PREDICTORS OF FUNCTIONAL WALKING ABILITY ON DISCHARGE FROM INPATIENT STROKE REHABILITATION

Maxine Leigh Farr

A Research Report submitted to the Faculty of Health Science, University of Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Science in Physiotherapy.

Johannesburg, 2025

Declaration

I, Maxine Leigh Farr, declare that this Research Report is my own, unaided work. It is being submitted for the Master of Science in Physiotherapy at the University of Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

Maxine Leigh Farr

Name of candidate

Signature of candidate

21st day of October 2025 in Worcester, United Kingdom

Abstract

Background:

Stroke is a leading cause of disability worldwide and in South Africa. Following stroke, walking is often negatively affected and is consistently reported by patients as the primary goal with improvements directly increasing quality of life and community participation. To the author's knowledge, this is the first study exploring predictors of walking ability after stroke within South Africa.

Aim:

To determine predictors of functional walking ability on discharge from inpatient stroke rehabilitation.

Methods:

A quantitative, retrospective, record review was conducted of patients post-stroke between June 2017 to June 2021 at a private inpatient sub-acute hospital in Gauteng. The inclusion criteria included primary stroke diagnosis, first time stroke and walking speed less than 0.80m/s with the primary outcome measure being the 10 Metre Walk Test (10MWT) The univariate analysis included demographic and clinical variables and following this, a multivariate binary logistic regression was used to build a predictive model.

Results:

Of the 216 records available, 48 met the inclusion criteria. Three predictors were identified: cognition (measured by the Functional Independence Measure [FIM] category: social cognition, $p<0.05$, OR=1.687), balance (measured by Berg Balance Scale [BBS], $p<0.05$, OR=1.655), and length of stay [LOS] in acute hospital ($p<0.05$, OR=1.067). The predictive model showed excellent discrimination ability (AUC=0.914) and explained 63% of the variance in walking outcomes.

Conclusion:

Cognition, balance and acute LOS are significant predictors of walking ability on discharge from inpatient stroke rehabilitation. The findings emphasise the importance of early assessment and intervention targeting cognition and balance and supporting the routine use of the standardised outcome measures, FIM and BBS, in post-stroke care. The results provide evidence-based guidance for clinicians to optimise

rehabilitation and set realistic goals with patients following stroke, within the South African context.

Keywords:
Stroke rehabilitation, walking ability, functional walking, gait, gait speed, predictors, South Africa, Ten Metre Walk Test, Berg Balance Scale, balance, cognition, length of stay

Acknowledgements

I wish to acknowledge the following people and organisations for their contributions to this literature:

The participants included in this study.
The sub-acute hospital that formed the setting of this study and the colleagues who helped me through this research.
My family, for their never-ending encouragement, support and understanding.
And last but certainly not least, my supervisors whose patience knows no bounds and who provided guidance and encouragement right to the end.

Table of Contents

List of Tables

List of Figures

List of Appendices

List of Abbreviation

10MWT	Ten Meter Walk Test
5MWT	Five Meter Walk Test
5TSTS	Five Times Sit to Stand
AIC	Akaike Information Criterion
AUC	Area Under the Receiver Operating Characteristic curve
BBS	Berg Balance Scale
BIC	Bayesian Information Criterion
DVT	Deep vein thrombosis
EPV	Events per variable
FIM	Functional Independence Measure
HIV	Human Immunodeficiency Virus
LOS	Length of stay
MMSE	Mini-Mental State Examination
NPRS	Numeric Pain Rating Scale
ROC	Receiver Operating Characteristic
SA	South Africa
TUG	Timed Up and Go
VIF	Variance inflation factor

Definitions

Acute care:	This involves care to perform diagnostic, therapeutic or surgical interventions to treat illness or injury (Australian Institute of Health and Welfare, 2024). In this study, acute care refers to the acute hospitals the participants were admitted to initially after their stroke.
Functional walking ability:	In this study, functional walking ability refers to the categories of walking ability based on walking speed, proposed by Perry *et al.* (1995), the pioneer study that created the following walking categories: home ambulation, limited community ambulation and full community ambulation
Length of stay:	This is the length of time, measured in days, a patient is in hospital for and is calculated by subtracting the admission date from the discharge date and subtracting any days the patient was on leave. This is typically longer in the sub-acute phase than the acute phase (Australian Institute of Health and Welfare, 2024).
Rehabilitation:	A set of interventions designed to optimize functioning and reduce disability in individuals with health conditions in interaction with their environment (World Health Organisation, 2024)
Sub-acute care:	Involves all types of care after the initial acute care that aim to improve functional ability or optimise quality of life after an impairment due to illness. This can include rehabilitation care (Australian Institute of Health and Welfare, 2024). In this study, a facility providing sub-acute care is the setting the participants records are from.
Walking ability:	A term commonly used in literature, typically measured by walking speed, to broadly describe a person's walking, considering both function and assistance required, used by authors of pioneer studies in predictors of walking outcomes after stroke (Perry *et al.*, 1995; Lord *et al.*, 2004).

Chapter 1 Introduction

1.1 Background

Worldwide, stroke is one of the most common causes of mortality and disability with a high likelihood of it remaining so due to the modest decline in stroke incidence compared to improvements in survival rates, population aging, and increased exposure to stroke risk factors, all leading to an increased disability, economic and social burden (Bryer *et al.*, 2010; Johnson *et al.*, 2019). In South Africa, it is no different, with approximately 75,000 strokes a year resulting in around 25,000 deaths and 95,000 years lived with disability (Bertram *et al.*, 2013).

With stroke remaining a leading cause of disability, the impact on life after stroke is an important consideration. Limited recent data is available on the incidence and effect of stroke in South Africa, however, Bryer *et al.*, (2010) state that strokes are the ninth cause of disability in South Africa and an estimated 66% of people that have experienced stroke have disabilities resulting in the need for assistance (Connor *et al.*, 2004). With a stroke comes the myriad of changes to a person's physical, cognitive and social abilities and these changes often impact the ability to participate in meaningful activities and reintegrate into the community (Singam *et al.*, 2015). A South African study that included participants living in community at least six months after stroke, found that mobility, specifically the ability to stand up, move around inside and outside, and walk a distance of around one kilometre, significantly predicted community participation post-stroke (Elloker *et al.*, 2018), which is also seen in studies conducted worldwide (Kuys *et al.*, 2009; Singam *et al.*, 2015).

"Walking ability" is a term commonly used in literature to broadly address a person's walking, considering both function and assistance required. Perry *et al.*, (1995) used walking speed to define different levels of walking ability into full community (>0.80 m/s), limited community (0.40–0.80 m/s) and home ambulation (<0.40 m/s). The use of walking speed has become a widely accepted measure used to clinically describe walking ability (Lord *et al.*, 2004).

Walking ability, measured specifically through walking speed, has been found to have a direct correlation with quality of life, with increasing levels of walking ability leading to significantly improved quality of life (Khanittanuphong and Tipchatyotin, 2017; Grau-Pellicer *et al.*, 2019). These findings suggest that as walking speed and ability improves, strength improves, independence with activities of daily living increases, outdoor mobility increases, sedentary time decreases and community participation and social interaction increases, with all these contributing to improve quality of life (Khanittanuphong and Tipchatyotin, 2017; Grau-Pellicer *et al.*, 2019). Specifically, Khanittanuphong and Tipchatyotin (2017) found that community ambulators had significantly higher quality of life scores than limited community or household ambulators. These associations shows the importance that walking ability has on the lives of those who have experienced a stroke, which also gives insight into why the most important rehabilitation goals of patients following a stroke usually centre around walking (Lord *et al.*, 2004; Krishnan *et al.*, 2017).

Several variables have been found to be predictive of walking ability post stroke. Key functional abilities on admission that have been found to predict walking after stroke are walking speed and balance abilities (measured through the Berg Balance Scale which includes static and dynamic balance tests in sitting and standing) on admission (Louie and Eng, 2018), while other factors such as time since stroke (Louie and Eng, 2018), bladder continence (Preston *et al.*, 2021), age and cognition (Preston *et al.*, 2021) have also been shown to be predictive of walking ability.

In South Africa, studies investigating predictive factors after a stroke have focussed on predictions of general functional outcomes rather than specific walking ability. A study by Joseph and Rhoda, (2013) found that the only predictor of functional ability at discharge was functional ability on admission, with functional ability being measured through the Barthell Index which includes items related to mobility, feeding, self-care, and continence. In a study performed in a tertiary hospital in the Western Cape, functional ability on admission was again found to be an important influence of functional outcomes on discharge and two months post-discharge, along with age and stroke severity (Parekh and Rhoda, 2013). Groenewald and Rhoda, (2017) found a significant correlation between higher functional outcomes on discharge and patients' perceived health-related quality of life and satisfaction with the multidisciplinary rehabilitation they received. In another study, performed in the Western Cape, factors predicting increased community participation were mobility, cognition, self-care, household activities and getting along with people, while exposure to stroke risk factors was associated with a decrease in community participation (Elloker *et al.*, 2018).

Looking at the differences in stroke rehabilitation in Australia, Finland and South Africa, a study compared the length of stay, functional status on admission and discharge, functional improvement throughout the hospital stay, the age distribution of the patients treated, and the organisation of the rehabilitation services offered in each country (Green *et al.*, 2005). In South Africa, the patients tended to be younger with similar functional improvement scores and length of stays, however, when looking at the functional status of the patients, the functional status on admission and discharge in South Africa was much lower than in Finland or Australia. Other differences include a higher mortality rate for South African patients during their rehabilitation and the commencement of rehabilitation services following a stroke starting later than those of Finland or Australia (Green *et al.*, 2005).

1.2 Problem Statement

The most common goal of patients after experiencing a stroke is to be able to walk again (Lord *et al.*, 2004; Krishnan *et al.*, 2017), thus questions from patients and their families often centre around regaining the ability to walk.

Within South Africa, walking ability has been shown to directly impact participation in activities of daily living, community reintegration, and quality of life, with South African research demonstrating that mobility significantly predicted community participation post-stroke (Elloker *et al.*, 2018). Internationally, predictors of walking ability include walking speed and balance on admission (Louie and Eng, 2018), time since stroke, age and cognition (Preston *et al.*, 2021). However, no South African studies have specifically investigated what predicts walking ability after stroke. This is problematic because South African stroke patients demonstrate different demographics and clinical outcomes compared to international populations, with patients tending to be younger but having much lower functional status on admission and discharge than patients in Finland or Australia (Green *et al.*, 2005).

Living in South Africa where stroke was declared a “catastrophic disease” at the Joint World Congress on Stroke in October 2006 (Bryer *et al.*, 2010), we should be able to give patients and families evidence-based answers from within the context of our own country.

1.3 Aims and Objective

1.3.1 Research question

What are the predictors of functional walking ability of participants on discharge from inpatient stroke rehabilitation at a private sub-acute hospital in South Africa?

1.3.2 Aim

To determine the predictors of functional walking ability on discharge from inpatient stroke rehabilitation.

1.3.3 Objectives of the study

1. To establish the demographic and clinical profile of the participants admitted to a private inpatient sub-acute hospital for stroke rehabilitation.
2. To establish the functional walking ability of the participants upon discharge from a private inpatient sub-acute hospital.
3. To establish the factors that predict the functional walking ability of participants upon discharge from a private inpatient sub-acute hospital.

1.4 Significance

Regaining the ability to walk is unsurprisingly important to patients following a stroke. It influences their ability to participate in meaningful activities such as activities of daily living, community participation and social interaction and impacts their quality of life (Khanittanuphong and Tipchatyotin, 2017; Elloker *et al.*, 2018; Grau-Pellicer *et al.*, 2019). To be able to predict a patient's expected walking ability on admission to a rehabilitation facility would not only aid in setting realistic goals with the patient but would also assist with treatment plans, anticipating equipment needs, possible home modifications, carer education and training, and discharge planning (Bland *et al.*, 2012; Louie and Eng, 2018; Preston *et al.*, 2021). This study will contribute to the growing amount of knowledge in South Africa on predictors of functional outcomes after strokes, however, within the specific outcome of walking ability. The findings will benefit multiple stakeholders and allow for a targeted approach to improve the lives of those affected by stroke: patients and families will receive more accurate walking recovery expectations; healthcare professionals will have evidence-based predictors for goal setting, intervention planning, and discharge decisions; healthcare administrators and policymakers will have more data for service and resource allocation; and researchers will have foundational data on stroke predictors and demographics within South Africa to inform future walking intervention studies.

1.5 Outline of this Research Report

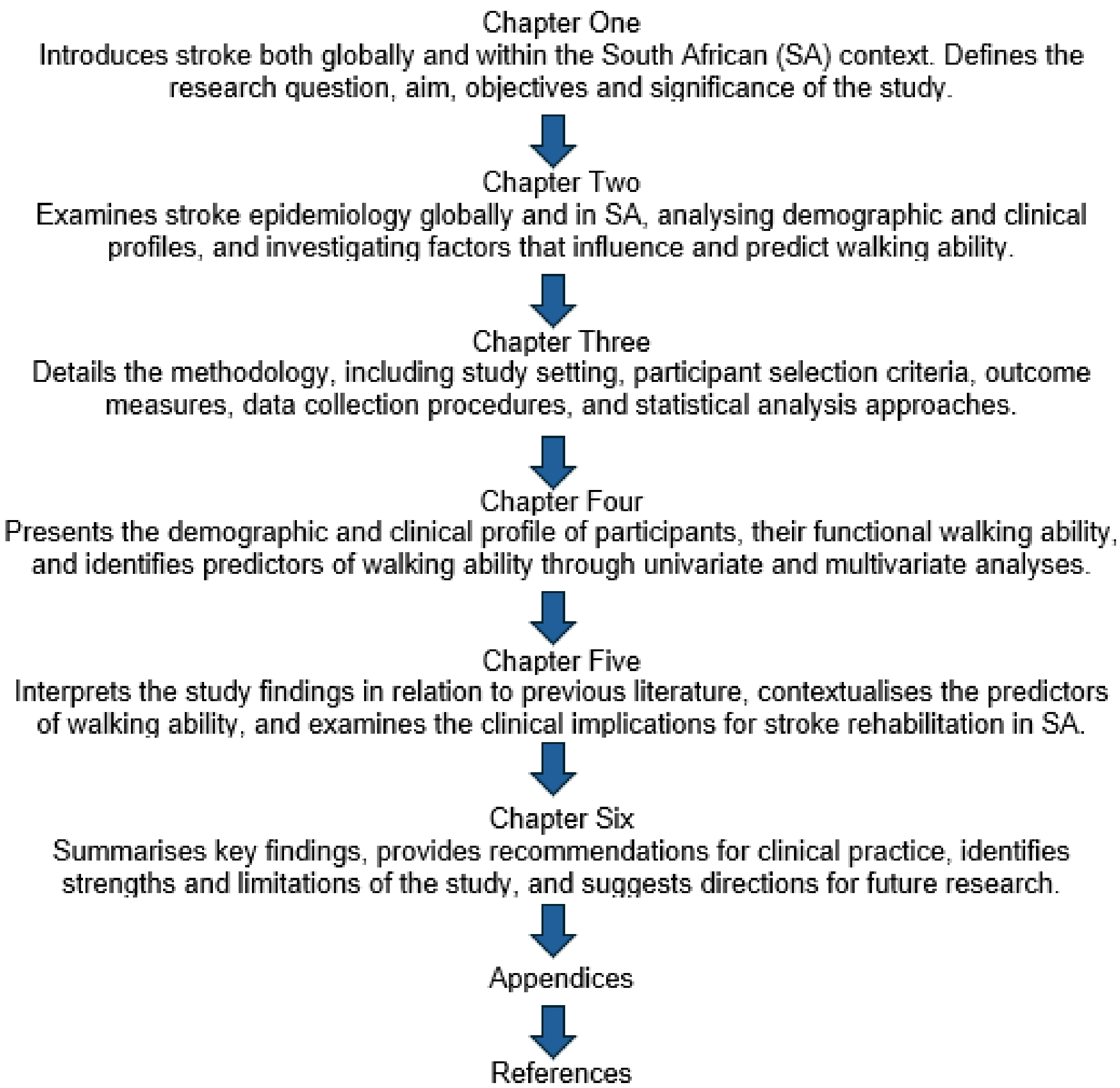


Figure 1.5. 1 Outline of the research report

Chapter 2 Literature Review

2.1 Introduction

Stroke is a leading cause of disability and mortality worldwide, with a key goal of rehabilitation after stroke being regaining the ability to walk (Lord *et al.*, 2004; Johnson *et al.*, 2019). This review aims to examine the current evidence around walking post-stroke, with a particular focus on identifying and analysing predictive factors that may influence walking ability. It will also give a basic overview of the epidemiology of stroke globally, in Africa and South Africa; while also looking at the demographic and clinical profile of people who have experience stroke in South Africa. By understanding the epidemiology, demographic and clinical profile of those who have experienced stroke globally and locally in South Africa, as well as the factors that influence and predict walking ability, researchers, healthcare professionals and policymakers would be able to target their efforts in improving the lives of those affected by stroke.

