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Energy expenditure and perceived effort in patients with stroke during sit to stand

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ENERGY EXPENDITURE AND PERCEIVED EFFORT IN PATIENTS WITH STROKE DURING SIT TO STAND

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A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Masters of Science (Physiotherapy)

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ABSTRACT

Background

The energy expenditure of adults with no known disease has previously been calculated and the determinants of sit to stand in individuals with hemiparesis post stroke have also been established. Perceived effort has been established for patients with stroke during walking and other activities. However, the amount of energy expended and their perceived effort in a patient with stroke during sit to stand has not yet been established.

Objectives

The aim of the study was to establish the actual energy expended and perceived effort of a patient with stroke during sit to stand.

Methods

A descriptive cross sectional pilot study was conducted. The study used nine participants and took place at the Chris Hani Baragwanath Academic Hospital Physiotherapy Department and Life Flora Hospital. The participants were sourced from both in and outpatient physiotherapy departments. The study was explained to them, and an information document was issued. Once consent was given, a once off demographic questionnaire was completed and participants' weight and height were measured to calculate the body mass index. The triaxial accelerometer (RT3) was positioned at their hips on a belt, they stood up from a chair twice and on finishing this movement they completed the Modified Borg Scale for perceived effort. Information was captured on a Microsoft Excel™ for data analysis. STATA was used to analyse the data.

Results

Nine participants were included in this pilot study and consisted of four (44.4%) male and five (55.5%) female participants. The mean age of the group was 52.77 (±11.33) years with most having had a haemorrhagic stroke (n=6, 66.6%) who presented with left hemiplegia (n=6, 66.6%). The median energy expenditure during sit to stand was 2.62 (2.09-3.17) kCal/min. The median perceived effort was 3 (3-4) indicating a 'somewhat severe' effort rating. The correlation coefficient between the perceived effort and metabolic equivalent of task (METS) was r = 0.35 (p = 0.36).

Conclusion

This study found that participants could use the Modified Borg Scale to report their perceived effort during sit to stand and energy expenditure during sit to stand was much higher compared to published literature of healthy individuals. A fair positive correlation between perceived effort and METs was noted for patients with stroke during sit to stand. The results from this study show that the participants did have increase in EE compared to normal adults, thus training should focus to prevent the unnecessary waste of energy that can be reserved for other activities such as walking, running and stair climbing.

Keywords: “stroke”, “sit to stand”, “energy expenditure”, “triaxial accelerometer”, “perceived effort” and “physiotherapy”.

DECLARATION

I, Tracy Harington, hereby declare that this research report is my original work. It is being submitted for partial fulfilment of the degree of Masters of Science (Physiotherapy) at the University of the Witwatersrand, Johannesburg. Neither the substance of any part of this work has been, or is being, or is to be submitted for another degree at this or any other university.

Signed: .....

Date: 04 day of September 2022

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LIST OF ABBREVIATIONS

1RM	One-repetition maximum (Maximal Strength for 1 repetition)
ADL's	Activities of daily living
AIDS	Acquired Immune Deficiency Syndrome
BMI	Body mass index
CHBAH	Chris Hani Baragwanath Academic Hospital
cm	Centimetres
CNS	Central nervous system
CoM	Centre of mass
CVs	Coefficient variables
EE	Energy expenditure
EMG	Electromyography
ES	Electrical stimulation
FES	Functional electrical stimulation
FFM	Fat free mass
GAIN	Glycine Antagonist in Neuroprotection
GBD	Global Burden of Diseases, Injuries, and Risk Factors Study
HR	Heart rate
HREC	Human Research Ethics Committees
HRR	Heart rate reserve
HS	Haemorrhagic stroke
ICH	Intracranial haemorrhage
IS	Ischaemic stroke
IQR	Interquartile range
$kCal/min^{-1}$	kilocalorie per minute
Kgs	kilograms
LOC	Level of consciousness
LOS	Length of stay
m	metres
MBS	Modified Borg Scale
MEC	Metabolic energy cost
METs	Metabolic equivalent of task
NIHSS	The National Institutes of Health Stroke Scale
PA	Physical activity
REE/RMR	Resting energy expenditure

ROM	Range of movement
RPE	Ratings of perceived exertion
RT3	Triaxial accelerometer
s	Seconds
SA	South Africa
SD	Standard deviation
SMD	Standardised mean difference
SASP	South African Society of Physiotherapy
STS	Sit to stand
TB	Tuberculosis
TEE	Total Energy Expenditure
TEE.min−1	Total Energy Expenditure per minute
USA	United States of America
VAS	Visual analogue scale

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CHAPTER 1

1. INTRODUCTION AND SCOPE OF THE RESEARCH REPORT

1.1 INTRODUCTION

1.1.1 BACKGROUND AND NEED

Globally, there are 15 million people who suffer from stroke every year (Gund *et al.*, 2013). Nearly five million people die from stroke with five million people left permanently disabled (Gund *et al.*, 2013). Following dementia, stroke is the second leading cause of disability (Gund *et al.*, 2013). Worldwide, the second leading cause of death in people older than the age of 60 years is stroke and in people aged 15 to 59 years it is the fifth leading cause of death.

The prevalence of stroke in the United States of America (USA) is about 3%, which equates to about seven million strokes per year. In China, the incidence of stroke per year ranges between 1.8% (rural areas) and 9.4% (urban areas). China's stroke mortality (19.9% of all deaths in China) is one of the highest globally with similar rates being reported in Africa and parts of South America. In South Africa (SA), death has been reported in a third of patients who suffered from stroke with about 66% of patients who had stroke presented with some disability in rural SA. The disability can include minor difficulties such as weakness of an arm or leg in a small stroke, whereas in a larger stroke paralysis on one side of the body or the loss of the ability to speak can also be present (Connor *et al.*, 2004; Gund *et al.*, 2013).

Stroke is accountable for more deaths per year than those accredited to acquired immunodeficiency syndrome (AIDs), tuberculosis (TB) and malaria combined (Gund *et al.*, 2013). There is a disproportion between the influence of the burden of stroke and individuals residing in resource-poor countries (Gund *et al.*, 2013).

A study done by Mudzi, Stewart and Musenge, (2012) followed up on 200 patients over a period of one year post stroke revealed that the average of one physiotherapy session was being received during hospitalisation, with a mean length of six days for hospital stay. Following discharge the total mortality at three-months was 25.5%, 35.5% at six-months and 38% at 12 months. The cause of death in these patients was not established but the possible contributing factors could include the short hospital stay with little or no acute

rehabilitation, resulting in a decreased functional ability of the patients with stroke. This could have increased the possibility of bed-rest complications, mainly pressure sores and chest infections.

Disability post stroke is determined by multiple factors: it differs according to the amount of recovery that occurs neurologically, where the lesion occurred, the premorbid status of the patient and the environmental support systems (Teasell and Hussein, 2014). During hospitalisation patients' physical level of activity is lower than that of the premorbid level and it has been found that there is little time spent on moderate to high level physical activity (PA) during formal therapy sessions of rehabilitation (West and Bernhardt, 2012). In patients admitted within 14 days following their stroke as well as those that have been admitted to conventional care, low levels of PA occur more often (West and Bernhardt, 2013).

Post stroke, there is a number of problems that can be experienced associated with the ability to come from sit to stand (STS) independently. Independent function of activities of daily living (ADL) can be limited due to the inability to STS independently (Pollock *et al.*, 2014). During STS, the weight distribution has shown a large amount of asymmetry, with a large increase of the weight-bearing on the unaffected side for people with hemiplegia (Cheng *et al.*, 2001; Pollock *et al.*, 2014). When people who suffered from a stroke were compared with healthy adults, the stroke group frequently displayed a longer length of time to finish the movement of STS, as well as a reduction in the peak vertical reaction force and a larger medio-lateral centre of pressure displacement occurs (Cheng *et al.*, 2001).

One of the most frequently repeated tasks done daily is the movement of standing up from a seated position (Pollock *et al.*, 2014). Evidence suggests that it may be one of the most mechanically demanding functional tasks that people perform on a regular basis (Pollock *et al.*, 2014). The action of coming from STS is where the body's centre of mass (CoM) moves upward from a seated position to a standing position without the loss of balance (Roebroeck *et al.*, 1994). Successfully completing the STS movement is dependent on the person executing the movement having sufficient balance, range of motion (ROM), coordination and strength as well as being able to move the CoM of the body forward from a wide base of support to a narrow one (Prudente, Rodrigues-de-Paula and Faria, 2013). Standing from a seated position requires a greater joint ROM and more leg strength than walking or stair climbing (Mazzà *et al.*, 2004). It is an important pre-cursor to walking and is essential for prevention of falls and independent living (Culhane *et al.*, 2005). For one to achieve STS, it is necessary for the activation of the muscles in a coordinated manner, to control the segmental mobility and the total body momentum (Prudente *et al.*, 2013).

Energy expenditure (EE) is the production of energy from the combustion of natural sources in the form of fat, alcohol, carbohydrate, or protein. During this process, oxygen is used, and carbon dioxide is made. It is referred to as direct calorimetry whereby the measurement of EE involves the amount of heat loss directly or heat production (Hills, Mokhtar and Byrne, 2014). In patients with stroke, this may vary compared to able-bodied people. Morio *et al.*, (1997) did a study on gender effects on energy expended and the consequences of daily energy expended during a variety of exercises such as light seated activities, cycling, walking, and sleep. Their study found that there were no differences between genders in the different physical activity EE. A study done by Júdice *et al.*, (2016) quantified the energy expended for sitting, standing and STS transitions, in a group of adults with no known disease. The study found the transition from STS (and sitting down again) had a modest metabolic cost of 0.32 kcal min−1 above sitting regardless of gender and body composition. Júdice *et al.*, (2016) study results will be used as the norm to compare to that of this EE study. Training received, spasticity and degree of weakness may cause a variation in the EE, which may lead to the higher levels of energy expended required to accomplish the task which may cause their perception of their inability to be increased and further decreasing engagement in this task (Singh, Stewart and Franzsen, 2011).

Post stroke, patients' problems relating to the ability to STS independently can be attributed to a number of factors. According to Jeyasurya *et al.*, (2013) static and dynamic stability, extensor effort, momentum transfer energy and subjective preference can affect STS. Ratings of perceived exertion (RPE) are thought to be very important in the regulation of intensity during self-paced PA. The development of effort and exertion perceptions is an intricate process which involves copious neural processes taking place in various regions within the brain (Abbiss *et al.*, 2015). Sufficient therapy time is required to optimise STS and minimise unnecessary compensations (Jette *et al.*, 2005). Boukadida *et al.*, (2015), using relevent scientfic publications, did a literature review revealed that there are four important factors that influence STS in the majority of patients with hemiparesis who are able to come from STS independently. These changes included: "angular displacements of lower limbs and trunk; muscular activation changes after stroke, postural control and weight bearing distribution". Boukadida *et al.*, (2015) concluded that there is a requirement for further research to improve the understanding of this activity and to highlight that the clinical impairments effect are related to stroke.

1.2 PROBLEM STATEMENT

Due to short hospital length of stay and minimal physiotherapy sessions received during hospital admission, decreased functional ability of the patients with stroke, can lead to increased complications of bed-rest. It is therefore important to mobilise the patient with stroke as soon as possible. Thus, the energy expenditure of adults with no known disease has previously been calculated and the determinants of STS in individuals with hemiparesis post stroke have also been established. Perceived effort has been established for patients with stroke during walking and other activities. However, the amount of energy expended and their perceived effort in a patient with stroke during STS has not yet been established.

1.3 RESEARCH QUESTION

What is the actual energy expended and perceived effort during STS in patients with stroke?

1.4 RESEARCH AIM

The aim of the study was to establish the actual energy expended and perceived effort of a patient with stroke during sit to stand.

1.5 RESEARCH OBJECTIVES

1. To establish energy expenditure during STS in patients with stroke.
2. To establish perceived effort during STS in patients with stroke.
3. To establish the association between actual energy expended and perceived effort during STS in patients with stroke.
4. To determine the demographic and clinical profile of participants.

1.6 SIGNIFICANCE OF STUDY

A literature review done by Boukadida *et al.*, (2015) concluded that there is a requirement for further research to enhance the understanding of the STS activity and to outline the effect of clinical impairments related to stroke. The main goal would be for a clearer understanding of STS and how it can be used to advance rehabilitation programs and thus improved independence for individuals post stroke (Boukadida *et al.*, 2015).

The rehabilitation of STS can therefore be said to be an important goal after stroke. It is important to know which evidence has been proven the effectiveness of treatments aimed at improving the ability to STS after stroke to facilitate and promote evidence-based practice (Pollock *et al.*, 2014). The clinical implications of such differences between perceived and actual energy expended and the understanding of this role in such perceptions can assist in

the regulation of pace during exercise (Abbiss *et al.*, 2015). The results from this study can be the baseline for the development of treatment guidelines for future rehabilitation of patients with neurological disabilities to ensure a holistic treatment especially focusing on where the potential increase or decrease in EE may occur.

1.7 ORGANISATION OF THE RESEARCH REPORT

The general outline of the research report is summarised below:

Chapter 1: Introduction

Chapter 2: Literature Review

Chapter 3: Methodology

Chapter 4: Results

Chapter 5: Discussion

Chapter 6: Conclusion, limitations and recommendations

Chapter 7: References

CHAPTER 2

2. LITERATURE REVIEW

2.1 INTRODUCTION

Databases used to review the literature pertaining to this study were: CINAHL Plus, Cochrane Library, EBSCO, Google Scholar, OVID/ Wolters Kluwer and PubMed. The search strategy included the use of the following key words: “stroke”, “sit to stand”, “energy expenditure”, “triaxial accelerometer”, “perceived effort” and “physiotherapy” and searches were limited to the time period of 2007-2021. The literature discussed in this chapter is structured using the following headings to provide the background to the study: epidemiology of stroke; physiotherapy; perceived effort and energy expenditure. The level of evidence looked at systematic reviews, randomised and non-randomised controlled group, as well as comparison groups.

2.2 EPIDEMIOLOGY OF STROKE

Worldwide, the prevalence of stroke is more than 42 million people and the annual incidence of stroke is 16 million people (Rennert *et al.*, 2019) with stroke remaining the second leading cause of mortality. Gund *et al.*, (2013) reported that there were almost five million people who died from stroke yearly. A study done by Rennert *et al.*, (2019) showed that this number increased to 6.3 million people per year by 2019. It was also noted that approximately five million people suffer from being permanently disabled following stroke (Gund *et al.*, 2013). Globally stroke, in people older than 60 years of age, is the second biggest cause of disability and death, whereas in people aged 15 to 59 years of age, it is the fifth leading cause of death (Adams *et al.*, 2007).

The prevalence of stroke in the USA in 2013 was about 3% which equates to about seven million strokes per year whereas in China, the incidence ranged between 1.8% (rural areas) and 9.4% (urban areas) (Gund *et al.*, 2013). In 2019, the prevalence of stroke in people aged 20 years and older decreased to about 2.7% (7.2 million people in total) however in people over 60 (6%) to 80 (13%) years old it increased with age. The yearly incidence of new or recurrent strokes in the USA is nearly 800 000 (Rennert *et al.*, 2019). The highest rate of stroke mortality worldwide is in China (19.9% of all deaths in China) with similar rates being reported in Africa and parts of South America (Gund *et al.*, 2013). In SA, the third cause of death is stroke of which about 66% of the patients with stroke being found to have some disability in rural areas. Stroke causes more deaths annually in SA than those

accredited to AIDs, TB and malaria combined (Gund *et al.*, 2013). The disability can include minor difficulties such as decreased muscle strength of an arm or leg in a small stroke, whereas in a larger stroke paralysis on one side of the body or inability to speak can also be present depending on the severity and type of stroke (Connor *et al.*, 2004; Gund *et al.*, 2013). There are two subtypes of strokes.

