcher's current place of employment; all types of stroke's who met the inclusion criteria were included in the study (Payton, 1988; Brink, 2006).

The randomization process to assign participants to the control or experimental group was done by a research assistant at Netcare Rehabilitation Hospital. This first research assistant, who is an experienced and qualified occupational therapist employed at the rehabilitation unit, then screened each patient on arrival according to the inclusion and exclusion criteria.

Inclusion criteria

- Patients with an acute stroke and no longer than 1 week admission into the rehabilitation unit
- Male and female inpatients
- One quarter of stroke patients in South Africa are aged between 14-49 (Hoffman, 2000) the other three quarters consist of the elderly which can extend to late in life (Mudzi, et al., 2012). Thus the inclusion criteria for this study was that of adults including young adults from 20 years of age until 90.
- Receiving daily therapy 5 days per week

Exclusion criteria

- Previous history of injury or deficits to the affected upper limb
- Individuals with motor apraxia or receptive aphasia
- Individuals who have received botulinum toxin injections
- Individuals who have scored 2 or less on 2 or more of the components of the cognitive subsection in the Functional Independence Measure (FIM)

The research assistant then placed suitable participants according to a random numbers table, into either the experimental or control group.

3.2.2 Sample size

The sample size of 11 per group was calculated using a power analysis. This was based on difference of 7.6 and a standard deviation of 6 on the Fugl-Meyer Assessment total motor function score, with a power of 80% and significance level of 0.05 (Dodakin, et al., 2013) . Due to limited availability of participants a total of 24 participants were obtained and data were collected over a period of six months for six participants in the experimental group and nine participants in the control group. A total of nine participants were excluded due to no written consent being obtained and/or the participant being discharged before the post-test could be completed. Furthermore, the individuals who were discharged did attend the arranged outpatient follow up in attempt to obtain the data needed for the post-test to be completed.

3.3 Measurement techniques

3.3.1 Demographic questionnaire (Appendix A)

A demographic questionnaire was designed by the researcher. This questionnaire obtained the following information about the participant: Age, sex, race, home language, residential address, type of home, highest level of education, current employment, marital status, diagnosis, date of onset, date of admission to the rehabilitation facility, limb affected, limb dominance and risk factors. This demographic questionnaire was completed during the initial contact with the participant at the pre-test by the researcher who is also the assessor along with the Fugl-Meyer assessment of Motor recovery (FMA) and the Disabilities of the arm shoulder and hand outcome measure (DASH) were also administered.

3.3.2 The Fugl-Meyer Assessment of Motor Recovery (FMA) (Appendix B)

The Fugl-Meyer Assessment of Motor Recovery was used to assess five domains of upper limb function. These included motor function, sensory function, coordination, joint range and pain. This outcome measure is aimed at evaluating and measuring the recovery in patients with hemiplegia following a stroke. (Anon., n.d.). Items are scored on a three-point ordinal scale and participants can receive a maximum of 226. Reliability and validity have been determined on this outcome measure.

The test retest reliability was of great importance. It has been found to have excellent reliability in the total motor score of an ICC value 0.97, excellent reliability in the total sensation score with ICC value of 0.81 and excellent reliability in passive joint motion total score of ICC value of 0.95. Furthermore interrater reliability using Pearsons r in the upper extremity was excellent with values of 0.98 – 0.99. Criterion, construct and content validity have been established (Anon., n.d.).

3.3.3 The Disabilities of the Arm, Shoulder and Hand Outcome Measure (DASH) (Appendix C)

The Disabilities of the Arm, Shoulder and Hand Outcome Measure (DASH) was used to determine the functional implications as a result of reduced movement of the upper limb, which was measured by the Fugl-Meyer assessment. The DASH is a 30 item questionnaire which consists of a two four-itemed optional modules of sport and work. For the purpose of this study these optional modules were not included as it is not appropriate for an inpatient population. This assessment looks at the participant's view of how difficult it is to perform a variety of functional tasks which require bilateral hand use within the last week. A few items include opening a tight jar, preparing a meal, putting on a shirt and participation in leisure tasks. The participants' rates on a scale from one to five, with one indicating 'no difficulty' and a five indicating 'unable'. The Dash also reviews how impairment of the upper limb has affected participation in social activities and work and the impact that pain has on sleeping patterns.

Reliability of this outcome measure has been determined with Chronbach Alpha's measured at 0.96. Test retest reliability which is the most important form of reliability for this study, was 0.96, which is excellent reliability. Face and content validity has been established by consultation with a variety of upper limb experts. Criterion validity has not been established due to the absence of a gold standard in upper limb function (Solway, et al., 2002).

The independent variables, which is the intervention being provided, is that of the Lycra garment, and the dependent variables are that of upper-limb movement and sensation.

3.3.4 Lycra compression garment comfort questionnaire (Appendix D)

A comfort questionnaire was developed after it was noted in the follow up sessions with the nursing staff that the initially developed compliance checklist was not being complete. The aim was to identify any adverse effects, explore aspects of comfort of the compression garment, determine the ease of application and identify if the participant would continue with the use of the garment based on previous experience. These questions were formulated around previous literature which reported that Lycra compression garments were hot, uncomfortable and difficult to do and doff which often reduced compliance (Knox, 2003).

3.4 Research procedure

Ethical clearance was obtained for the study from the Human Ethics Research Committee (HERC) at the University of the Witwatersrand (M140866) (Appendix E) and permission from Netcare Rehabilitation hospital (Appendix F), Care Cure Vereeniging (Appendix G) and Summit Rehabilitation (Appendix H) before data collection commenced.

3.4.1 Training of treating occupational therapists

Since the Lycra compression garments for each participant would be applied and monitored by their treating occupational therapist the researcher provided training and information to all the therapists working at Netcare rehabilitation hospital Neurology unit. This training included the monitoring of the use of the compression garments, donning of the garments to ensure correct use of the garment, and monitoring the skin for any adverse effects (Appendix I)

3.4.2 Provision of Lycra compression garments and pre-test assessment

The research assistants, who were practicing therapists identified by the researcher at both facilities, determined based on the inclusion and exclusion criteria if a patient formed a part of the sample. The participant was assigned to the experimental or control group through the use of a randomized Excel spreadsheet. Once this was done the patient or patient's family members were provided with an information letter and a consent form (Appendix J). After consent was obtained, the participant was then assessed within their first week of admission to the facility by the researcher, using the demographic questionnaire, the FMA and the DASH. The researcher performed assessments once per week or when patients were available. This was done for a period of six months.

The assessments were conducted in no particular order, and the tests were conducted in a different order with each participant through the use of a randomisation table. The researcher completed the outcome measures at the participant's bedside with the curtain drawn to provide privacy to the participant. However there were occasions where the participant was not at their bedside and in this case they were assessed in the rehabilitation gym at a private area. The researcher provided the assessment tools and equipment for the assessment (Anon., n.d.), as well as the printed outcome measures used to record the data collected. The file numbers, group status and participants' files were not accessible to the researcher, whom was also the assessor, and this was one of the measures used to attempt to maintain blinding of the assessor. All assessments were completed by the researcher to control for inter-rater differences.

The research assistant then informed the treating therapist of the group in which the patient was to be placed so as to provide those in the experimental group with a Lycra compression garment. The participants in the experimental group were measured by the treating therapist (Appendix K) for the Lycra compression garment and these measurements then sent to a second research assistant.

The second research assistant who is a therapist at summit was trained on the construction and measurement of the garments. She then constructed the compression garments for those individuals who required one, for the purpose of this study each garment was custom made. The Lycra compression garments were fitted and issued to the patients within two days of the pre-test assessment.



Figure 3.1 Lycra compression Garment design

The Lycra compression garment is made of Silastic elastomer (Pendleton & Schultz-Krohn, 2001). This material has a one way stretch property which allows for stretch to be applied in specific directions. The stretch of the garment is in a circumferential manner. The pressure applied was 15% less of the circumference measured. The therapist checked that the garment was correctly fitted by pinching the material - if the material was easily lifted off the skin the garment was too loose.

3.4.3 Intervention

The participants in both the experimental and control groups continued to receive the rehabilitation programme usually provided at Summit Rehabilitation practices for all patients with stroke (Appendix L).

The participants in the experimental group, who were provided with a Lycra compression garment, had the garment applied daily to the upper limb whilst the rehabilitation programme was continued. Based on studies performed on children with CP, which reported children tolerated wearing Lycra compression garments for a total of six hours a day (Nicholson, et al., 2001), the adults were expected to tolerate wearing the garment for a longer period of between six and eight hours per day for a period of six weeks.

A training session was completed with the nursing unit managers to educate them on the research study, the manner in which donning and doffing of the garments should be performed, as well as how to monitor the skin for any changes (Appendix M).

3.4.4 Post-test assessment

The post-test assessments were then completed after six weeks of inpatient rehabilitation, and in some instances where patients were discharged prior to the six weeks a post-test was performed before the six week period. The researcher was informed of the pre-morbid discharge via email and efforts were made to ensure the assessment was completed before the participant was discharged home. The post-test assessments included the FMA and the DASH. Once these assessments were completed the researcher was informed of whether the participant was in the control or experimental group. Thereafter a checklist on the comfort of the Lycra compression garment was completed by those participants in the experimental group who had worn the Lycra compression garment.

Throughout the study all attempts were made to ensure that the researcher remained blinded, however, there were instances where this was not possible. In a few circumstances the participant's garment had not been removed prior to contact being made with the researcher for the post-test. In other circumstances the participant informed the researcher that they had received a garment or had queries regarding their garment. Therefore the researcher could not be blinded in this study for all participants. The blinding of the treating therapist was not necessary.

3.4.5 Data analysis

Descriptive statistics were used to describe the data in this study. Frequencies were used to describe the demographic data. Median values as well as lower quartile and upper quartiles were used to describe the data obtained from the FMA and the DASH to compare data within the same group. Median values were used to describe the data obtained from the FMA and DASH data between the control group and the experimental group.

The outcome measures used in this study were that of ordinal data and for this purpose non-parametric statistics was applied. Non-parametric statistics are applied to data in which no statements are made in terms of the standard distribution of the population being targeted. For the purpose of this study the Mann-Whitney u test was used in order to determine noteworthy differences between the experimental and control group (Brink, 2006). Wilcoxon signed rank test was used to determine change from the pre-test to the post-test within the same group of participants (Rosner, et al., 2006).

Effect size allows the researcher to determine the difference between the control and experimental group means (Sullivan & Feinn, 2012). It allows the researcher to observe the size of the effect from the intervention provided between the two groups despite the influences of a small sample size as seen in this study. Using Effect size allowed the researcher to show that effects were large enough to show clinical significance where there is a lack of statistical significance (Fritz, et al., 2012) Effect size was used with Cohens r and using the data obtained from the Mann-Whitney u test to describe the size of the effect between the control group and the experimental group. The statistical program which was used was that of Statistica.

CHAPTER 4: RESULTS

4.1 Introduction

The results of this study will be discussed according to the sample size presented in the CONSORT diagram (Figure 4.1). The sample size was smaller than expected as many of the participants did not fall within the inclusion criteria. A total of 24 individuals were assessed for both experimental and control groups combined, but at the end of the study only 15 participants could be included in the data analysis as all required data was not collected for the other participants.

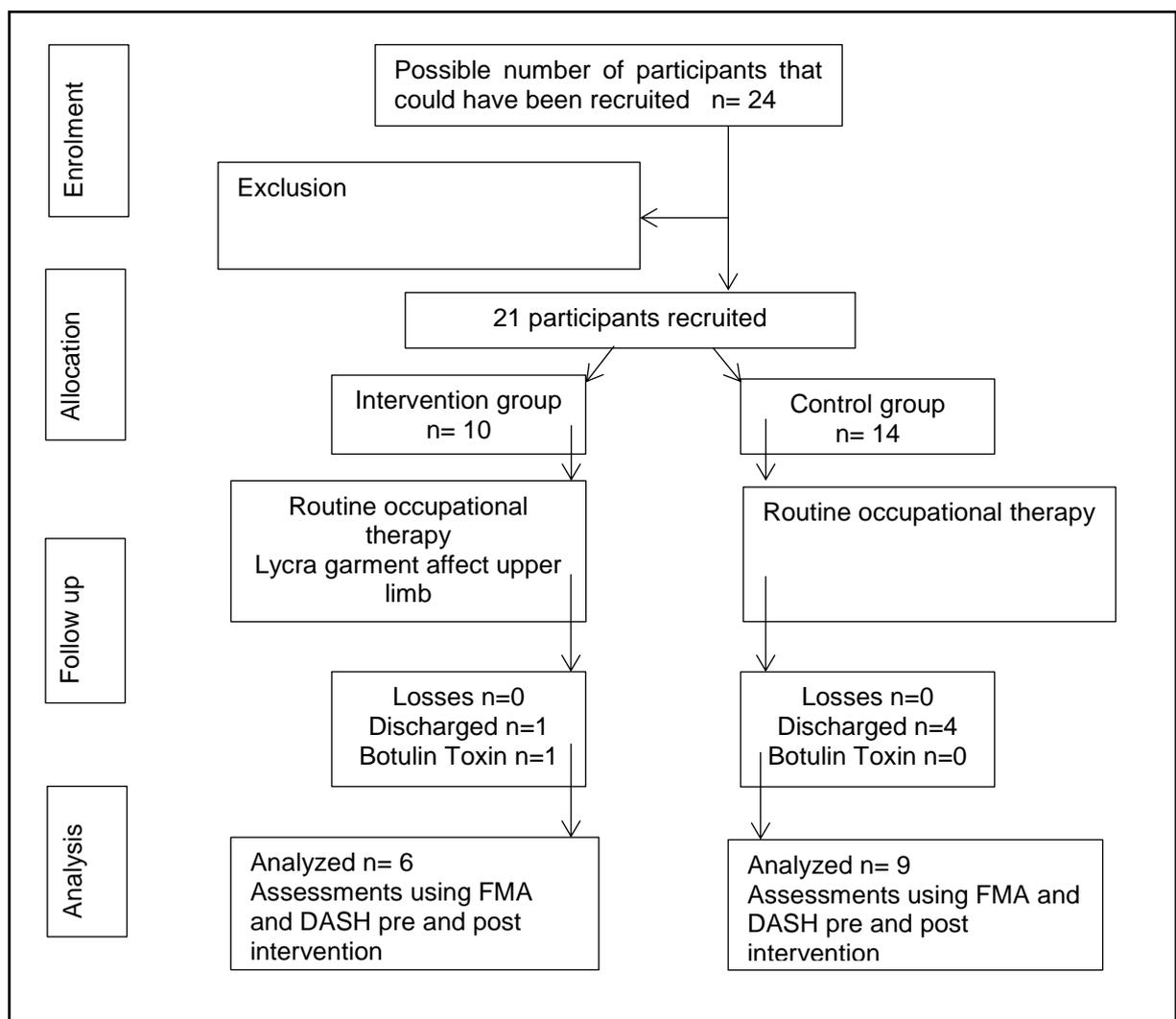


Figure 4.1 Adapted CONSORT flow diagram for randomized control intervention for a non-pharmaceutical study

A total of 24 participants could be recruited. Of those, three were excluded as written consent could not be obtained. There were no losses in both groups in terms of voluntary drop out from the research study. There were five participants excluded due to premature discharge and the researcher not being able to conduct the post-tests and one was excluded as Botox was administered during the time of the study. There was thus a dropout rate of 28.5%. The total number in the experimental group was six participants and nine participants in the control group. The results include the patient demographics, socioeconomic background, medical history, results of the Fugl Meyer Assessment (FMA) and results of the Disabilities of the Arm, Shoulder and Hand (DASH).