This literature review was conducted using the PubMed database, ClinicalKey, Access Physiotherapy, EbscoHost, Cochrane Library and Google Scholar. Only English literature was used and all types of evidence were use, such as systematic reviews, meta-analyses and retrospective reviews. The following keywords were used when searching for literature: stroke; functional walking ability; gait; ambulation; gait velocity; predictors; quality of life; epidemiology; prevalence; incidence; global; Africa; South Africa. The literature was reviewed over two months and articles from the period of 2015 to 2025 were included, with the exception of indicated older pioneer studies and literature where no newer evidence could be found.

2.2 Definition of stroke

While stroke is a leading cause of disability and mortality worldwide, there are inconsistencies in medical literature around the definition of stroke. This review will follow the World Health Organisation's definition of stroke which states that stroke is defined as 'A focal (or at times global) neurological impairment of sudden onset and lasting more than 24 hours (or leading to death), and of presumed vascular origin' (Farooq *et al.*, 2008, p.4). This definition includes ischemic stroke, which occurs because of occlusion of the arteries supplying the brain; intracerebral haemorrhage, which occurs when arteries in the brain bleed into structures within the brain; subarachnoid haemorrhage, which occurs when arteries bleed into the arachnoid space between the pia mater and arachnoid mater. The definition excludes transient ischaemic attack, subdural haemorrhage, epidural haemorrhage and injury due to trauma (Farooq *et al.*, 2008).

2.3 Epidemiology

Stroke poses a significant global burden, ranking among the leading causes of death and disability (Johnson *et al.*, 2019). In 2019, 12.2 million people had a stroke, with a resulting 6.55 million resulting in death. These 2019 statistics show a 70% increase in stroke incident cases and a 43% increase in deaths due to stroke since 1990. Of the stroke-related deaths in 2019, 86% occurred in lower to upper-middle-income countries, confirming that the burden of stroke is higher in low to middle-income countries than in high-income countries (Feigin *et al.*, 2021).

This is noteworthy to those living in Africa, a continent where the majority of countries fall in the low to lower-middle income classification, with only seven of the 54 countries being classified as upper-middle income according to the World Bank Income Classification, of which South Africa is one (Metreau, Young and Eapen, 2024).

Keeping these income levels in mind, the annual incidence rates of stroke show the impact of poverty. While the annual global incidence rate for stroke is 150.8 per 100 000, in Africa, the average incidence rate is more than double this at 316 per 100 000 (Akinyemi *et al.*, 2021), with South Africa just above the global rate at 158-175.8 per 100 000 (Johnson *et al.*, 2019). A study looking at the burden of stroke in a rural town in South Africa found a higher incidence of strokes in rural areas, with a crude incidence rate of 244 per 100,000 (Maredza, Bertram and Tollman, 2015).

The disproportionate incidences of stroke between lower and higher income countries have been noted to be due to a multitude of issues such as increased exposure to modifiable risk factors, a younger age of onset of stroke, poverty-related diseases such as human immunodeficiency virus, malaria and tuberculosis, malnutrition in utero and early life thereby increasing the risk of cardiometabolic diseases later in life, and exposure to particulate air pollution (Akinyemi *et al.*, 2021). Once a stroke has occurred, the outcomes are compounded by lower-income countries experiencing a delay in receiving acute stroke care, low reported use of IV thrombolysis and a lack of advanced imaging technology and specialist-trained staff (Saini, Guada and Yavagal, 2021).

2.4 Demographic and clinical profile of people with stroke in South Africa

It is well documented that South Africa is undergoing an epidemiological change as the country moves from a lower to upper-middle-income country and experiences changes in lifestyle, culture and demographics (Connor, Modi and Warlow, 2009; Maredza *et al.*, 2016; Ranganai and Matizirofa, 2020). This is increasing the incidence of stroke, and the demographic and clinical profile of those who have experienced stroke in South Africa must be well documented to ensure that efforts can be strategically targeted to the key areas to reduce the incidence of stroke. However, with a lack of a national stroke registry (Tribelhorn, Motara and Lewis, 2021) and with statistics often poorly documented, particularly in public hospitals (Ranganai and Matizirofa, 2020), the literature on the true incidence of stroke in South Africa is sparse and outdated.

2.4.1 Demographic profile

2.4.1.1 *Age*

Age is a strong, non-modifiable risk factor for stroke. Globally, the incidence of strokes increases with age, with 88% of strokes occurring in those 65 years and older, 11% between 40-64 and 1% under 40 years of age (Avan *et al.*, 2019). This age-related increase in incidence is associated with biological changes such as impaired vascular function, a cumulative exposure to risk factors and a decrease in neuroprotective mechanism (Roy-O'Reilly and McCullough, 2018).

South African studies demonstrate varying stroke ages depending on healthcare setting and population studied. A comprehensive analysis of 14,645 suspected stroke cases from both public and private hospitals over a period of three years found a mean age of 66.95 years, ranging from 18 to 98 (Ranganai and Matizirofa, 2020), while a more recent study from a public tertiary hospital (a setting associated with lower socioeconomic status in South Africa) in Johannesburg reported a lower mean age of 57.7 years among 160 stroke patients (Tribelhorn, Motara and Lewis, 2021). This 9-year age difference between mean ages in the two studies, with the public hospital-based study participants experiencing stroke earlier than the study including both public and private settings, may reflect a higher incidence of stroke in younger populations of lower socioeconomic status, supporting global findings that those in with lower socioeconomic countries face increased incidence of stroke at earlier ages due to poor management of modifiable risk factors, limited access to healthcare and societal barriers (Avan *et al.*, 2019). Tribelhorn, Motara and Lewis', (2021) study faced limitations of being a hospital-based study and not generalised to the whole population, as well as being a low sample size relative to the incidence of strokes in South Africa in 12 months, however, the younger stroke age in the public hospital setting has important implications on the economic, social and disability burden in South Africa (Bryer *et al.*, 2010) and those with stroke in the public hospital setting may face greater socioeconomic barriers to accessing comprehensive stroke rehabilitation services leading to poorer outcomes (Avan *et al.*, 2019; Akinyemi *et al.*, 2021).

2.4.1.2 *Sex*

Globally, females are at higher risk of stroke than males, 53% and 47% respectively (Feigin *et al.*, 2022), with reasons for this being linked to pregnancy, oral contraceptive use, hormonal replacement therapy, menopause and shared risk factors such as hypertension, atrial fibrillation and type 2 diabetes conferring a greater risk of stroke in females than males (Roy-O'Reilly and McCullough, 2018). This disparity between sex appears to be echoed in the South African population with findings of similar frequencies of females to males affected by strokes (Ranganai and Matizirofa, 2020; Tribelhorn, Motara and Lewis, 2021), reflecting that the sex-based differences in stroke risk are consistent across diverse populations and healthcare contexts.

2.4.1.3 *Race*

There have been key differences in stroke incidence between racial groups. In South Africa, black stroke patients are on average ten years younger than white patients (Connor, Modi and Warlow, 2009; Tribelhorn, Motara and Lewis, 2021), which is in keeping with a study performed in London which found that black stroke patients were approximately eight years younger than white stroke patients with reasons given being higher prevalence of certain risk factors, genetic susceptibility and socioeconomic status, however, even after controlling for all known factors, black patients still showed an increased incidence of stroke at younger ages, leaving differences not fully explained and suggesting further research is needed into whether systemic inequalities and social determinants could be at play (Markus *et al.*, 2007). With the similarities in stroke incidence in younger populations in both South Africa and London, it could be reflected that despite geographical and socioeconomic differences, the black population's increased risk of stroke at a younger age remains consistent, further supporting the need to investigate systemic factors beyond traditional risk factors. Other differences in incidence of stroke related to race included black patients experiencing twice the number of intracerebral haemorrhages than white patients and a higher number of white patients with ischemic heart disease as a cause of stroke (Connor, Modi and Warlow, 2009) corroborating the findings of the London study in that different races experience different risk factors resulting in different stroke types.

2.4.2 Clinical profile

2.4.2.1 *Stroke types*

According to a systematic analysis for the Global Burden of Disease (GBD) study performed in 2019, globally, ischaemic stroke accounted for 62% of strokes in 2019, whereas, haemorrhagic strokes accounted for 38% (Johnson *et al.*, 2019) and this large difference in incidence could be because of the multiple mechanisms that could lead to ischaemic stroke such as thrombosis, embolism, small vessel occlusion and hypoperfusion versus haemorrhagic strokes which have fewer mechanisms, being mainly vessel rupture or aneurysms. Studies performed in the South African population showed similar incidence with ischemic strokes having a higher prevalence than haemorrhagic strokes (Connor, Modi and Warlow, 2009; Tribelhorn, Motara and Lewis, 2021) suggesting that stroke type is not dependent on geographical or socioeconomic differences. Within the South African context, patients with haemorrhagic stroke were on average eight years younger than those with ischemic stroke and males were more likely to experience haemorrhagic stroke (Tribelhorn, Motara and Lewis, 2021). These stroke type differences may have implications for walking recovery, potentially influencing rehabilitation strategies and outcomes and this will be explored in sections to come.

2.4.2.2 *Risk factors*

The leading causes of stroke globally and in Sub-Saharan Africa in 2019, were hypertension, high BMI, diabetes, air pollution and smoking (Feigin *et al.*, 2021). Within South Africa, Hypertension, diabetes, hyperlipidaemia, tobacco and alcohol use, and family history of stroke are the most common risk factors (Connor, Modi and Warlow, 2009; Ranganai and Matizirofa, 2020) showing a similarity with the risk factors globally and suggesting that socioeconomic differences don't necessarily lead to differing risk factors.

A risk factor important to the South African context yet not always discussed is HIV. HIV increases stroke risk through multiple mechanisms, including vasculopathy, coagulopathy and an increased likelihood of opportunistic infections (Tribelhorn, Motara and Lewis, 2021). Tribelhorn, Motara and Lewis, (2021) found HIV to be the third most common risk factor, with 12% of the 160 stroke patients having HIV, while Corbett *et al.*, (2022) found that stroke patients with HIV were younger (mean age 46 versus 55) and had a higher number of ischaemic strokes but clinically did not present significantly differently to stroke patients without HIV. This initial similarity in clinical presentation suggests that rehabilitation and functional outcomes for those with HIV-related strokes may be comparable to those with strokes unrelated to HIV, however, the impact of HIV on long-term recovery and walking rehabilitation outcomes requires further investigation.

2.4.2.3 *Presentation after stroke*

Clinical presentation after stroke is varied and depends on the location and extent of the cerebral damage (National Institute for Health and Care Excellence, 2023). Clinical features post-stroke include motor impairment resulting in hemiparesis or hemiplegia, sensory impairment, spasticity, dysarthria and dysphagia, visual impairments, aphasia, cognitive impairments, pain and fatigue (Markus, 2016; National Institute for Health and Care Excellence, 2023). Mobility is a significant functional challenge after a stroke with walking being impaired in up to 80% of patients (Tasseel-Ponche *et al.*, 2022) and 25% of stroke patients unable to walk independently at 3 months post stroke (Kennedy *et al.*, 2021).

2.5 Walking after stroke

Life after a stroke is often severely impacted, for those that have had a stroke and their loved ones. While stroke can impact various aspects of function including cognitive, emotional, and social domains (Singam *et al.*, 2015), the ability to walk is consistently reported as the most important goal for those affected by stroke (Krishnan *et al.*, 2017).

In this review, the term "walking ability" will be used to describe a person's capacity to ambulate and "ambulation" used when discussing formal classification systems as these terms are used by two pioneer studies around the development of ambulation categories (Perry *et al.*, 1995; Lord *et al.*, 2004).

2.5.1 Importance of walking

Most stroke patients express the desire to walk again as their primary goal (Bohannon, Andrews and Smith, 1998; Lord *et al.*, 2004; Krishnan *et al.*, 2017), however, the significance of regaining the mobility after a stroke extends beyond the physical act of walking. Research consistently shows that improvements in walking ability is strongly correlated with improvements in community participation, quality of life scores, and satisfaction with rehabilitation (Groenewald and Rhoda, 2017; Elloker *et al.*, 2018; Grau-Pellicer *et al.*, 2019).

A large consideration for stroke patients, their families and their interdisciplinary team is discharge destination (Chevalley *et al.*, 2023). Recent meta-analysis evidence published in 2023 aimed to discover what physical functional abilities were associated with a discharge home after inpatient stroke rehabilitation. The researchers analysed 45 studies which included 204 787 participants and found that higher independence with physical activities of daily living such as rolling, sitting, transferring, standing balance and walking, were directly correlated with a home discharge. The study also found that home discharge increased by 24% with just one additional point on the motor Functional Independence Measure scale. Finally, the researchers found a home discharge was more likely for participants admitted to inpatient rehabilitation with scores above 20 on the Berg Balance Scale or above 26 on the motor Functional Independence Measure scale (Chevalley *et al.*, 2023).

Knowing what functional abilities are associated with a home discharge enables health professionals to predict and plan discharge outcomes from admission. This knowledge could also provide evidence-based justification for extending rehabilitation stays when this might allow patients to achieve functional milestones strongly associated with home discharge. These findings underscore the practical importance of understanding and accurately predicting functional outcomes and walking ability after stroke, both for optimal patient care and efficient resource allocation (Bland *et al.*, 2012; Louie and Eng, 2018; Preston *et al.*, 2021).

2.5.2 Walking ability

Researchers have used different measures to assess walking, with walking speed the widely accepted measure to assess and categorise walking ability (Lord *et al.*, 2004).

Perry *et al.'s* (1995) seminal work classified walking abilities into categories and used walking speed and a self-reported walking ability questionnaire to define different levels of walking ability into six different categories which covered household and community walking. The authors found that of the 147 community-dwelling patients at least three-months after their strokes of varying aetiologies, the mean velocity of the highest category of community walker was 0.80m/s while the limited community walker groups had the minimum walking speed of 0.40m/s, those walking with speeds of under 0.40m/s were limited to household walking. It was from this research that the categories of full community (>0.80 m/s), limited community (0.40–0.80 m/s) and home ambulation (<0.40 m/s) were formed (Perry *et al.*, 1995). The mean age of Perry *et al.*'s (1995) study participants was 55.5 years which is significantly younger than current demographics with 88% occurring after 65 years old (Avan *et al.*, 2019), this may show a trend within the community that participants were living, or it may be indicative of demographics of stroke in 1995 versus now. While this is a pioneer study, there are significant limitations. The lack of stroke type and severity render it difficult to generalise the findings. Additionally, Perry *et al.* (1995) warns against using walking speed as a sole measure of classifying walking ability. While walking speed was a significant discriminator between community and household walkers in the study by Perry *et al.* (1995), it was not able to strongly discriminate between the functional abilities of household walkers. Lastly, given the age of the study, there are concerns regarding relevance to today's climate; thus, while this study should be recognised as a pioneer study in walking ability research, needs to be analysed alongside newer research.