2.2.1 STROKE SUBTYPES

There are two subtypes of strokes, namely ischaemic and haemorrhagic stroke (Andersen *et al.*, 2009). Around 10% of all strokes reported in individuals are due to an intracerebral haemorrhage (ICH) (Kelly *et al.*, 2003; Paolucci *et al.*, 2003). Kalra and Langhorne, (2007) showed that Eastern European and Asian countries, where there was a higher prevalence of untreated hypertension, had a proportional effect on the patients who presented with haemorrhagic stroke (HS). When compared, patients with ICH have a better recovery than patients with ischaemic strokes (IS) even though there is higher mortality and greater neurologic impairment in the acute phase. Jørgensen *et al.*, (1995) showed that once the potential confounders that showed stroke type (ischaemic vs haemorrhagic) were controlled, there was no influence on the time taken for neurological recovery, mortality, neurological outcome, or the time taken for recovery from disability. The initial stroke severity that was greater in the patients with haemorrhagic stroke showed an effect of poorer outcome amongst them. There is an initial increase rate of mortality associated with an ICH which is time dependent, disappearing after three months (Andersen *et al.*, 2009).

A study done by Chiu *et al.*, (2010) studied whether the initial stroke severity could be associated with the long-term prognosis associated with haemorrhagic stroke using the Glycine Antagonist in Neuroprotection (GAIN) study. The outcome revealed that the ICH was an independent factor in poor neurological outcome (Chiu *et al.*, 2010). Paolucci *et al.*, (2003) reported that the ICH patients demonstrated a higher therapeutic response to ADL's and had greater rehabilitation outcomes, when these patients were matched according to age, sex, onset to admission time and initial stroke severity. The study also showed that patients with ICH had higher efficiencies in scores and scored more in both the Canadian Neurological Scale scores and the Rivermead Mobility scores. The length of hospital stays between the ICH and the haemorrhagic patient groups were similar. With these findings the researchers as well as Kelly *et al.*, (2003) suggested that the greater recovery, in relation to patients with IS to better neurological recovery, was associated with resolution of the pressure on the brain. Functional status at discharge was strongly predicated by the initial stroke severity, even though the initial disability did not play a large part on the amount of recovery during rehabilitation (Lipson *et al.*, 2005).

2.2.1.1 The National Institutes of Health Stroke Scale

A number of scales are available to assess the level of impairment in an individual who had a stroke. One such scale is the National Institutes of Health Stroke Scale. The National Institutes of Health Stroke Scale (NIHSS) is a combined scale that was created from the Cincinnati Stroke Scale, the Oxbury Initial Severity Scale, the Edinburgh-2 Coma Scale and the Toronto Stroke Scale (Meyer and Lyden, 2009). There are 15 items on this scale that assess the severity of impairment and these items are:

1. the level of consciousness (LOC) of a person;
2. the person's ability to respond to questions
3. the person's ability to follow simple commands;
4. the presence of deviation of an person's gaze;
5. papillary response;
6. the presence of facial palsy;
7. the extent of hemianopsia;
8. the resistance to gravity in the weaker limb;
9. the presence or absence of plantar reflexes;
10. limb ataxia;
11. sensory loss;
12. visual neglect;
13. dysarthria and aphasia severity (Meyer and Lyden, 2009).

The scale is scored between a range of 0 to 42, the points on the scale are rated on a 3- or 4-point ordinal scale; 0 means no impairment, the higher the score the greater severity of impairment. The severity of the stroke may be presumed on the basis of the NIHSS scores as follows (Brott *et al.*, 1989): "(1) Very Severe: >25, (2) Severe: 15 – 24, (3) Mild to Moderately Severe: 5 – 14, (4) Mild: 1 – 5". Test-retest reliability was excellent (ICC = 0.93) and interrater reliability was excellent as well with ICC = 0.95 (Goldstein and Samsa, 1997).

2.2.2 DISABILITY POST STROKE

Disability post stroke has several factors in its determination: it can vary based on the amount of neurological recovery, where the lesion occurred, the patient's functional status before the lesion and the environmental support systems (Teasell and Hussein, 2014). During hospitalisation patients' physical level of activity is lower than that of the premorbid level and it has been found that there is little time spent on moderate to high level physical activity during formal therapy sessions' of rehabilitation (West and Bernhardt, 2012). More commonly patients admitted to conventional care and those that are two weeks post stroke,

showed decreased levels of physical activity. Conventional care units are units that include any acute care which admit both stroke and non-stroke diagnoses patients (West and Bernhardt, 2012). There is a disproportion when it comes to the consequence of how it affects people with stroke living in countries with poor resources (Gund *et al.*, 2013).

Several factors post stroke can be influenced by disability, these factors are described in literature as “prognostic factors”, which are linked by the functional outcome and their association between them following stroke (Kwakkel and Kollen, 2012). These “prognostic factors” are divided into three subgroups which include: (1) stroke related (clinical); side of brain lesion and level of disability on admission (2) socio-demographic i.e. age, gender and living alone (3) rehabilitation related factors i.e. categorised time-frame between stroke to initiation of rehabilitation and rehabilitation duration (defined by number of months in which rehabilitation was received) (Musicco *et al.*, 2003). These factors are but a few which have been used across multiple worldwide settings yet are inconsistent as the stroke samples are too diverse (Kwakkel and Kollen, 2012). The understanding and comprehension of these factors and the influence they have is important to develop a specific rehabilitation approach, to set goals that will allow for maximum functional gain in the crucial, early phase post stroke and allow for appropriate discharge planning (Kwakkel and Kollen, 2012) and furthermore to minimise any strain that is placed on caregivers or the family following the stroke.

2.2.3 DIFFERENT TYPES OF STROKE RECOVERY

The two main types of recovery include spontaneous recovery or intrinsic neurological recovery, and adaptive or functional recovery. Impairments are used to describe the result of neurological deficits caused by a stroke. These impairments are mainly depending on the area and degree of the stroke. The prognosis for recovery is inversely proportional to seriousness of the initial deficit. During the first three to six months after the stroke the most spontaneous recovery occurs. As time continues following a stroke it takes longer to recover (Skilbeck *et al.*, 1983). Activity of daily living is the term used to measure functional deficits. Functional recovery depends on several factors including how motivated the patient is, family support and capacity to learn as well as the intensity and quality of the treatment therapy. Functional recovery is adaptable by various treatments and is influenced by, but not dependent on neurological recovery (Skilbeck *et al.*, 1983).

This recovery information can be used to assist with the rehabilitation of the patient focusing not only on the physical impairments, but the psychosocial aspects as well for optimal recovery to occur.

2.2.4 MECHANISMS OF NEUROLOGICAL RECOVERY

The recovery from stroke can be associated with surrounding oedema resolving and the return of blood flow within the ischemic penumbra, while several of the factors have been noted to play a role in neurological recovery following stroke, these roles are not fully understood (Dombovy, 1991). The spontaneous recovery can, however, pass into the resolution period of acute structural changes which were due to the stroke, with recovery taking place four to six weeks following the stroke (Brodal A, 1973). The two processes that recovery can be grouped into are: the early recovery called local central nervous system (CNS) processes and the later recovery known as CNS reorganisation.

The local patho-physiological processes known as the early recovery leads to the initial improvement, and it is independent of the stimuli or behaviour of the individual. It consists of three occurrences.

a) Post stroke oedema

Neuronal function may be disrupted due to the oedema surrounding the lesion. As the oedema surrounding the infarcted area starts to resolve, the early recovery may be accelerated (Lo, 1986) and as the oedema subsides, this allows for the neurons to regain function. This is an ongoing process and may occur for up to eight weeks following the stroke, but is usually achieved much quicker (Inoue *et al.*, 1980). Cerebral haemorrhages may be related with a longer recovery as it tends to be associated with a larger amount of oedema, which takes longer to decrease.

b) Reperfusion of the Ischaemic Penumbra

The ischemic penumbra is a focal ischemic area which is made up of a collection of low blood flow which inevitably leads to an infarct. This core area is encircled by an area of moderate blood which is at risk of infarction but is still repairable(Astrup, Siesjö and Symon, 1981; Lyden and Zivin, 2000). A local process that allows for early recovery is reperfusion of the ischemic penumbra. During reperfusion of this area, the affected and previously non-functioning neurons will be able to continue functioning with clinical improvement following (Astrup *et al.*, 1981; Lyden and Zivin, 2000).

c) Resolution of Diaschisis

Nudo, Plautz and Frost, (2001) described diaschisis as “a state of low reactivity or depressed function as a result of a sudden interruption of major input to a part of the brain remote from the site of brain damage”. Once damage has occurred to one area in the brain, the surrounding area as well as other areas of the brain is being deprived of an important

stimulation (Nudo *et al.*, 2001). Diaschisis can be described as the process by which the surrounding cortical tissues and regions are inhibited or suppressed early after injury at a distance that is interconnected with the injury neurons (Nudo *et al.*, 2001). Once the resolution of the oedema occurs, it leads to a reversibility and allows for a percentage of spontaneous recovery to follow (Nudo *et al.*, 2001). Once the resolution of diaschisis has occurred, if the connected area of the brain is still intact, neuronal function may return, however, in cortical injury this is mostly correct of the noncortical structures (Lo, 1986).

Rehabilitation is necessary for the restoration of function as the training can influence neurological reorganisation. Cortical reorganisation, known as neuroplasticity, plays a large role in the basis of rehabilitation as well as a key neurological foundation of the neurological recovery following stroke. During the recovery period, neuroplasticity can take a longer period of time compared to that of the local process, such as reperfusion of the penumbra or the resolution of oedema (Nudo, 2003). Research has demonstrated that once a small, focal lesion occurs in the motor cortex where the same fundamentals of motor learning and development of functional connections are taking place in adjacent, undamaged tissue (Nudo, 2003).

Nudo, (2003) reported that in reference to damage of the motor cortex, neuroplasticity post stroke is based on three key ideas: (a) predicable functional changes within the motor cortex are required to learn skilled movements in a non-stroke brain; (b) functional changes occur in the remaining motor cortical tissue post stroke; (c) following a cortical stroke, functional neurological rehabilitation will require reorganisation in the undamaged cortex. This will require both observation (a) and (b) to interact for the retraining of motor skills (Nudo, 2003).

2.2.5 TIME COURSE OF RECOVERY

During the first one to three months following stroke the peak neurological recovery occurs. The recovery may take longer rate up until six months, after which up until one year, 5% of patients continue to recover. Plateauing can occur at any of the stages during recovery with only a small amount achieving full recovery (about 10%) who suffered a moderate to severe stroke. In severely affected patients at the time of the first assessment, this recovery pattern is mostly seen (Bonita and Beaglehole, 1988; Duncan *et al.*, 1992; Ferrucci *et al.*, 1993).

A large number of people who have suffered a stroke, showed activity limitation were as a result of their impaired extremities (Flynn, MacWalter and Doney, 2008). Activity limitations experienced by people who have suffered from stroke provide important information which

can be collected from their habitual PA and the paretic arm mobility evaluation (Rabadi and Rabadi, 2006).

2.3 PHYSIOTHERAPY

According to the South African Society of Physiotherapy (South African Society of Physiotherapy, 2021); physiotherapy is defined as follows; “Assessing, treating and preventing human and animal movement disorders, restoring normal function or minimising dysfunction and pain in adults and children with physical impairment, to enable them to achieve the highest possible level of independence in their lives; preventing recurring injuries and disability in the workplace, at home, or during recreational activities and promoting community health for all age groups.”. One of the ways that physiotherapists can assist patients is with stroke rehabilitation. Stroke rehabilitation is comprised of many goals; the primary goals include encouragement and the fostering of functional improvement and neurological recovery. The escalation of stroke care includes a care and rehabilitation aspect, these have been found vital in the promotion of better outcome overall in people with stroke. The care includes the initial organised stroke care as well as the processes of care. Early initiation and high intensity of the rehabilitation comprise the rehabilitation aspect.

To improve the ability to STS independently, two main interventions have been used. The first is a variety of physical rehabilitation interventions starting with the impairments required for STS such as providing feedback, strength muscle training and repeating the STS as a practice. The second intervention would change the environmental features for coming from STS, such as adjusting the height of the chair, the chair design, or the initial position before starting the STS movement (Pollock *et al.*, 2014).

2.3.1 RECOVERY OF SPECIFIC FUNCTIONS

Rehabilitation shows a progression of care, while the recovery demonstrates the level to which the body structure and functions, as well as activities, have returned to their premorbid stroke function. This allows us to look at the term “recovery” and the two ways in which it can be represented: “(1) the change (which is considered to be progression) of the given outcome that is achieved by an individual between two (or more) time points, or (2) the mechanism underlying this improvement in terms of behavioural restitution or compensation strategies” (Bernhardt *et al.*, 2017).

a) Ambulation

Following a stroke, the majority of patients are able to ambulate, but it does not always return back to normal (Lennon, 2001). A study compared the walking performances of stroke

patients, to healthy subjects. The main difference was decreased walking speed and residual left-right spatial and temporal asymmetry (Hsu, Tang and Jan, 2003). The key elements noted by the authors for determining a fast or comfortable walking speed were predicted by the strength of the hip flexor and the knee extensor muscles of the hemiplegic side. On the other hand, another important element was the ankle planter flexor's spasticity which contributed to the asymmetry, as well as the ability to affect the walking speed (Hsu *et al.*, 2003). Although other elements observed during a 10-metre walking test demonstrated a decrease in step length, as well as the swing phase of the hemiplegic side, with increase weight bearing time on the unaffected side and an increased double support phase (Wist, Clivaz and Sattelmayer, 2016).

Thus, the role of physiotherapy management for gait re-education is significant for patients following stroke. The gait patterns for both patients with hemiplegia as well as individuals without mobility problems have been well researched (Lennon, 2001). When comparing EE between hemiplegic subjects to that of healthy subjects, it was shown that the pathological gait of the patients with a high possibility of a twice the energy cost compared to that of a healthy subject (Wist *et al.*, 2016).

b) Upper extremity function

Approximately 5% of people with stroke will regain full functional use of their upper extremity (Tsu, Abrams and Byl, 2014). Therefore, the poor function of the upper limb creates a larger disability and is associated with an increase in impairments in ADL's. At a six month follow up, approximately 65% of the individuals with stroke are still experiencing difficulties in completing ADL's with the paretic limb and up to 40% will never regain functional use of the upper limb (Kerimov *et al.*, 2021).

There are a few contributing factors to the upper limb disability in people post stroke which can include: neglect, central pain, tone abnormalities, motor and/or sensory loss and hemiplegic shoulder pain. For healthcare professionals, the patient as well as the caregivers, the main priority generally is to focus on the ambulating aspect of rehabilitation, and in doing so underestimate the rehabilitation of the upper limb. Therefore, this sole focus on the lower limb in early rehabilitation post stroke is another contributing factor for underlying upper limb disability (Tsu *et al.*, 2014). It is important to remember that the largest amount of recovery occurs within the first six months post stroke, and therefore specific attention should be paid to the early rehabilitation of the paretic upper limb (Kerimov *et al.*, 2021).