4.2 Demographics

4.2.1 Personal demographics

The age of the participants in the study ranged from 43 years to 79 years. There was an even distribution of participants in the 40-49, 50-59 and 60-69 age groups in the experimental group. Within control group however the participants were older but not significantly so, with more participants in the 40-49 age group. (Table 4.1).

Table 4.1 Personal demographics of participants n=15

		Experimental n=6 n (%)	Control n=9 n (%)	p value
Age in years	40 – 49	2(33.33%)	3(33.33%)	0.203
	50 – 59	2(33.33%)	2(22.22%)	
	60 – 69	2(33.33%)	2(22.22%)	
	70 – 79	0%	2(22.22%)	
Gender	Male	2(33.33%)	3 (33.33%)	0.201
	Female	4 (66.67%)	6 (66.67%)	

Significance $p \leq 0.05^*$

Significance $p \leq 0.01^{**}$

There were an even distribution of male participants between groups and more female participants in the control group, but this difference was not significant.

There was an equal distribution of participants who had an education level of diploma or above. The experimental group had fewer participants who had completed their matric compared to those in the control group. More participants in the experimental group had an education level below Grade 10 but the difference between the groups was not significant.

Overall most of the participants in the control group received some form of income with 11.11% not remunerated due to the fact that this participant was a student. Of those receiving an income 33.33% were receiving a pension. In the experimental group 16.67% of participant's received a pension and 16.67% were unemployed and receiving no remuneration. The lack of a significant difference between the groups meant that they were considered comparable in terms of demographic factors (Table 4.2).

Table 4.2 Educational and employment demographics of participants n=15

		Experimental n=6 n (%)	Control n=9 n (%)	p-value
Highest level of education	Matric	1 (16.67%)	3 (33.33%)	0.480
	Diploma	2 (33.33%)	3 (33.33%)	
	Degree	0%	1 (11.11%)	
	Higher tertiary	1 (16.67%)	0%	
	Other (under standard 8)	2 (33.33%)	2 (22.22%)	
Employment	Employed	4 (66.67%)	5 (55.56%)	0.530
	Unemployed	1 (16.67%)	0%	
	Student	0%	1 (11.11%)	
	Pension	1 (16.67%)	3 (33.33%)	

Significance $p \leq 0.05^*$

Significance $p \leq 0.01^{**}$

The context, in terms of the type of dwelling the participants lived in and their access to their community, is considered based on their ability to drive or not.

All of the participants in the control group living in a bricked dwelling i.e. free standing home, flat or duplex with 77.78% living in a free standing house. However in the experimental group 16.67% of participants lived in an informal homestead with only 66.67% living in a free standing brick home (Table 4.3).

Table 4.3 Contextual factors related to type of dwelling and community mobility (driving) n=15

		Experimental n=6 n (%)	Control n=9 n (%)	p-value
Type of home	House	4 (66.67%)	7 (77.78%)	0.810
	Flat	1 (16.67%)	1 (11.11%)	
	Duplex	0%	1 (11.11%)	
	Informal homestead	1 (16.67%)	0%	
Drivers licence	Yes	4 (66.67%)	7 (77.78%)	0.400
	No	2 (33.33%)	2 (22.22%)	

Significance $p \leq 0.05^*$

Significance $p \leq 0.01^{**}$

Most of the participants in both groups had driver's licences, but more participants in the control group had a licence. There was no significant difference between the groups for these variables.

4.2.2 Medical history

Participants in the experimental group all suffered from an ischemic stroke compared to the control group where 88.89% of the participants had an ischemic stroke. There was an equal distribution of left hemiplegic participants and right hemiplegic participants in the experimental group, however in the control group more participants presented with left hemiplegia.

All of the participants in the experimental group were right hand dominant and 88.89% of the participants in the control group were right hand dominant.

The three comorbidities which were most common amongst participants was that of hypertension, with 83.33% in the experimental group and 77.78% in the control group presenting with this condition.

There were 44.44% of individuals with hypercholesteraemia in the control group which was more than those in the experimental group. A total of 33.33% of individuals disclosed their HIV status all of which were in the experimental group.

Collectively 27.78% of participants suffer from diabetes, 27.78% participants were on hormone replacement therapy and 11.11% had a known heart condition. The two most common lifestyle factors which contribute to the risk factors for a stroke in the participants include in increased BMI in 33.33% of individuals in the experimental group and smoking in 33.33% in the control group. (Table 4.4).

Table 4.4 Medical history of participants n=15

		Experimental n=6 n (%)	Control n=9 n (%)	p- value
Type of stroke	Ischemic	6 (100%)	8 (88.89%)	0.640
	Haemorrhagic	0%	1 (11.11%)	
Limb affected	Left	3 (50%)	6 (66.67%)	0.322
	Right	3 (50%)	3 (33.33%)	
Dominance	Left	0%	1 (11.11%)	0.620
	Right	6 (100%)	8 (88.89%)	
Comorbidities	Hypertension	5 (83.33%)	7 (77.78%)	0.230
	Diabetes	1 (16.67%)	1 (11.11%)	
	Heart condition	0%	1 (11.11%)	
	Hormone replacement therapy	1 (16.67%)	1 (11.11%)	
	Hypocholesteraemia	1 (16.67%)	4 (44.44%)	
	HIV	2 (33.33%)	0%	
Lifestyle factors	Stress	1 (16.67%)	1 (11.11%)	0.340
	Increased BMI	2 (33.33%)	1 (11.11%)	
	Family history	0%	1 (11.11%)	
	Contraception	0%	1 (11.11%)	
	Smoking	1 (16.67%)	3 (33.33%)	
	Alcohol use	1 (16.67%)	0%	

Significance $p \leq 0.05^*$

Significance $p \leq 0.01^{**}$

Other factors reported by the participants were 27.78% who indicated stress to be a risk factor, 16.67% who consumed alcohol, 11.11% who had a family history of stroke and 11.11% who were using contraception. None of these medical factors differ significantly between the experimental and control groups

On average, most participants received inpatient rehabilitation within the first four weeks of the onset of their stroke. Only 11.11% of participants in the control group received therapy after 4 weeks. The time of admission to rehabilitation after the stroke was shorter but not significantly different for the experimental group with 16.67% of participants admitted within the first week of onset, 50% within the first 3 weeks and 33.33% within the first 4 weeks. The control group had most of their admissions between the one to two week period, followed by 22.22% being admitted within the first 3 weeks and 22.22% admitted within the first 4 weeks. (Table 4.5)

Table 4.5 Length of time to admission for rehabilitation after stroke (n=15)

		Experimental n=6 n (%)	Control n=9 n (%)	p-value
Time of onset to rehabilitation	0 – 1 week	1 (16.67%)	0%	0.12
	1 – 2 weeks	0%	4 (44.44%)	
	2 – 3 weeks	3 (50%)	2 (22.22%)	
	3 – 4 weeks	2 (33.33%)	2 (22.22%)	
	5 – 6 weeks	0%	1 (11.11%)	

Significance $p \leq 0.05^*$

Significance $p \leq 0.01^{**}$

4.3 The Fugl-Meyer Assessment of Motor Recovery and the Disabilities of the Arm, Shoulder and Hand Outcome Measure (DASH) for the experimental and control groups

4.3.1 Within group analysis

The Wilcoxon signed rank test was used to analyse the data obtained from the Fugl-Meyer Assessment of Motor Recovery.

4.3.1.1 The Fugl-Meyer Assessment

Control group

There was a statistically significant improvement demonstrated in the control group when comparing the pre-test scores to the post-test scores in the FMA for upper extremity ($p=0.018$) and sensation ($p=0.018$). The movement in the wrist as well as coordination and speed did not display a change in scores from pre-test to post-test. Movement in the hand had a small change in score from pre-test to post-test, however this change was not statistically significant. As a result of the change in the upper extremity and sensation the overall score of total motor function therefore demonstrated a positive significance change ($p=0.018$). (Table 4.6). Small negative changes were found in passive joint motion and pain.

Table 4.6 Pre-test and Post-test scores for control group (n=9)

		Pre test	Post test	Difference	p value
		Median (Lower and upper quartile)	Median (Lower and upper quartile)		
The Fugl-Meyer Assess- ment of Motor Recovery	Upper extremity	4 (1-23)	18 (12-30)	14	0.018*
	Wrist	0 (0-6)	0 (0-5)	0	0.655
	Hand	0 (0-10)	1 (0-12)	1	0.068
	Co- ordination and speed	0 (0-2)	0 (0-2)	0	1.000
	Total motor function	4 (1-43)	19 (13-52)	15	0.018*
	Sensation	6 (2-9)	10 (8-12)	4	0.018*
	Passive joint motion	24 (23-24)	23 (22-24)	-1	0.101
	Pain	20 (18-21)	18 (16-22)	-2	0.721

Significance $p \leq 0.05^*$

Significance $p \leq 0.01^{**}$

The experimental group

The positive change in function in the experimental group at pre-test and post-test demonstrated statistical significance at the upper extremity ($p=0.028$), the wrist ($p=0.043$), the hand ($p=0.028$) and sensation ($p=0.028$). This reflected on the total motor function of the upper limb as well ($p=0.028$). A small change in scores was evident in co-ordination and speed but the difference was not significant (Table 4.7). Passive joint motion was found to have decreased between the pre-test and post-test assessments and pain had a small positive increase.

Table 4.7 Pre-test and Post-test scores for experimental group (n=6)

		Pre test	Post test	Difference	p value
		Median (Lower and upper quartile)	Median (Lower and upper quartile)		
The Fugl-Meyer Assessment of Motor Recovery	Upper extremity	13.0 (8-30)	26.5 (21-36)	13.5	0.028*
	Wrist	2 (0-6)	6 (5-9)	4	0.043*
	Hand	4 (2-7)	7 (5-14)	3	0.028*
	Co- ordination and speed	0 (0-9)	1.5 (0-4)	1.5	0.108
	Total motor function	19 (10-45)	41 (31-63)	22	0.028*
	Sensation	9 (9-10)	12 (11-12)	3	0.028*
	Passive joint motion	23.5 (18-24)	19 (17-24)	-4.5	0.068
	Pain	17 (11-24)	19 (13-24)	2	0.465

Significance $p \leq 0.05^*$

Significance $p \leq 0.01^{**}$

4.3.1.2 The Disabilities of the Arm, Shoulder and Hand Outcome Measure (DASH)

Control group

A smaller score on the DASH is indicative of better functional use of the affected upper limb and hand. There was a small improvement in the DASH scores from pre-test to post-test however this was not statistically significant for the control group ($p=0.171$) (Table 4.8).

Table 4.8 Pre-test and Post-test scores for control group (n=9)

	Pre test	Post test	Difference	p value
	Median (Lower and upper quartile)	Median (Lower and upper quartile)		
The Disabilities of the Arm, Shoulder and Hand Outcome Measure (DASH)	67.5 (52.5-76.7)	61.67 (55-65)	5.83	0.171

Significance $p \leq 0.05^*$ Significance $p \leq 0.01^{**}$

Experimental group

The scores in the DASH declined in the experimental group which indicated a positive change for functional performance, however this was not statistically significant for the experimental group ($p=0.074$) (Table 4.9).

Table 4.9 Pre-test and Post-test scores for experimental group (n=6)

	Pre test	Post test	Difference	p value
	Median (Lower and upper quartile)	Median (Lower and upper quartile)		
The Disabilities of the Arm, Shoulder and Hand Outcome Measure (DASH)	74.99 (65=79.17)	57.91 (48.83-72.5)	17.08	0.074

Significance $p \leq 0.05^*$ Significance $p \leq 0.01^{**}$

4.3.2 Between group analysis

4.3.2.1 The Fugl-Meyer Assessment

The scores for the experimental group and control group were compared for the pre-tests initial assessment. The experimental group had higher scores on the initial pre-test assessment for all the motor function on the FMA and DASH scores, although there were no significant differences between the groups for the pre-test assessment, and therefore the groups were considered comparable in terms of their upper limb movement initially. (Table 4.10)

Table 4.10 Pre-test Fugl-Meyer Assessment scores for control and experimental group (n=15)

		Control group	Experimental group	p value
		Pre test		
		Median (Lower and upper quartile)	Median (Lower and upper quartile)	
The Fugl-Meyer Assessment of Motor Recovery	Upper extremity	4 (1-23)	13.0 (8-30)	0.262
	Wrist	0 (0-6)	2 (0-6)	0.953
	Hand	0 (0-10)	4 (2-7)	0.555
	Co-ordination and speed	0 (0-2)	0 (0-9)	0.953
	Total motor function	4 (1-43)	19 (10-45)	0.443
	Sensation	6 (2-9)	9 (9-10)	0.443
	Passive joint motion	24 (23-24)	23.5 (18-24)	0.479
	Pain	20 (18-21)	17 (11-24)	1.00
The Disabilities of the Arm, Shoulder and Hand Outcome Measure (DASH)		67.5 (52.5-76.7)	74.99 (65=79.17)	0.517

Significance $p \leq 0.05^*$

Significance $p \leq 0.01^{**}$

In order to accommodate for the differences between the groups on the pre-test assessment, the change in scores for the groups were compared to establish the effect of the Lycra compression garments (Figure 4.2).

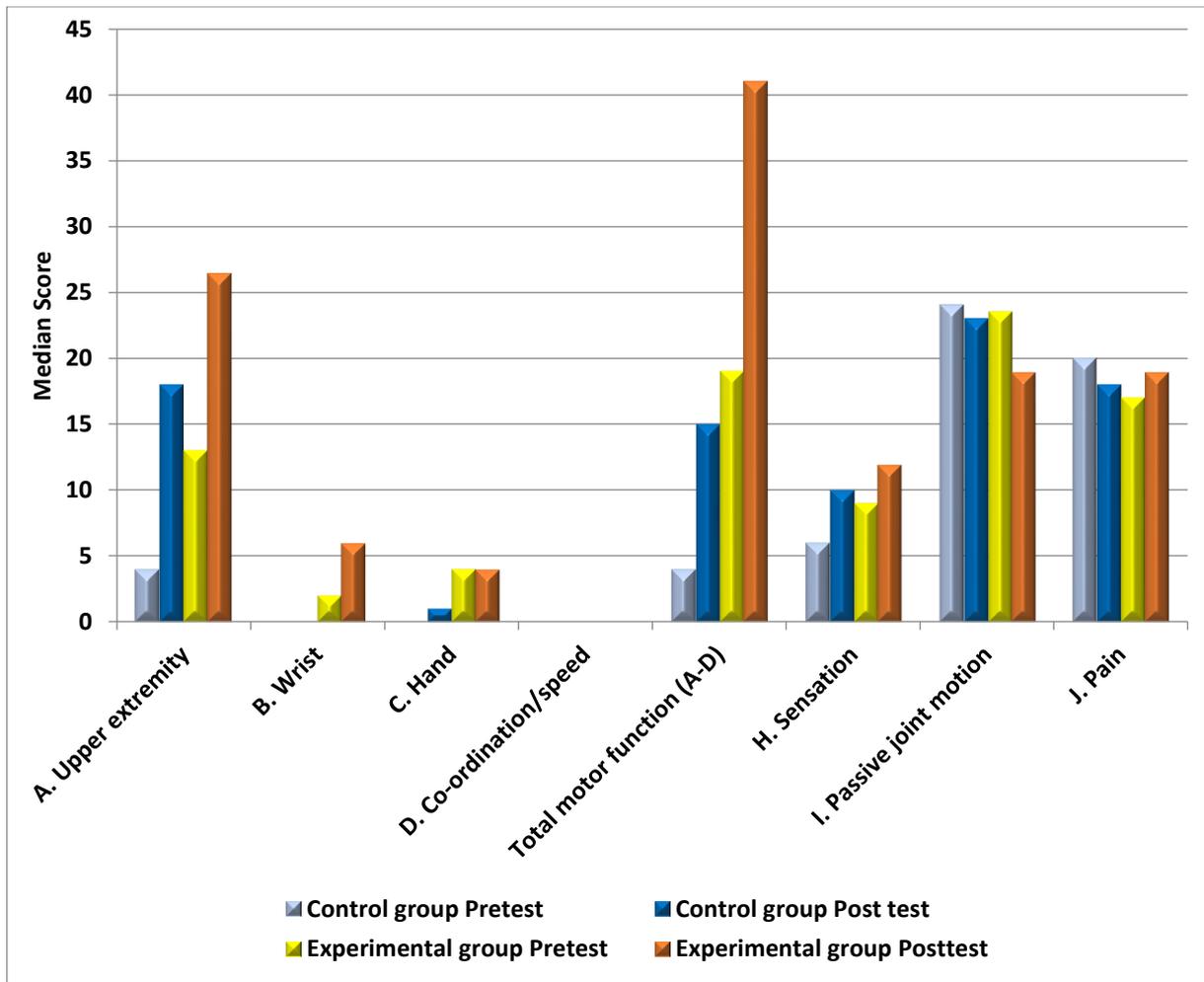


Figure 4.2 Pre-test and post-test median Fugl Meyer Assessment scores for control and experimental groups

Both groups showed similar positive change in the scores for upper extremity with no statistically significant difference between the groups. The negative effect size of -0.29 indicated little difference between the groups, with the control group having a slightly greater improvement than the experimental group (Table 4.11). Cohen's r was used in determining the effect size from the control and experimental group.