Walking speed has a direct correlation with the quality of life, with improved walking ability leading to significantly improved quality of life (Khanittanuphong and Tipchatyotin, 2017). Another pioneer study by Lord *et al.* (2004), an observational study based in New Zealand recruited 115 first-time or recurrent stroke patients who had been discharged from hospital. The first group who had undergone community physiotherapy were assessed within one week after discharge from community physiotherapy whereas the second group were more mobile and did not require community physiotherapy and were assessed within two weeks after discharge from hospital. The second group of higher mobility patients was included by researchers to explore whether those without motor impairment were able to and desired to participate in community ambulation. Both groups were observed to assess the importance of community ambulation to those post-stroke and the relation between community ambulation and other aspects of mobility. Participants in Lord *et al.'s* (2004) study had a mean age of 68.8 years old, following global statistics and a mean walking speed of 0.9m/s. The authors found that while 67% of the participants achieved at least 0.80m/s for walking speed which would classify them as full community walkers, 17% were not walking outside or only walking as far as the letterbox and were hesitant or unable to use public transport rendering them reliant on care-givers to access community through transportation, suggesting that ambulating in community requires more complex skills than walking speed alone. This study did not explore what additional skills people post-stroke would need to access the community, but this could be related to environmental challenges of community walking such as curbs, uneven terrains and crowded places; as well as cognitive skills and mood characteristics that improve participation. The limitations of this study include a homogenous sample of those post-stroke who returned home and did not include those who had lower functional abilities discharged to destinations with more support resulting in potentially skewed results.

This finding that walking speed does not always equate to functional mobility has been reinforced by more recent literature which has found that walking speed is a clinical measure that is not necessarily able to differentiate walking ability in real-world scenarios and possibly overestimate the higher walking levels ability corroborating the finding that walking speed is not sufficient as a sole indication of walking ability and that walking is a complex task that requires far more than speed alone (Bansal *et al.*, 2024).

2.6 Factors that influence and predict walking ability

Many factors influence and predict walking ability after a stroke, from demographic characteristics such as age and sex, stroke-specific features such as type of stroke, to clinical variables such as pain which may limit engagement and movement and physical impairments, such as spasticity, sensory, coordination, motor impairments which may impede the ability to engage in rehabilitation and the high intensity of repetitions required to improve motor function (Liao *et al.*, 2021; Preston *et al.*, 2021). By determining reliable predictors, healthcare workers would be able to set evidence-based goals with patients and families, make informed discharge planning decisions, justify rehabilitation funding and resources, and contribute to healthcare policy development (Preston *et al.*, 2021).

While the unique nature of South Africa's stroke epidemiology has been covered, there is a lack of research into predictors of stroke outcomes specific to the population. Although research into predictors of activities of daily living, community participation and functional outcomes exists, no specific research into predictors of walking abilities after stroke exists. The following subsections analyse specific predictors of walking ability that have been identified through research.

2.6.1 Walking

Walking parameters, particularly speed, represent some of the most studied predictors of walking outcomes after stroke. Several studies have investigated how initial walking measurements might predict later walking ability.

Bland *et al.* (2012), extracted two separate samples from patient records from rehabilitation databases that collect records from multiple rehabilitation services. The first sample contained 110 records and was used to generate the predictive model. The second sample contained 159 records and was used to validate it. Outcome measures measured on admission to the inpatient rehabilitation unit, relevant to this literature review, included the FIM walk item, the Berg Balance Scale and the 10m walk test, the 10m walk test was then repeated on discharge with the results used to classify walking ability. The results showed that participants on admission had a median speed of 0m/s and 0.5m/s on discharge and participants with low scores for both the BBS and FIM walk item on admission only achieved household ambulation on discharge. Bland *et al.*'s (2012) mean discharge speed was significantly lower than the 0.9m/s achieved in Lord *et al.*'s (2004) study, and this could possibly be due to different time periods, the inclusion of the higher mobility participants with no motor impairments in Lord *et al.*'s (2004) study and Lord *et al.*'s (2004) study only assessing participants discharged to home, most of whom would have had better mobility outcomes than those who did not return home whereas Bland *et al.*'s (2012) study's patients were still inpatient and would have had a broader range of functional ability. The participants who achieved community ambulation on discharge had a larger range of BBS scores and/or FIM walk item scores. The authors concluded that with their findings they were able to formulate a clinical decision rule that clinicians can use to predict that those with a FIM walk item score of one to two and a BBS of ≤20 on admission to an inpatient rehabilitation unit will be unlikely to achieve more than household ambulation on discharge. The importance of the FIM as a strong predictor of functional outcomes has been corroborated in another more recent study (Brown *et al.*, 2015), further supporting the use of Bland *et al.'s* (2012) rule of thumb for that uses FIM to predict walking post stroke.

Louie and Eng (2018), aimed to identify what variables on admission to an inpatient rehabilitation unit can predict walking ability on discharge and to establish BBS cut-off scores to predict walking ability. They used data from a randomised control trial with 123 participants who were assessed on admission, four weeks post-discharge, as well as six and 12 months post-stroke. The independent variables collected were the type of stroke, the 5MWT, the MMSE, the BBS, a stroke severity scale and a depression scale. The primary outcome was a 5MWT four weeks after discharge from which participants were classed as community ambulators if they were able to ambulate at 0.80m/s or faster. The results showed a strong correlation between BBS and the 5MWT when analysing all the independent variables' relationships with achieving community ambulation and thus the authors created two parallel multivariate analyses to analyse the two variables independently. They found that walking speed on admission was a significant predictor of achieving community ambulation.

Liao *et al.* (2021), explored the relationship between clinical variables on admission and community ambulation among 120 post-stroke participants on discharge from an inpatient rehabilitation unit. They also aimed to create admission BBS cut-off scores to predict walking ability on discharge. The independent variables collected on admission included the BBS, the 5m Walk Test (5MWT), the MMSE, and the Mini Nutritional Assessment. Demographic characteristics were also collected and analysed. The primary outcome of the study was community ambulation on discharge, with community ambulation classified as those able to achieve ≤205m during the 6m Walk Test (6MWT) and those under 205m being household ambulators. The authors used a univariate analysis and found that the 5MWT, the BBS and age were significantly associated with the community ambulators. They then used a multivariate logistic regression model to predict community ambulation on discharge and faster walking speed was no longer significant, with the only significant predictor being balance on admission. This may indicate that balance is a better predictor of walking ability than walking speed.

2.6.2 Balance

While walking parameters provide valuable predictive information, research suggests that balance may be an equally, if not more important, predictor of walking outcomes after stroke.

Preston *et al.* (2021), analysed 15 studies comprising 2344 participants to find predictors of independent walking at three, six and 12 months for people who are not walking a month after stroke. Sitting balance was measured using the Trunk Control Test in four studies and the trunk impairment scale in one study, data regarding sitting balance was pooled together from five studies with a total of 350 participants. Good sitting was found to be a predictor of independent walking. Those with good sitting balance by 17 days after stroke were 7.9 times more likely to walk independently at three months than those with poor sitting balance and those with good sitting balance by five days were 19.1 times more likely to walk independently by six months. Earlier recovery of sitting balance (five days) was surprisingly associated with a later return to independent walking (six months), though the authors do not elaborate on this finding. Two explanations for this finding could be that patients who recovered sitting balance earlier experienced a rapid recovery in the acute phase that subsequently plateaued, while the patients who experienced a slower return to sitting balance maintained a steady recovery and achieved independent walking by three months. It is also possible that earlier versus later sitting recovery influenced the intensity of therapeutic intervention resulting in different timelines for walking recovery.

Louie and Eng's (2018), retrospective study used multivariate analyses to identify the relationship between balance and walking ability. The authors found that greater balance was associated with achieving both community walking and unassisted walking. They also established BBS cut-off scores needed on admission to predict these achievements, with a cut-off score of 29 needed to predict community ambulation and 12 to predict unassisted walking.

Similarly, Liao *et al.* (2021), found that BBS was a significant predictor of community ambulation on discharge from an inpatient stroke rehabilitation unit. The authors also explored cut-off scores for BBS scores on admission to predict community ambulation on discharge and they established a cut-off score of 29. This cut-off value was the same as the cut-off score established by Louie and Eng (2018), despite differences in the studies.

2.6.3 Cognition

While physical measures like balance and walking ability are strong predictors, cognition plays an important role in regaining the ability to walk after a stroke. Post-stroke cognitive impairments commonly include deficits in executive function, attention, memory, processing speed, and language comprehension, all of which can significantly impact rehabilitation through reduced comprehension of therapy tasks, decreased attention to task, impaired motor learning and planning and increased fall risk (Lingo VanGilder *et al.*, 2020). Furthermore, cognitive impairments are often associated with more severe stroke, with patients with cognitive impairments being less likely to be selected for rehabilitation resulting in less therapeutic input (Preston *et al.*, 2021).

Preston *et al.'s* (2021) systematic review combined data regarding cognition from three studies of 457 participants. Cognition was measured in these studies using the mini-mental state examination or by the presence of cognitive disorders. Those without cognitive impairment at 19 days post-stroke were 3.5 times more likely to walk independently three months post-stroke than those with cognitive impairment. There was insufficient data available to explore the relationship between cognition and independent walking at six months.

Louie and Eng's (2018) study showed similar findings with their participants with higher cognitive scores, measured with the MMSE, being significantly ($p<0.05$) more likely to achieve the walking speed required for community ambulation. The authors also explored the relationship between cognition and unassisted walking, and while they say that when analysing data with the univariate logistic regression cognition was significantly associated with walking outcome, they state the p-value was <0.25, which would not be considered statistically significant. Despite this mixed finding, the overall evidence suggests cognition is a strong predictor of community ambulation.

2.6.4 Pain

While factors such as walking, balance and cognition have been extensively studied as predictors of walking ability, pain represents an important yet often overlooked area in stroke research and rehabilitation that can significantly impact functional outcomes (Harrison and Field, 2015). Pain after stroke can present as many different types of pain, including central post-stroke pain, musculoskeletal pain, complex regional pain syndrome, post-stroke headaches, and spasticity related pain. This expansive presentation of types of pain is further complicated by a change in experience of pain and sensation after stroke (Harrison and Field, 2015; Köseoğlu *et al.*, 2017; Westerlind *et al.*, 2020).

No studies could be found that studied pain as a predictor of walking ability at the time that this literature review was conducted. The diversity and complexity of post-stroke pain presentations may explain why pain has been understudied as a predictor of walking recovery, and the difficulty would be further compounded by the challenges in assessing subjective pain especially in patients with speech and cognitive impairments. Despite this, pain remains an important consideration post-stroke, with 11-66% of stroke patients experiencing some form of regular pain and up to 70% of those experiencing pain daily (Harrison and Field, 2015)

In a study that recruited people 5 years after their stroke, 271 participants were asked about their pain levels. Of the participants, 15% had frequent pain described as “always” or “often”. These 15% of participants experienced significantly higher levels of depression and lower levels of mobility than those who did not have frequent pain and on the self-reported health status and stroke recovery scales, those who had frequent pain scored themselves significantly lower than those with less frequent pain. The authors also found that those who were functionally dependent on discharge post-stroke were 2.4 times more likely to experience more frequent pain five years after their stroke (Westerlind *et al.*, 2020).

Köseoğlu *et al.* (2017), looked at the impact of lower extremity pain conditions in patients with stroke. They recruited 185 participants with self-reported lower extremity pain and collected data on pain with the visual analogue scale (VAS) and the characteristics of the experienced pain, as well as demographic and clinical variables which included a motor assessment, walking ability assessed using the Functional Ambulation Category (FAC), spasticity, cognition (MMSE), depression, health-related quality of life, and activities of daily living measured with the Barthel Index which includes an assessment of walking on a level surface and due to the limited research on pain predicting walking ability, results related to this will be included. Of the 185 participants, 69% presented with lower extremity pain and 71% experienced moderate to severe pain. Of those with lower extremity pain, 40% described walking as an aggravating factor and 47% found rest to be a relieving factor. The only pain characteristic that was a significant predictor of ambulation status was the onset of pain (before or after the stroke), however, the authors don't elaborate on whether ambulation status was impacted by pain that began before or after the stroke. The intensity of pain was the only pain characteristic that was significantly associated with activities of daily living, measured by the Barthel Index.

It is evident that pain impacts functional abilities post-stroke but due to the limited research, a conclusion cannot be drawn as to whether a stroke survivor's experience of pain or lack thereof can predict their walking ability.

2.6.5 Age

In contrast to the limited research on pain as a predictor, age is one of the most widely studied demographic factors potentially influencing walking abilities after a stroke, with younger patients post-stroke demonstrating superior recovery potential because their brains are less susceptible to secondary atrophy, show better structural integrity of residual brain regions, experience a greater rate and extent of recovery attributed to improved reorganisation of neural networks and creation of alternative pathways for recovery of impaired functions (Liew *et al.*, 2023).

Younger age is a predictor of independent walking at three and six months post-stroke (Preston *et al.*, 2021). The studies included in the review measured age continuously or categorised into younger or older than 50, 64, and 70. Age-related data from eight studies with 896 participants was collected and examined. Younger age participants were 3.4 times more likely than older participants to regain independent walking at three months and were 2.1 times more likely to regain independent walking at six months (Preston *et al.*, 2021). A shortcoming is that the authors do not expand on what they have classified younger and older age to be from all the data they have pooled together. Similarly, Kennedy *et al.* (2021) using data from 2,104 participants in an international stroke rehabilitation trial (AVERT) found that older age was one of the factors associated with longer time taken to achieve 50m unassisted walking.

Liao *et al.* (2021) used univariate analysis to determine the relationship between variables on admission and community ambulation on discharge. A younger age was found to be associated with community ambulation on discharge, however, once the authors analysed the data further with a multivariate logistic regression, age was no longer associated with community ambulation. This is a finding that is at odds with other research as a younger age is commonly predictive of improved functional outcomes, a possible reason for this occurring could be shared variance with age being correlated to balance which is the stronger predictor in this sample.

Similar to Liao *et al.'s* (2021) findings, Louie and Eng (2018) found that while age was initially moderately associated with community ambulation using univariate analysis, once multivariate analysis was performed, no association was found.

2.6.6 Sex

Like age, sex is another demographic factor that has been studied as a potential predictor of walking recovery after stroke, however, walking ability is not influenced by sex in any of the studies reviewed in this literature review (Louie and Eng, 2018; Kennedy *et al.*, 2021; Liao *et al.*, 2021; Preston *et al.*, 2021) suggesting that recovery of walking ability is not dependent on the biological differences between sexes.

2.6.7 Type and region of stroke

Moving from the demographic variables of age and sex to diagnostic variables of stroke, research has investigated whether the type and region of stroke can predict walking ability post-stroke.

Preston *et al.* (2021) found no association between the type nor side of stroke and independent walking at three months and there was insufficient data to explore this association at six months. However, the authors did find a strong association between an intact corticospinal tract and independent walking at three months, with patients with the integrity of the tract maintained being 8.3 times more likely to achieve independent walking at three months than those without an intact corticospinal tract. The integrity of the corticospinal tract was measured with transcranial magnetic stimulation, however, only two studies in the systematic review collected this data and therefore they had a low sample size of 45 participants.

Louie and Eng (2018), found a strong association between haemorrhagic stroke and achieving community ambulation, with no association between type of stroke and achieving unassisted walking. However, Kennedy *et al.* (2021), found that those with haemorrhagic stroke took longer to achieve 50m unassisted walking, possibly due to differences in acute management, haemorrhagic strokes often presenting with worse clinical status and severity in the acute phase and different initial healing processes, but by three months there was little difference in walking ability between those with haemorrhagic versus ischaemic stroke (Salvadori *et al.*, 2021). This finding is in keeping with recent evidence which demonstrates that when severity of stroke is matched and patients are given equal access to rehabilitation, recovery from haemorrhagic and ischaemic stroke is similar (Iqbal, Bhat and Melam, 2024). Kennedy *et al.* (2021) also found that right hemisphere strokes showed a longer time to achieve 50m unassisted walking than left hemisphere strokes and the authors hypothesised that this was due to the impairments of perceptual disturbances and neglect, characteristic of right hemisphere strokes.