The rehabilitation post stroke of the upper extremity is a multifactorial task. The focus of these rehabilitative approaches should be at a functional and activity level, as well as at a social participation level (Timmermans *et al.*, 2009). An essential component of stroke rehabilitation training is the sensorimotor system which has numerous stages which include improvement in their basic functions, skills and endurance. Improving muscle tone, ROM and muscle force are all part of the first stage of sensorimotor training focus (Kerimov *et al.*, 2021).

c) Higher cerebral functions

Aphasia can be defined as “a disorder of language that is acquired secondary to brain damage; it is a disorder of language rather than speech”(Kirshner and Wilson, 2021). In patients with acute stroke, this can occur in a third of them (Stefaniak and Halai, 2020). In the acute patients with stroke that are admitted, 18% will still experience aphasia once they are discharged from hospital and rehabilitation (Skilbeck *et al.*, 1983; Pedersen *et al.*, 1995). The most recovery for aphasia is within the first 12 weeks, thereafter the recovery for social function may take up to a year (Dobkin, 1997). Both Kokmen *et al.*, (1996) and (Tatemichi *et al.*, 1994), found that other higher cerebral functions, such as dementia became more prevalent in patients with stroke, and found that within the first-year post stroke, dementia was nine times more common.

2.3.2 WEAKNESS POST STROKE

After a hemiplegic stroke, secondary injury to the corticofugal motor (i.e., corticobulbar and corticospinal) pathways can occur, resulting in a higher dependence on the indirect contralesional corticoreticulospinal pathways (Binder-Markey, Murray and Dewald, 2019). As a result of the greater need on these contralesional corticoreticulospinal pathways, there is a change to the spinal motor neurons from the neural input which presents as their motor impairments such as muscle weakness, loss of independent joint control, and motor neuron hyperactivity manifesting as hypertonicity and spasticity (Binder-Markey *et al.*, 2019). This different motor drive may, over time, cause alterations to the mechanical structure of muscle; thus, causing more increased brain injury induced motor impairments. Post stroke, however, a unilateral weakness normally occurs, and it has been well described. In most hemiplegic or hemiparetic patients with strokes it has been found that weakness is less focused on compared to the synergistic movements or spasticity (Miller, Garland and Koshland, 1998). This muscle weakness can lead to immobilisation and a prominent decrease in physical activity (Wist *et al.*, 2016).

2.3.3 ASSOCIATION BETWEEN STRENGTH AND FUNCTIONAL ACTIVITIES POST STROKE

There have been correlational studies done to examine the relationship between lower limb functional abilities and strength following stroke, they found statistically significance and positive correlations between different types of functional activities and the strength of specific muscle groups (Lindmark and Hamrin, 1995; Miller *et al.*, 1998; Bohannon, 2007). Ng and Hui-Chan, (2012), demonstrated that a statistically significant predictor of walking capability following stroke was the ankle dorsiflexion strength of the affected leg. Additionally, a nonlinear relationship was found between muscle strength and walking capability in the lower limbs, indicating a threshold which muscle strength is adequate to complete a functional activity (Carvalho, Sunnerhagen and Willén, 2013).

2.3.4 STRENGTH TRAINING

Muscle strength training is an important part of rehabilitation following stroke. Strength training is used to improve all limb strength and function in individuals with stroke. However, it can have side effects such as muscle soreness in this particular patient group. There are several methods of muscle strength training available, these are the four main ones used among patients following stroke as part of their rehabilitation.

a) Progressive resistance training

The most common form of exercise is progressive resistance training, by which the muscle strengthening is based on a workload of 70 to 80% maximum strength (1RM) or more. The 1RM needs to be re-evaluated regularly by means of manual dynamometers, isokinetic devices or manual testing, so that the training can be adapted to accommodate the constant improvements in the patient. There has been no agreement as yet as to the frequency of the treatments, but it does seem that the treatments that last at least 16 hours provided for an improvement in the functional capabilities (Wist *et al.*, 2016).

b) Task-specific training

There has been efficacy shown between functional (task-specific) training in walking improvement when the training has been done intensively. Since the final purpose of all training is to see functional improvement, it is important to have integrated therapies (Pak and Patten, 2008).

c) Intensive aerobic exercising

When muscle strength training and aerobic exercise training are combined, it has shown to have a positive effect among elderly people. Walking speed and recruitment of motor units has been seen as a result of this combination (Pang *et al.*, 2013). The Karvonen formula is

used to calculate the intensity of exercising; the formula uses the heart rate reserve (HRR) to define the exercise heart rate (HR). The target intensity of aerobic exercising is 50 to 70% of the HRR in patients with stroke (Ivey, Hafer-Macko and Macko, 2008).

d) Functional electrical stimulation

Functional electrical stimulation (FES) is a tool that uses the transmission of electrical signals to the muscles training them to mobilise more muscular fibres and therefore an increase in their metabolic activity. When used as part of cycling, it was shown to assist the patient to relearn correctly, complete the movement and the increase the sensory feedback from the movement as a result of the bilateral cycling motions (Ferrante *et al.*, 2008).

The main intervention used to increase the force-generation capacity of hemiplegic limbs and improve functional capabilities following stroke is muscle strength. The aim would be to increase the strength of the muscle strength without increasing the spasticity. There has been evidence that promote progressive resistance strength training to be used; however, the possible beneficial effects on functional outcome were uncertain. As there is a large variety of training regimes and intensities of the strength-training programmes, it makes it difficult to come to a general conclusion (Cooke *et al.*, 2010). Ada, Dorsch and Canning, (2006) systematic review where interventions for both upper and lower limbs were included, showed an overall treatment effect (0.33 standardised mean difference (SMD) [95% CI: 0.13 to 0.54, p=0.001]). Whereas the interventions which focused on strengthening showed an overall effect on the activity as 0.32 SMD (95% CI: 0.11 to 0.53, p=0.002). They did not find an effective treatment effect to reduce spasticity. The interventions used were characterised as “(i) biofeedback, including force, electromyography (EMG), or positional biofeedback, (ii) electrical stimulation (ES), including activity triggered ES, such as EMG, or position triggered ES, (iii) muscle re-education where the intervention progressed from passive and assisted movements to active and resisted movements, including robot-assisted movements, (iv) progressive resistance exercise if the intervention consisted of movement against progressively increased resistance, including robot-resisted movements, or (v) mental practice if the intervention consisted of the cognitive rehearsal of an attempt to move” (Ada *et al.*, 2006). The authors of these studies concluded that strengthening should be included in stroke rehabilitation programs (Ada *et al.*, 2006).

2.3.5 SIT TO STAND

A functional task that an individual should be able to complete as it is the most frequently performed task is being able to stand up from a seated position (Pollock *et al.*, 2014). Some evidence has suggested that it is likely to be the most mechanically challenging functional

task that people with stroke would perform on a regular basis (Pollock *et al.*, 2014). Wist, Clivaz and Sattelmayer, (2016) reported that the ability to come from STS is a complex motor task which requires sufficient postural control as well as dynamic movement. This movement mainly requires muscle strength, balance and coordination. Roebroeck *et al.*, (1994) described STS as a movement where the body's CoM moves upward from a seated position to a standing position without loss of balance. Prudente, Rodrigues-de-Paula and Faria, (2013) noted the same requirements as Wist, Clivaz and Sattelmayer, (2016) to complete the STS movement but included the capability to move the CoM of the body forward from a wide base of support to a smaller one. The ability to come from a seated position into a standing requires greater joint ROM and more leg strength than walking or climbing stairs (Mazzà *et al.*, 2004). The quadriceps and the hamstrings are the two main muscles involved in achieving STS. If the STS activity is performed quickly, it demonstrates an improved symmetry in standing position, and improvement in postural stability and in directional control (Wist *et al.*, 2016). Being able to STS is an essential requirement for walking and key for independent living and prevention of falls (Culhane *et al.*, 2005). For one to achieve STS, it is important to achieve control of the segmental mobility as well as the total body momentum, which is accomplished with the activation of the muscles in a coordinated manner (Prudente *et al.*, 2013).

2.3.5.1 DETERMINANTS OF STS IN HEALTHY INDIVIDUALS

Janssen, Bussmann and Stam, (2002) described the STS determinants in healthy individuals and summarised them into three categories: (1) angular displacements of trunk and lower limbs, (2) activation pattern of the musculature of lower limbs and (3) CoM behaviour. The literature indicated that use of armrests, height of the chair seat, and the position of the feet play a key role in the ability to do a STS movement. When a higher seat chair was used, it led to lower movement at hip level (up to 50%) and knee level (up to 60%). When the chair seat is lowered an increase in momentum generation is needed or repositioning of the feet to lower the required movements. When the armrests are used, it lowered the movements needed at the hip by 50%, most likely without influencing the ROM of the joints. When the feet were repositioned, the strategy of the STS movement was affected, allowing lower maximum mean extension moments at the hip (Janssen *et al.*, 2002). Janssen, Bussmann and Stam, (2002) also showed that the height of the chair seat, foot position and use of armrests are able to greatly affect the ability to complete a STS movement.

2.3.5.2 DETERMINANTS OF SIT TO STAND IN POST STROKE INDIVIDUALS

Sufficient therapy time is required to optimise STS and minimise unnecessary compensations in individuals post stroke (Jette *et al.*, 2005). In another study, a literature review done by Boukadida *et al.*, (2015) revealed that there are four important factors that influences STS in the majority of patients with hemiparesis who were able to come from STS independently. This study used both English and French articles with the following search keywords “stroke”, “rehabilitation” and “STS”, there was an initial 122 articles found but only 46 were extracted and used for this literature review as they matched the objectives of the review. These changes included: (1) angular displacements of trunk and lower limbs, (2) post stroke muscle activation changes, (3) postural control, (4) weight bearing distribution compared to the STS results of healthy participants. The authors concluded that there is a requirement for further research to improve the comprehension of this activity and to illuminate the effect of clinical impairments related to stroke.

Post stroke, patients’ difficulties relating to the ability to STS independently can be attributed to a number of factors. A study done by Jeyasurya *et al.*, (2013), who investigated “the mechanics of assisted STS motion in order to better understand how load sharing STS mechanisms may facilitate STS motions while still requiring activation of the leg muscles”, found that there were five areas that influenced the ability to STS. This included the following: static and dynamic stability, extensor effort, momentum transfer energy and subjective preference can affect STS.

The static stability is defined as the separation between participant CoM and their ankle at the time when the load-sharing assistance ended or at seat-off time in the cases where load-sharing assistance is not provided ($p < 0.001$). The dynamic stability was determined by the location of the foot centre of pressure with correlation to the centre of the foot at the time when the load-sharing assistance ended or at seat-off time in the cases where load-sharing assistance was not provided. The dynamic stability is maximised when the foot centre of pressure is cantered between heel and toes (Jeyasurya *et al.*, 2013). The extensor effort was assessed by the peak knee torque as calculated from sensor data, with lower knee torques indicating less knee extensor effort required to rise. The momentum transfer strategy, based on the peak trunk flexion for every assisted STS, was compared with the peak trunk flexion of the unassisted STS using the momentum transfer strategy ($p < 0.001$) (Scarborough, McGibbon and Krebs, 2007). To determine participants preference, they completed a post experiment questionnaire for all of the modes of STS assistance and found the seat and bar assist modes scored higher than the arm and waist assist modes ($p < 0.001$) (Jeyasurya *et al.*, 2013).

2.3.5.3 PHYSIOTHERAPY AND SIT TO STAND

Strong evidence has found that post stroke functional tasks can be improved with repetitive training of sitting, standing up, standing and walking. Evidence has also shown that an increase to more than three times the normal amounts of additional training improves functional outcomes after stroke (Schneider *et al.*, 2016). That being said, it cannot be assumed that the additional training will have the same effects for all of these tasks as individual tasks may need different amounts of training (de Sousa *et al.*, 2019).

A study was done to investigate if intensive STS training in addition to standard care improve STS ability in people with stroke who are unable to stand up independently. The clinicians' reported that the mean between their impressions of the STS transition was 1.57/15 points (95% CI 0.02 to 3.11), and the gross lower limb extension strength and change in ability to move from STS, with mean between-group differences of 6.2 degrees (95% CI 0.5 to 11.8) and −7 (95% CI −1 to −13), respectively (de Sousa *et al.*, 2019), (both the experimental and control groups received usual care, bi-daily one-hour sessions of physiotherapy weekdays). The experimental group based their STS training on the principles of task-specific motor training, with a focus on repetition, and an external focus to movement with the help of visual aids. Training also incorporated verbal feedback. The training intensity was increased by setting a specified time and increasing the number of repetitions that needed to be performed with in it. The physical environment was also altered to gradually progress the training by lowering the height from which they need to stand, changing the foot position to increase weight-bearing through the affected lower limb, and altering the surface from which they stand up by placing a foam mat under the feet. All these strategies were used to ensure that each participant trained at their maximal capacity. Usual care was given to both the control and experimental groups, this included two one-hour sessions of physiotherapy each weekday (de Sousa *et al.*, 2019).

They concluded that two weeks of intensive STS training in addition to usual care improves the ability to achieve STS in people who are unable to do so independently after stroke with a treatment effect of gross lower limb extension differences between the two groups of 6.2 degrees (95% CI 0.5 to 11.8) and 27 (95% CI 21 to 213) for the ranking of change in ability to move from STS (de Sousa *et al.*, 2019).

A randomised control study done by Kerr *et al.*, (2017), looked at three different therapies (conventional, functional strength training and movement performance training) over a six week period. The main outcome measures assessed was the ability to STS, symmetry timing, co-ordination, quality of movement (smoothness) and knee velocity. These were

measured at baseline, outcome (after six weeks of intervention) and follow-up (three months after outcome). They found no significant differences the three groups (56% at baseline and 88% at follow-up). The study demonstrated several differences between the quality of movement, with only symmetry when rising showing significantly greater improvement in the movement performance therapy group; this benefit was not evident at follow-up. However, they concluded that the recovery of STS is constantly good during stroke rehabilitation, irrespective of the type of therapy experienced (Kerr *et al.*, 2017).

To promote and facilitate evidence-based practice it is necessary to have knowledge of evidence on the effectiveness of interventions aimed at improving the ability of a patient to STS following stroke (Pollock *et al.*, 2014).

2.4 PERCEIVED EFFORT

The complicated process of forming perceptions of both exertion and effort, involves several neural processes taking place in various areas within the brain. During self-paced physical activity, regulation of intensity is assessed by two important considerations: RPE (Abbiss *et al.*, 2015). The Oxford Dictionary defines “effort” as “strenuous physical or mental exertion” and “exertion” as “physical or mental effort”. Effort and exertion are synonyms which refer to slightly different concepts. These terms can be used interchangeably in everyday life, as well as in scientific writing such as Marcora, (2009) and Amann *et al.*,(2010). Preston and Wegner, (2009) stated that the experience of effort could be defined as “the particular feeling of that energy being exerted” and “is accompanied by a sensation of strain and labour, a feeling that intensifies the harder a person tries”. Perception of effort is crucial for the assessment of personal action and can be defined as “a cognitive feeling of work associated with voluntary actions” (Preston and Wegner, 2009).

Gunnar Borg originally defined perceived exertion as “the feeling of how heavy, strenuous and laborious exercise is” (Borg, 1962). Borg described perception of effort being “the sensation from the organs of circulation and respiration, from the muscles, the skin, the joints and force” (Borg, 1962). Noble, (1996) changed the definition to “the subjective intensity of effort, strain, discomfort, and/or fatigue that is experienced during physical exercise” after discovering a link between the notion of fatigue and/or discomfort. However, the definition of perceived effort has changed when they added discomfort and fatigue, any alteration in a sensation, such as pain, other than effort can lead the participants to incorrectly rate their perceived effort (Pageaux, 2016). Therefore one should take care when instructions are provided to the participants to collect accurate results. If there is a strong

correlation between the accelerometer and the Modified Borg Scale (MBS), the MBS can be used as a substitute in clinical practice if an accelerometer is not available as it is free and easily accessible.