The wrist and hand scores for the control group either had little or no change from pre-test to post-test compared to the experimental group, where a significant improvement was found. This yielded a statistically significant difference and large effect size for the change in scores between the two groups for wrist and hand movement. The effect size confidence intervals are both positive indicating significant clinical change as well.

Table 4.11 Comparison of change in median Fugl-Meyer Assessment scores for the control group and experimental group

		Control group	Experimental group	p value	Effect size Cohen r	Confidence intervals 95%
		Change in median	Change in median			
The Fugl-Meyer Assessment of Motor Recovery	Upper extremity	14	13.5	0.263	-0.29	-0.81 to 0.23
	Wrist	0	4	0.013**	0.64**	0.11 to 1.16*
	Hand	1	3	0.018**	0.61**	0.08 to 1.13*
	Co-ordination and speed	0	1.5	0.125	0.40*	-0.12 to 0.91
	Total motor function	15	22	0.009**	0.67**	0.14 to 1.19*
	Sensation	4	3	0.953	-0.02	-0.53 to 0.50
	Passive joint motion	-1	-4.5	0.262	-0.29	-0.81 to 0.23
	Pain	-2	2	0.443	0.20	-0.32 to 0.72

Significance $p \leq 0.05^*$
Significance $p \leq 0.01^{**}$

Small effect size 0.1
Medium effect size 0.3*
Large effect size 0.5**

The control group had no change in the co-ordination and speed scores from pre-test to post-test compared to the experimental group, where the change in scores from pre-test to post-test was 1.5. This was not significantly different from the lack of change in the control group although the effect size showed a moderate clinical difference.

Overall both the control and experimental group improved in total motor function scores, however a larger difference in the scores was evident in the experimental group. This showed a statistically significant difference ($p=0.009$) in total motor function of the upper limb with a large effect size of 0.67. The large effect size confirmed a clinically significant difference between the groups.

There was no statistical significance for sensation between the two groups with a greater improvement in the control group with a small effect size. Passive joint range was reduced in the experimental group by a large amount as compared to the control group, however both groups had a decrease which was not statistically significant with a small effect size. A similar finding was evident for pain scores, where scores decreased in the control group and increased in the experimental group.

4.3.2.2 The Disabilities of the Arm, Shoulder and Hand Outcome Measure (DASH)

The DASH scores for the experimental group and control group were compared based on the assessment from the pre-test. The experimental group had higher scores on the initial pre-test assessment which is indicative of poorer functional use of the upper limb. However, despite this, there were no significant differences between the groups for the initial assessment, and therefore the groups were considered comparable. (Table 4.12)

Table 4.12 Pre-test The Disabilities of the Arm, Shoulder and Hand Outcome Measure (DASH) scores for control and experimental group (n=15)

	Control group	Experimental group	p value
	Pre test		
The Disabilities of the Arm, Shoulder and Hand Outcome Measure (DASH)	67.5 (52.5-76.7)	74.99 (65-79.17)	0.517

Significance $p \leq 0.05^*$

Significance $p \leq 0.01^{**}$

In order to accommodate for the differences between the groups on the pre-test initial assessment, the change in scores for the groups were compared to establish the effect of the Lycra compression garments on functional use of the hand and upper limb.

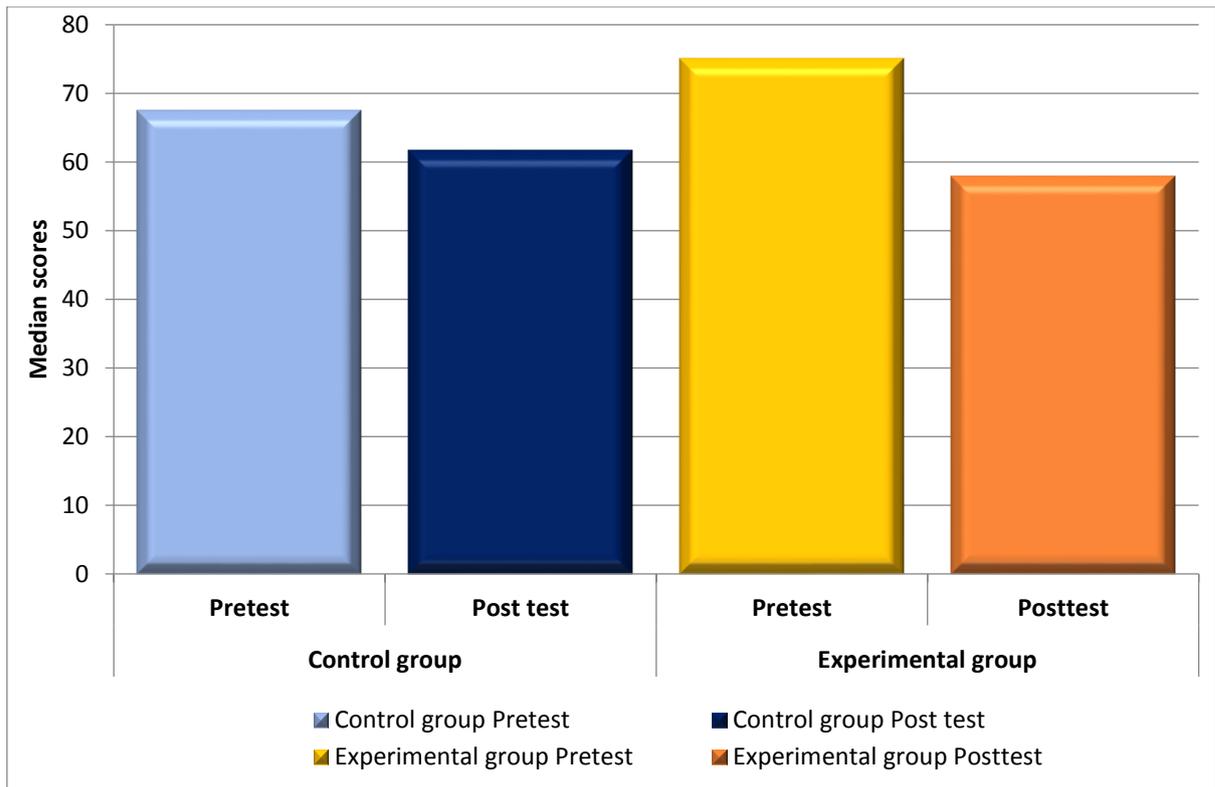


Figure 4.3 Pre-test and post-test median Disabilities of the Arm, Shoulder and Hand Outcome Measure (DASH) scores for control and experimental groups

The experimental group had a greater change in scores when compared to the control group (Figure 4.3). However this was not enough to produce statistical significance. Despite the fact that no statistical significance was evident there was a small effect size of 0.02 using Cohens r (Table 4.13).

Table 4.13 Comparison of change in median Disabilities of the Arm, Shoulder and Hand Outcome Measure (DASH) scores for the control group and experimental group

	Control group	Experimental group	p value	Effect size Cohen r	Confidence intervals 95%
	Change in median	Change in median			
The Disabilities of the Arm, Shoulder and Hand Outcome Measure (DASH)	5.83	17.08	0.952	0.02	-0.53 to 0.53

Significance $p \leq 0.05^*$
Significance $p \leq 0.01^{**}$

Small effect size 0.1
Medium effect size 0.3*
Large effect size 0.5**

4.4 Evaluation of Lycra compression garments from experimental group participants

At the end of the testing the participant was asked if a garment was issued and the researched obtained general feedback regarding the fit, comfort and adverse effects of the garment (Appendix F). Overall most participants in the experimental group hand no adverse effects from wearing the compression garment all but one (16.7%) who experienced swelling with the garment (Figure 4.4).

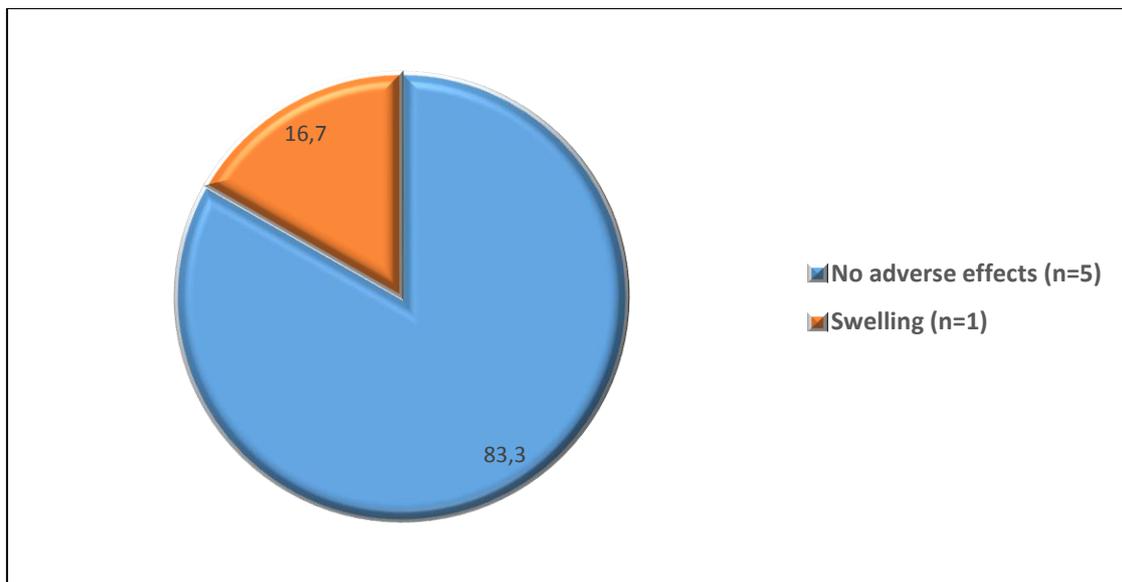


Figure 4.4 Adverse effects of the compression garment

Half of the experimental participants reported that the garment was comfortable with one participant requesting an additional garment for continued use at home. The remaining participants reported that the garment felt too tight (16.67%) and made them feel hot (33.33%) (Figure 4.5).

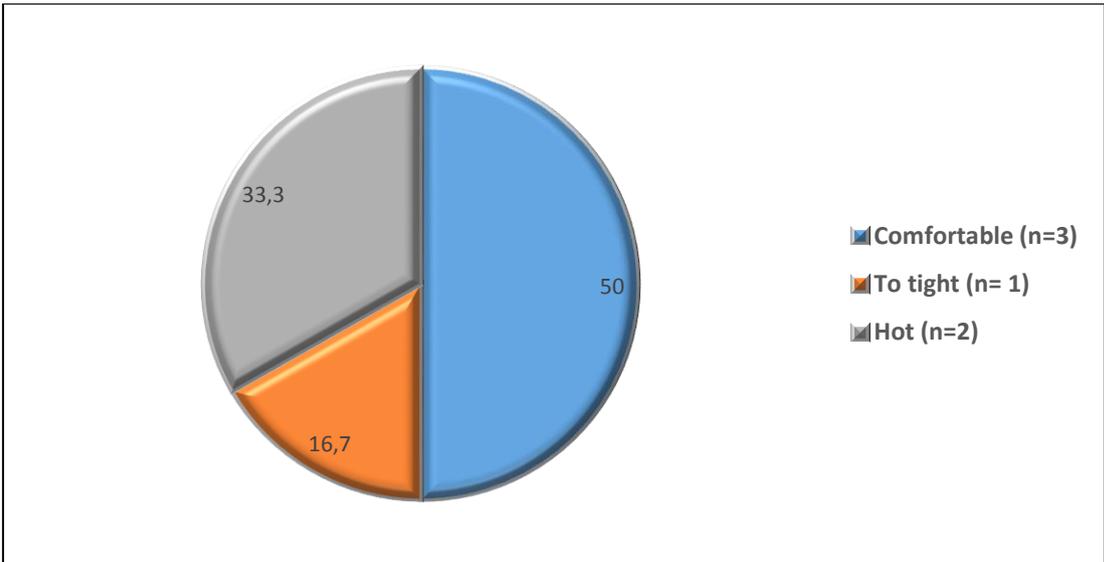


Figure 4.5 Comfort of the compression garment

Half of the participants reported that they would continue with the use of the compression garments (Figure 4.6).

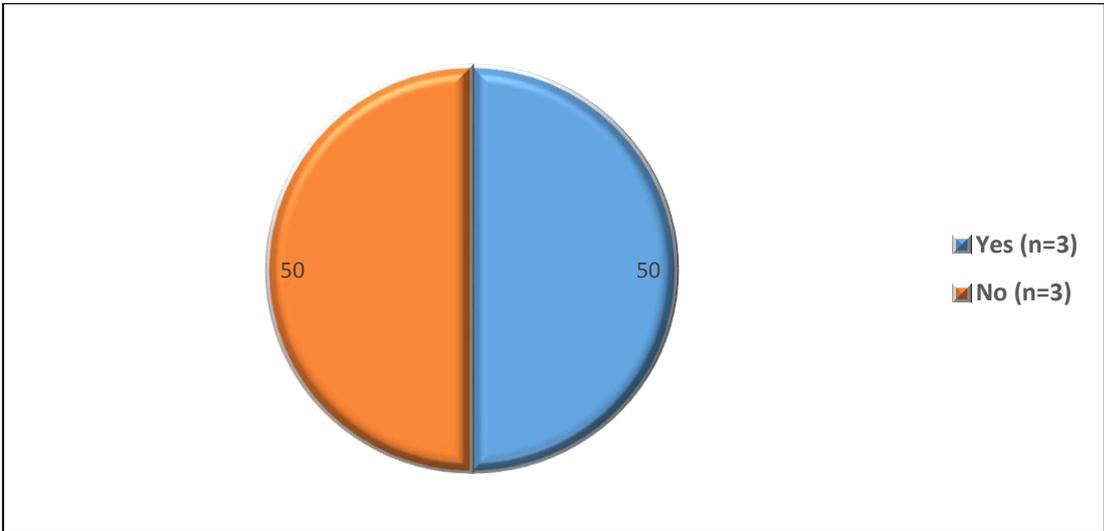


Figure 4.6 Continued use at home

More than half of the participants required assistance to don and doff the garment and only a small portion (16.67%) were able to independently and easily don the the garment (Figure 4.7).