2.6.8 Other predictors

While the above predictors are the primary focus of this literature review, studies have identified other variables that may influence walking ability after a stroke.

An association between continence and independent walking has been found. Preston *et al.*, (2021) pooled continence data from four studies with a total of 570 participants where continence was measured with the FIM bladder sub-score of more than five, the Barthel Index bladder sub-score of less than two, and observable urine leakage. From this data, it was found that those with continence at 18 days post-stroke were 2.3 times more likely to walk independently at three months than those who were incontinent at 18 days post-stroke. Continence was also found to predict independent walking at six months with stroke patients who were continent at six days post stroke being 13.8 times more likely to achieve independent walking at six months. The authors reason that incontinence is associated with more severe stroke thus it may be stroke severity rather than continence that predicts walking outcomes.

Kennedy *et al.* (2021) found that some comorbidities were linked to walking outcomes while others were not, with diabetes showing strong association with delayed time to achieving walking 50m unassisted with authors speculating that this could be due to the impact of chronic complications associated with diabetes such as peripheral neuropathy, whereas hypertension, ischaemic heart diseases, hypercholesterolemia, atrial fibrillation and thrombolysis were not associated with walking outcomes and this lack of association may be explained by these conditions primarily affect cardiovascular function rather than the neurological systems directly involved in walking control.

Another strong association was found between time since stroke and achieving both community ambulation and unassisted walking which authors found unsurprising as neurological recovery is in part dependent on time (Louie and Eng, 2018). This relationship reflects the underlying mechanisms needed for recovery, including time needed for resolution of diaschisis, reduction of cerebral oedema, renewed circulation to ischaemic area if applicable and the gradual formation of new neural pathways through the process of neuroplasticity (Dey *et al.*, 2024).

2.7 Conclusion

This review has highlighted the global burden of stroke and its impact on low to middle-income countries, including South Africa. This is evidenced by South Africa's overall stroke incidence rate being slightly higher than the global rate, with significantly higher incidence rates in the rural areas.

The demographic profile of stroke in South Africa highlights important trends. While the mean age of stroke patients across both public and private hospitals is on par with the global mean age, stroke patients in public hospitals are significantly younger, reflecting the socioeconomic disparities in South Africa affecting stroke onset. The disparities extend into race, with a significantly younger age of onset in black patients compared to white patients. The key risk factors for stroke in South Africa show both common and context-specific factors. While hypertension and diabetes are key risk factors globally, HIV is a significant risk specific to the South African context.

Walking after a stroke has consistently been identified as patients' primary goal and significantly affects community participation and quality of life. Researchers have used walking speed to categorise walking abilities into meaningful functional categories and while this has proved useful, there are limitations to using walking speed and thus it should not be used as the sole indicator of walking ability. Several key predictors of walking ability have been identified, with varying levels of evidence strength. Balance is a particularly strong predictor, potentially more significant than initial walking parameters. Cognition demonstrated an important predictive value, especially for community ambulation. While age showed some predictive value, findings were inconsistent across studies. Pain, although potentially significant and prevalent in people post-stroke, remains understudied as a predictor. Notably, this review has found a large gap in research around predictors of walking ability within the South African context.

These findings have important implications for stroke rehabilitation in South Africa. Given that South Africa has a higher incidence of stroke with context-specific risk factors, the need for rehabilitation approaches tailored to the South African population is evident. Understanding predictors of walking ability will help make evidence-based decisions about rehabilitation, set realistic goals and optimise resource allocation and discharge planning. Future research is needed to address the under-studied areas identified in this review, particularly the role of pain in walking recovery and the long-term outcomes of walking ability beyond the typical three to six-month study period. Additionally, more South African research is needed to better understand how the demographic and clinical profile of people with stroke in this context influences stroke outcomes and specifically, walking ability.

Chapter 3 Methods

3.1 Study Design

This study is a quantitative, retrospective record review conducted at an inpatient sub-acute hospital setting in Centurion, Gauteng.

3.2 Study Setting

The 50-bed hospital provides high-care, sub-acute and rehabilitation services to orthopaedic, neurological, ventilated and medically complex patients, with an on-site general practitioner doctor and full nursing care. Patients admitted for neurological rehabilitation, are generally referred from acute hospitals in the Gauteng province and are seen daily by physiotherapists, occupational therapists, therapy assistants and as needed, speech and language therapists, neuropsychologists, dieticians and social workers. This hospital was used as the source for the records due to it being a site of convenience for the primary investigator who was employed there. Despite this employment relationship, no bias was introduced into data collection or reporting. All data was extracted by the primary investigator from routine clinical assessments using predetermined inclusion criteria, and the employment relationship did not influence the objective reporting of results.

While data was collected exclusively from this inpatient sub-acute hospital setting, patient records contained information about their previous acute hospital care length of stay, which was included in the analysis as it may influence rehabilitation outcomes.

3.3 Participants

3.3.1 Source of Participants

Hospital records were sourced from the inpatient sub-acute hospital setting in Centurion, Gauteng. Records between the period of June 2017 to June 2021 were analysed, with this time period chosen in accordance with when the therapy teams in the sub-acute hospital set a batch of outcome measures to routinely use in stroke. Admission and discharge information was reviewed for all participants with a diagnosis of stroke.

3.3.2 Sample Size

The full number of files available to the research were reviewed between the set time period. Two-hundred and sixteen records had patients with the diagnosis of stroke and of those 48 records met the inclusion criteria and were included in the analysis.

3.3.3 Sample Selection

Table 3.3.3. 1 Inclusion and exclusion criteria of the participants

Inclusion criteria	Exclusion criteria
Primary stroke diagnosis.	Transferred back to acute care.
First-time stroke.	Discharged against medical advice.
Age range of 18-70 years.	Died during hospital admission.
Walking ability lower than full community (walking speed of <0.80m/s) on admission, including those who are non-ambulatory and those requiring either physical assistance and/or an assistive device.	Presence of physical walking-limiting impairments (e.g., amputation, lower limb fracture) pre- or post-stroke.
Admitted anytime from June 2017 to June 2021 (discharged by June 2021).	Files with incomplete data for the primary outcome measure and/or incomplete data for three or more of the secondary outcome measures.

The inclusion and exclusion criteria were designed to ensure a homogeneous population where walking limitations were due to stroke-related factors, allowing for identification of predictors of walking ability on discharge from an inpatient sub-acute hospital. Primary stroke diagnosis and first-time stroke criteria ensured participants had neurological impairment specifically related to cerebrovascular events without the confounding effects of multiple strokes or other neurological conditions. The age range of 18-70 years excluded paediatric populations which are not admitted into this sub-acute hospital while avoiding age-related comorbidities and frailty in older adults that could impact walking ability and rehabilitation outcomes. Including only participants with walking ability lower than full community speed (<0.80m/s) on admission ensured all participants had walking impairments requiring rehabilitation intervention, allowing for identification of clinically relevant predictors. The timeframe of June 2017 to June 2021 provided sufficient time to gather an adequate sample size while ensuring consistency in rehabilitation assessment tools. Exclusion criteria were equally important for maintaining study validity: participants transferred back to acute care were excluded due to medical instability that would impact walking ability. Those discharged against medical advice were excluded to ensure discharge assessments were completed and deaths during admission were excluded for the same reason. Physical impairments unrelated to stroke that impacted walking ability, (amputation, fractures), were excluded to isolate stroke-specific predictors and participants with incomplete primary outcome data or substantial missing secondary measures were excluded to ensure adequate statistical analysis and maintain the integrity of the predictive model, as incomplete data could bias results and reduce the reliability of identified predictors.

3.4 Instrumentation and Outcome Measures

The primary outcome measure was walking speed (10 Meter Walk Test), and the secondary outcome measures were balance (Berg Balance Scale), mobility (Timed Up and Go), pain (Numeric Pain Rating Scale), functional lower extremity strength (Five Times Sit to Stand Test), cognition (Mini-Mental State Examination), and functional ability (Functional Independence Measure). All outcome measures can be found in the Appendices (Appendix B-G).

Due to many participants being unable to complete the various tests on admission and discharge due to the tests not being indicated, to allow the use of this data in the analysis, for tests that standardised interpretations, scores were put into categories that followed the interpretations and for tests that were time based, scores were put into the following categories created by the investigator: not indicated, 0-15 seconds, 16-30 seconds, 31-45 seconds, 45-60 seconds and more than 61 seconds. These time intervals were chosen to provide meaningful clinical distinctions in functional performance levels while ensuring adequate distribution of participants across categories for statistical analysis. This will be indicated under the outcome measures below.

3.4.1 10 Meter Walk Test

The Ten Meter Walk Test (10MWT) determines walking speed in meters per second over a short distance. This data was used to classify the patient's walking ability into full community, limited community and home ambulation (Perry *et al.*, 1995). Within the stroke population, the tool has excellent intrarater (ICC=0.87-0.88) (Collen, Wade and Bradshaw, 1990), and interrater (ICC=0.998) (Wolf, Catlin and Robertson, 1999) reliability and excellent criterion validity when correlated with the Barthel Index (r=0.78) (Tyson and Connell, 2009), and excellent construct validity when correlated with the Berg Balance Scale (p=0.0004) (r=0.627) (Wolf, Catlin and Robertson, 1999).

3.4.2 Berg Balance Scale

The Berg Balance Scale (BBS) is a 14-item tool that assesses balance and the risk of falling in the adult population. Item scores range from 0-4 and the maximum score is 56, with higher scores indicating increased balance abilities. Within the stroke population, the tool has shown excellent intrarater (ICC=0.98) and interrater (ICC=0.97) reliability (Alghadir *et al.*, 2018); excellent internal consistency (Cronbach's alphas=0.92-0.98) (Mao, Hsueh and Tang, 2002); and excellent criterion validity when correlated with the 10MWT (r=0.81) (Wang *et al.*, 2004).

3.4.3 Timed Up and Go

The Timed Up and Go is used to assess mobility and the risk of falling in elderly people, it involves a person moving from sitting to standing, walking three metres, turning and walking back to the chair and sitting down and is measured in seconds. The tool has shown excellent test-retest reliability in patients with stroke (ICC=0.96), and while there is limited evidence of a correlation between the TUG and 10MWT, there is an excellent criterion validity correlation between the TUG and the 6-meter walk test (r=0.92) within the stroke population (Flansbjer *et al.*, 2005). Participants results from the TUG test were allocated into the categories: not indicated, 0-15 seconds, 16-30 seconds, 31-45 seconds, 45-60 seconds and more than 61 seconds.

3.4.4 Numeric Pain Rating Scale

The Numeric Pain Rating Scale (NPRS) is a self-report tool used to subjectively assess the intensity of pain experienced, scoring pain on a scale from 0-10 with higher numbers indicating more pain. There is limited evidence on reliability and validity in the stroke population, however, a small study showed that there are consistent results observed when comparing various self-reporting pain scales within the stroke population and their study recommended clinical use of the NPRS within the stroke population (Mandysová, Nedvědová and Ehler, 2017). Within a healthy population aged 65-94 years, the NPRS has been found to have 100% interrater reliability, excellent internal consistency (Cronbach's alpha= 0.87) and excellent construct validity (r= 0.95) (Herr *et al.*, 2004). Pain after stroke has also been shown to have a significant correlation (p= 0.009) with restricted mobility (Westerlind *et al.*, 2020) and thus could have an impact on walking speed. Participants results were allocated into the following categories (scores for each category in brackets): not indicated, none (0), mild (1-3), moderate (4-6), and severe (7-10).

3.4.5 Five Times Sit-to-Stand Test

The Five Times Sit-to-Stand Test (5TSTS) is a functional measure of lower extremity strength and assesses the transitional sit-to-stand movement, with the time taken to perform five sit to stands measured in seconds. It has excellent intrarater (ICC= 0.97) and interrater reliability (ICC= 0.999); as well as excellent criterion validity when correlated with affected and unaffected knee flexor strength (r= -0.753; -0.830 respectively) in the stroke population (Mong, Teo and Ng, 2010). Participants results from the 5TSTS test were allocated into the categories: not indicated, 0-15 seconds, 16-30 seconds, 31-45 seconds, 45-60 seconds and more than 61 seconds.

3.4.6 Mini-Mental State Examination

The Mini-Mental State Examination (MMSE) is a short screening tool that can be used to test for cognitive impairments, it uses a 0-30 point scoring system with higher scores denoting less impairment. It has been shown to have internal consistency indicated as Cronbach's alpha of 0.60 (Toglia *et al.*, 2011). Louie and Eng, (2018) found that higher MMSE scores correlate with a higher chance of achieving community ambulation. Participants results were allocated into the following categories (scores for each category in brackets): not indicated, mild (21-24), moderate (10-20), and severe (0-10).

3.4.7 Functional Independence Measure

Lastly, the Functional Independence Measure (FIM) is a tool used to measure the level of disability by assessing the amount of assistance required to complete functional tasks. The tool contains 18 items, 13 motor tasks and 5 cognitive tasks. Each item is scored from 1-7, with higher scores indicating less assistance required. Total scores range from a minimum of 18 to a maximum of 126. It has shown excellent interrater (ICC=0.95) and test-retest reliability (ICC=0.95) (Ottenbacher *et al.*, 1996). Hsueh *et al.*, (2002) found that the FIM had excellent internal consistency on admission and discharge from an inpatient rehabilitation facility (Cronbach's alphas=0.88 and 0.91 respectively) as well as excellent correlation on admission and discharge between the FIM motor subscale and the Barthel Index (r= 0.92-0.94). While the outcome measure would have been purchased by the sub-acute hospital to allow for usage, no additional licencing is needed for retrospective analysis and write up of the data and the outcome measure is not included in the appendices due to licencing restrictions.

All data extracted from records was data that was routine for the diagnosis and management of the patients admitted to the hospital with neurological conditions. On the admission and discharge assessment, all the above outcome measures were performed if indicated and recorded by relevant therapists (physiotherapists, occupational therapists, speech and language therapists) employed by the sub-acute hospital. The data was extracted from the patient files and collated in a table format (Appendix H) by the researcher.

3.5 Procedure

3.5.1 Pilot Study

A pilot study was done following the same procedure as the main study to ensure the adequate functioning of the data extraction tool. Ten patient records were accessed, a code was allocated to each patient and de-identified data was collated in the data extraction tool and no adjustments were required. As no adjustments were required, these 10 records were added to the main study.

3.5.2 Main Study

Hospital records of an inpatient sub-acute hospital setting in Centurion, Gauteng, between the period of June 2017 to June 2021 were analysed by the researcher, with admission and discharge information reviewed for participants with the diagnosis of stroke. The records were accessed using the online platform where the records were stored.

3.6 Ethical Considerations

Ethical clearance was applied for and obtained from the University of the Witwatersrand Human Research Ethics Committee, m210805 (Appendix I). Permission to access the participants' data was obtained from the hospital (Appendix J). All participants' data was de-identified to ensure confidentiality. Any identifying codes were stored separately from the extracted data.

3.7 Data Reduction

The data was extracted from the patient files and collated in a table format by the researcher. Data was only extracted from files that met the inclusion criteria. To ensure confidentiality, all data was de-identified by allocating a code to each participant. The identifying codes were stored separately from the extracted data. Once all the data was captured, it was cleaned by checking for missing values, identifying outliers, and coding descriptive words with assigned numeric values. Collected data was recorded and analysed in Microsoft Excel and JASP 0.19.3.

3.8 Statistical Analyses

Data was analysed using Microsoft Excel and JASP 0.19.3, an open-source programme. Analysis was carried out in order of the objectives. A biostatistician was consulted to guide choice of appropriate statistical tests. Descriptive statistics included the demographic and clinical variables. For categorical data, frequencies and proportions are stated, for continuous data, the Shapiro-Wilk test was performed to determine distribution before analysing mean and standard deviation for normally distributed data and median and interquartile range for non-normally distributed data.