2.4.1 THE BORG SCALE OF PERCEIVED EXERTION

The Rating of Perceived Effort (RPE) scale, the MBS and the CR100 scale are the outcome measures often used to assess perception of effort (Pageaux, 2016). The RPE correlates with the objective measurements of exercise intensity and is therefore used to assess exercise intensity. It is a 15 point scale (from 6 to 20) initially designed for continuous steady effort aerobic exercise as rating increases linearly with oxygen consumption and heart rate (Borg, 1998). The test/retest reliability has not yet been reported in patients with stroke but it is used widely in other populations. A study done in geriatric and frail older adults showed a high correlation with an ICC of 0.85-0.91 (Mendelsohn *et al.*, 2008). A more recent study based on office exercise training reported a high reliability (0.898) (Shariat *et al.*, 2018). In a study done by Eng *et al.*, (2002) on community-dwelling individuals with stroke, the predicted HR based on the RPE was significantly higher than the actual HR during a six and 12 minute walk test, and there was no correlation between the predicted and actual HR.

2.4.2 THE MODIFIED BORG SCALE (MBS)

The MBS also known as the Borg CR10 scale was created to observe direct estimation of intensity levels between participant evaluations. It is a category scale with ratio properties containing numbers associated to verbal expressions; which allow for a comparison between the rate and the levels of intensity in clinical settings (Shariat *et al.*, 2018).

Studies that have been done on the MBS has mostly been on the application during aerobic exercise, but newer studies have been done with other types of training showing it to be an effective method of quantifying different types of exercise training (Shariat *et al.*, 2018).

Both the Borg scale and the MBS have been described are reliable and valid for isolated exercises and full body assessments as long as the standardised protocols are followed when instructions are given and administration of the scale (Borg, 1998). The RPE was measured using the Borg scale 6–20 as recommended in the physical activity recommendations for stroke survivors. Additionally, a high correlation between the MBS and Visual Analog Scale (VAS) have been identified ($r = 0.754$, $p < 0.01$).

2.4.3 PERCEIVED EFFORT AND STROKE

It has been found that the greater post stroke fatigue, the greater perceived effort (De Doncker *et al.*, 2020). A study done by Compagnat *et al.*, (2017), measured the RPE between walking and climbing stairs and found no significant difference ($p = 0.10$). They did however find those people post stroke are not as active compared to people with no stroke history, which in turn could impact the perceived effort. This could lead to a possible difficulty in judging one's own perceived effort as there is a lack of experience of physical activity (Compagnat *et al.*, 2017). Gurari *et al.*, (2019) did a study suggesting there could be an inability to adapt perceived effort of the hemiparetic limb, in people post stroke, to its weakened state and, therefore in the absence of visual and corrective feedback they do not generate symmetric torques.

There are only a few ways to assess the intensity of physical effort, this includes the RPE. During rehabilitation it is important to monitor the intensity of the exercise as approximately 25% of people post stroke are affected with silent myocardial ischemia, which could lead to cardiac ischemia if the physical effort is too intense. Therefore, the convenience of tools such as the RPE for real life situations, are relevant in this context. The monitoring of the intensity of the physical effort becomes a vital factor to observe whether a patient has reached the required amount of PA or not (Compagnat *et al.*, 2017).

2.5 ENERGY EXPENDITURE

Energy expenditure is defined as "the amount of energy (or calories) that a person requires to complete a physical function such as breathing, blood circulation, food digestion, or physical movement" (Hills *et al.*, 2014; Skotte *et al.*, 2014). The metabolic/energy cost (MEC) of sitting and standing is not well understood, and MEC related with coming from STS has not yet been described (Júdice *et al.*, 2016). Physical activity and EE are different constructs. Where PA is defined as any bodily movement that leads to EE (Caspersen, Powell and Christenson, 1985) and consequently, energy is expended as a product of the PA. It should be noted that the PA and EE are different products and are often thought to be equivalent but are distinctively different and thus it can be measured using different methods (Hills *et al.*, 2014).

Resting energy expenditure (REE/RMR) is the energy used by a fasted individual in a thermos-neutral environment at rest and represents the largest proportion of total energy expenditure (TEE) (Hills *et al.*, 2014). Individual REE and metabolic rate can vary due to a few major factors contributing to them; these include body size, age, gender, body

composition, hormonal status, physical fitness level, ethnicity, and a range of environmental and genetic influences (Nelson *et al.*, 1992; DeLany *et al.*, 2013; Hills *et al.*, 2014). Usually, REE decreases with age as a function of biological changes (Frisard *et al.*, 2007; Hills *et al.*, 2014) including loss of associated metabolic activity and lean body mass (Piers *et al.*, 1998). The bigger the individual's body size the more tissue and therefore the need of higher metabolic activity/ energy requirements than that of smaller individuals. Additionally gender, body size, age and body composition (the proportion of muscle and fat) also play a role in the amount of energy required. Gender differences are due to the differences in body composition where average adult males have more muscle in proportion to fat than females (DeLany *et al.*, 2013; Hills *et al.*, 2014). Morio *et al.*, (1997) did a study on gender effects on energy expended during light seated activities, walking, cycling, and sleep and their significances it has on daily EE. It was found that there were no gender-related differences in the various physical activity energy expenditures. Body composition plays a large role in REE with the primary factor being fat-free mass (FFM) (Weinsier, Schutz and Bracco, 1992). The amount and proportion of FFM is influenced by gender and age but physical fitness has a key impact as well. Therefore, most of the inter-individual variability in REE can be accounted for by differences in FFM (Nelson *et al.*, 1992).

Accelerometer-based activity monitors offer real-time assessments of the intensity, frequency, and duration of free-living physical activity, as well as the limitations defined as "the level of activity that the patients, within their physical limitations, at their own pace, and in their own environment, typically perform," (Trost, Mciver and Pate, 2005; Moy *et al.*, 2009). A review by Green *et al.*, (2005) showed that with patients with stroke, a variety of accelerometry-based systems can be used in a variety of settings. In 2016, Júdice *et al.*, (2016) completed a study on calculating the MEC for sitting, standing and STS transitions in a sample of adults with no known disease, adjusting for FFM and age. They found that the metabolic cost of a single STS transition was 0.32 kcal (35% above sitting expenditure).

2.5.1 ENERGY EXPENDITURE AND STROKE

Patients with stroke have higher EE; the exact cause of this is still not completely understood (Houdijk *et al.*, 2010). Factors that have been suggested to create a higher energy demand includes post stroke impairments such as abnormal muscle spasticity, activation patterns and reduced oxygen uptake capacity of the hemiparetic skeletal musculature (Kramer *et al.*, 2016). The most frequent method to analyse metabolic EE has been used during the performance of an activity such as walking, using an external and/or internal mechanical calculations of body functions (Detrembleur *et al.*, 2003; Houdijk *et al.*, 2010). There has been no analysis of mechanical work to reliably or completely account for the increased EE

in patients with stroke as well as other patient populations (Detrembleur *et al.*, 2003; Houdijk *et al.*, 2010). Another explanation that could be used to describe the increase in EE after stroke could be the increase effort for balance control (Donelan, Kram and Kuo, 2002). In patients with stroke during balance control tasks, increased muscle activation and altered postural responses are found in both the affected and the unaffected leg (Garland *et al.*, 2003). These increases of balance control seem to remain undetected in mechanical work assessment, but are likely to require increased metabolic energy. In patients with stroke these increases may vary compared to able-bodied people depending on the severity of the stroke (Houdijk *et al.*, 2010).

Energy expenditure may differ due to the level of weakness, spasticity, and training that was received. As a result the higher levels of energy that are required to complete a task could lead to perceived inability leading to further loss of engagement in the specific task (Singh *et al.*, 2011). Houdijk *et al.*, (2010) compared the EE of able-bodied persons and patients who suffered a stroke during postural control tasks in standing. The results showed on average twice as high increase in EE in patients with stroke than the able-bodied persons. There was no significant group where condition interaction effect was found. Overall correlations between posturegraphy measures, EMG and EE ($r = 0.33–0.60$) were significant ($p < 0.001$). This reinforces the idea that following stroke there is an increased required amount of energy needed to complete tasks compared to that of the able-bodied persons.

The higher energy demands can lead to the limitation of the person's ability who suffered a stroke to be physically active and partake in the rehabilitation programme (Kramer *et al.*, 2016). The clinical implications of such differences between perceived and actual energy expended and the understanding of this role in such perceptions can assist in the setting and regulating of the pace during exercise (Abbiss *et al.*, 2015).

2.5.2 OUTCOME MEASUREMENTS

2.5.2.1 TRIAXIAL ACCELEROMETER

To measure the required energy of patients with stroke during STS, the EE needs to be measured accurately. The triaxial accelerometer has been shown to be an accurate and objective means of measuring EE and physical activity (Verbunt *et al.*, 2001; Mathie *et al.*, 2004). Accelerometry has become an efficient way in recent decades to measure energy expenditure of activities and tasks in daily life (Rand *et al.*, 2009). Accelerometers can be placed on a number of locations on the body, generally including the thigh and waist, as well

as other locations (Mathie *et al.*, 2003). For this study the triaxial accelerometer will be placed at the waist and it will be discussed further on.
During a study done by Rand *et al.*, (2009) they showed that accelerometry is a reliable method to use for measuring EE with stroke survivors that are walking. In a study done by Mathie *et al.*, (2003) the participants were required to STS only once which showed a sensitivity of >0.98 and specificity between 0.88 and 0.94. Van Lummel *et al.*, (2013) had the participants do five cycles of STS at a self-selected speed (start and end in a sitting position) on a standard chair without arm rests and only included the transitions that were completed correctly. Júdice *et al.*, (2016) had the participants STS in one movement ten times over a ten minute period in which it was a thirty second transition and thirty second rest, this study was done in a healthy population. All three studies used a triaxial to assess EE during sitting, standing and STS transition. Skotte *et al.*, (2014), validated the accelerometer by developing a method for detecting physical activity types such as sitting, standing, walking, etc. This method was established to differentiate between these physical activity types based on threshold values of standard deviation of acceleration and the derived inclination showed a high sensitivity and specificity with both being between 99-100% (Skotte *et al.*, 2014).

2.5.2.2 RT3 ACTIVITY MONITOR

One of the triaxial accelerometer based devices which has gained approval in clinical studies is called the RT3 activity monitor (Stayhealthy, Inc., Monrovia, California, USA). There is a high degree of reliability in measurement with little variation over time (Mathie *et al.*, 2004). A study done by (Krasnoff *et al.*, (2008) showed a minimal shaker variance with coefficients of variation (CVs < 0.52%). It also revealed a good reliability within RT3s (CVs < 1.81%). When using the RT3, it is housed in a holder made of plastic that clips onto the participant's belt. It uses two AAA batteries and has a battery life of 60 days. The LCD display on top of the device features the elapsed time, the status indicator as well a full memory alert. To download the data to the computer, the RT3 is removed from the plastic holder and is placed into the docking station, the user profile is created, and then the software estimates activity EE (METs or kcal/minute) based on counts (Bassett and Dinesh, 2010). The RT3 uses registered equations to convert acceleration counts to activity EE. This allows simplification of the data for the interpretation, and it also provides more consistency across studies (Bassett and Dinesh, 2010).

Accelerometry can be used to provide a source for a more accurate, quantitative study of STS performance in clinical practice (Van Lummel *et al.*, 2013), yet the use of an accelerometer is expensive and not readily accessible by all clinicians which can add a practical burden for both the physiotherapist and participants (Pedišić and Bauman, 2015).

2.6 CONCLUSION

This chapter discussed the background to the study; the epidemiology of stroke; recovery from stroke; the role of physiotherapy in stroke rehabilitation; perceived effort and EE; as well as methods used to assess both perceived effort and EE. The majority of the articles discussed both the assessment as well as interventions used to manage the recovery following stroke. The information reinforces the idea that following stroke there is an increased required amount of energy needed to complete tasks compared to that of the able-bodied persons. There is still a large gap within the research comparing EE during activities of people with stroke to that of able-bodied persons. The information presented in this chapter demonstrates that research has been done on both perceived effort as well as EE, but it has not been done when looking at perceived effort and EE in patients with stroke during STS.

Chapter 3 will consist of a discussion on the methodology followed to conduct the study.

CHAPTER 3

3. METHODOLOGY

3.1. STUDY DESIGN

This was a descriptive cross sectional pilot study looking at EE and perceived effort during the STS activity in patients with stroke.

3.2. PARTICIPANTS

3.2.1. SOURCE OF PARTICIPANTS

The participants were initially recruited from the Chris Hani Baragwanath Academic Hospital (CHBAH) catchment area, however due to the slow nature of the data collection process from this site, another site was added. In March 2021, Life Flora Hospital was approved as a second recruitment site for participants (HREC: M180209). Participants were patients with stroke admitted to CHBAH and Life Flora Hospital as well as those who attended outpatient physiotherapy sessions. A sample of convenience was used for this study.

3.2.2. SAMPLE SIZE AND SELECTION

3.2.2.1. SAMPLE SIZE

The sample size was calculated using the STATA programme with the test comparing one mean to a reference value. It was calculated with a power at 80% and α at 0.05. Two mean estimates 0.019 (± 0.45) is the rate of $1/min^{-1}$ for the STS transition reported in the study by Júdice *et al.*, (2016), as used during sample calculation. A total of 45 patients with stroke were required for a full study.

3.2.2.2. SAMPLE SELECTION

a) Inclusion criteria

Participants were recruited into the study if they met the following criteria:

- aged 35-80 years
- had a stroke in the last three months and presented with hemiparesis or hemiplegia; and
- able to perform STS without the use of either an assistive device or their upper limbs when standing up from a surface where their feet are flat on the ground and hips and knees flexed at 90°.

b) Exclusion criteria

Participants were excluded from the study if they:

- had a previous stroke or
- were unable to follow instructions or provide feedback on perceived effort when using the MBS due to any perceptual, language or cognitive deficits

3.3. INSTRUMENTATION AND OUTCOME MEASURES

a) THE TRIAXIAL ACCELEROMETER (RT3)

To measure the energy used by patients with stroke when performing STS, the EE needed to be measured accurately. The triaxial accelerometer is a device that accurately and objectively measures EE and physical activity of individuals (Verbunt *et al.*, 2001; Mathie *et al.*, 2004).

Accelerometry is an efficient way to measure EE of individuals during activities and tasks of daily life (Rand *et al.*, 2009).Rand *et al.*, (2009)'s study demonstrated that accelerometry is a reliable method that can be used to measure EE during walking in people with stroke.

The current methods used for identifying different physical activity types demonstrated a high sensitivity and specificity with both being between 99-100% (Skotte *et al.*, 2014). When using the accelerometer it was found to have a high degree of reliability during measurement with little variation over a period of time (Mathie *et al.*, 2004). Krasnoff *et al.*, (2008) study showed a minimal shaker variance with coefficients of variation (CVs < 0.52%). The study also revealed good reliability within the RT3s (CVs < 1.81%).