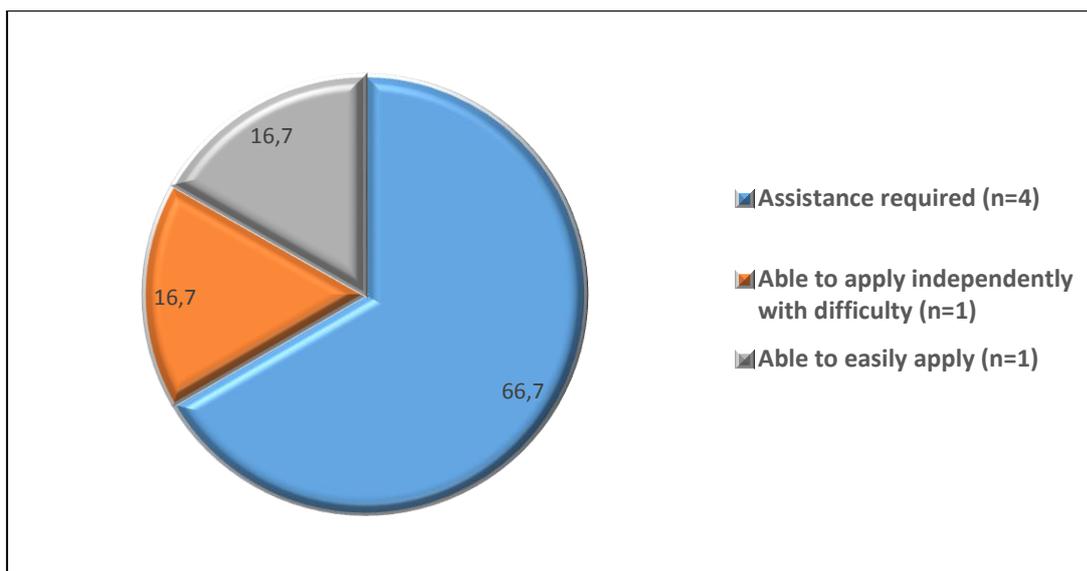


Figure 4.7 Ease of application of the compression garment

4.5 Summary of results

A total of 15 patients were used in the study with a dropout rate of 37.5% due to loss, premature discharges, and participants being injected with Botulin Toxin during the course of the study. Despite the small sample size there was statistically and clinically significant differences when comparing pre-test and post-test data from both control and experimental groups as well as when comparing the control group to the experimental group.

The groups were comparable for gender. More participants in the experimental group fell into a younger age group and had a lower socio-economic status compared to the control group. There were fewer participants in the experimental group and a higher number of participants had a level of education below Grade10.

All participants in the control group lived in a bricked dwelling. More participants in the experimental group lived in an informal homestead and had a small number of participants who were unemployed.

There were small differences in the medical conditions of the patients. The experimental group had no haemorrhagic strokes and had an even distribution of left hemiplegia and right hemiplegia.

The control on the other hand had one participant with haemorrhagic stroke and a greater number with left hemiplegia. Most participants were admitted to rehabilitation within 4 weeks from the time of onset of the stroke, the control had one participant being admitted after 4 weeks. The most common co-morbidities amongst both groups were hypertension. The control group had a high incidence of hypercholesterolemia and the experimental group had more participants with HIV. The two most common lifestyle factors present were that of increased BMI and smoking.

The within group analysis in the control group showed a statistically significant improvement in the upper extremity, total motor function and sensation of the control group. There was no change or a very small change in scores of: the wrist, hand, co-ordination and speed of movement, with no statistically significant change evident. Passive joint range and pain had a decline in scores demonstrating that pain was worse and that there was a decrease in joint range. There was a positive change in DASH scores but this was not enough to produce statistical significance.

The within group analysis in the experimental group showed a statistically significant improvement in upper extremity function, wrist, hand, total motor function and sensation. There was a small change in co-ordination and speed but this was not enough to produce statistical significance. Pain improved but did not produce statistical significance. As seen in the control group passive joint range declined in the experimental group. DASH scores improved in both the control group and the experimental group but a greater difference in scores was evident in the control group.

When comparing the control and experimental groups to one another there was a statistically significant difference in the change in the FMA scores wrist, hand and total motor function, with the experimental group achieving higher scores. The effect size for these components indicated clinically significant change as well. The null hypothesis was therefore rejected for movement of the wrist, hand and total motor function.

The change in upper extremity function and coordination did not show a significant difference between the two groups; with the control group achieving a bigger change in upper extremity scores, and the null hypothesis was accepted for upper extremity function and coordination, as well as passive joint motion, pain and sensation.

Both groups had a decrease in passive joint motion however, the control group had a smaller decrease in passive joint motion. The negative scores indicates an increase in pain in the control group in contrast to the experimental group who had a decrease in pain. There was a similar improvement in sensation in both groups. The functional use of the upper limb was assessed using the DASH. Despite a greater change in scores from pre-test to post-test in the experimental group there was no statistical significance. However, a small effect size was evident indicating clinically that there was little difference in the change in functional use of the hand and upper limb between the groups. The null hypothesis was accepted for the change in functional movement of the upper limb assessed by the DASH.

Half of the participants that were issued compression garments (experimental group only) reported that the garment was comfortable and that they would continue with the use of the garment. Overall there was only one participant who reported swelling after the compression garment had been issued. More than half of the participants required assistance to don the compression garment and only one participant was able to independently don the garment.

CHAPTER 5: DISCUSSION

5.1 Introduction

Stroke is a disabling disease with a large range of impairments. Often the most visible being hemiplegia or hemiparesis, however other impairments such as loss of sensation and proprioception, frequently accompany the hemiplegia (Fuller & Manford, 2010). In developing countries such as South Africa, 30% of individuals that have had a stroke will remain with permanent disability following the stroke (Lemogoum, et al., 2005). Of these individuals who experience hemiplegia or hemiparesis only 5% to 20% will regain full functional use of the affected limb (Kwakkel, et al., 1999). This discussion considers a small sample of stroke survivors with hemiplegia or hemiparesis and their demographics, medical context, and medical management. The effect of the use of the therapeutic technique of compression garments on recovery of the upper limb after a stroke is also discussed. In terms of active selective movement, range of motion, sensation, pain and speed and co-ordination of movement and whether this movement could be translated to functional tasks are also discussed.

5.2 Demographics

Stroke is a disabling disease which is no longer considered a disease of the elderly especially in developing countries (Mensah, 2008). About a third of the patients in both the experimental and control groups were younger than 50 years of age in both the experimental and control groups although the sample in this study was slightly older than the 35-65 years typically reported in South African research.as a result of the high number of individuals with HIV/AIDS (Bryer, et al., 2010) . The age range up to 69 years of the participants was also reflective of the fact that there is an increasing aged population with stroke as the elderly are now living beyond the age of 65 due to advances in health care when compared to what was previously available (Lemogoum, et al., 2005).

As indicated in prevalence studies on stroke in South Africa (Bryer, et al., 2010) there was a greater percentage of female patients in this study. Since race was not recoded in this study, ethnic difference cannot be commented on.

The participants in this study came from varying socio-economic backgrounds. Although treated at a private rehabilitation centre, most participants in the experimental group came from a lower socio-economic group than the control group's participants. Their level of education was lower, more of the participants in the experimental group lived in informal homesteads and their unemployment rate was higher. Despite the fact that the literature reports those from lower socio-economic groups are less likely to receive quality stroke related services and may have more deficits related to their stroke, that was not the case in this study (Addo, et al., 2012). Despite low socio-economic status noted in the participants, these individuals had access to rehabilitation, as many low income employees receive medical funding from their company or their spouses who may be working at a company with medical funding benefits.

5.2.2 Medical history

As reported in the literature the between 98-100% of the participants in this study presented with ischemic strokes. This is by far the most common reason for stroke with at least 85% of all strokes being this type (Bryer, et al., 2010). Although research indicates that patients with haemorrhagic strokes show better, and somewhat faster gains in terms of function and motor recovery; only one participant in the control group in this study had a haemorrhagic stroke. The results indicated that the experimental group had better perceived functional use of their affected upper limbs, and also displayed better improvements in motor recovery. Thus due to a poor representation of haemorrhagic stroke in this study, the results did not support the evidence in the literature, and no conclusions could be drawn about the outcomes due to the type of stroke the participants had experienced.

Furthermore, the cerebral hemisphere in which damage occurs appears to have a stronger overall prognostic predictor, than the type of stroke experienced. The participants in this study had an equal distribution of left versus right cerebral hemisphere damage, whilst the control group had more participants with right cerebral hemisphere damage. This may have affected the outcomes found as Coupar et al (2012) in their systematic review concluded that, individuals who have had a stroke in the left cerebral hemisphere have better outcomes in terms of motor recovery of the affected upper limb.

There is no evidence that other outcomes related to stroke, such as balance, shoulder pain and stiffness, communication and sensation, have any predictive effect on motor recovery (Coupar, et al., 2012). The incidence of stroke has been associated with a variety of risk factors which are categorized as modifiable or non-modifiable. These include factors such as smoking of cigarettes, diabetes, diet, and lack of physical exercise, obesity and underlying cardiac complications. Whilst these are all important, the highest modifiable risk factor contributing to stroke, especially within the South African context, is hypertension (Mensah, 2008). The results in this study for both the control and experimental groups were consistent with reported risk factors, and both groups had hypertension as their leading co-morbidity. Participants in both groups also presented with a variety of co-morbidities and risk factors, which could not be analysed further due to the small sample size.

5.2.3 Management of stroke

In terms of rehabilitation after a stroke, Gracies et al (1997) identified a 'critical window period' which falls within the first 7 days following the stroke. In this study, only one participant in the experimental group received inpatient rehabilitation at a dedicated stroke centre within the first week following the stroke. However, all the participants were admitted for rehabilitation and received therapy within the first month after their stroke, with the exception of one participant in the control group. Although not ideal, the period between onset of stroke and admission to rehabilitation is affected by a lack of dedicated stroke facilities and rehabilitation facilities in South Africa (Bryer, et al., 2010)

The differences between the experimental and control groups for the demographic medical and management factors were not significant however. Therefore, the groups could be considered as comparable and therefore the data for the two groups were analysed to determine the effectiveness of the Lycra compression garment intervention in this study (Bryer, et al., 2010).

5.3 Effectiveness of Lycra compression garments

5.3.1 Active selective movement of the upper limb

The first objective of this study was to determine change in the motor function which includes active voluntary movement and co-ordination in the upper limbs of patients with stroke, when Lycra compression garments were and were not used.

Compression garments applied to the upper limb of patients with stroke are considered as an adjunctive therapy technique which should be used with routine traditional therapy to improve upper limb function. In this study, significant improvement was found for the upper limb movement of both the control group who did not wear Lycra compression garments and the experimental group who did. (Table 4.6 and Table 4.7)

When the experimental and control groups' scores were compared for the scores on the Fugl Meyer assessment the experimental group had higher scores for upper limb movement, wrist and hand movement and the total movement score. These differences were not statistically significant from the control group and therefore the changes in the scores were compared to establish the effectiveness of the Lycra compression garments as the groups were considered comparable on pre-test for this component (Table 4.10).

Overall, the total motor score indicated a significantly greater positive change or improvement in the total motor function for the experimental group than the control group, with a large effect size indicating that this change was clinically significant. However, the change in active selective movement was not consistently greater for the experimental group.

The improvement found for the upper limb movement of the participants was greater than the reported return of some movement reported for between 25% to 45% patients with stroke (Au-Yeung & Hui-Chan, 2009). In this study 100% of the participants in the experimental group and 77% (n=7) of patients in the control group had some improvement in upper limb movement over the period of the research. Only two participants who had no upper limb movement on the pre-test initial assessment showed no improvement for upper limb movement on the post-test assessment.

Although the control group had a lower median score for the pre-test initial assessment the change in the Fugl-Meyer score for the upper limb component for both groups was similar.

The overall paucity of literature in the use of compression garments on the upper limb in stroke makes it difficult to compare to previous research. In their study on the use of compression garments with patients with stroke in 2000, Gracies, et al., noted that there was improved active selective movement in the shoulder (Gracies, et al., 2000). Although similar changes in movement were found in this study, this movement did not differ from the control group and could not be attributed to the wearing of the Lycra compression garments. The null hypothesis was accepted for upper limb movement in that the Lycra compression garments did not result in a greater change in motor function in the upper limb of the participants in the experimental group.

The results however, did show that the greater statistically significant improvement in the experimental group was for components of movement for the wrist and hand. The greater change in the experimental group although small in terms of score was also clinically significant as seen by the large effect sizes (Table 4.7). Furthermore, co-ordinated and smooth movement in the experimental group was better than the control group and although the difference was not statistically significant, the large effect size indicated that clinical significance was evident. While between 22% to 44% of participants in the control group had improvement in wrist and hand movement, between 83% to 100% of participants in the experimental group had improvement for these components respectively. It would therefore appear therefore that Lycra compression garments may have resulted in improved distal movement in the upper limbs of the participants in the experimental group resulting in a small clinically significant improvement in their coordinated movement. The null hypothesis was therefore rejected for voluntary and selective movement in the wrist and hand as well as coordination of movement.

This finding supports that of Gracies (1997) in that a change in motor recovery was seen in the experimental group who used the Lycra compression garments (Gracies, et al., 1997).

While in this study it appears that compression garments did have beneficial effect, particularly on the ability to actively and selectively initiate movement in the hand and wrist, this differs from the findings reported by Gracies et al (2000). The only effect they noted in their study was reduced spasticity in the wrist and fingers with active selective distal movement actually being reduced with the application of compression garments (Gracies , et al., 2000). A factor which may have contributed to the difference in findings of the two studies relates to the methodology and the design of the compression garment. Gracies et al. (2000) only used the garments for between three to four hours a day for two days. In this study, the compression garment to be applied for a minimum of six hours a day. Thus, wearing time in this study was significantly more than that of the compression garments worn in the study by Gracies et al. (2000)

The garment constructed in this study consisted of a single sheet of Lycra sewn to a gauntlet style sleeve that extended from the axilla over the thumb and to the heads of the metacarpal joints. The garment constructed by Gracies, et al., (2000) consisted of a sleeve with various segments of Lycra sewn in a particular manner in order to produce a particular stretch (Gracies , et al., 1997). Their garments did not provide compression over the hand, as does the garment constructed in this study, which could explain the better outcomes in the hand and wrist noted in the experimental group. Despite the fact that the garments in both studies did not extend over the shoulder, the segmented Lycra sewn together produced a better effect on the shoulder, compared to the single sheet of Lycra used in this study.

Whilst the activation of muscle contraction is often seen as a vital component for movement, more research is revealing the importance of sensory input for the production of movement (Shumway-Cook & Woollacott, 2007). This is particularly true for proprioception (Aman, et al., 2015). It is possible that proprioceptive input from the Lycra compression garments had an effect resulting in greater improvement in the wrist and hand movement for the experimental group. The design of the Lycra compression garments used in this study incorporated compression of the affected limb from the axilla to the metacarpal phalangeal joints incorporating the elbow, wrist and hand.

It is interesting to note that no statistical or clinical change was evident in the experimental group over areas where proprioception was not applied through the Lycra compression garment. All the participants in the experimental group had improvement in active selective movement of the hand and wrist compared to the control group where only two participants had improvements in the hand and wrist. This supports the theory that sensation, particularly proprioceptive input, may play a role in motor re-learning by facilitating cortical neuroplastic changes and re-organization (Hummel & Cohen, 2005). However due to the results of the improvement in upper limb movement in both groups, the association between motor function and proprioceptive input still needs further investigation (Stillman, 2002; Aman, et al., 2015).