A univariate analysis was initially completed to determine associations between the demographic and clinical variables documented on admission and walking ability on discharge. Categorical data was analysed in contingency tables. Chi-squared tests were used for data where more than 80% of the expected cell counts were 5 or higher, and Fisher exact test was used if more than 20% or the expected cell count was less than 5. For continuous data, normality was first determined and from this, for normally distributed data, a p-value was obtained from the Student’s t-test, and for non-normally distributed data, from the Mann-Whitney test. Results were deemed significant when $p \leq 0.05$.

Following this, a multivariate binary logistic regression was performed to identify predictors of walking ability on discharge. The dependent variable was walking ability at discharge, with two categories being “not walking” or “walking” of which “walking” consisted of the participants that achieved walking speeds that placed them into the functional walking categories of home ambulation, limited community and full community. Predictor variables with p-values <0.25 were considered for inclusion in the multivariate analysis and additionally, clinically relevant variables were included regardless of the univariate significance if they were known to influence walking outcomes or if they improved model stability.

Using forward selection alongside clinical relevance, the logistic regression model was built to have an efficient, stable model with few variables due to the small sample size. First, the most significant variables (<.001) were entered, and then variables were added based on their clinical relevance and contribution to the model. Contribution to the model was assessed by the independent variables Wald test significance, the Odds Ratio and the 95% confidence interval. The model fit was assessed by analysing the Log-likelihood ratio test ($\Delta\chi^2$), Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) to compare models, with lower values indicating better fit and finally, deviance, where lower values also indicated better fit. The model's predictive capability was assessed by using Nagelkerke's R^2, and its discrimination ability was assessed using the Area Under the Receiver Operating Characteristic (ROC) curve (AUC), while multicollinearity among predictors was assessed by analysing Variance Inflation Factors (VIF), with values below 5 considered acceptable.

Table 3.8. 1 Data analysis

Objectives	Data	Statistical test
To establish the demographic and clinical profile of the participants admitted to a private inpatient sub-acute hospital for stroke rehabilitation.	Continuous data: − Date of stroke − Date of admission to acute hospital − Date of admission to the sub-acute hospital for rehabilitation − Date of discharge − Age − Outcome measures (10MWT, BBS, TUG, NPRS, 5TSTS, MMSE, FIM) Categorical data: − Sex − Area of stroke − Comorbidities	Descriptive statistics Continuous data: − Mean and standard deviation for normally distributed variables − Median and interquartile range for non-normal data. Categorical data: − Frequencies and proportion
To establish the functional walking ability of the participants upon discharge from a private inpatient sub-acute hospital.	Categorical data: Walking speed established from the 10MWT and allocated into the three categories (Full community, limited community, and home ambulation)	Descriptive statistics: Frequencies and percentage
To establish the factors that predict the functional walking ability of participants upon discharge from a	Analysis of the relationship between each variable and the discharge walking ability.	Univariate analysis: Categorical data: − Fisher exact test. − Chi-squared test Continuous data:

private inpatient sub-acute hospital.	Independent variables: Both categorical and continuous data Dependent variable: categorical	− Student's T-test for normally distributed data − Mann-Whitney test for non-normally distributed data. Multivariate logistic regression to determine predictive model

Chapter 4 Results

4.1 Introduction

The results from this study are presented in this chapter according to the study's objectives:

1. To establish the demographic and clinical profile of the participants admitted to a private inpatient sub-acute hospital for stroke rehabilitation.
2. To establish the functional walking ability of the participants upon discharge from a private inpatient sub-acute hospital.
3. To establish the factors that predict the functional walking ability of participants upon discharge from a private inpatient sub-acute hospital.

4.2 Objective one: Demographic and clinical profile

Of 216 patient records with the diagnosis of stroke, 48 records met the inclusion criteria and were included in the analysis. The demographic and clinical profile of these 48 patients are detailed in the tables below.

4.2.1 Demographic profile

4.2.1.1 *Age, sex and length of stay*

Table 4.2.1.1. 1 Demographical profile of participants

Variables	Levels	N=48 (%)	Median (IQR)
Age (years)			58 (63-46.5)
Sex	Male	31 (65)	
	Female	17 (35)	
Length of stay (days)	Acute		14.5 (26.5-9)
	Rehab		40.5 (56-28.8)
	Total		62.5 (76.5-42)

The distribution of ages of the participants can be seen below in Figure 4.2.1.1. 1 Age distribution of participants, which uses five-year age bins and shows the median age of participants. All participants were admitted to acute hospital on the same day as their stroke, with a length of stay in the private sub-acute hospital nearly three times longer than the stay in the acute hospital.

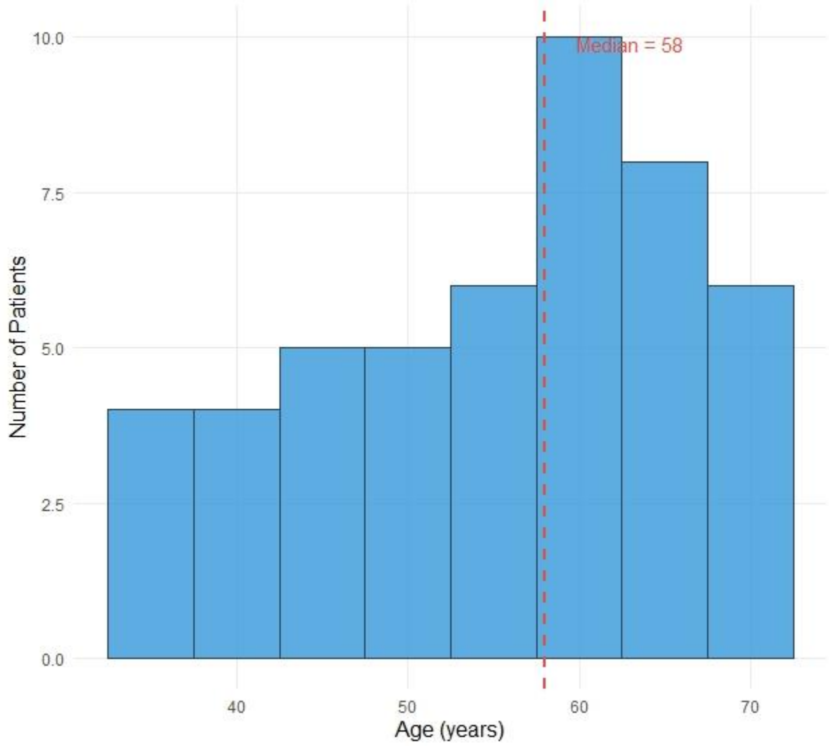


Figure 4.2.1.1. 1 Age distribution of participants

4.2.2 Clinical Profile

4.2.2.1 *Area of stroke*

Table 4.2.2.1. 1 Areas of stroke: frequencies and percentages

Variables	Levels	N=47	%
Areas of stroke	Left	20	43
	Right	24	51
	Other (bilateral, brainstem, multi-territory)	3	6

One participant was missing information on area of stroke. Most of the participants (n=24, 51%) sustained a right sided stroke, with 43% (n=20) experiencing a left sided stroke. The ‘other’ category included bilateral strokes, brainstem strokes and multi-territory strokes. These areas were consolidated into one category due to the low frequencies.

4.2.2.2 *Comorbidities*

Table 4.2.2.2. 1 Comorbidities: frequencies and percentages

Variables	Levels	N=48	%
Comorbidities	Hypertension	36	75
	Diabetes	10	21
	Hypercholesterolemia	9	19

	Epilepsy	8	17
	Atrial fibrillation	6	13
	Depression	3	6
	Anaemia	3	6
	HIV	2	4
	Renal disease	3	6
	COPD	1	2
	Parkinson's	1	2
	Hypotension	1	2

The five leading comorbidities were hypertension (n=36, 75%), diabetes (n=10, 21%), hypercholesterolemia (n=9, 19%), epilepsy (n=8, 17%) and atrial fibrillation (n=6, 13%). As seen in the pie chart below, Figure 4.2.2.2. 2, most patients had either one (n=16, 33%) or two (n=17, 35%) comorbidities and five (10%) participants had no comorbidities. The most frequent combinations of comorbidities were hypertension and hypercholesteremia (n=8, 19%), and hypertension and diabetes (n=8, 19%). Relevant to the South African population, only two (4%) participants were HIV positive, and both occurred in combination with hypertension.

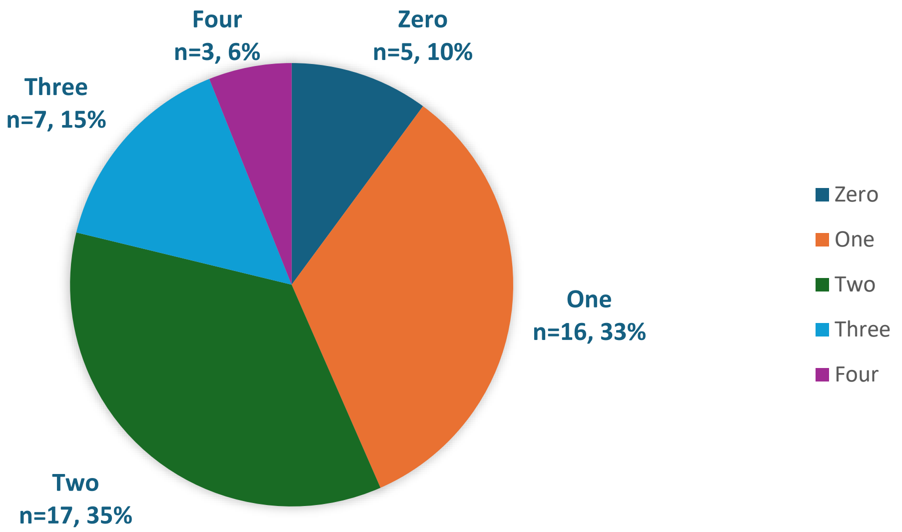


Figure 4.2.2.2. 1 Comorbidity burden: frequencies and percentages

4.2.2.3 *10 Metre Walk Test*

Table 4.2.2.4. 1 Primary outcome measure, 10 Metre Walk Test

Variables	Levels		N=48 (%),	Mean (SD)
10 Metre Walk Test (m/s)	Completed	Admission	13 (27)	
		Discharge	32 (67)	
	Not indicated	Admission	35 (73)	
		Discharge	16 (33)	
	Admission			0.32 (0.2)

	Discharge		0.73 (0.5)

On admission, 35 (73%) of the 48 participants were unable complete the 10MWT, as recorded in the files. Of the 13 (27%) participants that were able to complete the test on admission, the mean walking speed was 0.3 m/s (SD: 0.2). On discharge, most (n=32 66.7%) were able to complete the test with the mean walking speed 0.7 m/s (SD: 0.5). Sixteen (33%) were unable to complete the test on discharge.

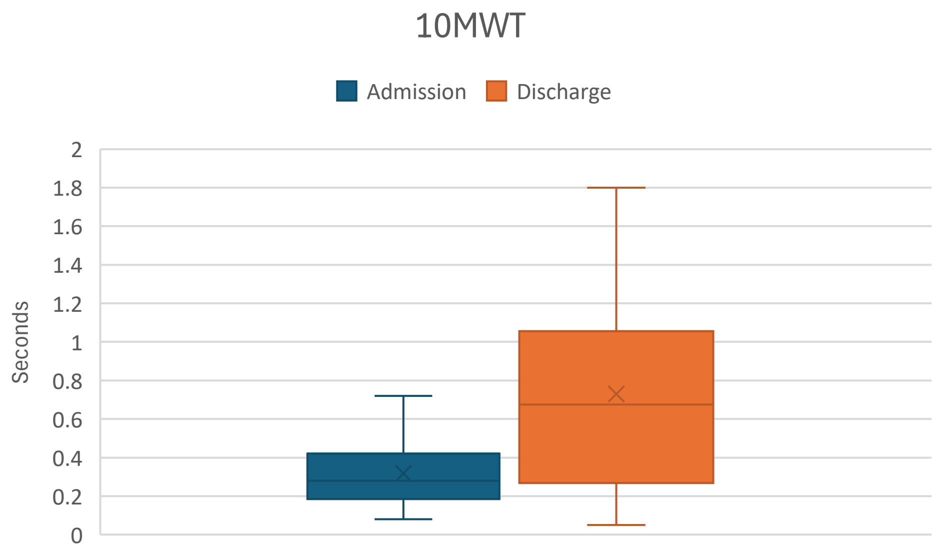


Figure 4.2.2.4. 1 Box and Whisker plot of admission and discharge 10 Metre Walk Test scores

4.2.2.4 *Berg Balance Scale*

Table 4.2.2.5. 1 Berg Balance Scale: median and interquartile range

Variables	Levels	Median (IQR)
Berg Balance Scale	Admission	3 (8-1)
	Discharge	38 (48-5.5)

Of the 48 patients, 47 had BBS scores completed on admission and discharge, for one patient, the outcome measure was not indicated due to a low level of consciousness. The median score on admission was three (IQR: 8-1) and on discharge, 38 (IQR: 48-5.5).

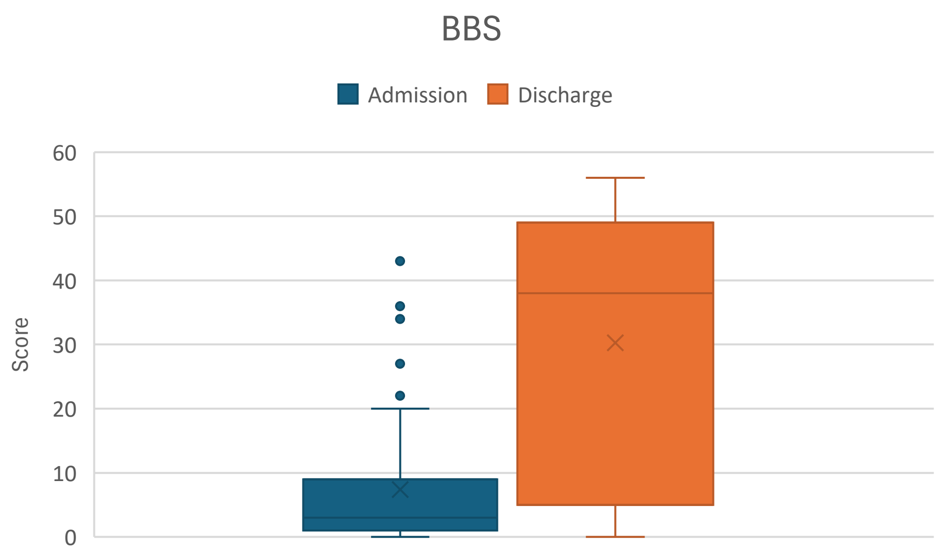


Figure 4.2.2.5. 1 Box and Whisker plot of admission and discharge Berg Balance Scores,

4.2.2.5 *Five Times Sit-to-Stand*

Table 4.2.2.6. 1 Five Times Sit-to-Stand: descriptive statistics

Variables	Levels (seconds)	Admission		Discharge		Median (IQR)
		n=48	(100%)	n=46	(100%)	
	Not indicated	37	77	17	37	
	0 – 15	1	2	13	28	
	16 – 30	4	8	15	33	
	31 – 45	3	6	1	2	
	45 - 60	2	4	0		
	> 61	1	2	0		
5 Times Sit to Stand	Admission					32 (43.8-27.2)
	Discharge					17 (21-13)

For the 5TSTS, there was missing data for two patients (4%) on discharge. On admission, the majority (n=37, 77%) of participants were unable to complete the 5TSTS test, on discharge, this number halved and only 37% (n=17) of participants were unable to complete the test.