During the study, the RT3 accelerometer was linked to the computer using the Body Composition Indicator docking station. The accelerometer is a self-calibrating and uses a profile for each user. These profiles were created by inputting the participant's identification (code of participant), their age, weight and height. Each participant had their own profile created and the device was then used for data collection.

b) THE MODIFIED BORG RATING SCALE OF PERCEIVED EXERTION

The MBS is used by patients to rate and evaluate their effort or exertion when exercising. Although not a true ratio scale, for statistical calculations it has been described as such, but is more appropriately described as a categorical scale or a "category scale with ratio properties" (Bausewein *et al.*, 2007).

When used between tests and within the period of a single exercise test, the MBS scores are said to be more reproducible than the VAS scores (Wilson and Jones, 1989). The MBS appears to be a reasonable indicator of the intensity of exercise after stroke when done at moderate (60%-70% Vo_{2peak}) but not high-intensity exercise level (80% Vo_{2peak}) (Sage *et al.*, 2013).

A study done by Grant *et al.*, (1999) tested a group of active male volunteers to determine which of the subjective scales, the Likert Scale, the VAS or the MBS, was more sensitive to change and reproducible in the assessment of general fatigue and breathlessness during sub-maximal exercise. In general, the MBS proved to be the most sensitive in assessing change (Roos and Eales, 2002).

The Borg scale rating of perceived exertion which has been modified to measure symptoms such as breathlessness is known as the MBS. The most common format which it uses is a 10-point scale with a nonlinear scaling scheme using descriptive terms to anchor responses (Mahler and Wells, 1988). The MBS was used during the STS test to include the subjective perception of physical strain used to complete the activity. This information could improve the researcher's understanding of what patients experience during the STS activity when recovering from a stroke (Roos and Eales, 2002).

c) THE NATIONAL INSTITUTE OF HEALTH STROKE SCALE (NIHSS)

The National Institutes of Health Stroke Scale (NIHSS) is most commonly used as a scoring system in stroke research trials; it is a valid, reproducible scale that measures neurological deficits (Kasner, 2006). During suspected acute strokes, the clinicians rely upon the NIHSS to evaluate patients and to make decisions about the best acute treatment. The NIHSS correlates with infarct size, clinical severity, and long-term outcome (Martin-Schild *et al.*, 2011).

The scale is scored between a range of 0 to 42, the items are graded on a 3- or 4-point ordinal scale; 0 means no impairment, the higher the score the greater severity of impairment. The severity of the stroke may be presumed on the basis of the NIHSS scores as follows (Brott *et al.*, 1989): (1) Very Severe: >25, (2) Severe: 15–24, (3) Mild to Moderately Severe: 5–14, (4) Mild: 1–5. Test-retest reliability was excellent (ICC = 0.93) and interrater reliability was excellent as well with ICC = 0.95 (Goldstein and Samsa, 1997).

d) CALIBRATED SCALE

A calibrated scale was used to measure weight in kilograms (kg).

e) STADIOMETER

A stadiometer was used to measure participant's height in centimetres (cm). Baharudin *et al.*, (2017) showed a narrow range of ±1.96SD for the intra-examiner, inter-examiner and inter-instrument aspects. They were therefore in acceptable limits suggesting that the portable stadiometer is valid and reliable for use in community surveys. The ADAM: Digital Physician Scale (MDW-250L) was the device that was used during this study, and it is designed to measure both weight and height.

3.4. PROCEDURE

3.4.1. PILOT STUDY TO PLAN LOGISTICS

3.4.1.1. AIM

To evaluate the reliability when performing the assessments, determine the time taken for each assessment, establish the layout of the assessment area and familiarise the researcher with the equipment.

3.4.1.2. METHOD

Ten percent of the calculated main sample size was used to achieve the aim; therefore five participants were used. The researcher met with the CHBAH physiotherapy department to discuss the research that was to be done as well as to explain the inclusion and exclusion criteria of the study. The neurology and medical section staff screened for potential study participants and informed the researcher when a potential participant was identified. The researcher went through to the recruitment site and explained the research study to the participants and invited them to participate. Once consent was received, the assessment was done, and the data was captured as explained in section 3.4.2.

3.4.1.3. RESULTS

A correlation study done on the intra-rater reliability of the assessor's ability to measure the height and weight using the stadiometer was done using EXCEL™, the height correlation was r = 0.99 (p = 0.48) and weight r = 0.99 (p = 0.37), this shows a high correlation with no statistical significance between to two assessments done for each parameter. The time taken for each assessment was on average 60 minutes which included the collection of the patient, the explanation of the study as well as the consent, followed by the actual assessment of the patient and the returning the patient back to the ward.

3.4.1.4. DISCUSSION

The pilot study helped to determine any unforeseen logistical problems before the main study started. It also measured the time it would take to transfer patients from the ward to the neuro gym and set up each patient for the assessment and explain the equipment to them as well as complete the measurement using the RT3 and the MBS. There were two gyms that were accessible for the data collection, the gym which was selected depended on which one the physiotherapy staff of CHBAH was busy using, but the layout was reproducible in both gyms. This pilot study assisted in familiarising the researcher with the equipment.

3.4.1.5. CONCLUSION

This pilot study showed that there was a high correlation for intra-rater reliability (height r = 0.99 [p = 0.48] and weight r = 0.99 [p = 0.37]). Once the pilot study related to logistics was completed, there were only two participants found within a six-month period. Therefore, Life Flora Clinic was approached and included in the study catchment area.

3.4.2. MAIN STUDY

Following the initial request made to the physiotherapy departments at both CHBAH and Life Flora Hospital, to conduct research, both physiotherapy departments were informed once permission was received from CHBAH and Life Flora Hospital to commence the data collection. Both departments were given copies of the inclusion and exclusion criteria for the study. Once the participants were identified by the physiotherapists at the data collection sites, the researcher made arrangements with dates and times and visited the department and discussed the research with the participant and consent was given to participate in the study. Additionally, the researcher screened the wards at CHBAH on average every two weeks and daily screening was done at Life Flora Hospital.

Patients who met the inclusion criteria were invited to be a part of the study through an information letter (Appendix A1 & Appendix A2). Once they signed the informed consent form (Appendix B) they were seen in the neurology gym at the CHBAH physiotherapy department and the consulting rooms at Life Flora Hospital. Demographic information, age, duration of stroke and the NIHSS (Appendix E), was recorded on the demographic questionnaire (Appendix C). The participants removed their shoes for weight and height measurement. The weight was measured using a calibrated scale, it was placed on a smooth, even surface, the participants were required to step on to the scale once it had gone on and showed 00 and once the measurement was shown they stepped off. The height was

measured using the stadiometer: the participant was assisted onto the scale; the measuring rod was adjusted, and the slider was placed on top of the participants head while they looked directly forward. The measuring rod was then moved up again, while the participant was still on the scale, and repositioned again to take the second reading. The participant was then assisted down from the scale back to the bed. Both height and weight were measured twice for reliability. The body mass index (BMI) was calculated using the following equation: Mass (kg)/ Height (m) ^{2} and recorded on the demographic questionnaire (Appendix C), which was automatically calculated by the RT3 software when creating a participants profile.

The EE was measured using the RT3 triaxial accelerometer. Participants were fitted with the triaxial accelerometer by the researcher on a Velcro belt which was worn on the participant's left hip at midpoint of the iliac crest. Once activated, participants were required to perform the STS activity twice. It was measured twice to familiarise the participant with the activity and the second performance was used with data analysis. On completion of the first STS, the stop button was activated, and the accelerometer was removed, and the data downloaded. The accelerometer was re-calibrated and placed on the left hip, the second STS was then done. Each STS was timed with a stopwatch by the researcher for the time taken to complete the movement.

On completion the accelerometer was deactivated, removed and the data downloaded. Once the data was automatically downloaded, it provided a spreadsheet of information indicating the following:

- The age of the participant.
- The height of the participant.
- The weight of the participant.
- The total caloric expenditure of the task in kilo calories.
- The X value indicating the activity counts that a participant moved in an anterior-posterior plane.
- The Y value indicating the activity counts that a participant moved in a vertical plane.
- The Z value indicating the activity counts that a participant moved in a mediolateral plane.

The RT3 device was calibrated such that the total caloric expenditure can be calculated by multiplying the total caloric expenditure by 70 and dividing by the weight of the individual (DeVoe, Gotshall and Mcarthur, 2003). The MBS (Appendix D) was used to evaluate the

participant's perception of difficulty of the STS task and recorded on the demographic questionnaire (Appendix C). The data collated from the computer software was documented on the summary sheet (Appendix F).

Following approval of the study, the data collection started in November 2018 at CHBAH. This was the only data collection site for a year, during this time only eight participants were identified, and it was decided to include a secondary data collection site as well as to change the age criteria in the inclusion criteria from 35-65 years to 35-80 years. This allowed for a larger age to source participants from as the majority of the initial participants were excluded as they were older than 65 years.
The application process started in October 2019 for the use of Life Flora Hospital (where the researcher has been employed) and Life Wilgeheuwel Hospital. The Life Healthcare group granted ethical clearance for only the Life Flora Hospital to be used as a data collection site. This approval was received in April 2020. Due to the COVID-19 pandemic, CHBAH informed the researcher that they will not allow access to the hospital for research to be done and thus there was a leave of absence taken from March 2020 to February 2021.

As a result of this absence the researcher was unable to apply for ethical clearance from the Human Research Ethics Committees (HREC) with the Life Flora Hospital approval, as they were not registered. When the researcher was able to register again in the beginning of 2021, the application was sent through to the HREC to apply for ethical clearance. In March 2021, the ethical clearance was granted, and data collection commenced at Life Flora Hospital and concluded end of September 2021.

A total of 23 months was taken for data collection at both sites. A total of nine participants were sourced during this period. Since the COVID-19 pandemic, the researcher has still not been granted access to continue data collection at CHBAH. Following the start of the pandemic there has been a change in the patients being admitted to Life Flora Hospital, as this was one of the main COVID-19 treatment facilities in the West Rand. The majority of admissions during this time were COVID-19 patients as well as patients with post-COVID-19 complications.

It was decided to conclude the data collection as only one participant was identified to fit the inclusion and exclusion criteria during a seven-month period. As a result of only nine participants out of the required 45 to be identified and assessed, it was recommended to change the study into a pilot study.

3.5 ETHICAL CONSIDERATIONS

- Ethical clearance was applied for from the Human Research Ethics Committee (Medical) of the University of the Witwatersrand. (M180209) (Appendix G).
- Amended ethical clearance was applied for from the Human Research Ethics Committee (Medical) of the University of the Witwatersrand to include Life Flora Hospital (M180209) (Appendix H).
- The head of department at CHBAH was informed regarding the study and consent was obtained to conduct the study (Appendix I).
- The hospital manager at Life Flora Clinic was informed regarding the study and consent was obtained to conduct the study (Appendix J).
- NHRD approval was received before the commencement of the study (Appendix K).
- Liaison with the physicians and other physiotherapy practices at Life Flora Hospital to gain permission to include their patients in the study.
- Informed consent was signed by each participant prior to data collection (Appendix B).
- Each participant's documentation was allocated a number as no names were used to ensure confidentiality.
- Participant privacy and dignity was maintained during assessment by ensuring the environment was screened off and private.
- Participants could withdraw from the study at any stage and feedback was provided if requested.

3.6 DATA MANAGEMENT AND ANALYSIS

The data collected during the study was stored on the laptop and an external hard drive and accessed on the evaluation sheets (Appendix C & E). The data was cleaned and captured on Microsoft Excel™ Spread sheets (which were password protected) for data analysis. The data was analysed using STATA and a statistician was consulted when needed. The data was tested in STATA using the normal probability plot and this showed that the data was not always normally distributed, thus the data analysis described below was selected.

The correlation was then analysed using the Spearman's R correlation test. The strength of association of the correlation coefficient between two variables was measured and interpreted as follows 0.00 to 0.25 = little or no relationship, 0.25 to 0.50 = fair relationship; 0.50 to 0.70 = moderate to fair relationship and above 0.75 = good to excellent relationship (Portney and Watkins, 2009).

The demographics and clinical profiles data was analysed in Excel™ using means and standard deviations.

Table 3.1: Data Analysis

Objective	Variables	Type of data	Data Analysis
To establish energy expenditure during STS in patients with stroke.	Independent: EE Dependent: Time	Ratio	Medians and IQR
To establish perceived energy expenditure during STS in patients with stroke.	Independent: EE Dependent: MBS	Ratio Ordinal	Medians and IQR
To establish the association between actual energy expended and perceived energy expended during STS in patients with stroke.	Independent: EE Dependent: MBS	Ratio Ordinal	Spearman's R correlation test

3.7 CONCLUSION

This was a descriptive cross sectional pilot study looking at EE and perceived effort during the STS activity in patients with stroke, a total of nine participants were recruited and assessed. As a result of slow participant sourcing for the study from CHBAH, a second location, Life Flora Hospital, was applied for and ethical clearance was obtained. During the data collection, the demographic questionnaire, height, weight, STS and MBS was assessed for each participant. The data was collected and analysed.

Chapter 4 will discuss the results of the pilot study.

CHAPTER 4

1. RESULTS

4.1. INTRODUCTION

Demographic information, results of energy expenditure and perceived effort will be presented in this section, as per the study objectives. The objectives were to; (1) determine the demographic and clinical profile of participants; (2) establish energy expenditure during STS in patients with stroke; (3) establish perceived effort during STS in patients with stroke; (4) establish the association between actual energy expended and perceived effort during STS in patients with stroke.

Results of the demographic questionnaire, the perceived effort and the energy expenditure will be depicted in the form of tables and figures.

4.2. SUMMARY OF PARTICIPANT RECRUITMENT PROCESS

Figure 4.1 outlines the summary of the recruitment of participants as per the study inclusion and exclusion criteria.