5.3.2 Sensation, passive range of motion and pain

The second objective of this study was to determine change in sensory function and awareness of the limb, as well as pain, in the upper limb of patients with stroke when Lycra compression garments were and were not used as adjunctive therapy technique were.

Sensation plays a vital role in movement as it does not necessarily affect initiation of movement but rather it has a greater impact on the fluidity and control of movement (Abbruzzese, et al., 2014). The groups were comparable on the pre-test initial assessment for these components (Table 4.10) although the control group had better overall sensation on pre-test initial assessment (Table 4.6). The higher scores for sensation in the control group was not associated with better distal movement in the hand and wrist. In this study sensation was assessed using the Fugl-Meyer assessment. Here sensation is referred to as a subtest comprising of both light touch and proprioception. These were not analysed separately and overall no significance or large effect size was evident for this component (Table 4.11). Both the experimental and control group had similar changes in their sensation over the study period. Therefore, the null hypothesis in terms of change in sensation was accepted.

It must be noted that improvement in movement occurs through a collaboration of aspects in the environment, and the task as well as the coordination of body mechanisms working together to produce the movement (Shumway-Cook & Woollacott, 2007). Co-ordinated and smooth movement in the upper limb in the participants in the experimental group was better than the control group with clinical significance evident. This study did not explore conscious proprioception as a result of the manner in which the Fugl Meyer is administered, the role of unconscious proprioception must be considered (Kerem, et al., 2001).

The concept of conscious and unconscious proprioception was the reason therapists began exploring the use of compression garment. It was thought that the proprioceptive input provided at the cutaneous skin receptors and the deep compression would affect movement (Kerem, et al., 2001). This supported the use of proprioceptive training used in physiotherapy and promoted better awareness of the affected limb so that more movement could be achieved (Hylton & Allen, 1997). Proprioception has both a conscious and unconscious components, the effects of which were observed by the experimental participants, wherein awareness of their upper limb was better than the control groups, even in the absence of adequate sensation, due to the input from the Lycra compression garments this implies that conscious proprioception had improved through the application of Lycra compression garments (Abbruzzese, et al., 2014; Aman, et al., 2015).

In terms of passive range of motion and pain, it is common to find that individuals with hemiplegia often develop abnormal movement patterns as a result of increased excitability of the stretch reflex which is primarily in the flexors and pronators of the upper limb. This often results in shortening and contractures as a result of immobilization (Barnes, 2001; Shumway-Cook & Woollacott, 2007).

The results of this study indicated that the passive range of motion in both the experimental and control groups decreased over the study period. The decrease in range of motion for the experimental group indicated an increase in spasticity, and thus an increase in the resistance to passive range of movement. Therefore, contrary to the findings of Gracies, et al., (2000) the garments appear to have no effect on passive range of motion over a prolonged period of six weeks.

The theory that the pressure provided by the garments results in neural warmth and prolongs stretch on the spastic muscles thus relaxing and reducing spasticity and allowing more free movement, did not apply in this study (Gracies , et al., 1997). Thus, the null hypothesis for passive range of motion was accepted for this study.

Due to nature of the Fugl Meyer assessment, the data analysis for passive range of motion refers to the upper limb as a whole, rendering it difficult to identify which joints were impaired. It would have been better to assess the joints separately so that changes could have been reported for each joint and results could have been compared to those of Gracies et al. (2000) who reported decrease in spasticity in specific joints (Gracies , et al., 2000). It is possible that the pressure garment provided a similar effect to that of a standard rigid splint wherein they may have in fact resulted in a reduction in active movement at the joints applied (Corn, et al., 2003) and thus passive movement of the affected limb.

The loss of passive range can also be associated with the presence of pain in patients with stroke (Fugl-Meyer, et al., 1975) but this was not the case in this study. The experimental group in this study reported a reduction in pain in comparison to the control group although this was not statically or clinically significant. While the reduction in pain for the experimental group was small; with only one participant experiencing an increase in pain, 55% (5) participants in the control group experienced an increase in pain over the study period. Therefore, although the null hypothesis for the change in pain could not be rejected it would appear that the Lycra compression garments may have had an effect in the experimental group. One could speculate that this is as a result of participants in the experimental group having better active selective control of movement in the affected limb and thus using the limb more within functional tasks and thus reducing pain.

5.4 The effect of compression garments on perceived upper limb function

The third objective of the study was to determine change in the participants' ability to perform functional tasks when Lycra compression garments are used as an adjunctive therapy technique.

There was no statistically significant difference in the participants' perceived functional use of their hand, however a greater change was evident in favour of the experimental group. The improvement in both groups was similar on the DASH when functional change was assessed, thus so no clinically relevant change between the groups was found. However, no change was recorded for more participants in the control group (33%) than in the experimental group (16%) however.

The lack of more significant functional movement in the experimental group was possibly due to the lack of more significant improvement in shoulder and elbow movement which was similar to that seen in the control group. The shoulder girdle is an essential component needed for movement, in particular for reach. The upper limb is not functional without the ability to reach, any movement which is available at the hand and wrist level is purposeless, as the individual is unable to reach in order to place the hand and wrist in a functional position for activity (Shumway-Cook & Woollacott, 2007). The results therefore indicate that wrist and hand movement and coordination alone in the experimental group could not be translated into better functional movement in their hemiparetic upper limb. The null hypothesis for functional movement is therefore accepted.

From the results of this study, in terms of the improvement in functional movement, the emphasis on the occupation based model where activities are essential for movement appears to have been incorporated. Between 67% and 84% of participants did have an improvement in their functional movement but this cannot be ascribed to the wearing of Lycra compression garments but rather the therapy received where therapists often approach the impairments in movement by promoting participation in functional tasks (Carr & Shepherd, 2006).

5.5 Evaluation of the compression garment

It was important that the participants' perspectives in terms of wearing the Lycra compression garments were established, and thus determine if this technique is viable. Patients wearing Lycra compression garments generally have poor compliance due to them feeling hot and irritable from the friction (Knox, 2003).

This was confirmed by just under half of the participants who reported that they felt either hot or uncomfortable when the compression garment was on. Based on therapists' from the various hospitals reports, and poor compliance of nursing staff to complete the compliance checklists, the researcher is of the opinion that the pressure garments may in fact not have been worn for the prescribed eight hours a day. This may be particularly true if the participants were hot and uncomfortable, as they were more likely to remove the garment for these reasons, and thus reducing the number of hours that the garment was worn in total

Half of the participants reported that they would continue with the use of the garment. Those who indicated they would continue wearing the compression garment where those who felt that the compression garment was comfortable. It is possible that these participants were more tolerant of the garments as these participants may have recognized the benefits of the Lycra compression garment or it may have in fact been a placebo effect.

Due to the nature of the tight fitting compression garment more than half of the participants needed assistance to put on the garment which is a barrier in the compliance of compression garments as noted by Knox (2003). Based on report from the therapists at the rehabilitation centre, for the most part, garments were applied by the nursing staff. In cases where the Lycra compression garment was not applied, this was then facilitated by the therapists. However, there are notable instances where the participants, nursing staff and therapists did not apply the garment.

It was found in this study that precautions need to be taken when the garments are applied. The garments need to be monitored by the therapist and the patient. During this study, the researcher found that one participant experienced swelling in their hand of the affected limb with use of the compression garment. In this instance, the garment was removed and a new compression garment was fabricated. Thus, the problem was resolved.

5.6 Limitations

The dropout rate due to early discharge or the implementation of Botox therapy of 25% was higher than the accepted 20% and affected the sample size available for analysis. Despite this, the small sample obtained within the data collection period in this study showed some statistically and clinically significant differences for active selective movement. Even though research has shown that a small change in the Fugl Meyer score can be considered significant, allowing for a small sample size in the power calculation, the projected sample size and variation in the scores of the participants, may have opened the study up to a type II error.

Compliance of splints has been a notorious barrier for therapists during the rehabilitation process (Knox, 2003). Despite conducting training sessions with both nurses and therapists, compliance checklists were not completed, and subsequently compliance could not be monitored. This is an important factor to consider as the research could not conclude whether compression garments were being applied for the recommended 8 hours per day, or not. This could in fact play a role in the findings as there may have been times where compression garments were not being worn, which affected the outcomes of the experimental group. Furthermore, this highlights the importance of interdisciplinary co-operation for this type of program to be effective.

Originally the research was to be blinded so that the researcher who completed the assessments did not know to which group the participants had been assigned by the research assistant. However often the participant would inform the researcher about their garment without the researcher requesting such information. As a result the study was not truly blinded which may have affected the rigour of the research methodology.

During the analysis of the results the researcher was of the opinion that the DASH cannot be used to conclude if functional use of the affected limb had in fact improved as this is objective self-report measure of perceived performance. In future studies, an assessment measure should be used wherein the researcher can observe the limb within actual functional tasks would be more beneficial in determining improvement in functional use of the upper limb.

The participants in this study are in-patients whom have not had the opportunity to consider the use of the upper limb in functional tasks within their own home. The results reflected in the DASH are thus representative of an objective opinion of the individual's functional use of the upper limb while in hospital which may provide limited opportunities for functional use of the affected upper limb.

The Fugl Meyer has been shown to be a sensitive measure for the assessment of small change in impairments in the upper limb after a stroke (Anon., n.d.). However, this measure assesses components together. For instance, passive range of motion is totalled for the whole upper limb yet, for this study it would add value if each joint had been considered separately so as to identify specifically which joints are commonly problematic and better determine the change when wearing Lycra compression garments.

CHAPTER 6: CONCLUSION

This study aimed to determine whether Lycra compression garments could be used as an adjunctive treatment technique on the upper limb after a stroke. The challenges in terms of the researcher remaining blinded, finding enough participants, and obtaining consent was seen as barriers that would significantly affect the results of the study. Despite these challenges, there were significant results which could support the use of Lycra compression garments.

Although socioeconomic and medical factors were not the areas of focus, the experimental and control groups were comparable for these factors. The type of stroke and age of the participants could have contributed to better recovery of the upper limb. The sample was however too small and the researcher could thus not make accurate conclusions about these factors. The side of the lesion however had an unequal but non-significant distribution between the control and experimental group, with more participants with a left cerebral hemisphere lesion in the control group. This could have affected the poorer outcomes of these individuals.

Hypertension is strongly recognised as the most common risk factor for stroke, and this finding was supported by the results of this study. Thereafter, risk factors included HIV/AIDS, increased BMI and smoking. This was consistent with the predicted lifestyle choices in urban area's contributing to stroke.

The time from the onset to the commencement of rehab, known as the window period, is seen as vital for better outcomes both impairment based and functionally. Although the sample size was small and it is thus difficult to make such conclusions, it was noted that all except one participant started rehabilitation within four weeks of their stroke and that the groups were comparable for this variable.

The design and construction of the compression garment itself seems to be a strong factor in determining its effectiveness. The compression garment designed in this study extended from the axilla to the metacarpal joints of the affected limb.

What is interesting is that there was no clinical or statistical significance evident in the upper limb subtest of the Fugl-Meyer, where the compression garment did not extend over, yet there was statistical significance and strong clinical significance for the hand and wrist where the compression garment was placed.

Overall movement in the upper limb showed clinical and statistical significance in terms of the total scores. When examining the upper limb in terms of isolated components the greatest improvement was evident in active selective movement of the wrist and hand in the experimental group which has both clinical and statistical significance.

Sensation is viewed as being important for movement, and in particular proprioception. Although sensation was shown to improve in both groups, the control group had better sensation despite the fact that they had less improvement in active selective movement. Proprioception was not assessed directly but with the concept of unconscious proprioception, it was this mechanism in particular, to which the Lycra compression garments success could be attributed to. In improving active selective movement.

Passive range of motion decreased and was worse in the experimental group than the control group in this study. Analysis of these results was hampered by not assessing the range of motion at each joint as the decreased passive range of motion was evident in the shoulder, which is a joint the compression garment did not extend. The Lycra compression garments seemed to have some effect on pain. Although no statistical or clinical significance was evident, pain in the experimental group did improve despite decreases in passive range of motion, whilst the control group reported more pain.

There is a general assumption that function of the affected limb will improve with better upper limb movement. However, this study did not have statistically significant or clinically relevant change, based on the participants perception of their upper limb function. The researcher is of the opinion that a more objective functional test will provide more insight into the true functional recovery of the affected limb. The results in this study may also have been affected by poor compliance due to discomfort and difficulty donning the compression garment as reported in other research studies.

Checklist to determine if participants wore their garments were not completed and it was noted that half the participants reported discomfort and had indicated they would not continue the use of the compression garment. More than half needed assistance to don the garment, which also negatively affected compliance. Compliance of the wearing of the Lycra compression garments therefore cannot be confirmed for this study.

Recommendations

Clinical recommendations

It appears that the design of the compression garment used in this study would be effective if aiming to achieve better active selective movement in the wrist and hand, although it is not effective for active selective movement in the shoulder.

It is essential to ensure correct fit or the individual is at risk of developing swelling, particularly at the wrist. It would be valuable to add a zip so that donning the compression garment would be easier for the participant and caregivers. However, care must be taken to ensure that a flap be created so that the zip does not lie directly over the skin.

Research recommendations

Further studies are recommended to identify the effect compression garments have on spasticity and passive range of motion. Furthermore, the design of the compression garment appears to be the key in its effectiveness. Many of the garments constructed end at the axilla often excluding the shoulder joint, it seems that this plays a large role on functional use of the limb as the shoulder is needed for reach during functional tasks.

Additionally, there appears to be a certain population which will benefit most from the use of compression garments. It would also be valuable to identify if compression garments have a greater effect for movement and functional use of the affected upper limb if the individual had a left hemiplegia versus one with a right hemiplegia.

Based on clinical observations made by the researcher it seems that individuals with left hemiplegia perform better with a compression garment than those with right hemiplegia. However, further studies would be required as individuals with left hemiplegia tend to have a better prognosis, and thus one cannot conclude whether improvement noted by the clinician is due to the compression garment or the prognosis of individuals with left hemiplegia.

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Appendix A: Demographic Questionnaire

DEMOGRAPHIC QUESTIONNAIRE

			Participant number:			
Age			Sex	Male	Female	
Race:						
African	Caucasian	Asian	Mixed race	Indian	Other	
Home language			Second language			
Residential address			Drivers licence	Yes	No	
Type of home:						
House	Apartment	Flat	Informal homestead	Duplex	Garden cottage	
Area of home	Rural	Urban	Do you live alone	Yes	No	
Highest level of education:						
Matric/ NSC	Diploma	Degree	Higher tertiary	Other:		
Employed	Yes	No	Married	Yes	No	Divorced
Diagnosis:			Date of onset/ date of injury:			
Date of rehab admission:			Limb affected	Left	Right	
Risk factors:						
Hypertension	Diabetes	Heart problems	Other:			
Any previous injury/ disability to the upper limb	Yes	No	Hand dominance	Left	Right	
State injury						

Appendix B: Fugl Meyer Assessment

FUGL-MEYER ASSESSMENT UPPER EXTREMITY (FMA-UE) Assessment of sensorimotor function

ID:
Date:
Examiner:

Fugl-Meyer AR, Jaasko I, Leyman I, Olsson S, Steglind S: The post-stroke hemiplegic patient. A method for evaluation of physical performance. Scand J Rehabil Med 1973, 7:13-31.