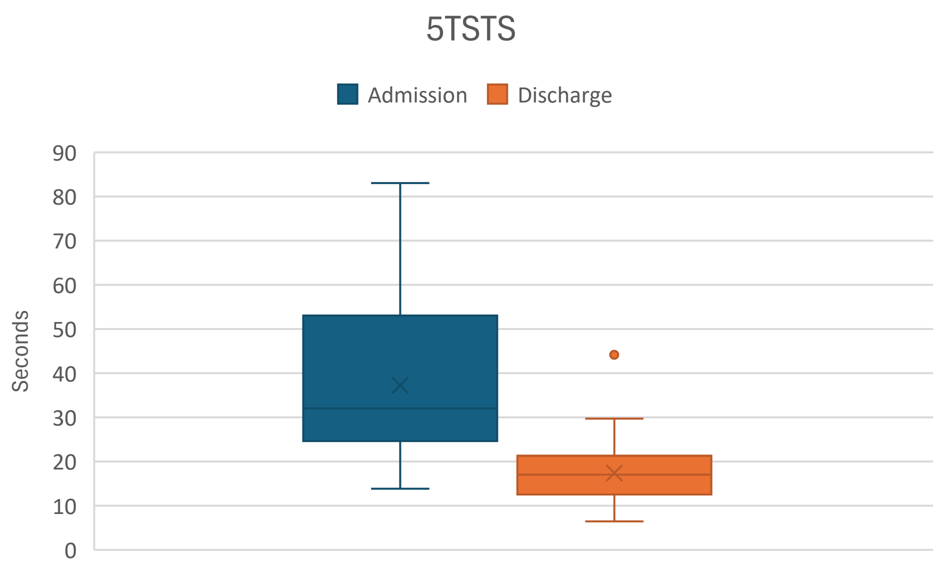


Figure 4.2.2.6. 1 Box and Whisker plot of admission and discharge 5 Times Sit to Stand scores

4.2.2.6 *Timed Up and Go*

Table 4.2.2.7. 1 Timed Up and Go: descriptive statistics

Variables	Levels (seconds)	Admission		Discharge		Median (IQR)
		n=41	(100%)	n=44	(100%)	
Timed Up and Go	Not indicated	34	83	18	41	
	0 – 15	1	2	9	20	
	16 – 30	1	2	9	20	
	31 – 45	2	5	1	2	
	45 - 60	1	2	4	9	
	> 61	2	5	3	7	
	Admission					38 (77-24.5)
	Discharge					21.6 (46.5-13.3)

Seven patients (15%) were missing data for the TUG test on admission and four (8%) on discharge. The TUG test was not indicated for most patients on admission (n=34, 83%), on discharge however, this number had halved and only 41% (n=18) were unable to complete the test.

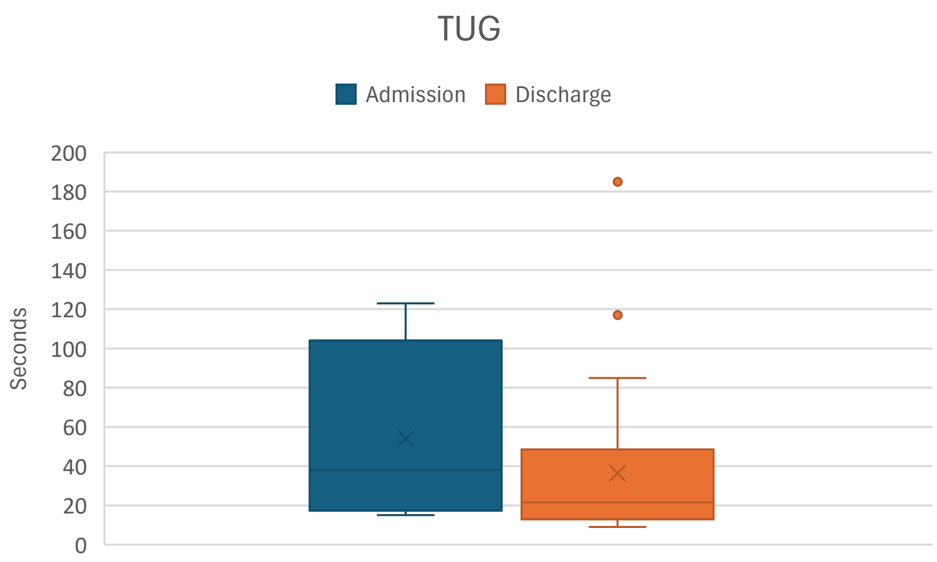


Figure 4.2.2.7. 1 Box and Whisker plot of admission and discharge Timed Up and Go scores

4.2.2.7 *Functional Independence Measure*

Table 4.2.2.8. 1 Functional Independence Measure: median and interquartile range

Variables	Levels		Median	IQR
Function Independence Measure	Self-care	Admission	16	20-11
		Discharge	29	36.3-21.8
	Sphincter control	Admission	4	7.8-2
		Discharge	12	14-6
	Transfers	Admission	5	7-3
		Discharge	14	17.3-9.8
	Locomotion	Admission	2	3-2
		Discharge	8.5	11-2
	Communication	Admission	6.5	10-4
		Discharge	11.5	12-8
	Social cognition	Admission	7	11.3-5
		Discharge	14	17.3-10.8
	Total	Admission	42.5	54.3-30.3
		Discharge	86.5	106-63.8

The total FIM median score on admission was 42.5 (IQR: 54.3-30.3) and on discharge 86.5 (IQR: 106-63.8). The individual category with the largest change in scores from admission to discharge was “locomotion” with the median score going from 2 (IQR: 3-2) to 8.5 (IQR: 11-2).

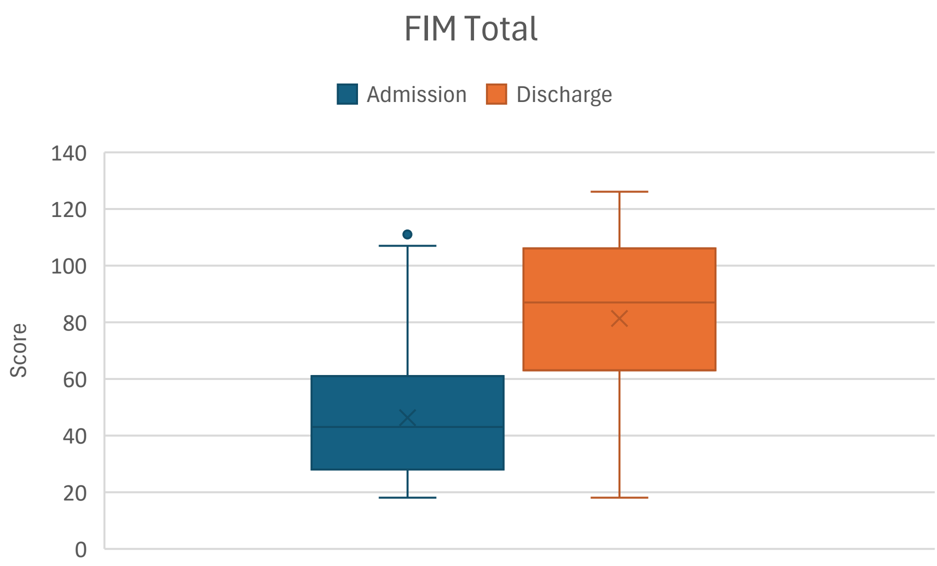


Figure 4.2.2.8. 1 Box and Whisker plot of admission and discharge Functional Independence Measure total scores

4.2.2.8 *Mini-Mental State Examination*

Table 4.2.2.9. 1 Mini-Mental State Examination: frequencies and percentages

Variables	Levels	Admission		Discharge	
		n=34	%	n=33	%
Mini-Mental State Exam	Not indicated	20	59	13	39
	Mild	7	21	11	33
	Moderate	3	9	5	15
	Severe	4	12	4	12

There were several missing data for this outcome measure with 14 (29%) participants missing data on admission and 15 (31%) on discharge. Fifty-nine per cent (n=20) of participants on admission were unable to complete the MMSE, occasionally reasons were written in such as “aphasia” or “fatigue”, however, for most, no reasons were given.

4.2.2.9 *Numerical Pain Rating Scale*

Table 4.2.2.10. 1 Numerical Pain Rating Scale: frequencies and percentages

Variables	Levels	Admission		Discharge	
		n=45	%	n=46	%
Numerical pain rating scale	Not indicated	14	31	13	28
	None	27	60	28	61
	Mild	2	4	3	7
	Moderate	1	2	0	
	Severe	1	2	2	4

Three patients (6%) were missing data for NPRS on admission and two (4%) on discharge. Most patients had no pain on admission (n=27, 60%) and discharge (n=28, 61%), with a large number unable to complete the NPRS on both admission (n=14, 31%) and discharge (n=13, 28%) due to cognition and language impairments rendering the test not indicated.

4.3 Objective 2: Functional walking ability of participants on discharge

Table 4.3. 1 Functional walking ability: frequencies and percentages

Functional walking ability	Admission		Discharge	
	N=48	%	N=48	%
Not walking	35	73	16	33
Home ambulation (<0.40 m/s)	9	19	11	23
Limited community (0.40–0.80 m/s)	4	8	7	15
Full community (>0.80 m/s)			14	29

Using the participants' 10MWT scores, they were allocated into four categories seen above. Of the 32 (67%) participants that were walking on discharge, most (n=14, 29%) were classified as being "full community" walkers. All participants walking on admission improved and moved up either one or two categories on discharge, except for one participant who regressed from "home ambulation" to "not walking" due to recurrent infections and medical instability. Of those who were "not walking" on admission (n=35, 73%), 15 (31%) remained at the same level, while the remaining participants progressed to walking and were distributed among all three walking categories.

4.4 Objective 3: Predictors of functional walking ability

4.4.1 Univariate analysis

The initial univariate analysis revealed that due to the low sample size and many variables and categories, there were variables and categories with no or low frequencies. In consultation with a biostatistician, to improve the accuracy of results, the dependent variable needed to be collapsed from four categories (not walking; home ambulation; limited community; full community) to two (not walking; walking), and variables with low frequencies and missing data were removed.

The final univariate analysis consisted of demographical information, the area of stroke, three frequent comorbidities of the participants and three clinical measures: functional walking ability, balance (BBS) and functional ability (FIM).

Table 4.4.1. 1 Univariate analysis

		Walking ability on discharge		
Predictor	Level	Not walking	Walking	p-value
		n (%), median (IQR), mean (SD)	n (%), median (IQR), mean (SD)	
Age		58 (62-51)	58 (65-45)	0.870
Sex	Male	9 (29)	22 (71)	0.393
	Female	7 (41)	10 (59)	
Acute LOS		16 (33-11)	14 (24.5-8)	0.375
Sub-acute LOS		45 (14)	38 (18)	0.237
Area of stroke	Left	8 (40)	12 (60)	0.450
	Right	7 (29)	17 (71)	
Hypertension	No	4 (33)	8 (67)	0.999
	Yes	12 (33)	24 (67)	
Diabetes	No	13 (34)	25 (66)	0.802
	Yes	3 (30)	7 (70)	
Epilepsy	No	14 (35)	26 (65)	0.584
	Yes	2 (25)	6 (75)	
Hyper-cholesterolemia	No	15 (38)	24 (62)	0.117
	Yes	1 (11)	8 (89)	
Functional walking ability	Not walking	15 (43)	20 (57)	0.071
	Home ambulation	1 (11)	8 (89)	
	Limited community	0	4 (100)	
Berg Balance Scale		0 (2-0)	5 (15-3)	**<.001**
Functional Independence Measure	Self-care	12 (16-6)	18 (24-13)	**0.008**
	Sphincter control	2 (4-2)	6 (12-3)	**0.002**
	Transfers	4 (5-3)	5 (9-3)	0.057
	Locomotion	2 (2-2)	2 (4-2)	**0.011**
	Communication	5 (3)	8 (4)	**0.003**
	Social cognition	5 (6-3)	10 (13-7)	**<0.001**

Multiple associations were found between the variables and walking on discharge. Highly significant variables include the BBS and the 'social cognition' category of the FIM scale, both with p-values of <0.001. Other significant variables included the remaining categories of the FIM scale, 'self-care', 'sphincter control', 'locomotion' and 'communication', except for 'transfers' which was borderline significant at p-value 0.057.

The choice of variables to include in the final univariate analysis provided a balanced picture of participants' demographic and clinical presentation on admission to guide the next step of the multivariate analysis.

4.4.2 Multivariate analysis

The results from the univariate analysis alongside clinical relevance and contribution to the model were used to guide the multivariate logistic regression to determine predictors of walking on discharge.

The dependent variable was walking ability, with two categories, 'not walking' and 'walking'. This was originally guided by the functional walking categories of home ambulation, limited and full community ambulation and these three categories were collapsed to form the 'walking' category.

The two highly significant variables (BBS and FIM social cognition) were included in the model and from there, systematic testing of predictor combinations was conducted. The addition of acute LOS formed the most stable and accurate model, with the lowest AIC (40.039) and highest AUC (0.914), and all three variables showed positive correlation and significant p-values. While acute LOS was not significant in the univariate analysis (0.375), it emerged as a significant predictor when balance and cognition were controlled, suggesting a suppressor effect.

Table 4.4.2. 1 Coefficients

						Wald Test			95% CI	
Model		Estimate	SE	OR	z	W	df	p	Lower Bound	Upper Bound
M_0	(Intercept)	0.693	0.306	2.000	2.264	5.125	1	0.024	0.093	1.293
M_1	(Intercept)	-5.777	2.025	0.003	-2.852	8.135	1	0.004	-9.746	-1.807
	BBS	0.504	0.219	1.655	2.302	5.297	1	0.021	0.075	0.933
	FIM SC	0.523	0215	1.687	2.429	5.902	1	0.015	0.101	0.944
	Acute LOS	0.065	0.030	1.067	2.172	4.718	1	0.030	0.006	0.124

Abbreviations: Berg Balance Scale (BBS), Functional Independence Measure: Social cognition (FIM SC) Acute length of stay (LOS), null model (M_0), final model (M_1) standard error (SE), odds ratio (OR), Wald statistic (W), freedom of degrees (df), confidence interval (CI)

FIM social cognition was the most significant predictor (0.015, OR = 1.687, 95% CI 0.101, 0.944) with each unit increase raising odds of walking by 68.7% and this remained true throughout the predictive model building showing that cognition is highly predictive of walking on discharge after stroke rehabilitation. Berg Balance Scale followed in significance as a predictor of walking with a p-value of 0.021, (OR = 1.655, 95% CI 0.075, 0.933), with each unit increase in BBS score increasing odds of walking by 65.5%. Acute LOS had a p-value of 0.030, with each additional day in acute care increasing the odds of walking by 6.7% (OR = 1.067, 95% CI 0.006, 0.124). None of the variables showed any multicollinearity with all variance inflation factor (VIF) values under 2, as seen in Table 4.4.2. 4 below.

Table 4.4.2. 2 Multicollinearity diagnostics

	Tolerance	VIF
BBS	0.734	1.362
FIM SC	0.752	1.329
Acute LOS	0.575	1.740

Abbreviations: Berg Balance Scale (BBS), Functional Independence Measure: Social cognition (FIM SC) Acute length of stay (LOS), variance inflation factor (VIF)

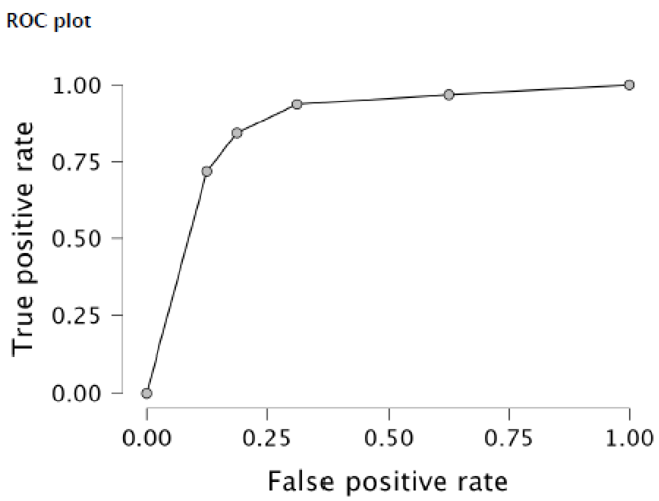


Figure 4.4.2. 1 Receiver operating characteristic curve

As seen in Table 4.4.2. 5 below, the model demonstrated significant improvement over the null model ($\Delta\chi^2 = 29.066$, $p < .001$), explained 63% (Nagelkerke R^2) of the variance in walking outcomes and showed excellent discrimination ability (AUC = 0.914). The final model contained three predictors and had 44 degrees of freedom compared to the null model with 47 degrees of freedom. With a sample size of 48, events per variable (EPV) equal 16, exceeding the recommended minimum of ten EPV thus suggesting adequate statistical power for the analysis.