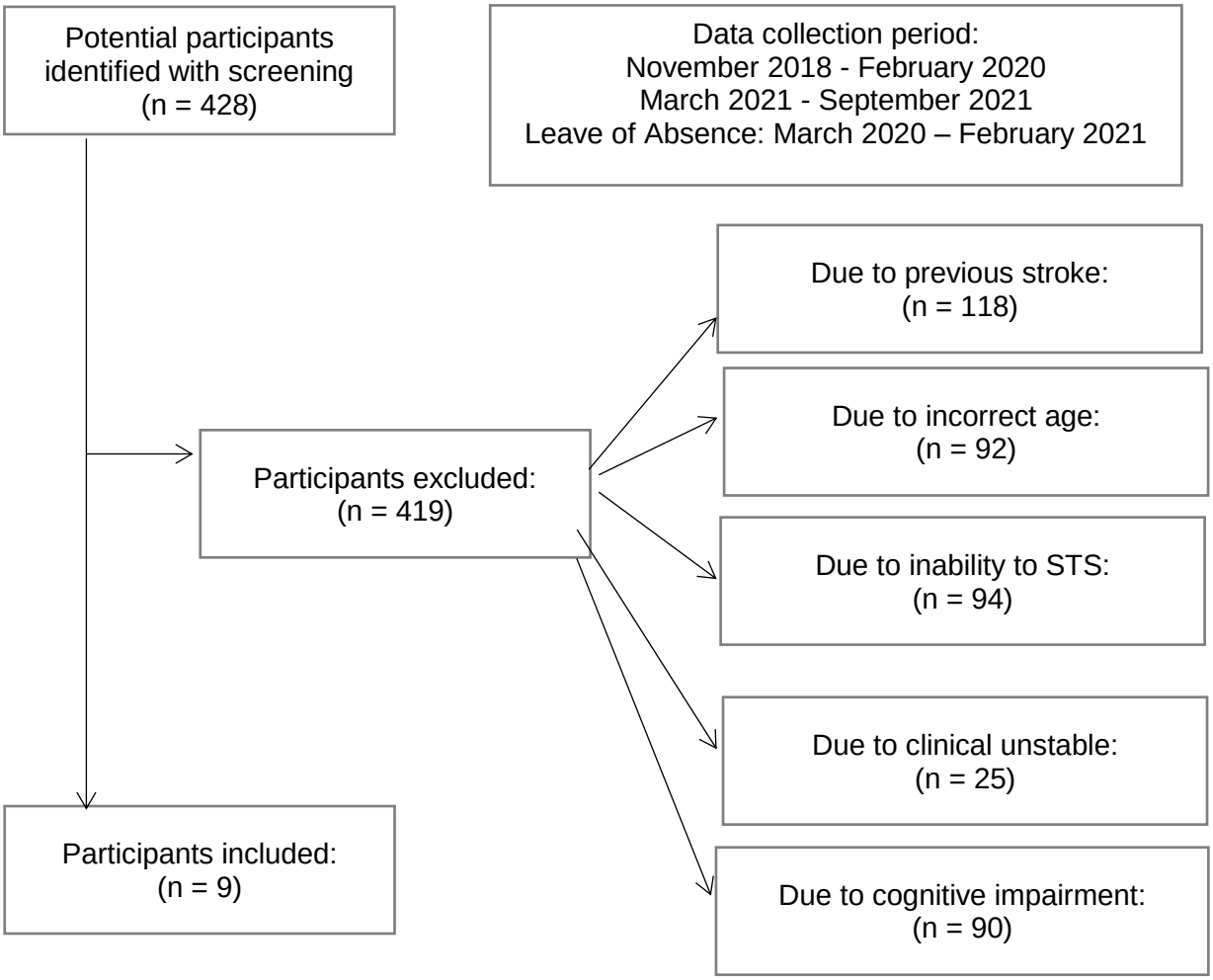


Figure 4.1 Flow diagram depicting the participant recruitment process

The total number of participants that met the inclusion and exclusion criteria was nine, of these nine, eight (89%) were from CHBAH and only one (11%) was from Life Flora Hospital.

4.3. DEMOGRAPHIC AND CLINICAL PROFILE OF THE STUDY PARTICIPANTS

Table 4.1 outlines the demographic and clinical profile of the study participants.

Table 4.1 Demographic and clinical profile of the study populations (n = 9)

		n (%)
Gender	Male	4 (44.4)
	Female	5 (55.5)
Stroke Type	Ischaemic	3 (33.3)
	Haemorrhagic	6 (66.6)
Side of Hemiplegia	Right	3 (33.3)
	Left	6 (66.6)

The majority of the study participants were female (n=5; 55.5%), had haemorrhagic stroke (n=6; 66.6%) and presented with a left hemiplegia (i.e. right hemisphere stroke) (n=6; 66.6%).

Results of the study participants' age, the number of days since the stroke occurred and the NIHSS, height (m), weight (kg) and BMI are presented in Table 4.2.

Table 4.2. Age, days since stroke, NIHSS stroke severity, height (m), weight (kg) and BMI for the study population (n = 9)

Variable	Mean	SD
Age, years	52.77	11.33
Age Female (n=5), years	54.4	9.56
Age Males (n=4), years	50.75	14.52
Days since Stroke	9.11	6.57
NIHSS*	4.55	1.94
Height, m	1.65	0.07
Weight, kg	66.0	12.73
BMI**	24.31	5.36

*BMI (body mass index), kg (kilogram), m (metres), NIHSS (*National Institute of Health Stroke Scale), ** Interpretation of NIHSS severity grading (/42): 0-5 mild, 6-14 mild to moderately severe, 15-24 severe and > 25 very severe, ***BMI : <18.5 underweight, 18.5-24.9 healthy weight, 25.0-29.9 overweight and >35 obese.*

The mean (SD) age of the study participants was 52.77 (± 11.33) years with the female participants having a mean age of 54.4 (± 9.56) years to that of the males of 50.75 (± 14.52) years. A mild grading on the mean NIHSS stroke severity scale (4.55 ± 1.94) was found. The participants presented with a healthy BMI (24.30 ± 5.36). The mean time for assessment and inclusion in this study was 9.11 (± 1.94) days post stroke.

4.4. SIT TO STAND MEDIAN VALUES: TOTAL CALORIC EXPENDITURE, METS AND ACTIVITY COUNTS IN THE THREE MOTION PLANES

Table 4.3 presents the median values for the caloric expenditure, METS and activity counts in the three motion paths during STS.

Table 4.3. The caloric expenditure, METS and activity counts in three motion paths during STS for the study population (n=9)

Variable	Group Results (n = 9) Median (IQR)
Time Taken, s	5.5 (3.4-7)
Total Caloric Expenditure, kCal	2.64 (1.62-3.79)
Total METS, kCal/min	2.62 (2.09-3.17)
Females total METS, kCal/min	2.89 (1.4-2.10)
Males total METS, kCal/min	4.39 (2.99-6.05)
Activity Counts: Anterio-Posterior Plane	28 (3–456)
Activity Counts: Vertical Plane	538 (425–785)
Activity Counts: Medio-Lateral Plane	325 (220–638)

The median time taken was 5.5 seconds (3.4-7), the median for the females (6.08 [5.5-7] seconds) was larger than that of the males (3.4 [2.7-6.21] seconds). The total caloric expenditure values for STS were 2.64 (1.62-3.79) kCal with a median of 5.5 (3.4-7) seconds for the time taken to complete the task. The three planes assessed showed that there was more movement in the vertical plane: 538 (425-785), followed by the medio-lateral plane: 325 (220-638) and then the antero-posterior plane: 28 (3-456). The males expended almost twice the energy during STS compared to that of the female group.

4.5. PERCEIVED EFFORT DURING SIT TO STAND

The perceived effort of study participants, as per MBS category, is depicted in Table 4.4.

Table 4.4 The perceived effort to complete the STS task in the study population (n=9)

MBS rating	n (%)
0 Nothing at all	0 (0)
0.5 Very, very light	0 (0)
1 Very slight	1 (11.11)
2 Moderate	1 (11.11)
3 Somewhat severe	3 (33.33)
4 Severe	2 (22.22)
5	1 (11.11)
6	1 (11.11)
7 Very severe	0 (0)
8	0
9 Very, very severe	0
10 Maximal	0

According to the participants 33.33% (n= 3) felt that the task of coming from STS was "somewhat severe" followed by 22.22% (n=2) stating it was "severe".

Table 4.5 presents the median of the MBS rating as well as the difference between the male and female participants during STS.

Table 4.5 The MBS rating and gender differences during STS in the study population (n=9)

	MBS Rating Median (IQR)
Participants (n = 9)	3 (3-4)
Females (n = 5)	3 (3-4)
Males (n = 4)	4 (2.5-5.5)

Males reported more effort when performing STS compared to female participants.

4.6. ASSOCIATION BETWEEN ENERGY EXPENDITURE AND PERCEIVED EFFORT

The association between the METs and the MBS was calculated using the Spearman's Rho. There was a fair positive correlation between METs and MBS r = 0.35 (p = 0.36) but the finding was not statistically significant.

4.7. CONCLUSION

The aim of this chapter was to demonstrate the results for each of the objectives set out. The objectives were to; (1) determine the demographic and clinical profile of participants (2) establish energy expenditure during sit to stand in patients with stroke; (3) establish perceived effort during sit to stand in patients with stroke; (4) establish the association between actual energy expended and perceived effort during sit to stand in patients with stroke. This information was depicted in tables comparing demographics, energy expenditure, time and the MBS, further analysis between genders were also done and described. It was also demonstrated that there was a total of 419 participants that were screened over a 23-month period of which only nine met the required inclusion and exclusion criteria.

Chapter 5 will discuss these findings in relation to existing literature.

CHAPTER 5

5. DISCUSSION

5.1 INTRODUCTION

This chapter will discuss the findings of this study with regards to demographics, energy expenditure during STS, perceived effort during STS and the association between the energy expenditure and perceived effort. This chapter will be presented as follows:

5.2 Sample demographics
5.3 Energy expenditure during STS
5.4 Time taken to complete a STS
5.5 Perceived effort during STS
5.6 Association between energy expenditure and perceived effort during STS
5.7 Limitations

5.2 SAMPLE DEMOGRAPHICS

A total of nine participants were recruited to be part of this pilot study. Of these nine participants eight were recruited from the public sector and only one was recruited from the private sector. The participants were admitted to various medical wards at CHBAH and Life Flora Hospital in the West Rand, Gauteng. All nine participants were screened from the ward. Rehabilitation by a physiotherapist, occupational therapist or both was provided during their hospital stay irrespective of the clinical site to which they were admitted.

5.2.1 Gender

In this study just over half of the participants were female (n=5; 55.5%), which is in keeping with another South African study done by Mamabolo *et al.*,(2009), which sourced its participants from four outpatient public health facilities for stroke in Soweto, Gauteng Province of SA, at which found that there are more female patients with stroke (60%) than males (40%). Avan *et al.*, (2019) used data from the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2017 and reported that strokes occurred more frequently in men (incidence 33% higher, and prevalence 41% higher) than in women. A more recent study done in the USA in 2021 showed that there is a large amount of evidence to reason why women are more likely to have a stroke and stroke-related outcomes to that of men (Jacobs and Ellis, 2021). This study evidence included the following factors: women tend to live longer than men and as a result of their increased age, the risk of stroke increases as well. Other risk factors that were mentioned included hypertension, diabetes mellitus, heart

disease, pregnancy and use of contraceptives containing oestrogen were more common among women comparatively to men (Jacobs and Ellis, 2021).

5.2.2 Age

The participants' mean (SD) age was 57 (±11.33) years. The oldest was 65 years old and the youngest was 35 years old. The mean age for the females (n=5) was 54.4 (±9.56) years compared to the mean for the males (n=4) being 50.75 (±14.52) years. A study done in SA found that the risk of stroke increases with age: where stroke is the most common cause of death of people >50 years (Taylor and Ntusi, 2019). When looking at community participation following stroke in the Western Cape, SA, it was reported that cognition is the most important predictor in females, whereas mobility was the more prominent predictor in males (Elloker *et al.*, 2019). A study done in SA looking at the stroke risk, participants had a mean age of 50.7 years (SD 13.9, range 30-100 years) and 73% of the participants were in the 30-59 year age range (Connor *et al.*, 2005). This study is in keeping with the mean age represented in this study.

5.2.3. Stroke Type

The sample consisted of patients with stroke type distributed unevenly between IS (33.3%) and HS (66.6%). In 2010, the estimated number of incidents worldwide for IS was 11.6 million and for HS 5.3 million, of which 63% of IS and 80% of HS occurred in low middle income countries (LMICs) (Krishnamurthi *et al.*, 2013).Saini, Guada and Yavagal, (2021) noted that during 1990 to 2010, although the general age for the mortality rates for IS and HS decreased, the total number of people with an IS and HS stroke increased by 37% and 47%, respectively. According to the South African Heart and Stroke Foundation, 80% of strokes are due to ischaemia and only 20% are due to haemorrhagic infarct (Heart and Stroke Foundation South Africa, 2020). This information confirms that the distribution found in this study for the IS and the HS are in keeping with the global trends.

5.2.4. Stroke Severity (NIHSS)

The mean stroke severity was 4.55 (± 1.94) which demonstrates a mild grading on the NIHSS stroke severity scale. For this study, this information was collected from the file and from the patients' report regarding their presentation on admission. This mean value indicates that the participants had the potential for better functional outcomes based on initial severity alone. A study done to determine whether the baseline NIHSS scores were still able to reliably predict post stroke functional outcome was done, and it was found that the median baseline of the NIHSS 8 (IQR 3–17), 24 hours NIHSS 4 (IQR 1–11), and discharge NIHSS 2

(IQR 1–8) (Reznik *et al.*, 2018). The correlation between the discharge NIHSS was $r = 0.60$ compared to that of the baseline NIHSS which was $r = 0.88$ for 24 hours NIHSS. All the participants (41%) that were reassessed at the three months follow up showed a favourable functional progress (Reznik *et al.*, 2018). They reported that the major limitation for this study was that a large proportion of patients were lost to follow-up.

This is probably attributable to the facts that many patients experience gradual recovery, and that the early stroke-related deficits tend to be unstable. Therefore, the NIHSS score associated with a specific disability outcome tends to shift toward lower values over time. Moreover, the correlation of NIHSS score with the subsequent disability increases with time (Turcato *et al.*, 2017).

5.2.5. Days since stroke

The mean days since the stroke for the current study participants were 9.11 days (± 6.57). In South African public tertiary health sectors, several studies have been done to establish the average length of stay (LOS) post stroke. Mudzi, Stewart and Musenge, (2012) reported six days, Parekh and Rhoda, (2013) 10.4 days and Mamabolo *et al.*, (2009) 12 days, while a secondary institution with a stroke unit had an average of eight days (De Villiers *et al.*, 2011). In contrast the average length of stay established in the private hospital sector of SA was 30-34 days (Green *et al.*, 2005). Mamabolo *et al.*,(2009) did however point out that both patients from private and government hospitals are discharged relatively early, of only 12 days, compared to their functional independence. This could indicate that the participants of this study could possibly be discharged soon as the mean of the four studies was nine days. There was only one participant that had been admitted longer than this mean time and that was 26 days. There was no record kept as to why the participant had been there for so many days before being assessed for this study. This short duration of admission following stroke to CHBAH, as well as the few physiotherapy treatment sessions received during hospitalisation (on average one) could contribute to the poor patient functional ability and high case fatality (Mudzi *et al.*, 2012). A study to determine post discharge functional outcome was also done at CHBAH and it found that a hospital stay of up to two weeks and of more than six weeks increased the probability of achieving functional independence (Mamabolo *et al.*, 2009).

Internationally the average LOS varied between countries, for example in Lebanon, the average LOS was 13-18 days, in Turkey it ranged from 0-75 days with an average LOS being 11-15 days and finally a study done in China showed an average of 27 days (Rochmah *et al.*, 2021).

5.3 ENERGY EXPENDITURE DURING SIT TO STAND

This pilot study found the median of EE for the participants to be 2.62 (2.09-3.17) kCal/min. In a study done by Júdice *et al.*, (2016) they reported an EE of a single STS in a normal healthy population to be 0.32 kCal/min. In another study, also done in a neurotypical population, results showed that the EE during STS to be 0.22 ± 0.09 kCal/min, however they only had 19 participants with a mean age of 23.1 (± 1.9) years compared to Júdice *et al.*, (2016) who had 50 participants with a mean age for males 32.5 (± 11.4) years and females 38.0 (± 15.7) years (Hatamoto *et al.*, 2016). This indicates that the current study participants with stroke used almost eight times more energy than that of the normal test participants. This could be as a result of the hemiplegia and the increased time taken to complete the movement of STS.

When comparing genders, there was one study that reported the STS to be 1.49 (± 0.25) kCal/min for males and 1.16 (± 0.16) kCal/min for females (Júdice *et al.*, 2016) which concurs with the results found in the study where the males 4.39 (2.99-6.05) kCal/min expended more energy compared to that of the females 2.89 (1.4-2.10) kCal/min. In a study comparing BMI and EE in a healthy population, the results found that there was no relative difference between the two, however overweight males (BMI [25.0-29.9]) had a higher increase in EE during STS compared to those with a normal BMI ([18.5-24.9]) (Júdice *et al.*, 2016). The mean BMI for this study was 24.31 (± 5.36) which falls within normal ranges, however the males (24.70 [±7.51]) did have a slight increase in BMI compared to that of the females (23.99 [±3.86]). The bigger the individual's body size the more tissue and therefore the need of higher metabolic activity/ energy requirements than that of smaller individuals (Hills *et al.*, 2014).