A. UPPER EXTREMITY, sitting position					
I. Reflex activity		none	can be elicited		
Flexors: biceps and finger flexors		0	2		
Extensors: triceps		0	2		
Subtotal I (max 4)					
II. Volitional movement within synergies, without gravitational help		none	partial	full	
Flexor synergy: Hand from contralateral knee to ipsilateral ear. From extensor synergy (shoulder adduction/ internal rotation, elbow extension, forearm pronation) to flexor synergy (shoulder abduction/ external rotation, elbow flexion, forearm supination). Extensor synergy: Hand from ipsilateral ear to the contralateral knee	Shoulder	retraction	0	1	2
		elevation	0	1	2
		abduction (90°)	0	1	2
		external rotation	0	1	2
	Elbow	flexion	0	1	2
	Forearm	supination	0	1	2
	Shoulder	adduction/internal rotation	0	1	2
	Elbow	extension	0	1	2
	Forearm	pronation	0	1	2
	Subtotal II (max 18)				
III. Volitional movement mixing synergies, without compensation		none	partial	full	
Hand to lumbar spine	cannot be performed, hand in front of SIAS hand behind of SIAS (without compensation) hand to lumbar spine (without compensation)		0	1	2
Shoulder flexion 0°-90° elbow at 0° pronation-supination 0°	immediate abduction or elbow flexion abduction or elbow flexion during movement complete flexion 90°, maintains 0° in elbow		0	1	2
Pronation-supination elbow at 90° shoulder at 0°	no pronation/supination, starting position impossible limited pronation/supination, maintains position complete pronation/supination, maintains position		0	1	2
Subtotal III (max 6)					
IV. Volitional movement with little or no synergy		none	partial	full	
Shoulder abduction 0 - 90° elbow at 0° forearm pronated	immediate supination or elbow flexion supination or elbow flexion during movement abduction 90°, maintains extension and pronation		0	1	2
Shoulder flexion 90°- 180° elbow at 0° pronation-supination 0°	immediate abduction or elbow flexion abduction or elbow flexion during movement complete flexion, maintains 0° in elbow		0	1	2
Pronation/supination elbow at 0° shoulder at 30°-90° flexion	no pronation/supination, starting position impossible limited pronation/supination, maintains extension full pronation/supination, maintains elbow extension		0	1	2
Subtotal IV (max 6)					
V. Normal reflex activity evaluated only if full score of 6 points achieved on part IV					
biceps, triceps, finger flexors	0 points on part IV or 2 of 3 reflexes markedly hyperactive 1 reflex markedly hyperactive or at least 2 reflexes lively maximum of 1 reflex lively, none hyperactive		0	1	2
Subtotal V (max 2)					
Total A (max 36)					

B. WRIST support may be provided at the elbow to take or hold the position, no support at wrist, check the passive range of motion prior testing		none	partial	full
Stability at 15° dorsiflexion elbow at 90°, forearm pronated shoulder at 0°	less than 15° active dorsiflexion dorsiflexion 15°, no resistance is taken maintains position against resistance	0	1	2
Repeated dorsiflexion / volar flexion elbow at 90°, forearm pronated shoulder at 0°, slight finger flexion	cannot perform voluntarily limited active range of motion full active range of motion, smoothly	0	1	2
Stability at 15° dorsiflexion elbow at 0°, forearm pronated slight shoulder flexion/abduction	less than 15° active dorsiflexion dorsiflexion 15°, no resistance is taken maintains position against resistance	0	1	2
Repeated dorsiflexion / volar flexion elbow at 0°, forearm pronated slight shoulder flexion/abduction	cannot perform voluntarily limited active range of motion full active range of motion, smoothly	0	1	2
Circumduction	cannot perform voluntarily jerky movement or incomplete complete and smooth circumduction	0	1	2
Total B (max 10)				

C. HAND support may be provided at the elbow to keep 90° flexion, no support at the wrist, compare with unaffected hand, the objects are interposed, active grasp		none	partial	full
Mass flexion from full active or passive extension		0	1	2
Mass extension from full active or passive flexion		0	1	2
GRASP				
A – flexion in PIP and DIP (digits II-V) extension in MCP II-V	cannot be performed can hold position but weak maintains position against resistance	0	1	2
B – thumb adduction 1-st CMC, MCP, IP at 0°, scrap of paper between thumb and 2-nd MCP joint	cannot be performed can hold paper but not against tug can hold paper against a tug	0	1	2
C - opposition pulpa of the thumb against the pulpa of 2-nd finger, pencil, tug upward	cannot be performed can hold pencil but not against tug can hold pencil against a tug	0	1	2
D – cylinder grip cylinder shaped object (small can) tug upward, opposition in digits I and II	cannot be performed can hold cylinder but not against tug can hold cylinder against a tug	0	1	2
E – spherical grip fingers in abduction/flexion, thumb opposed, tennis ball	cannot be performed can hold ball but not against tug can hold ball against a tug	0	1	2
Total C (max 14)				

D. COORDINATION/SPEED after one trial with both arms, blind-folded, tip of the index finger from knee to nose, 5 times as fast as possible		marked	slight	none
Tremor		0	1	2
Dysmetria	pronounced or unsystematic slight and systematic no dysmetria	0	1	2
		> 6s	2 - 5s	< 1s
Time	more than 5 seconds slower than unaffected side 2-5 seconds slower than unaffected side maximum difference of 1 second between sides	0	1	2
Total D (max 6)				

TOTAL A-D (max 65)				
---------------------------	--	--	--	--

H. SENSATION, upper extremity blind-folded, compared with unaffected side		anesthesia	hypoesthesia dysaesthesia	normal
Light touch	upper arm, forearm palmar surface of the hand	0 0	1 1	2 2
		absence less than 3/4 correct	3/4 correct considerable difference	correct 100% little or no difference
Position small alterations in the position	shoulder elbow wrist thumb (IP-joint)	0 0 0 0	1 1 1 1	2 2 2 2
Total H (max12)				

J. PASSIVE JOINT MOTION, upper extremity				J. JOINT PAIN during passive motion, upper extremity		
Sitting position, compare with unaffected side	only few degrees (less than 10° in shoulder)	decreased	normal	pronounced constant pain during or at the end of movement	some pain	no pain
Shoulder						
Flexion (0° - 180°)	0	1	2	0	1	2
Abduction (0°-90°)	0	1	2	0	1	2
External rotation	0	1	2	0	1	2
Internal rotation	0	1	2	0	1	2
Elbow						
Flexion	0	1	2	0	1	2
Extension	0	1	2	0	1	2
Forearm						
Pronation	0	1	2	0	1	2
Supination	0	1	2	0	1	2
Wrist						
Flexion	0	1	2	0	1	2
Extension	0	1	2	0	1	2
Fingers						
Flexion	0	1	2	0	1	2
Extension	0	1	2	0	1	2
Total (max 24)				Total (max 24)		

A. UPPER EXTREMITY	/36
B. WRIST	/10
C. HAND	/14
D. COORDINATION / SPEED	/ 6
TOTAL A-D (motor function)	/66

H. SENSATION	/12
J. PASSIVE JOINT MOTION	/24
J. JOINT PAIN	/24

Appendix C: Disabilities of the Arm, Shoulder and Hand Outcome Measure

DISABILITIES OF THE ARM, SHOULDER AND HAND

THE

DASH

INSTRUCTIONS

This questionnaire asks about your symptoms as well as your ability to perform certain activities.

Please answer *every question*, based on your condition in the last week, by circling the appropriate number.

If you did not have the opportunity to perform an activity in the past week, please make your *best estimate* on which response would be the most accurate.

It doesn't matter which hand or arm you use to perform the activity; please answer based on your ability regardless of how you perform the task.



DISABILITIES OF THE ARM, SHOULDER AND HAND

Please rate your ability to do the following activities in the last week by circling the number below the appropriate response.

	NO DIFFICULTY	MILD DIFFICULTY	MODERATE DIFFICULTY	SEVERE DIFFICULTY	UNABLE
1. Open a tight or new jar.	1	2	3	4	5
2. Write.	1	2	3	4	5
3. Turn a key.	1	2	3	4	5
4. Prepare a meal.	1	2	3	4	5
5. Push open a heavy door.	1	2	3	4	5
6. Place an object on a shelf above your head.	1	2	3	4	5
7. Do heavy household chores (e.g., wash walls, wash floors).	1	2	3	4	5
8. Garden or do yard work.	1	2	3	4	5
9. Make a bed.	1	2	3	4	5
10. Carry a shopping bag or briefcase.	1	2	3	4	5
11. Carry a heavy object (over 10 lbs).	1	2	3	4	5
12. Change a lightbulb overhead.	1	2	3	4	5
13. Wash or blow dry your hair.	1	2	3	4	5
14. Wash your back.	1	2	3	4	5
15. Put on a pullover sweater.	1	2	3	4	5
16. Use a knife to cut food.	1	2	3	4	5
17. Recreational activities which require little effort (e.g., cardplaying, knitting, etc.).	1	2	3	4	5
18. Recreational activities in which you take some force or impact through your arm, shoulder or hand (e.g., golf, hammering, tennis, etc.).	1	2	3	4	5
19. Recreational activities in which you move your arm freely (e.g., playing frisbee, badminton, etc.).	1	2	3	4	5
20. Manage transportation needs (getting from one place to another).	1	2	3	4	5
21. Sexual activities.	1	2	3	4	5

DISABILITIES OF THE ARM, SHOULDER AND HAND

	NOT AT ALL	SLIGHTLY	MODERATELY	QUITE A BIT	EXTREMELY
22. During the past week, to what extent has your arm, shoulder or hand problem interfered with your normal social activities with family, friends, neighbours or groups? (circle number)	1	2	3	4	5

	NOT LIMITED AT ALL	SLIGHTLY LIMITED	MODERATELY LIMITED	VERY LIMITED	UNABLE
23. During the past week, were you limited in your work or other regular daily activities as a result of your arm, shoulder or hand problem? (circle number)	1	2	3	4	5

Please rate the severity of the following symptoms in the last week. (circle number)

	NONE	MILD	MODERATE	SEVERE	EXTREME
24. Arm, shoulder or hand pain.	1	2	3	4	5
25. Arm, shoulder or hand pain when you performed any specific activity.	1	2	3	4	5
26. Tingling (pins and needles) in your arm, shoulder or hand.	1	2	3	4	5
27. Weakness in your arm, shoulder or hand.	1	2	3	4	5
28. Stiffness in your arm, shoulder or hand.	1	2	3	4	5

	NO DIFFICULTY	MILD DIFFICULTY	MODERATE DIFFICULTY	SEVERE DIFFICULTY	SO MUCH DIFFICULTY THAT I CAN'T SLEEP
29. During the past week, how much difficulty have you had sleeping because of the pain in your arm, shoulder or hand? (circle number)	1	2	3	4	5

	STRONGLY DISAGREE	DISAGREE	NEITHER AGREE NOR DISAGREE	AGREE	STRONGLY AGREE
30. I feel less capable, less confident or less useful because of my arm, shoulder or hand problem. (circle number)	1	2	3	4	5

DASH DISABILITY/SYMPTOM SCORE = $\frac{[(\text{sum of } n \text{ responses}) - 1]}{n} \times 25$, where n is equal to the number of completed responses.

A DASH score may not be calculated if there are greater than 3 missing items.

DISABILITIES OF THE ARM, SHOULDER AND HAND

WORK MODULE (OPTIONAL)

The following questions ask about the impact of your arm, shoulder or hand problem on your ability to work (including home-making if that is your main work role).

Please indicate what your job/work is: _____

I do not work. (You may skip this section.)

Please circle the number that best describes your physical ability in the past week. Did you have any difficulty:

	NO DIFFICULTY	MILD DIFFICULTY	MODERATE DIFFICULTY	SEVERE DIFFICULTY	UNABLE
1. using your usual technique for your work?	1	2	3	4	5
2. doing your usual work because of arm, shoulder or hand pain?	1	2	3	4	5
3. doing your work as well as you would like?	1	2	3	4	5
4. spending your usual amount of time doing your work?	1	2	3	4	5

SPORTS/PERFORMING ARTS MODULE (OPTIONAL)

The following questions relate to the impact of your arm, shoulder or hand problem on playing your musical instrument or sport or both. If you play more than one sport or instrument (or play both), please answer with respect to that activity which is most important to you.

Please indicate the sport or instrument which is most important to you: _____

I do not play a sport or an instrument. (You may skip this section.)

Please circle the number that best describes your physical ability in the past week. Did you have any difficulty:

	NO DIFFICULTY	MILD DIFFICULTY	MODERATE DIFFICULTY	SEVERE DIFFICULTY	UNABLE
1. using your usual technique for playing your instrument or sport?	1	2	3	4	5
2. playing your musical instrument or sport because of arm, shoulder or hand pain?	1	2	3	4	5
3. playing your musical instrument or sport as well as you would like?	1	2	3	4	5
4. spending your usual amount of time practising or playing your instrument or sport?	1	2	3	4	5

SCORING THE OPTIONAL MODULES: Add up assigned values for each response; divide by 4 (number of items); subtract 1; multiply by 25.

An optional module score may not be calculated if there are any missing items.

Appendix D: Lycra pressure garment comfort questionnaire

LYCRA COMPRESSION GARMENT COMFORT QUESTIONNAIRE

Subject number:

Please tick which is most appropriate

1.	Did you experience any adverse effects		
	Yes	No	State the problem experienced:
2.	Your pressure garment was:		
2.1	Comfortable	Tight	Hot
2.2	Easy to put on alone	I was able to put it on alone but it was difficult	I needed help to put on my pressure garment
3.	Will you continue to use your pressure garment now that the study has ended:		
	Yes		No

Appendix E: Ethic clearance



R14/49 Ms Carene Chanel Naubereit

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL) CLEARANCE CERTIFICATE NO. M140866

NAME: Ms Carene Chanel Naubereit
(Principal Investigator)

DEPARTMENT: Occupational Therapy
Summit Rehabilitation/ Rita Henn and Partners
Clayton House and Care Cure
East Rand

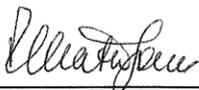
PROJECT TITLE: The Effectiveness of Lycra Garments on the Upper
Limb in Patients with a Cerebrovascular Accident

DATE CONSIDERED: 29/08/2014

DECISION: Approved unconditionally

CONDITIONS:

SUPERVISOR: Denise Franzsen

APPROVED BY: 

Professor Cleaton-Jones, Chairperson, HREC (Medical)

DATE OF APPROVAL: 03/11/2014

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Secretary in Room 10004, 10th floor, Senate House, University.

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report.**

Principal Investigator Signature

Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix F: Permission letter Netcare

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Netcare Management (Pty) Limited

Tel: + 27 (0)11 301 0000
Fax: Corporate +27 (0)11 301 0499
76 Maude Street, Corner West Street, Sandton, South Africa
Private Bag X34, Benmore, 2010, South Africa

RESEARCH OPERATIONS COMMITTEE FINAL APPROVAL OF RESEARCH

Approval number: UNIV-2014-0056

Ms CC Naubereit

E mail: anaubereit@gmail.com

Dear Ms Naubereit

RE: THE EFFECTIVENESS OF LYCRA GARMENTS ON THE UPPER LIMB IN PATIENTS WITH CEREBROVASCULAR ACCIDENT

The above-mentioned research was reviewed by the Research Operations Committee's delegated members and it is with pleasure that we inform you that your application to conduct this research at Netcare Rehabilitation Hospital, has been approved, subject to the following:

- i) Research may now commence with this FINAL APPROVAL from the Netcare Research Operations Committee.
- ii) All information regarding Netcare will be treated as legally privileged and confidential.
- iii) Netcare's name will not be mentioned without written consent from the Netcare Research Operations Committee.
- iv) All legal requirements regarding patient / participant's rights and confidentiality will be complied with.
- v) The research will be conducted in compliance with the GUIDELINES FOR GOOD PRACTICE IN THE CONDUCT OF CLINICAL TRIALS IN HUMAN PARTICIPANTS IN SOUTH AFRICA (2006)
- vi) Netcare must be furnished with a STATUS REPORT on the progress of the study at least annually on 30th September irrespective of the date of approval from the Netcare Research Operations Committee as well as a FINAL REPORT with reference to intention to publish and probable journals for publication, on completion of the study.
- vii) A copy of the research report will be provided to the Netcare Research Operations Committee once it is finally approved by the relevant primary party or tertiary institution, or once complete or if discontinued for any reason whatsoever prior to the expected completion date.