Table 4.4.2. 3 Model summary

Model	Deviance	AIC	BIC	df	Δχ²	p	Nagelkerke R²	Cox & Snell R²
M_0	61.105	63.105	64.977	47				
M_1	32.039	40.039	47.524	44	29.066	< .001	0.631	0.454

Note. M_1 includes BBS, FIM SC and Acute LOS

4.5 Conclusion

The results of the analyses were structured according to the study's objectives. Forty-eight records were included, and the participants had a median age of 58, were predominantly male and had a median length of stay of 14.5 days in acute care and 40.5 days in sub-acute rehabilitation. While the areas of stroke in the sample were similarly distributed between right and left, right-sided strokes (n=24, 51%) were more prevalent than left-sided strokes (n=20, 43%), with a small frequency of strokes occurring in 'other' areas (n=3, 6%).

The four most frequent comorbidities included hypertension (n=36, 75%), diabetes (n=10, 21%), hypercholesterolemia (n=9, 19%) and epilepsy (n=8, 17%). Most participants had either one (n=16, 33%) or two (n=17, 35%) comorbidities and five (10%) had none. Many of the outcome measures showed a large number of participants unable to complete the tests on admission: 10MWT (n=35, 73%), 5TSTS (n=37, 77%), TUG (n=34, 83%), MMSE (n=20, 59%), NPRS (n=14, 31%), however, all improved with most participants able to complete the tests on discharge. Berg Balance Scale scores showed a drastic improvement from a median of three on admission to 38 on discharge and the total FIM median score improved from 42.5 to 86.5. Excluding the primary outcome measure (10MWT), BBS and FIM, the outcome measures had several missing admission and discharge data. Functional walking ability on discharge showed that 67% (n=32) of participants were able to walk, compared to 27% (n=13) who were walking on admission.

The final univariate analysis consisted of the variables: age, sex, acute and sub-acute LOS, area of stroke, four most frequent comorbidities, functional walking ability, balance (BBS) and functional ability (FIM). Significant associations were found between walking ability on discharge and the admission variables: FIM (most significant being social cognition at <0.001) and BBS (<0.001). These two highly significant variables were included in the multivariate analysis and after systematic testing of predictor combinations, the final model showed the highest AUC (0.914) and included three variables which were all significant predictors, FIM social cognition ($p=0.015$), BBS ($p=0.021$) and acute LOS ($p=0.030$). The following discussion chapter will explore these results comparing them to previous literature, consider explanations for findings, examine clinical implications and explore how to utilise these findings to optimise walking recovery after stroke.

Chapter 5 Discussion

5.1 Introduction

This study aimed to determine the predictors of functional walking ability on discharge from inpatient stroke rehabilitation. Three significant predictors of walking ability on discharge were found: balance (measured by the BBS), cognition (measured by the FIM social cognition category) and length of stay in the acute hospital. The multivariate logistic regression model achieved excellent discrimination ability and explained 63% of the variance in walking outcomes. The findings show the multifaceted nature of regaining the ability to walk after a stroke with not only physical ability impacting outcomes but also cognition and initial medical management.

This chapter will discuss the findings of the study relative to previous literature in both the South African and global context. The discussion will follow the structure of the results chapter and will be presented according to the study's objectives…

1. To establish the demographic and clinical profile of the participants admitted to a private inpatient sub-acute hospital for stroke rehabilitation.
2. To establish the functional walking ability of the participants upon discharge from a private inpatient sub-acute hospital.
3. To establish the factors that predict the functional walking ability of participants upon discharge from a private inpatient sub-acute hospital.

5.2 Objective 1: Demographic and clinical profile

5.2.1 Demographic profile

5.2.1.1 *Age*

The median age of participants in this study was 58 years (IQR:63-46.5), which aligns closely with Tribelhorn, Motara and Lewis' (2021) hospital-based study findings of a mean age of 57.7 years in patients with stroke in a South African public hospital in Johannesburg, Gauteng, the same province as this study. Our study, however, had a notably younger age of onset than Ranganai and Matizirofa (2020) who reported a mean age of 66.95 years in their broader analysis of both public and private hospitals in South Africa. Our findings may have been limited due to our inclusion criteria restricting age to no older than 70 years resulting in a homogenous age distribution in our sample whereas Ranganai and Matizirofa (2020) had no limits on age and had a range of ages from 18-98. Avan *et al.*, (2019) reported only 11% of strokes globally are between the ages of 40-64 of which our participants' mean age falls. While South Africa is classified as an upper-middle income country, our findings of a younger age of onset of stroke support Avan *et al.'s* (2019) findings that stroke occurs at younger ages in countries of lower socioeconomic status and reflects the epidemiological transition described by Connor, Modi and Warlow (2009) that South Africa is experiencing with changing lifestyle, culture and demographics.

This younger age of stroke onset has significant implications for individuals, families, communities, the healthcare system and the economy. Experiencing stroke at a younger age means potentially decades of living with disability and may affect their ability to work, maintain family roles and participate in community life, with families often becoming long-term caregivers while experiencing reduced household income, creating financial strain and limiting employment opportunities. From a healthcare system perspective, younger stroke patients require decades of ongoing rehabilitation services and medical care, creating substantial long-term resource demands and placing strain on healthcare workers who may experience burnout from managing complex, long-term cases. The economic impact is compounded by both the direct costs of prolonged healthcare provision and the indirect costs of lost productivity from both the stroke survivor and family caregivers, which is particularly concerning in South Africa's context where healthcare resources are already stretched and the economy cannot afford significant losses in productive workforce capacity.

5.2.1.2 *Sex*

This study's participants showed a significant dominance in males (n=31, 65%) versus females (n=17, 35%), which differs from both global and South African literature where females are at higher risk of stroke (Ranganai and Matizirofa, 2020; Tribelhorn, Motara and Lewis, 2021; Feigin *et al.*, 2022). Several factors could potentially explain this male predominance, though without data on screening and referral patterns, these remain speculative. Possible explanations include selection bias during referral processes, regional demographic variations, or this study's exclusion criteria excluding more females than males if more females with stroke were older than 70 years, had already achieved full community walking, experienced multiple strokes or had complications requiring readmission. The inability to determine the cause represents a study limitation and raises questions about the generalisability of our findings to the broader stroke population.

5.2.1.3 *Length of stay*

While our study took place in a private sub-acute hospital, we had access to data on stroke onset dates, acute hospital admission and discharge dates, as well as sub-acute hospital admission and discharge dates. From this data, we were able to determine that all 48 participants received timely acute stroke care, being admitted to acute hospital on the same day as their stroke, with a median acute stay of 14.5 days (IQR: 26.5-9) before transfer to our sub-acute hospital for a median of 40.5 days (IQR: 56-28.8). While length of stay was not a primary focus of our literature review, acute LOS emerged as a significant predictor in our analysis, warranting discussion. Future research could explore typical post-stroke length of stay patterns in South Africa compared to international standards and their relationship with functional outcomes.

5.2.2 Clinical profile

5.2.2.1 *Area of stroke*

Our participants included those who had strokes affecting different areas of the brain. Fifty-one per cent (n=24) had right-sided stroke, 43% (n=20) left-sided and 6% (n=3) had strokes in other regions of the brain (bilateral, brainstem and multi-territory). These findings are similar to those in Kennedy *et al. (*2021), a study that found that right-sided strokes (47%) were more prevalent than left-sided strokes (39%) and only had a small number of brainstem strokes (2%). The South African literature reviewed explored types of strokes and the racial differences rather than area of stroke. A limitation of our study was that we did not have data on race or stroke type, preventing exploration of these relationships.

5.2.2.2 *Comorbidities*

Of the 48 participants, 90% (n=43) had between one to four comorbidities, with most having one (n=16, 33%) or two (n=17, 35%) comorbidities. The three most frequent comorbidities were hypertension (n=36, 75%), diabetes (n=10, 21%) and hypercholesterolemia (n=9, 19%), which aligns with both the South African literature and global literature (Connor, Modi and Warlow, 2009; Ranganai and Matizirofa, 2020; Feigin *et al.*, 2021). Only 4% (n=2) of our participants were HIV positive compared to the 12% reported by Tribelhorn, Motara and Lewis (2021) in their study conducted in a public hospital in Johannesburg, potentially reflecting the socioeconomic disparity between participants in private and public healthcare. The high prevalence of these modifiable risk factors highlights the importance of prevention strategies to reduce the incidence of these comorbidities and the need for education regarding management for those already diagnosed.

5.2.2.3 *10 Metre Walk Test*

Based on (Perry *et al.*, 1995) walking classification, the median admission walking speed (0.32 m/s) from our results would fall into the home ambulation category, whereas the median speed on discharge (0.73 m/s) would be categorised as limited community ambulation. Our median walking speeds on admission and discharge were higher than those of Bland *et al.* (2012) whose participants on admission had a median speed of 0m/s and 0.5m/s on discharge. While Lord *et al.'s* (2004) study had a different setting to ours, assessing those with stroke in community, their participants were no more than one week post discharge and thus could be related to our discharge findings. Given that Lord *et al.* (2004) is a pioneer study in functional walking ability, it is important to consider their findings relative to ours. Participants in Lord *et al.*'s (2004) study had a mean walking speed of 0.9m/s, higher than our discharge walking speed of 0.73m/s. This could possibly be due to participants being at different lengths of time post-stroke; the inclusion of the higher mobility participants with no motor impairments in Lord *et al.*'s (2004) study, whereas in our study those with limited motor impairments were excluded from our study with the inclusion criteria of "Walking ability lower than full community (walking speed of <0.80m/s)"; and Lord *et al.*'s (2004) study only assessing participants discharged to home, most of whom would have had better mobility outcomes than those who did not return home whereas our participants were still in a sub-acute hospital and were not necessarily all returning home.

The 10MWT was not explored in the univariate or multivariate analysis due to the large number unable to complete the test on admission, however, the results from the test permitted participants to be categorised into walking categories which allowed researchers to use the data of those that were not walking on admission in the univariate and multivariate analysis.

5.2.2.4 *Berg Balance Scale*

Our study found that median BBS scores improved from 3 (IQR: 8-1) to 38 (IQR: 48-5.5). The median admission BBS score of 3 was significantly lower than all literature reviewed, Bland *et al.* (2012) had a median admission score of 16, Liao *et al.* (2021) had a median of 15 and Louie and Eng (2018) had a median of 16. This difference may be attributed to all three studies being performed in rehabilitation facilities with no elaboration on their ability to take patients with higher medical and care needs whereas our setting is a sub-acute facility that performs rehabilitation and is able to admit patients with mechanical ventilation and high care needs, who would be at a lower functional level with lower BBS scores. Louie and Eng (2018) and Liao *et al.* (2021) both established that a score of 29 is needed for community ambulation. While our admission scores were well below this threshold and indicated severe balance impairment, our discharge scores exceeded this threshold, suggesting potential for community ambulation.

5.2.2.5 *Timed Up and Go*

The Timed Up and Go test is widely recognized as a valuable outcome measure in stroke rehabilitation; however, our literature review did not specifically examine TUG as a predictor of walking outcomes, which represents a limitation of the scope of our literature review. Additionally, TUG was not included in the univariate or multivariate analysis due to the large number of those unable to complete the test on admission (n=34, 83%) and missing data from files which would have reduced the statistical power and skewed results. The relationship between Timed Up and Go, with the outcome of walking, was also too closely linked, and there was potential for high multicollinearity between TUG, functional walking ability, 5TSTS and FIM locomotion. While the outcome was not used as a predictor, it is a useful outcome measure to include in rehabilitation to assess the risk of falls and mobility, with the test showing excellent criterion validity between TUG and walking ability in patients following stroke (Flansbjer *et al.*, 2005).

5.2.2.6 *Five Times Sit to Stand*

The Five Times Sit to Stand test is a recognised measure of lower limb strength (Mong, Teo and Ng, 2010) and functional mobility in stroke rehabilitation; however, our literature review did not specifically examine the test as a predictor of walking outcomes, which represents a limitation of the scope of our literature review. Additionally, the test was not explored in the univariate or multivariate analysis as, similarly to the TUG test, there was a large number unable to complete the test **on** admission (n=37, 77%)**,** alongside several missing data in files which would have reduced statistical power and skewed results. The test may contribute to walking ability gains and thus may be predictive of walking ability; however, this relationship would need to be explored in future research.

5.2.2.7 *Functional Independence Measure*

The total median FIM score on admission was 42.5 (54.3-30.3) and on discharge had more than doubled at 86.5 (106-63.8), indicating a large increase in functional independence on discharge. Our median FIM 'locomotion' admission score was similar to Bland *et al.* (2012) median score of 1 on admission and in our study, this was the individual category with the largest change in scores from admission to discharge and increased from a median score of 2 (3-2) to 8.5 (11-2). None of the studies included in the literature review explored the differences in FIM scores from admission to discharge, and it is out of the scope of this study to review this. This would be an area of future research and could be explored to analyse if improvements in functional independence in South Africa are consistent with other countries.

5.2.2.8 *Mini-Mental State Examination*

Our study did not analyse the MMSE scores but allocated the participants into the MMSE score interpretation categories of 'mild', 'moderate' and 'severe'. Evidence from our literature review demonstrates that cognition, including MMSE scores, is significantly linked to walking outcomes. Preston *et al.* (2021) using MMSE found that those without cognitive impairment at 19 days post-stroke were 3.5 times more likely to walk independently at three months, while Louie and Eng (2018) showed that higher MMSE scores were significantly associated with achieving community ambulation speeds. Our results, however, are not reflective of the true cognitive impairments faced by our participants due to several missing data and the large number of participants unable to complete the test. This represents a significant limitation, particularly given that our literature review establishes cognition as a strong predictor of walking outcomes. It is evident from our findings that cognition remained highly predictive of walking ability in our study when measured through FIM social cognition, suggesting that while the MMSE may have limitations due to language impairments and post-stroke fatigue, practical cognitive assessment tools that evaluate problem-solving and social interaction may be more suitable for predicting walking recovery.

5.2.2.9 *Pain*

Of our participants, the majority reported no pain on admission (n=60%) or discharge (n=28, 61%). Our literature review demonstrated that pain can significantly impact functional outcomes after stroke, with various types of pain affecting 11-66% of stroke patients (Harrison and Field, 2015). Köseoğlu *et al.* (2017) found that among patients post-stroke with lower extremity pain, 40% described walking as an aggravating factor, while Westerlind *et al.* (2020) showed that those with frequent pain experienced significantly lower levels of mobility and were 2.4 times more likely to be functionally dependent. Our literature review found no studies that specifically examined pain as a predictor of walking ability, suggesting this remains an understudied area. Pain was not included in our univariate or multivariate analysis due to the high number of those unable to complete the assessment due to cognition or communication difficulties, 31% (n=14) on admission and 28% (n=13) on discharge, and the addition of missing data. This represents a significant limitation, given the established impact of pain on mobility and functional outcomes. We recommend that methods of assessing pain after stroke be developed to be more inclusive of those with cognitive and language impairments, and that future research explore pain as a potential predictor of walking recovery

5.3 Objective 2: Functional walking ability of participants on discharge

Using Perry *et al.'s* (1995) functional walking categories, our discharge findings showed that 67% (n=32) of participants achieved some level of walking ability, with 29% (n=14) reaching full community walking speeds (>0.8 m/s). This is comparative to Kennedy *et al.'s* (2021) finding that 75% of people regain walking ability after stroke, though our 33% (n=16) non-walking rate may reflect the shorter observation period with a median of 62.5 days total (acute and sub-acute LOS) compared to Kennedy *et al.'s* (2021) 90-day follow-up. All participants in our study who were able to complete the 10MWT on admission to allow for categorisation into functional walking categories showed improvement by at least one category, except for one regression, and while walking speed alone may not fully capture the intricacies of community participation (Lord *et al.*, 2004), improvements in walking speed and overall walking ability has shown to be directly correlated with improvements in quality of life and community participation (Schmid *et al.*, 2007; Khanittanuphong and Tipchatyotin, 2017; Elloker *et al.*, 2018; Grau-Pellicer *et al.*, 2019).