When looking at performing tasks in standing, on average the patients with stroke required 125% ($33Jkg^{-1}s^{-1}$) more metabolic energy compared to healthy individuals (Houdijk *et al.*, 2010). During a walking task patients with stroke required 5.6 (±1.2) kcal.min−1 and 9.58 (±4.3) kcal.min−1 for the stairs task (Compagnat *et al.*, 2017).

During the movement of STS, there was greater force in the vertical plane (538 [425-785]) compared to that of the medio-lateral plane (325 [220-638]) and minimal movement in the anterior- posterior plane (28 [3-456]). The study done by Cheng *et al.*, (2001), showed that there was a reduced peak vertical reaction force and a larger medio-lateral centre of pressure displacement. The vertical plane could be due to the intuitive strategies created caused by the poor reliability of the hemiparetic side, thus the trunk deviation occurs resulting in a displacement of CoM and centre of pressure. Whereas the medio-lateral plane

could be due to the part knee placement and weight bearing asymmetry (Boukadida *et al.*, 2015). Following stroke, individuals may experience impaired perceptions of verticality, mainly visual vertical, the tactile vertical and the postural vertical. These vertical perceptions influence weight bearing in standing, especially if the stroke has occurred in the right hemisphere (Boukadida *et al.*, 2015), which is in keeping with the study population where 66.6% had right hemisphere strokes (n=6). The large increase in the vertical plane could explain by the EE is so much larger in the patients with stroke compared to patients in the normal population studies.

A study showed that patients with stroke consume less of their required energy requirements while they are hospitalised (Lieber *et al.*, 2018). There is an increase in REE in patients with stroke, thus they require an increase in their energy requirements to balance it out. If these two are not balanced, or if there is a failure to meet daily energy requirements, the patients with stroke will most likely have a negative energy balance. Therefore, caloric supplementation would benefit their recovery to prevent negative energy balance due to the increase EE and REE (Lieber *et al.*, 2018).

5.4 TIME TAKEN TO COMPLETE A SIT TO STAND

The median time taken for the STS was 5.5 (3.4-7) seconds where the female's median time was on the 75th percentile of the IQR with 6.08 (5.5-7) seconds and the males closer to the 25th percentile of the IQR at 3.4 (2.7-6.21) seconds. A study done on patients with stroke had a STS time of 3.57 (±1.69) seconds and a sample of adults with no known disease had a STS duration of 2.88 (±1.13) seconds for older adults and 2.31 (±0.63) seconds in the younger adults, whereas the patients with stroke had a STS duration of 3.57 seconds (±1.69) (Arcelus *et al.*, 2009). Whereas Cameron *et al.*,(2003) assessed a group of 15 patients with stroke who required almost twice as much time to complete the STS (3.86 [±1.52] seconds) compared to a control group (1.83 [±0.2] seconds). These findings show that the males in this pilot study had the same time duration to complete the STS movement as the participants in the two studies mentioned. In both studies by Arcelus *et al.*, (2009) and Cameron *et al.*, (2003) there was no distinction between male and female times.

Working on the speed of the task is as important as the actual execution of the task. Repetitive practice substantially improves strength after stroke (0.25 [95% CI 0.12 to 0.38, I2 = 36%]) (de Sousa *et al.*, 2019). One can assume that the increase in the time might influence the perceived effort as it could feel as if more effort is exerted. This was demonstrated by Singh, Stewart and Franzsen, (2011) who concluded that it is likely that

participants will rely on someone to provide assistance if the EE and time taken to complete the task is increased.

5.5 PERCEIVED EFFORT DURING SIT TO STAND

The study showed the comparison between the perceived effort options, that the most common choice selected on the MBS was the “somewhat severe” (option 3) (33.33% [n=3]) followed by the “severe” (option 4) (22.22% [n=2]) category. However, when comparing the values between males and females, the males median rating was 4 (2.5-5.5) and the females was 3 (3-4). These values compared to the time taken is inversely proportionate, where the males completed the STS activity quicker (3.4 seconds [2.7-6.21]) compared to that of the females (6.08 seconds [5.5-7]). Yet the females rated the activity as a somewhat severe compared to the severe rating of the males. The perception of the STS will impact the mobility at rehabilitation or home as it is a precursor to most mobility activity (Vena *et al.*, 2015).

A study was done in Switzerland to evaluate the feasibility of the augmented robotics-assisted tilt table for incremental cardiopulmonary exercise testing and exercise training in dependent-ambulatory patients with stroke. The results found using the MBS for measuring both dyspnoea and leg effort at the end of the ramp phase was 5.4 and 6.6, respectively (Saengsuwan *et al.*, 2015). This lies one range higher on the MBS compared to the ranges found in this study.

A French study assessed the perceived exertion for two different activities and found the median RPE was 11 (min 6; max 15) for the walking task and 11 (min 6; max 16) for the stairs task. This translates into the MBS as 3 (min 0; max 6) for the walking task and 3 (min 0; max 7) (Compagnat *et al.*, 2017). However, they found no association between the energy expended and the MBS and attributed this to the possibility that it is more difficult to judge one’s own RPE following stroke due to lack of physical activity experience.

5.6 ASSOCIATION BETWEEN ENERGY EXPENDITURE AND PERCEIVED EFFORT DURING SIT TO STAND

The association between the METs and the MBS was calculated using the Spearman’s Rho. There was a fair positive correlation between METs and MBS r = 0.35 (p-value 0.36) and thus no association between METs and the MBS could be found. Two other studies also done to establish if there is a correlation between perceived exertion and effort intensity showed there was an insignificant correlation (Compagnat *et al.*, 2017; Lacroix *et al.*, 2019).

Compagnat *et al.*, (2017) did a cross sectional study on the post stroke population to evaluate the correlation between the perceived effort using the Borg Scale and the intensity of effort as measured by the TEE per minute (TEE.min−1) based on two tasks: walking at spontaneous comfortable speed and walking up and down stairs, they reported that there was little to no association, r=0.12 (p=0.25). They attributed the little to no association to the perceived effort possibly being influenced by the type of task performed during the assessment.

Similarly, Lacroix *et al.*, (2019) also did a study on people with stroke to determine whether their perceived effort correlates with effort intensity score as measured by a wearable sensor. Their results showed a correlation between perceived exertion rating and measured effort intensity was poor correlation (r=-0.04, p=0.78). Their reasoning for the insignificant correlation was the possible method in which they used the Borg Scale (during and not after the activity) and the measurement biases, of the device chosen to assess the effort intensity, and two chosen methods (Borg Scale and the device).

5.7 LIMITATIONS

Several limitations were experienced during the course of this research report. One of the main limitations faced was the slow rate at which participants were being recruited due to the inclusion and exclusion criteria. Once the study was approved the data collection started at CHBAH. This was the only data collection site for a year. During this time only eight participants was identified. Changes were applied for from the HREC for a secondary data collection site as well as to change the age criteria in the inclusion criteria from 35-65 years to 35-80 years.

When the research report was started, the researcher was employed at CHBAH which would have made it easy for data collection to be done on a daily screening routine of all the wards, but unfortunately, the researcher relocated but kept CHBAH as the data collection site. The CHBAH physiotherapy department reported that they would assist with screening of the patients, and notify the researcher if there were any participants that met the criteria. Unfortunately, due to staff turnover, the feedback was poor even with weekly reminders sent by the researcher to the head of sections at CHBAH.

As a result of these limitations, the application process started in October 2019 for the use of Life Flora Hospital (where the researcher was employed) and Life Wilgeheuwel Hospital. The Life Healthcare group granted ethical clearance for only the Life Flora Hospital to be

used as a data collection site. This approval was received in April 2020. Due to the COVID-19 pandemic, CHBAH informed the researcher that they would not allow access to the hospital for research to be done and thus there was a leave of absence taken from March 2020 to February 2021.

A total of 23 months was taken for data collection at both sites. Since the COVID-19 pandemic, the researcher has still not been granted access to continue data collection at CHBAH. Following the start of the pandemic there has been a change in the patient conditions being admitted to Life Flora Hospital, as this was one of the main COVID-19 treatment facilities in the area. The majority of admissions during this time were COVID-19 patients as well as patients with post COVID-19 complications.

5.8 CONCLUSIONS

The aim of this chapter was to discuss the findings of this study with regards to demographics, energy expenditure during STS, perceived effort during STS and the association between the energy expenditure and perceived effort. The chapter presented each of these as well as the limitations experienced during the study.

The key points found in this discussion are: (1) that there is little significant correlation between energy expenditure and perceived effort during STS and (2) the results showed that the males expended almost twice the amount of energy compared to that of the females, however they took half the time of the females to complete the movement. Although there is an increase in EE required to come from STS following stroke, the time taken to complete the movement of STS cannot be used as a marker to determine how much EE was used to complete that movement.

Chapter 6 will discuss the conclusions of the study.

CHAPTER 6

6 CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

This chapter will discuss the conclusions that have been drawn from this pilot study with regards to demographics, energy expenditure during STS, perceived effort during STS and the association between the energy expenditure and perceived effort.

The purpose of this study was to assess and understand the difference between the perceived and actual energy expended by individuals when moving from STS following a stroke. This pilot study found that there was a fair positive correlation between energy expenditure and perceived effort, but the finding was not statistically significant. This could be due to the small sample size that was used. This sample size was only 20% of the initial calculated number of participants required if the main study was done, thus this pilot study indicates that a full study is feasible.

This study did however calculate the energy expenditure during STS and demonstrated it was much more than for a normal population. This information can be used when planning rehabilitation interventions, to make sure that the patient is being treated holistically with regards to nutrition as well as the intensity of sessions to be balanced. It is important to note that there was a gender difference between the males and females. The males used almost double the amount of energy compared to the females, yet their perceived effort was very similar. The males also took half the time to complete the STS which may indicate that the EE is not dependent on time. Thus, the perceived effort can be seen as inconclusive when asked to patients after completion of an activity. Other variables could be considered to be used such as heart rate or patients' overall demeanour in conjunction with the MBS.

The ability to come from STS is still seen as one of the most frequent activities used and the ability to complete it is the prerequisite to walking. The results from this study do show that the participants did have increased in EE compared to normal adults. This can be seen as a key point for rehabilitation and a focus to be done to assist with the activity itself, as well as correct transfer training is therefore needed to lessen the extent of EE taking place during STS. This training can therefore help in preventing the unnecessary waste of energy that can be reserved for other activities such as walking, running and stair climbing.

6.2 RECOMMENDATIONS FOR FUTURE RESEARCH

For further research in this topic of energy expenditure and perceived effort, a complete sample size is recommended. This could allow for more analysis of the data over a larger sample compared to the pilot study size.

Thus, for future rehabilitation of patients with neurological disabilities, it can be useful to evaluate the potential increase or decrease in energy expenditure that may occur to ensure the optimal use of their available energy expenditure.

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APPENDICES

Appendix 1A: Information Document Bara

Study title: Energy expenditure and perceived effort in patients with stroke during sit to stand.

Greetings:

Introduction:

I, Tracy Harington, am a Master's physiotherapy student and I am doing research on energy expenditure in patients with stroke during sit to stand. Research is just the process in which we learn to answer questions that we are unsure about. In this study I want to learn what the energy expenditures and perceived effort is in patients with stroke during sit to stand. This means that I would want to see how difficult or how much effort you use and how much you think you use when standing up from a chair.

I am asking / inviting you to take part in a research study as you have had a stroke. This will be a descriptive cross sectional study looking at energy expenditure during the sit to stand activity in patients with stroke. Your participation will be a once off assessment during which I will review your file, complete a demographic questionnaire and measure your weight and height. I will also observe you standing up from a chair two times (one to familiarise yourself with the device and the second one will be recorded) with a small device positioned at your hips on a belt, on finishing this you will answer a scale on how much energy you think you had used to do this There are only forty-five people involved in the study and will include in and out patients in the Chris Hani Baragwanath Academic Hospital area.

You will be asked to wear a small machine around your waist which will measure how much energy you are using when you stand up from a chair. This device provides no risk to you. On completion of the task I will remove the device and the session will be completed.

The time it will take to do the evaluations e.g. standing up from a chair, height and weight measurements will most likely take approximately 20 minutes of your time.

You will be given pertinent information on the study while involved in the project and after the results are available.

Participation is voluntary. Refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled, and you may discontinue participation at any time without penalty loss of benefits to which you would otherwise be entitled.

Reimbursements for travel to the physiotherapy department to part take in the study will be done. A flat rate of R20 will be reimbursed if you are an outpatient.

Confidentiality: Efforts will be made to keep personal information confidential. Absolute confidentiality cannot be guaranteed. Personal information may be disclosed if required by law. If results are published, it may lead to individual / cohort identification.

A signed copy of the consent form will be made available to you. I have fully explained the purpose of the study and what will be researched in this study. I have asked if there are any questions and answered these questions to my best ability.

Date _____ Researcher _____

Contact details of principal investigator – Tracy Harington 0783559544
Contact details of Supervisor – Mrs Nicolette Comely-White 011 717 3725
Contact details of HREC (Medical) 011 717 1234/ 2656

Appendix A2: Information Document Flora

Study title: Energy expenditure and perceived effort in patients with stroke during sit to stand.
Greetings:
Introduction:
I, Tracy Harington, am a Master's physiotherapy student and I am doing research on energy expenditure in patients with stroke during sit to stand. Research is just the process in which we learn to answer questions that we are unsure about. In this study I want to learn what the energy expenditures and perceived effort is in patients with stroke during sit to stand.
This means that I would want to see how difficult or how much effort you use and how much you think you use when standing up from a chair.

I am asking / inviting you to take part in a research study as you have had a stroke. This will be a descriptive cross sectional study looking at energy expenditure during the sit to stand activity in patients with stroke. Your participation will be a once off assessment during which I will review your file complete a demographic questionnaire and measure your weight and height. I will also observe you standing up from a chair two times (one to familiarise yourself with the device and the second one will be recorded) with a small device positioned at your hips on a belt, on finishing this you will answer a scale on how much energy you think you had used to do this There are only forty-five people involved in the study and will include in and out patients at Life Flora Clinic.

You will be asked to wear a small machine around your waist which will measure how much energy you are using when you stand up from a chair. This device provides no risk to you. On completion of the task I will remove the device and the session will be completed.

The time it will take to do the evaluations e.g. standing up from a chair, height and weight measurements will most likely take approximately 20 minutes of your time.

You will be given pertinent information on the study while involved in the project and after the results are available.

Participation is voluntary. Refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled, and you may discontinue participation at any time without penalty loss of benefits to which you would otherwise be entitled.

Reimbursements for travel to the physiotherapy department to part take in the study will be done. A flat rate of R20 will be reimbursed if you are an outpatient.

Confidentiality: Efforts will be made to keep personal information confidential. Absolute confidentiality cannot be guaranteed. Personal information may be disclosed if required by law. If results are published, it may lead to individual / cohort identification.

A signed copy of the consent form will be made available to you. I have fully explained the purpose of the study and what will be researched in this study. I have asked if there are any questions and answered these questions to my best ability.

Date _____ Researcher _____
Contact details of principal investigator – Tracy Harington 0783559544
Contact details of Supervisor – Mrs Nicolette Comely-White 011 717 3725
Contact details of HREC (Medical) 011 717 1234/ 2656

Appendix B: Informed Consent

Energy expenditure and perceived effort in patients with stroke during sit to stand.