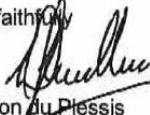
Directors: M S F Da Costa, J du Plessis, K N Gibson R H Friedland, M B Nkosi, C Pailman, N Phillipson,
P Warrenner, D van den Bergh

Company Secretary: L Bagwandeem Reg. No. 1995/012717/07

- viii) Netcare has the right to implement any recommendations from the research.
- ix) Netcare reserves the right to withdraw the approval for research at any time during the process, should the research prove to be detrimental to the subjects/Netcare or should the researcher not comply with the conditions of approval.
- x) APPROVAL IS VALID FOR A PERIOD OF 36 MONTHS FROM DATE OF THIS LETTER OR COMPLETION OR DISCONTINUATION OF THE TRIAL, WHICHEVER IS THE FIRST.

We wish you success in your research.

Yours faithfully

 18/11/2014

Prof Dion du Plessis

Full member: Netcare Research Operations Committee & Medical Practitioner evaluating research applications as per Management and Governance Policy

Shannon Nell



Chairperson: Netcare Research Operations Committee
Network Healthcare Holdings Limited (Netcare)

Date:

26/11/2014



Appendix G: Permission letter Care Cure

Permission to conduct research

This hereby confirms that you have read the information regarding the study of the effectiveness of a Lycra pressure garment on the upper limb following a stroke. We agree to the above study and

Confirm that we hereby give permission for Carole Charel Naubereit to conduct research at

Carole Charel Naubereit

Signed



Date:

17 November 2015

Witness



Date:

17/11/2015

Appendix H: Permission letter Rita Henn and Partners

<p>Reg.no. 2003/024744/2 Pr.no. 050 000 0206822 Vat no. 4040209365</p> <p>PostNet Suite 224, Private bag X 9 Melville, Johannesburg 2109</p>	 <p>RITA HENN & PARTNERS INC PHYSICAL REHABILITATION THERAPISTS</p> <p>Affiliated with  SummitRehab</p>	<p>Tel: +27(0)11 489 1226 Fax: 086 545 5557 info@physicalrehab.co.za</p> <p>Netcare Rehabilitation Hospital Cnr Canary & Bunting road Auckland park, 2006</p>
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17th October 2014

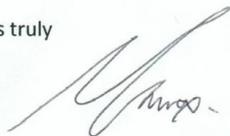
To Whom It May Concern

Re: Research on pressure garments in hemiplegic upper limb management

RITA HENN & PARTNERS INCORPORATED

Following discussion and reading over your protocol for use of our patients from Rita Henn and Partners at Netcare Rehabilitation Hospital, we are extremely willing to collaborate with Carene Naubereit in this regard. Thus regarding your letter requesting approval and permission to conduct this study at Netcare Rehabilitation Hospital we are extremely willing and grant permission for this study to be conducted during the foreseen period to complete your data collection from November 2014.

Yours truly



Dr M Knox
Clinical Manager Rita Henn and Partners Inc.

Directors of Rita Henn & Partners Inc
Rita Henn • Megan Knox • Hilary Tiernay • Mariette Marx • Luschka Dearle • Franja Serfontein
Sheldene Reynolds • Sarah Quinlan • Almari Smit • Rae Tovell-Holdt

Appendix I: Therapist training notes

The effectiveness of Lycra garments on the upper limb in a patient with a Cerebrovascular accident

Carene Chanel Naubereit

Introduction

- Present uses of Lycra pressure garments are that of burn injuries for scar management⁽¹⁾ and in cancer patients for lymphedema following a mastectomy⁽²⁾
- New developments in the use of pressure garments have been observed in children with Cerebral palsy (CP)⁽³⁾ (4) (5) the garments have found to result in the following changes:
 - Improved proximal stability⁽⁶⁾
 - Decreasing spasticity⁽⁶⁾
- Based on the use of pressure garments in children it is thought that it may have the same effects in adults with neurological deficits
- Lycra garments are thought to assist improving awareness and reducing visual neglect by providing the sensory inputs such as deep touch, light touch and visual stimuli⁽⁶⁾
- The continuous deep pressure and slight biomechanical support provided by the pressure garment has also been attributed to the possible reason for the benefits of Lycra garments⁽⁵⁾

Statement of the problem

- Lack of reliable studies in literature of Lycra pressure garments in adult neurological conditions, most literature is based on the use of the garments in children with Cerebral palsy.
- Lycra garments have been shown to result in change in with these children and these changes are beneficial in terms of the children's functional movement⁽³⁾ (7) (5) (4)
- Clinical observations noted by the researcher indicates that there may be benefits of the Lycra garments in the adult neurologically impaired population .

Purpose of the study

- Current upper limb treatment modalities used by occupational therapists include⁽⁸⁾ (9):
 - Neurodevelopmental techniques
 - Strength training
 - Bilateral arm training
 - Constrain induced training
 - Mirror therapy
 - Mental imagery
 - Positioning through the use of splinting
- Further studies needed to identify the effectiveness of Lycra garments as an adjunctive therapy technique
- Purpose of this study will be to identify changes in the upper limb of patients with CVA which can be attributed to the wearing of Lycra garments and if these changes have any beneficial value in terms of functional movement in the upper limb.

Aims

- To evaluate change in functional domains including motor function, sensory function, co-ordination, joint range, pain and functional ability of the upper limb in patients with a CVA when Lycra garments are used as an adjunctive therapy technique

Methodology

Study sample

- Randomisation will be done as patients are admitted
- A total of 32 control participants and 32 experimental participants

Inclusion criteria

- Patients with an acute CVA of no longer than 3 weeks after onset at the initial pre-test
- Male and female inpatients
- Between the ages of 35 - 90 receiving daily therapy 5 days per week

Exclusion criteria

- Previous history of injury or deficits to the affected upper limb
- Individuals with motor apraxia or receptive aphasia
- Individuals who have received botulinum toxin injections
- Individuals functioning on the incidental level of Creative Ability

Procedure for data collection

- Patients will be randomised into control or experimental group
- Assessments will be conducted on a Tuesday and measurements for pressure garment obtained
- Pretest done within first week of admission
- Posttest done after 6 weeks of wearing the pressure garment

Intervention

- The treating therapists will carry out the traditional occupational therapy programme provided at Summit Rehab to both experimental and control groups
- Experimental Group
 - Lycra garment which is to be applied daily
 - Each garment is custom made and issued and fitted within 2 day of pre-test (Thursday)
 - Treating therapist to monitor garment use and encourage compliance

Pressure garment considerations

- Minimum of 8 hours of wearing
- Compliance of garment monitored daily through checklist
- Seam of the garment to be on the outside of the skin to prevent pressure areas
- Monitor for skin irritability
 - Note this on checklist

Appendix J: Information letters and Informed Consent

Information letter Control group

Good day

I am Carene Chanel Naubereit an occupational therapist currently completing my Master's degree in Occupational therapy at the University of the Witwatersrand. I am conducting a study on the effectiveness of a Lycra pressure garment on the upper limb in a patients with acute stroke. Lycra pressure garments have recently been used in children with cerebral palsy with improvements noted in functional abilities of the child. Based on the use of pressure garments in children it is thought that pressure garments may have similar beneficial effects on the upper limb after a stroke in adults.

I am inviting you to participate in this study.

What is expected of you?

You will receive the traditional therapy techniques used in improving function in the arm that is currently being used by rehabilitation occupational therapists. As part of the control group you will not receive a Lycra garment for your arm but am asking that I can assess your arm by checking how much you can move it and asking you how lack of movement in your arm affects your activities at the beginning the study and again 6 weeks later at the end of the study.

It is important to note that all personal information will be kept confidential as only codes will be used on all forms used to record information. Personal details will be known only to the researcher who will ensure access control of data by keeping it in a locked secure place. Should you refuse to participate or withdraw from the study, which you may do at any time, there will be no consequences and this will not affect your treatment in any way. If you wish to withdraw however it is requested that the researcher is contacted and informed of the withdrawal from the study.

The results of the study will be made available on request to any of the participants at the end of the study. Following the completion of the study, if the study results are found to significantly improve upper limb function you will be offered treatment using the Lycra pressure garments.

I would greatly appreciate your participation in the study so that we may contribute to the lack of current literature of pressure garments in the adult neurological population. For any queries please contact Carene Naubereit on 076 839 3505 or email via cnaubbereit@gmail.com or alternatively contact my supervisor Denise Franzsen on 011-717 3711. If you are happy to participate in the study please read and sign the attached informed consent form. Should there be any ethical queries about the research please feel free to contact the Human Research Ethics Committee (HREC) Chairman Prof P Cleaton-Jones at 011 7171234 or anisa.keshav@wits.ac.za for reporting of complaints / problems

Kind regards

Carene Chanel Naubereit
Occupational Therapist
Bsc (OT) Wits

Informed consent

I hereby confirm that I have read the information regarding the study of the effectiveness of a Lycra pressure garment on the upper limb following a stroke.

I, _____ agree to the above study and confirm that I hereby give consent to participate in the study described above. Read and signed on this day _____, at _____ hospital.

Signed

Witness

Information letter Experimental group

Good day

I am Carene Chanel Naubereit an occupational therapist currently completing my Masters degree in Occupational therapy at the University of the Witwatersrand. I am conducting a study on the effectiveness of a Lycra pressure garment on the upper limb in a patients with acute stroke. Lycra pressure garments have recently been used in children with cerebral palsy with improvements noted in functional abilities of the child. Based on the use of pressure garments in children it is thought that pressure garments may have similar beneficial effects on the upper limb after a stroke in adults.

I am inviting you to participate in this study.

What is expected of you?

You will receive the traditional therapy techniques used in improving function in the arm that is currently being used by rehabilitation occupational therapists while in rehabilitation as well as a custom made Lycra pressure garment – a sleeve that fits over your affected arm. The sleeve conforms to the skins surface providing continuous pressure to the surface of the skin and underlying surface muscles.

You will be expected to wear the Lycra pressure garment for a period of 8 hours a day for 6 weeks. I will assess your arm by checking how much you can move it and asking you how lack of movement in your arm affects your activities at the beginning the study and again 6 weeks later at the end of the study. There will be no cost implication to you or your family once you have been issued with the pressure garment. There has only been a few identified risks of wearing the pressure garment and this includes a possible allergy to the material. The garment should be tight fitting but should not cause any harm or damage to the skin surface, the tolerance of the arm to the garment will be monitored by the treating therapists and any adjustments to the garment will be made if necessary. No other risks have been identified.

It is important to note that all personal information will be kept confidential as only codes will be used on all forms used to record information. Personal details will be known only to the researcher who will ensure access control of data by keeping it in a locked secure place. Should you refuse to participate or withdraw from the study, which you may do at any time, there will be no consequences and this will not affect your treatment in any way. If you wish to withdraw however it is requested that the researcher is contacted and informed of the withdrawal from the study.

The results of the study will be made available on request to any of the participants at the end of the study.

I would greatly appreciate your participation in the study so that we may contribute to the lack of current literature of pressure garments in the adult neurological population. For any queries please contact Carene Naubereit on 076 839 3505 or email via cnaubereit@gmail.com or alternatively contact my supervisor Denise Franzsen on 011-717 3711. If you are happy to participate in the study please read and sign the attached informed consent form.

Should there be any ethical queries about the research please feel free to contact the Human Research Ethics Committee (HREC) Chairman Prof P Cleaton-Jones at 011 7171234 or anisa.keshav@wits.ac.za for reporting of complaints / problems

Kind regards

Carene Chanel Naubereit
Occupational Therapist
Bsc (OT) Wits

Informed consent

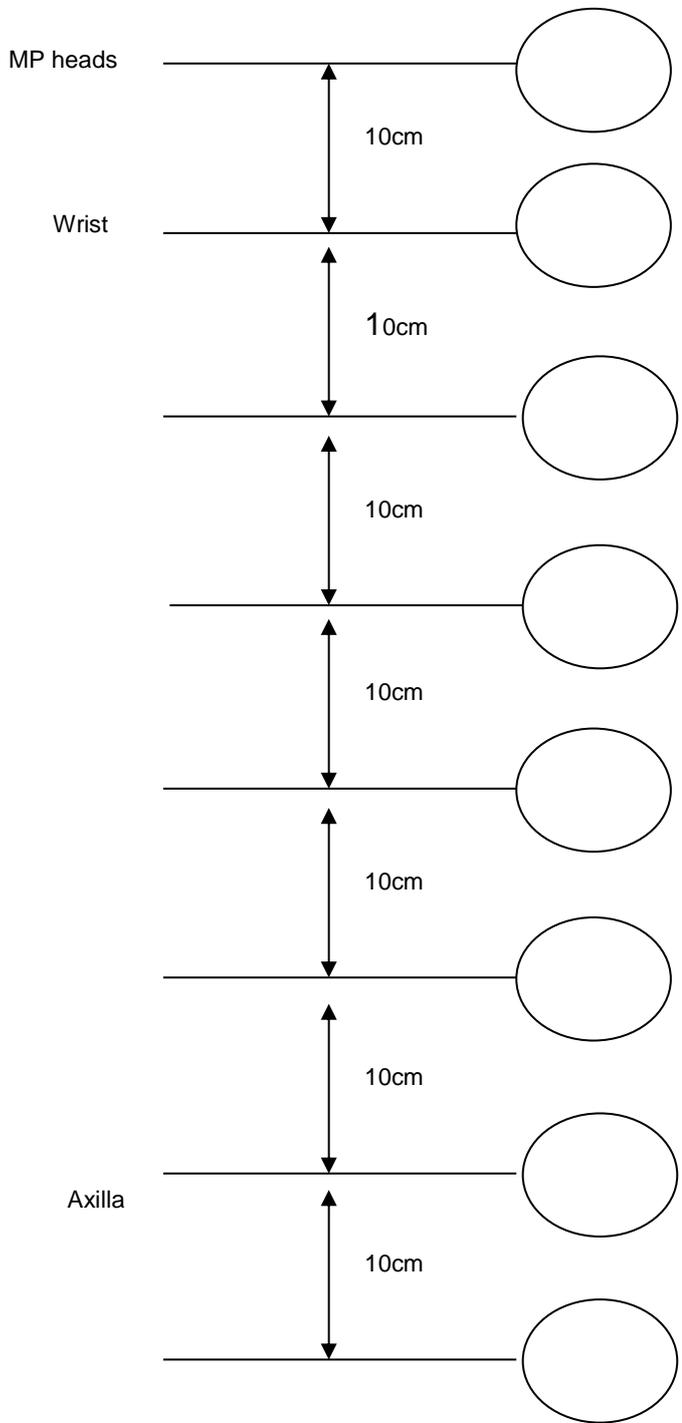
I hereby confirm that I have read the information regarding the study of the effectiveness of a Lycra pressure garment on the upper limb following a stroke.

I, _____ agree to the above study and confirm that I hereby give consent to participant in the study described above. Read and signed on this day _____, at _____ hospital.

Signed

Witness

Appendix J: Lycra pressure garment measurement record sheet



Participant number:

Trace the thumb here

Appendix L: Neurological Rehabilitation Clinical Protocol for Service Provision at Summit Rehab

At Summit, Neurological Rehabilitation is performed by an interdisciplinary team which consists of the patient, family, caregivers, physiotherapists, speech therapists, occupational therapist, counsellors and rehabilitation programme managers. All information presented below is based on evidence based practice guidelines in particular the SIGN, EBRSR and Australian Stroke Foundation recommendations are adopted.

Patient, Carer and Family Support

Patients, family and carers should have early active involvement in the rehabilitation programme.

Carers should be invited to attend therapy sessions at an early stage.

Comprehensive caregiver training and education is encouraged for efficient rehabilitative support and optimal carry-over.

Caregiver training should include the provision of information regarding causes and consequences of the patient's specific injuries, as well as the goals and prognosis of rehabilitation. Information should be provided at different stages of the recovery process.

Counselling services should be offered and given to patients and families.

Patients receiving rehabilitation at Summit should receive as much education regarding their medical status and management of their condition as possible. Home programme education and training should be provided as written material alone is not sufficient.

Education and Training

Effective stroke unit care includes programmes of education and training for staff to provide them with the knowledge and skills to deliver effective therapeutic care and rehabilitation. A variety of approaches have been described, from weekly short seminars to less frequent study days.

Rehabilitation Programme Managers

Rehabilitation Programme Managers co-ordinated the process of one's rehabilitation with the objective of facilitating and ensuring that all aspects of one's rehabilitation are covered and are not left out. They also provide emotional and social support and information to stroke patients and their families and liaised with services with the aim of improving and optimising the aspects of participation and quality of life for patients with stroke and/or their carers. The backgrounds of the programme managers is varied extensively, and their level of knowledge and skills is extensive.

Standardised Evaluation and Outcome Measures

Clinicians at Summit should use standardized valid assessment tools to assist in the evaluation of the patients' related impairments and functional status.

In addition patient's progress should be recorded and objectively measured when appropriate.

Impairment measures include:

- Pain use Visual Analogue Scale
- ROM
- Modified Ashworth
- Muscle strength use Oxford scale
- Volitional motivation use Vona du Toit

Functional Ability Measures:

- Functional independence measure (FIM/FAM)
- Berg Balance Scale/ Short/ HiMat
- Timed up and go
- Timed sit to stand
- 10 metre walk test both fast and comfortable
- 6 Minute Walk Test
- MAS/ UL section
- Nine hole peg test

- Time measured tests:
 - Manipulation board
 - Shoulder exercise ladder
 - Graded peg board
- Wolfe Motor Function
- SIS 16 for OPD Patients
- JFK
- Rancho Levels of Cognitive Functioning

Intensity/ Duration of therapy

Patients should receive as much therapy as can be provided and found tolerable. Where considered safe, every opportunity to increase the intensity of therapy for improvement should be pursued.

While the evidence suggests more therapy results in better mobility, functional and quality of life outcomes, the optimal amount is not known. International best practice guidelines recommends and at Summit facilities we adopt their recommendations, an individualized supervised treatment plan with a minimum of 1 hour of therapy per discipline provided by the multidisciplinary team for a minimum of 5 days per week. This intensity is based on individual need and tolerance. The duration of therapies is dependent on patient severity and made up of a combination of individualised sessions, group based sessions and individual supervised practice in the gyms, wards and outdoors.

Weekend therapy is not recommended as it is an essential time for patients to rest, be with their family and be involved in recreational leisure activities. When weekend therapy is recommended it is guided by the weekend on call protocol as laid out by Summit. This can be found in the electronic resource centre.

Programme Structure:

At Summit rehabilitation a programme consisting of group therapy, individual therapy and supervised training sessions are provided as deemed optimal for each patient.

Treatment is performed in the gyms, wards, outdoors around the hospital grounds in the community and at times in the patient's own home as deemed appropriate by

the treating team. Certain activities such as eating, grooming, dressing and other tasks are performed in the wards to facilitate more real to life situations.

Therapists should not limit their practice to one 'approach', but should select interventions according to the individual needs of the patient.

B.General Rehabilitation and Management Principles:

At Summit rehabilitation therapy emphasises functional activity in training.

Compensation and Neural Plasticity

Treatment interventions should always consider the balance between quality and compensation during tasks.

Controlling selective movements allows for more co-ordinated sequences of movement rather than pure compensation which may encourage poor movement patterns.

Postural control is essential as a backbone for optimal task performance, thus at Summit rehab postural control is an integral part of training.

Excessive compensatory strategies during movement are an indicator that the patient does not yet have enough postural control to perform the task as it is currently set-up.

Optimal Skill Acquisition

Therapy should include repetitive and intense use of novel tasks that challenge the patient to acquire the necessary motor skills to use involved limbs during functional tasks and activities.

The team should promote the practice of skills gained in therapy into the patients' routine in a consistent manner.

Our treatment does not consist of a number of exercises, but rather we are preparing each patient for daily life and to be able to perform movement in real life functional positions which are meaningful

Therapy must be motivating to the patient. Working on the appropriate functional activities in daily life situations ensures that contextual factors are taken into consideration and allows us to measure meaningful outcomes

Clinical Reasoning

Therapists at Summit Rehab use clinical reasoning in their task/movement analysis to enable them to identify the specific underlying impairments critical cues that are key and impacting on the performance/ success of the task and the underlying postural control and movement requirements. An understanding of and importance of afferent information for all movement must be remembered. Exercise and functional training should be directed to enhance motor control for restoring sensori-motor and functional abilities. During rehabilitation much emphasis is placed on patients regaining as much functional independence as possible in all ADLs and IADLs.

Early Mobilization

A number of post-stroke complications are associated with immobility.

The aim of positioning the patient is to try to promote optimal recovery by modulating muscle tone, providing appropriate sensory information and increasing spatial awareness and to prevent complications such as pressure sores, contractures, pain and respiratory problems and assist safer eating. Patients should be placed in an upright sitting position, if their medical condition allows. Hypoxia inducing positions (lying on the left side regardless of affected side or slumped in a chair) should be avoided.

Therapeutic Positioning

Encourage patients to use their limbs and perform activities as independently as possible. Always ensure they are ready for action. Thus even if you cannot use your arm put it where it would normally be in each and every task done daily. The aim of positioning the patient is to try to promote optimal recovery by modulating muscle tone, providing appropriate sensory information and increasing spatial awareness and to prevent complications such as pressure sores, contractures, pain and respiratory problems and assist safer eating.

In this way advise families and patients to the best positioning for all tasks and when at rest.

The consensus from a literature review is that in the upper limb the affected shoulder should be protracted with the arm brought forward and the fingers extended to counteract the tendency for the shoulder to adduct and rotate internally. The trunk

should be straight and in the midline avoiding forward or side flexion. For the lower limb there should be avoidance of external rotation and abduction of the hip through the use of support such as pillows. Generally knee flexion is advocated but patients should also know how to ensure they do not lose full length of hamstrings (vastus lateralis).

Activities of Daily Living

Activities of daily living (ADL) training is essential in stroke rehabilitation. The intervention can be divided into personal activities (self care) and extended activities. Therapists must use the process of activity analysis to grade activities of daily living so that they are achievable, but challenging, with limited compensation in order to promote recovery after stroke.

Task specificity and context specificity is recommended to improve performance and assist in grading of such selected activities.

An extra 11-13 reps/ day of STS should be included in the patients therapy programme.

Oral baclofen may be recommended when spasticity results in pain, poor skin hygiene or decreased function to the patient's norm. For post acute stroke patients Botox injection may be used to increase ROM and decrease pain for focal treatment.

Contracture Serial casting can be used to reduce severe, persistent contracture when conventional therapy has failed.

Gait, Balance and Mobility Rehabilitation Recommendations

Training sitting balance can be effective; patients must reach beyond arm's length out of their base of support with the non -paretic arm. Placement of feet, speed, distance and direction during reaching tasks must be varied.

Individualised interventions are recommended with an emphasis on:

Muscle strength training to improve muscle strength when a patient is still unable to walk. Repetitive task training to optimise aspects of gait required to improve functional mobility.

Task specificity and context specificity is strongly recommended for all patients. As patients increase their tolerance of therapy so the intensity of rehabilitation training should be increased.

Gait-oriented physical fitness training should be offered to all patients assessed as medically stable and functionally safe to participate, when the goal of treatment is to improve functional ambulation..

Gait retraining with a treadmill assists walking speed and walking ability.

The use of an AFO or FES must be considered initially to facilitate clients who need stabilization for walking, with more expensive custom bracing reserved for those who require long term use.

Treadmill training should be considered in independent walkers to increase gait speed.

In patients unable to walk body weight supported gait training should be considered. Walking aids should be considered only after a full assessment of the potential benefits and harms of the walking aid in relation to the individual patient's stage of recovery and presentation.

Routine use of walking aids, treadmill training, TES should not be used.

Physiotherapists should not limit their practice to one 'approach', but should select interventions according to the individual needs of the patient.

(Please refer to gait rehabilitation guideline for more detailed therapeutic guidelines.)

Upper Extremity Rehabilitation Recommendations

General Guidelines for UL Rehabilitation

Attempts to regain function in the affected upper extremity should be limited to those individuals already showing signs of some recovery.

For patients not showing any arm movement recovery the focus of therapy must be teaching the patient to know how to maintain a painfree shoulder and to mobilize their UL to maintain range of movement.

Shoulder pain should be prevented with positioning the UL supported on a surface that reduces and weight of the UL causing subluxation.

UL positioning must also encourage any shoulder motor control recovery possible. Sensory-motor retraining includes passive and active ROM facilitation and placement of the upper limb in a variety of positions within the patient's visual field.

Evidence regarding the use of supportive slings and supports is conflicting. At Summit, the use of a hemi-sling for extended periods of the day is not recommended. Such slings are only used when indicated by the presence of pain while walking or performing functional tasks.

Therapy needs to target increasing awareness of the arm and how to position it in all activities of daily living (ready for action). Please refer to UL clinical guideline for further intervention strategies.

Repetitive task specific training techniques can be recommended to increase upper extremity function, however careful movement analysis is indicated to ensure specific underlying impairments and problematic movement sequences are targeted in the training set up.

Using TES and FES treatment improves upper extremity function in acute stroke. In addition neuromuscular electrical stimulation can reduce spasticity and improve motor function in the upper extremity.

Sensorimotor training with robotic devices (this includes CPM machines) improves upper extremity functional outcomes, and motor outcomes of the shoulder and elbow.

Spasticity

Botox injection alone or in combination with therapy significantly decreases spasticity in the upper extremity in stroke survivors.

Electrical stimulation combined with Botulinum Toxin injection is associated with reductions in muscle tone.

Oedema Management

Both neuromuscular nerve stimulation and continuous passive motion help to reduce hand oedema compared to limb elevation.

Constraint Induced Movement Therapy

Only considered for a select group, those with 20 degrees wrist extension and 10 degrees finger extension, with minimal sensory and cognitive deficit. Benefit has only been proven with 6-8 hours of 2 weeks therapy.

Modified CIMT in the acute/subacute stage of stroke may also be beneficial in comparison to traditional therapies in the chronic stage of stroke. Benefits appear to be confined to stroke patients with some active wrist and hand movements, particularly those with sensory loss and neglect.

Shoulder Pain Prevention

Presence of pain in stroke should be identified early and treated accordingly. Therapists must try to identify factors that cause or exacerbate pain.

Interventions that should be considered to prevent shoulder pain may include:

1. Foam supports
2. Passive assisted movement within painfree ROM
3. Position and support limb to minimize pain
4. Protect limb to minimize pain during functional mobility tasks, with using slings , pocket, therapist
5. Teach patients to respect the pain
6. Facilitate active movement of the upper limb and trunk
7. Use some means of external support to protect the upper limb during wheelchair use, e.g. tray, trough.
8. Educate caregivers and staff about correct handling of hemiplegic arm

Management of shoulder pain:

1. Treat pain and limitations in ROM with gentle stretching and mobilization techniques focussing especially on external rotation and abduction.
2. Reduce Hand Oedema by:
 - a) Active self ROM exercises in conjunction with elevation to gain full ROM of fingers thumb and wrist.
 - b) Retrograde massage
 - c) Gentle grade 1 and 2 mobs for accessory movements of the hand and fingers
 - d) Cold water immersion(Evidence Level B) or contrast baths
3. Consider using FES to increase painfree ROM of shoulder lateral rotation(

Evidence level A)

4. Consider use of analgesia to manage pain
5. The use of Botox injections into subscapularis and pectoralis muscles will be considered for individuals with shoulder pain (Evidence Level C)

Assessment and management of ROM of both the LL and UL and spasticity is critical.

Please note that the uses of overhead pulleys and the motomed has been found to increase the development of shoulder pain and are thus not used for clients who do not have an UL muscle strength of grade 3 for pulley type actions and a grade 2 for the motomed UL training.

Management of Complex region pain syndrome

Oral Coricosteroids in tapering doses may be used to reduce swelling and pain due to this condition (Evidence Level B)

Tricyclic anti depressants trial should be trialled in persons with stroke with unresolving CRPS.

Cognitive Rehabilitation

All patients should be screened for cognitive and perceptual deficits using validated and reliable screening tools.

Cognitive rehabilitation should aim to:

- 1) reinforce, strengthen or re-establish previously learned patterns of behaviour
- 2) establish new patterns of cognitive activity through compensatory cognitive mechanisms for impaired neurological systems
- 3) establish new patterns of activity through external compensatory mechanisms such as personal orthoses or environmental structuring and support
- 4) enable persons to adapt to their cognitive disability.

Cognitive rehabilitation should be a team approach that includes both combination of individual and group tasks that aim to address all areas of cognition in functional tasks. Individual drill training can be used for specific skills required. It should be noted that general cognitive tasks e.g. paper based or computer tasks are helpful

for stroke survivors with attention and concentration deficits but carryover to general functioning is often limited.

The use of compensatory strategies is the best approach for memory deficits. Patients with memory impairment causing difficulties in rehabilitation or adaptive functioning should be assessed to see if compensatory techniques can be used to reduce their disabilities, such as notebooks, diaries, electronic organizers.

Compensatory strategies and external cues such as a pager can be used to initiate / structure everyday activities in stroke / TBI survivors with impaired executive functioning. The manner in which this information is provided should be appropriate for the patient and specific functional problems solving and executive skills will need to be retrained in most cases. Carers and family's involvement is important for carry over.

For persons with confirmed apraxia, tailored interventions (strategy training) can be used to improve ADL. Approaches such as errorless learning, hand over hand guiding and forward and backward trailing should be used. (see Clinical Guideline for Management of Apraxia for more detail).

Patients with unilateral neglect or impairment of spatial awareness should have a full assessment using validated tools. Such patients should be trialled with one or more of the following interventions.

- Cues to draw attention to the affected side
- Visual scanning training in addition to sensory stimulation
- Prism adaptation
- Eye patching
- Structured feedback and strategy training

(see Clinical Guidelines on Vision and Visuospatial Perception for more details)

Executive functioning: Reasoning, Problem solving and Pragmatics:

Executive functions refer to higher-level cognitive functions that are primarily mediated by the frontal lobes. These functions include insight, awareness, judgment, planning, organization, problem solving, multi-tasking and working

memory (Lezak, 1983). Disorders of executive functions within the ABI population have been found to be heterogenous (Kennedy et al., 2008).

Treatment goals:

- Improve ability to consider multiple solutions, perspectives
- Encourage systematic approach to problem solving
- Improve an individual's ability to change their focus
- Improve organization, planning, initiation and impulse control

Treatment strategies:

- Define the problem;
- Develop a list of possible solutions and the pros and cons of each;
- Evaluate the success of each solution and be willing to try again;
- Targeting goal setting, planning, initiation, monitoring, time management and impulse control (CASLPO 2002).

Materials and Devices:

- Didactic educational instruction
- Specialized computer software
- Reading and homework activities
- Mindfulness training
- Paging systems
- Group therapy

Should any complications occur extending ones length of hospital stay, as much active rehabilitation will continue as appropriate and where not contra-indicated?