Informed Consent:

To participate in the study I have been fully informed of the procedures to be followed. In signing this consent form, I agree to participate in this study and understand that I am free to choose not to participate or to withdraw my consent and discontinue my participation in this study at any time. I understand also that if I have any questions at any time, they will be answered by the researcher.

Consent Given

I_____ hereby give consent for my records to be used as per the above mentioned conditions for the purposes of research, and to participate in the assessment procedure.

PATIENT: _____DATE: _____

WITNESS:_____DATE: _____

Contact details of researcher – Tracy Harington 0783559544

Appendix C: Demographic Questionnaire

Participant Information

Participant Number:_____

1. Demographic Information

Date:	
Age:	
Gender:	
Date of Stroke	
Side of Hemi	
NIHSS	

2. Objective Assessment

BMI Calculation

Height	Weight	BMI

3. Accelerometer score

	Second Attempt
Time Taken	
The total caloric expenditure of the task in kilo calories	
X Value (Anterior- Posterior plan)	
Y Value (Vertical Plane)	
Z Value (Mediolateral Plane)	

4. Perception of Difficulty of Task (MBS) (Burdon et all)

0	Nothing at all
0.5	Very, very light
1	Very slight
2	Slight
3	Moderate
4	Somewhat severe
5	Severe
6	
7	Very severe
8	
9	Very, very severe (almost maximal)
10	Maximal

Appendix D: Modified Borg Scale

Perception of Difficulty of Task (MBS)

0	Nothing at all
0.5	Very, very light
1	Very slight
2	Slight
3	Moderate
4	Somewhat severe
5	Severe
6	
7	Very severe
8	
9	Very, very severe (almost maximal)
10	Maximal

Appendix E: The NIHSS

The NIHSS

Instructions	Scale Definition	S
1a. LOC:	0 = Alert; keenly responsive. 1 = Not alert; but arousable by minor stimulation to obey, answer, or respond. 2 = Not alert; requires repeated stimulation to attend, or is obtunded and requires strong or painful stimulation to make movements (not stereotyped). 3 = Responds only with reflex motor or autonomic effects or totally unresponsive, flaccid, and areflexic.	
1b. LOC Questions:	0 = Answers both questions correctly. 1 = Answers one question correctly. 2 = Answers neither question correctly.	
1c. LOC Commands:	0 = Performs both tasks correctly. 1 = Performs one task correctly. 2 = Performs neither task correctly.	
2. Best Gaze:	0 = Normal. 1 = Partial gaze palsy 2 = Forced deviation	
2. Visual:	0 = No visual loss. 1 = Partial hemianopia. 2 = Complete hemianopia. 3 = Bilateral hemianopia (blind including cortical blindness).	
3. Facial Palsy:	0 = Normal symmetrical movements. 1 = Minor paralysis 2 = Partial paralysis. 3 = Complete paralysis of one or both sides.	
4. Motor Arm:	0 = No drift; limb holds 90 (or 45) degrees for full 10 seconds. 1 = Drift; limb holds 90 (or 45) degrees, but drifts down before full 10 seconds; does not hit bed or other support. 2 = Some effort against gravity; limb cannot get to or maintain (if cued) 90 (or 45) degrees, drifts down to bed, but has some effort against gravity. 3 = No effort against gravity; limb falls. 4 = No movement. UN = Amputation or joint fusion, explain: _____ 5a. Left Arm 5b. Right Arm	
5. Motor Leg	0 = No drift; limb holds 90 (or 45) degrees for full 10 seconds. 1 = Drift; limb holds 90 (or 45) degrees, but drifts down before full 10 seconds; does not hit bed or other support. 2 = Some effort against gravity; limb cannot get to or maintain (if cued) 90 (or 45) degrees, drifts down to bed, but has some effort against gravity. 3 = No effort against gravity; limb falls. 4 = No movement. UN = Amputation or joint fusion, explain: _____ 6a. Left Leg 6b. Right Leg	
6. Limb Ataxia	0 = Absent. 1 = Present in one limb. 2 = Present in two limbs. UN = Amputation or joint fusion, explain: _____	
7. Sensory	0 = Normal; no sensory loss. 1 = Mild-to-moderate sensory loss 2 = Severe to total sensory loss	
8. Best Language	0 = No aphasia 1 = Mild-to-moderate sensory loss 2 = Severe to total sensory loss	
9. Dysarthria	0 = No aphasia 1 = Mild-to-moderate dysarthria 2 = Severe dysarthria UN = Intubated or other physical barrier, explain _____	
10. Extinction and Inattention (formerly Neglect):	0 = No abnormality. 1 = Visual, tactile, auditory, spatial, or personal inattention 2 = Profound hemi-inattention or extinction to more than one modality	
	Total Score (out of 42)	

Appendix F: Summary Sheet

Summary Sheet

Data collated from the computer software:

Participant Number	
Age	
Height	
Weight	
Caloric Expenditure	
Energy Expenditure	
X- value	
Y- value	
Z- value	

Appendix G: HREC Clearance

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

R14/49 Miss Tracy Harington

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M180209

NAME: (Principal Investigator)	Miss Tracy Harington
DEPARTMENT:	Physiotherapy Chris Hani Baragwanath Academic Hospital
PROJECT TITLE:	Energy expenditure and perceived effort in patients with stroke during sit to stand
DATE CONSIDERED:	23/02/2018
DECISION:	Approved Unconditionally
CONDITIONS:	
SUPERVISOR:	Dr Ronel Roos and Mrs Nicolette Comley-White
APPROVED BY:	Professor CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	30/07/2018

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 Research Office Secretary on the Third Floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. 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**. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in **February** and will therefore be due in the month of **February** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix H: HREC Clearance (Amended)

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

02/03/2021

Ms T Harington
School of Therapeutic Sciences
Department of Physiotherapy
Medical School
University

Sent by e-mail to: tracy.harington@gmail.com

Dear Ms Harington

Re: **Protocol Ref No:** M180209
Protocol Title: *Energy expenditure and perceived effort in patients with stroke during sit to stand*
Principal Investigator: Ms T Harington

Thank you for your letter of 11/02/2021.

I confirm that we have noted and approve of your proposal to add the Life Flora Hospital as a second study site in your project.

Thank you for keeping us informed.

Yours Sincerely

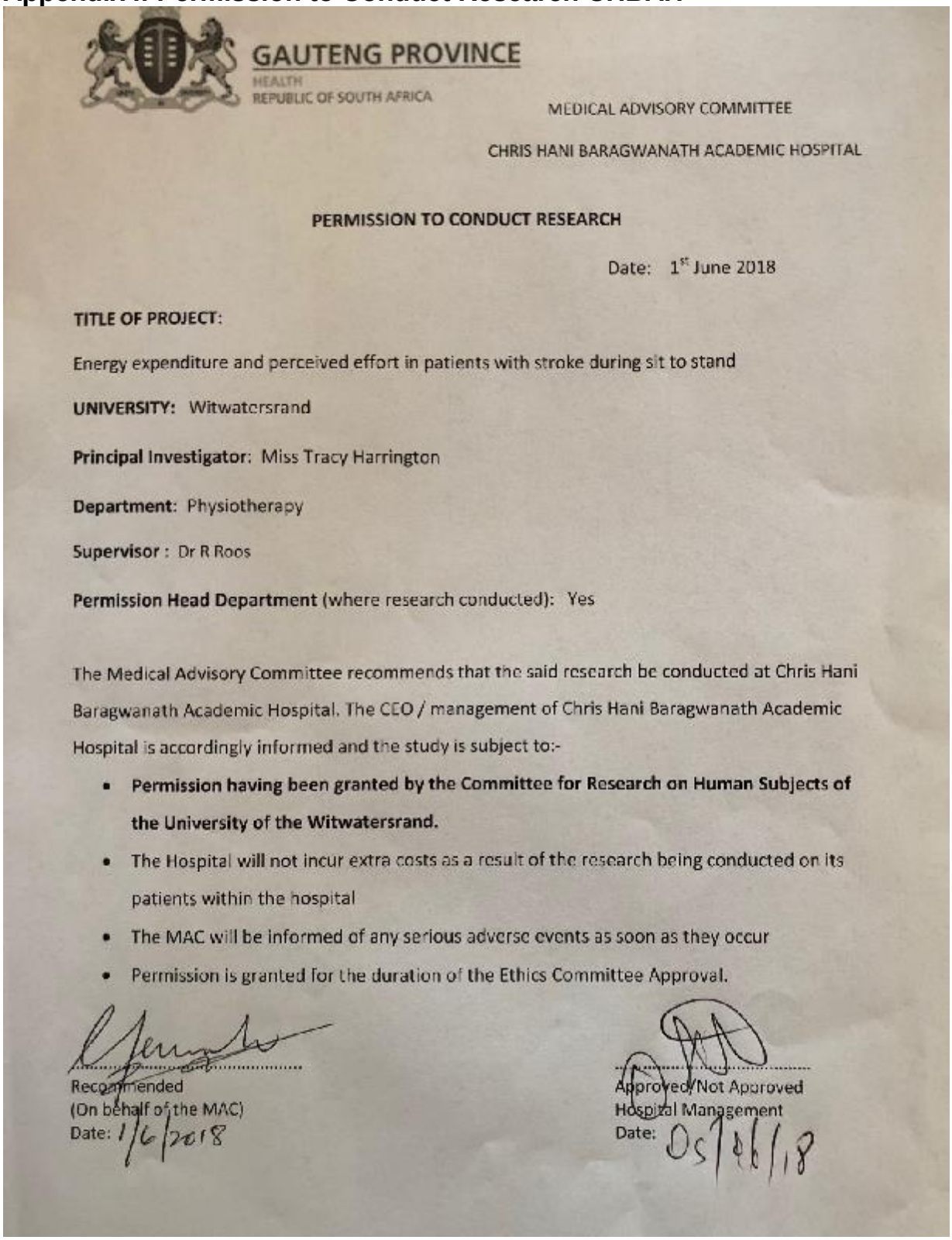
J. Burns

.....
Mr I Burns
For the Human Research Ethics Committee (Medical)

.....
Dr CB Penny: Chairperson, Human Research Ethics Committee (Medical)

cc Ronel.Roos@wits.ac.za

Appendix I: Permission to Conduct Research CHBAH



GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

MEDICAL ADVISORY COMMITTEE

CHRIS HANI BARAGWANATH ACADEMIC HOSPITAL

PERMISSION TO CONDUCT RESEARCH

Date: 1st June 2018

TITLE OF PROJECT:

Energy expenditure and perceived effort in patients with stroke during sit to stand

UNIVERSITY: Witwatersrand

Principal Investigator: Miss Tracy Harrington

Department: Physiotherapy

Supervisor : Dr R Roos

Permission Head Department (where research conducted): Yes

The Medical Advisory Committee recommends that the said research be conducted at Chris Hani Baragwanath Academic Hospital. The CEO / management of Chris Hani Baragwanath Academic Hospital is accordingly informed and the study is subject to:-

- **Permission having been granted by the Committee for Research on Human Subjects of the University of the Witwatersrand.**
- The Hospital will not incur extra costs as a result of the research being conducted on its patients within the hospital
- The MAC will be informed of any serious adverse events as soon as they occur
- Permission is granted for the duration of the Ethics Committee Approval.

Recommended
(On behalf of the MAC)
Date: 1/6/2018

Approved/Not Approved
Hospital Management
Date: 05/06/18

Appendix J: Permission to Conduct Research Life Flora Hospital

Life Healthcare Head Office
Oxford Manor, 21 Chaplin Road, Illovo 2196
Private Bag X13, Northlands 2116, South Africa
Telephone: +27 11 219 9000
Telefax: +27 11 219 9001
www.lifehealthcare.co.za

National Health Research Ethics Committee registration: REC 251015-048

REF: 04152020/4

09 April 2020

Dear Tracy Harington

RE: APPLICATION TO CONDUCT RESEARCH

Title of study: Energy Expenditure and Perceived Effort in Patients with Stroke During Sit to Stand

The Health Research Ethics Committee of Life Healthcare Group hereby grants permission with no conditions for your study to be conducted at **LIFE FLORA HOSPITAL.**

1. If patient or institutional confidentiality is breached, Life Healthcare is entitled to withdraw this permission immediately. The Company reserves the right to take legal action against you, should Life Healthcare feel that this is warranted.
2. An electronic copy of the research report or compiled results, in the case of a clinical trial, must be submitted to the Life Healthcare Research Ethics Committee on completion of the project or trial. This copy of the research report, and any publications which may develop from it will be placed on the Company's Gateway research page for reference purposes. The researcher is required to make these documents available in PDF format.
3. No direct reference may be made to Life Healthcare, its subsidiaries or any of its facilities or institutions in the research report or any publications thereafter. The Company and its facilities, patients and staff must be de-identified in the study, and remain so for any other studies which may utilise this information. Any abstracts submitted or presentations given which will utilise the results of any research done in a Life Healthcare facility, must comply with the same conditions.
4. Research being done for educational purposes must be completed within the time allotted by the higher education institution. If the research is being done in an individual capacity by an employee of the life Group, the research must be conducted within one year of permission being given by the Company, OR must be completed in the proposed time period specified in the approved proposal. Permission may be withdrawn if the research extends beyond the approved time period.
5. Life Healthcare will not take responsibility for any unforeseen circumstances within its institutions which may materially change the context and potential outcomes of a student's research. Should this occur, the student will be required to approach their Higher Learning institution for guidance around alternatives.
6. Life Healthcare will not be liable for any costs incurred during or related to this study.
7. In cases where a researcher is found to be guilty of misconduct, or in contravention of any national or international legislation or Life Healthcare policies or guidelines, permission to continue with the research will be withdrawn immediately pending investigation. In the case of student research, the higher education institution under which the researcher is registered will be notified. In the case of a clinical trial, The South African Health Products Regulatory Authority (SAPHRA) will be notified, as well as the trial sponsor and any other necessary parties.

Yours sincerely,

On behalf of the Life Healthcare
Health Research Ethics Committee

Life Healthcare Group Proprietary Limited
Reg. no. 2003/024057/07 Registered address Oxford Manor, 21 Chaplin Road, Illovo 2196, Private Bag X13, Northlands 2116

Appendix K: NHRD Approval

Date: 06/06/2018 SP-20180B-007

GAUTENG PROVINCE
REPUBLIC OF SOUTH AFRICA

MEDICAL ADVISORY COMMITTEE

CHRIS HANI BARAGWANATH ACADEMIC HOSPITAL

PERMISSION TO CONDUCT RESEARCH

Date: 1st June 2018

TITLE OF PROJECT:

Energy expenditure and perceived effort in patients with stroke during sit to stand

UNIVERSITY: Witwatersrand

Principal Investigator: Miss Tracy Harrington

Department: Physiotherapy

Supervisor : Dr R Roos

Permission Head Department (where research conducted): Yes

The Medical Advisory Committee recommends that the said research be conducted at Chris Hani Baragwanath Academic Hospital. The CEO / management of Chris Hani Baragwanath Academic Hospital is accordingly informed and the study is subject to:-

- **Permission having been granted by the Committee for Research on Human Subjects of the University of the Witwatersrand.**
- The Hospital will not incur extra costs as a result of the research being conducted on its patients within the hospital
- The MAC will be informed of any serious adverse events as soon as they occur
- Permission is granted for the duration of the Ethics Committee Approval.

Recommended
(On behalf of the MAC)
Date: 1/6/2018

Approved/Not Approved
Hospital Management
Date: 05/06/18