5.4 Objective 3: Predictors of functional walking ability

5.4.1 Berg Balance Scale

Balance emerged as a significant predictor (p=0.021) of walking ability on discharge, with each unit increase in Berg Balance Scale score, raising the odds of walking by 65.5%. This finding aligns with previous research by Liao *et al.* (2021) who found that balance was the only predictor of community walking when controlling for other variables and Louie and Eng's (2018) finding that balance is significantly associated with achieving both community and unassisted walking. Our findings also support Preston *et al.'s* (2021) findings that good sitting balance predicts independent walking at 3 months post stroke, however, while it supports that balance is a predictor, it is important to note that a different balance outcome measure was used in this study. The median BBS score of our participants on admission was notably low at three (IQR: 8-1), reflecting the severe balance limitations post-stroke in the study population, however, by discharge, this had dramatically increased to a median score of 38 (48-5.5), exceeding the BBS cut off score of 29 that both Louie and Eng (2018) and Liao *et al.* (2021) had established as predictive of community ambulation. This strong predictive ability that balance has on walking is potentially reflective of the complex nature of walking in which a centre of mass is moving over an alternating base of support while navigating obstacles and different terrains. We recommend that given the predictive nature of balance on walking outcomes post-stroke, clinicians should aim for early balance intervention to optimise walking ability.

5.4.2 Functional Independence Measure: Social Cognition

Cognition, based on the FIM Social Cognition score, was found to be the most predictive of walking ability (p=0.015) and the most consistent predictor with it having the highest significance throughout the predictive model building through logistic regression. For each point increase in the FIM Social Cognition score, the odds of walking were raised by 68.7%. Our findings that cognition predicts walking ability post-stroke support the findings from previous literature, such as Preston *et al.* (2021) and Louie and Eng's (2018) findings. The FIM social cognition category assesses social interaction, problem-solving and memory, our study's findings that this is predictive of walking ability may indicate the importance of these individual skills for walking ability. We recommend that cognitive intervention is optimised early to improve walking outcomes after stroke.

5.4.3 Length of stay

This study found that while length of stay in acute care was not significant in the univariate analysis it emerged as a significant predictor (p=0.030) after the multivariate logistic regression, suggesting that once confounding factors were controlled, length of stay in acute care after stroke impacts walking ability. For each additional day spent in acute care, the odds of walking increased by 6.7% and the median days spent in acute care was 14.5 (IQR: 26.5-9). This finding contradicts the assumption that longer acute stays are associated with greater stroke severity which in turn are associated with poorer outcomes for walking ability (Kennedy *et al.*, 2021). Possible explanations for our findings could be that our sub-acute facility's capacity for high-care patients may paradoxically result in earlier transfer of those with more severe strokes due to economic pressure from insurances to discharge, while less severe cases experience longer acute stays due to reduced economic pressure. The longer acute stay may also reflect that those with greater stroke severity receive more intensive medical management, possibly preventing secondary complications that impede recovery thus allowing for better walking outcomes. Our results suggest that adequate time for comprehensive medical management in the initial acute hospital admission may positively influence walking outcomes.

Length of stay in the sub-acute hospital was not significantly associated with walking ability in the univariate analysis (p=0.237) and did not contribute to the multivariate analysis during the predictive model-building phase. This was surprising given the assumption that more therapeutic input would lead to greater functional outcomes. Possible explanations for this could be the individualised nature of recovery post-stroke, the similar distribution in ages of the sample population and that targeted, effective interventions may be more important determinants of walking outcomes than simply duration of stay.

5.4.4 Functional walking ability

Functional walking ability, categorised by walking speed, on admission was not found to be significant (p=0.071) in the univariate analysis. The participants who were walking on admission (n=13, 27%) had a mean speed of 0.32 m/s, which falls into the household ambulation category and was higher than Bland *et al.'s* (2012) participants who had a median speed of 0 m/s on admission. Louie and Eng (2018) found that higher initial walking speeds were a significant predictor of achieving community ambulation on discharge. Our findings align more closely with Liao *et al.* (2021) who found walking speed on admission was not significant in the multivariate analysis when balance was included, suggesting that balance may be a more fundamental predictor than initial walking speed. Our findings may have been influenced by the small sample size only including 27% (n=13) who were walking on admission. The clinical implications of these findings suggest that initial walking speed may still be relevant for prognosis, however, it may be less so than balance and cognition, suggesting that these interventions should be prioritised in the early stages of rehabilitation.

5.4.5 Functional Independence Measure (not including social cognition)

All items of the FIM scale, except for 'transfers' (p=0.057), showed significant associations in the univariate analysis: sphincter control (p=0.002), communication (p=0.003), self-care (p=0.008), and locomotion (p=0.011). The significant association between sphincter control (bladder and bowel management) and walking ability aligns with Preston *et al.*'s (2021) findings that continence at 18 days post-stroke increased the likelihood of independent walking by 2.3 times at three months. While this may reflect stroke severity, bladder and bowel awareness may also indicate preserved neurological pathways important for mobility control. The communication domain (comprehension and expression) may show understanding of safety instructions, therapy directions, and the ability to communicate needs or concerns during therapy. Self-care items (eating, grooming, bathing, dressing, toileting) demonstrate upper limb coordination, trunk control, balance, and the cognitive sequencing required for complex motor tasks, skills that directly transfer to the motor planning and postural control needed for walking.

Our findings suggest that the FIM is a strong assessment tool that should continue to be used throughout inpatient stroke rehabilitation. While the FIM transfer item was not significant, it was borderline significant and may have been influenced by confounding factors and its close relationship to BBS and FIM locomotion, thus it should still be considered when exploring the relationship between FIM and walking ability after stroke.

5.4.6 Age

Age was not found to be significantly associated (p=0.087) with walking ability in this study, with both walkers and non-walkers having a median age of 58 years. This finding contradicts Preston *et al.'s* (2021) large systematic review findings that younger age predicted independent walking. Notably, the mean age in their study was 69 (SD: 5), significantly older than our participants, and this leaves the question as to whether this age difference is an explanation for the discrepancy between our study findings. It is possible that in an older population, age is predictive of walking ability, whereas in a younger population, it is not. In both Louie and Eng (2018) and Liao *et al.*'s (2021) studies, age was significantly associated in the univariate analysis but not predictive of walking in the multivariate analysis which supports our finding. Our findings may reflect that our inclusion criteria restricted age to no older than 70 years resulting in a homogenous age distribution in our sample and they may also reflect that age may be less important than comorbidity burden and pre-stroke function. This finding suggests that age alone should not be used as a criterion for prognostic purposes or for deciding on therapeutic interventions and referral to rehabilitation after a stroke.

5.4.7 Sex

The sex distribution in our study differed from previous literature, with males more prevalent than females and 71% (n=22) of males and 59% (n=10) of females achieving walking by discharge. It is noteworthy that despite these discrepancies, sex was not associated with walking ability in the univariate analysis (p=0.393) and was not predictive of walking in the model-building phase of the logistic regression. This finding supports all predictive literature analysed in our literature review (Louie and Eng, 2018; Liao *et al.*, 2021; Preston *et al.*, 2021) and despite the predominance of males in our sample, differing from both global and South African statistics, this did not affect our findings, suggesting that sex has minimal to no association with walking outcomes post-stroke. This consistent lack of association between sex and walking ability strengthens the conclusion that walking potential should not be assessed on unmodifiable demographical characteristics such as sex.

5.4.8 Area of stroke

No association (p=0.450) was found in this study between the area of stroke and walking ability. Forty-three per cent of our participants sustained a left-sided stroke and of those, 60% achieved walking, compared to the 51% that sustained a right-sided stroke with 71% achieving walking. Our findings support that of Preston *et al.* (2021) who found no association between stroke location and independent walking at 3 months post-stroke. Our findings, however, differed from Kennedy *et al.*'s (2021) who found that right hemisphere strokes showed a longer time to achieve walking, a potential reason that could be further explored is that the rehabilitation interventions offered to our participants countered the effects of a right-sided stroke and therefore, did not delay walking outcomes. Findings from the literature that our study did not explore due to lack of data include an association between intact corticospinal tract and walking (Preston *et al.*, 2021) and haemorrhagic stroke being strongly associated with community walking (Louie and Eng, 2018). Our findings alongside previous literature suggest that there are a multitude of factors when looking at the area of stroke and its impacts on walking ability and may suggest that if rehabilitation is patient-centred and tailored to specific impairments such as balance and cognition, the region of stroke does not impact walking outcomes.

5.4.9 Comorbidities

No comorbidities were found to be significant for walking ability on discharge in this study, which aligns with most previous literature explored in this study (Avan *et al.*, 2019; Preston *et al.*, 2021). However, Kennedy *et al.*'s (2021) study found that diabetes was associated with a longer time to achieve walking possibly due to chronic complications associated with diabetes such as peripheral neuropathy impacting walking. In our study diabetes was not found to be significantly associated (p=0.802) with walking ability possibly due to our shorter observation period compared to the longer follow up period in Kennedy *et al.*'s (2021) study. While our study did explore the descriptive statistics of multiple comorbidities, with most having between two to four comorbidities, we did not explore the relationship between multiple comorbidities and the impact on walking outcomes which may be more relevant than specific conditions. While comorbidities may not directly influence walking recovery, complications from comorbidities may impact walking ability and the management of comorbidities is important for stroke prevention.

5.5 Conclusion

This study identified three predictors of walking ability on discharge from inpatient rehabilitation following stroke: balance, cognition and length of stay in acute care. Many of our findings align with previous research, with both balance and cognition previously established as predictors of walking (Louie and Eng, 2018; Liao *et al.*, 2021), no association between the area of stroke and walking ability (Preston *et al.*, 2021), and demographics such as sex consistently not predictive of walking outcomes (Louie and Eng, 2018; Liao *et al.*, 2021; Preston *et al.*, 2021).

Our findings differed from previous literature in several aspects: age was not a predictor in our study despite Preston *et al.* (2021) finding that younger age predicted independent walking; we found no association between area of stroke and walking, while right-sided strokes have showed delayed time to achieve walking in some literature (Kennedy *et al.*, 2021); initial walking ability was not predictive in our multivariate analysis contrary to Louie and Eng's (2018) findings; and no comorbidities predictors of walking ability, despite diabetes being linked associated with longer time to achieve walking (Kennedy *et al.*, 2021). While each of these differing findings was addressed individually in our discussion, a common thought was that these differences may be explained by our study's unique characteristics, including a younger, more homogeneous sample with a median age of 58 years, inclusion criteria limited to those under 70 years, and limited sample size with only 27% (n=13) of participants walking on admission.

Our discussion revealed the multifaceted nature of walking recovery after stroke, highlighting that optimal outcomes require a comprehensive approach addressing physical abilities, cognitive function, and adequate medical management. The predictive model developed in this study, with its excellent discrimination ability and explaining 63% of the variance in walking outcomes, could serve as a valuable clinical tool for rehabilitation planning and prognostication in similar settings.

Chapter 6 Conclusion and Recommendations

6.1 Introduction

This chapter will present recommendations for clinical practice, future research and strengths of the study while acknowledging the limitations faced and concluding the findings of this study.

6.2 Clinical Recommendations

The findings from our study inform several important clinical recommendations. First, the strong predictive value of both balance and cognition for walking ability on discharge suggests that targeted balance and cognition assessment and intervention should be prioritised in stroke rehabilitation. We recommend that standardised assessment tools such as the Berg Balance Scale and the Functional Independence Measure should be routinely implemented in post-stroke care due to their prognostic abilities. Clinicians can utilise these balance and cognitive measures to help guide realistic expectations of walking outcomes in discussions with patients and their families and help plan for discharge equipment needs and home modifications.

The multifaceted needs of people post-stroke highlighted by our findings emphasise the need for interdisciplinary collaboration. To optimise outcomes by addressing both physical and cognitive aspects, we recommend a comprehensive team approach consisting of physiotherapists, occupational therapists, speech and language therapists and neuropsychologists. Our finding that length of stay in acute care is positively associated and predicts walking ability after stroke, suggests the importance of medical management before transfer to rehabilitation. Clinicians and those with influence should use these findings to advocate for sufficient hospital management before transfer to sub-acute rehabilitation facilities.

Noteworthy to the South African context, this study had a younger median age of onset of stroke (58 years) than the global average. This has significant implications for rehabilitation planning and resource allocation as those who experience strokes at earlier ages may have different goals and responsibilities, alongside different recovery potential than their older counterparts.

Finally, with 90% (n=43) of our participants having at least one comorbidity and the majority having multiple comorbidities, the high prevalence of these modifiable risk factors highlights the importance of prevention strategies to reduce the incidence of these comorbidities and the need for education regarding management for those already diagnosed. We recommend that clinicians should incorporate education on comorbidity prevention and management into their interactions with patients, carers and family, as well as colleagues. This approach would extend our impact of rehabilitation beyond recovery to overall health promotion and stroke prevention.

6.3 Recommendation for Future Research

Our study has identified several areas requiring more research to better understand the impact of stroke on both the South African and global populations. Within the South African population, research should focus on determining appropriate walking parameters needed after a stroke to be able to participate in the community. We recommend larger sample sizes spanning multiple regions and including both public and private settings to provide a more representative analysis of predictors of walking ability across the diverse South African population. We also recommend research into how the younger stroke onset age in South Africa impacts the individuals experiencing stroke (their goals, responsibilities and recovery potential), their families and society (economic burden and resource allocation).

The implementation of a national stroke register in South Africa would aid in collating stroke statistics to allow for more research into incidence and outcomes post-stroke, assist in economic planning for the country and aid global understanding of the country's incident rates and unique contributors. As South Africa undergoes an epidemiological transition, with increasing comorbidity burden and stroke incidence, research exploring the relationship between multiple comorbidities and the impact on functional outcomes is essential. This would allow clinicians to better understand how various combinations of conditions affect rehabilitation and functional recovery.

Pain after stroke remains an under-explored area despite being a frequent experience of those who have experienced a stroke. Our study was limited in assessing pain due to challenges in assessing those with cognitive and communication impairments, thus it is important for future research that pain assessment tools are more inclusive of common post-stroke impairments as this would allow for more research into predictors of pain post-stroke and the impact of pain on functional outcomes.

6.4 Strengths and Limitations

6.4.1 Strengths

This study had many strengths; however, notable limitations exist. The strengths include a comprehensive assessment of multiple potential predictors that spanned over the physical, cognitive, functional and medical implications of a stroke and included data from standardised, validated assessment tools. The study focused on a critical functional outcome (walking) that is the primary goal of most patients after a stroke and one that impacts quality of life. We were able to contribute to the limited South African research on stroke rehabilitation outcomes, with this study being the first, to the author's knowledge, to explore the predictors of walking ability after stroke within the South African population. Our statistical approach was robust, and the predictive model had excellent accuracy with all three variables being predictive of walking post-stroke.

6.4.2 Limitations

The limitations that our study faced were a small sample size of 48 participants, with some variables having large amounts of missing data, which prevented their inclusion in the predictive analysis and reduced the pool of potential predictors available for the model. The lack of systematic documentation of reasons why the 10MWT was not indicated for participants, limits interpretation of the "not-indicated" data. Future studies should distinguish between non-ambulatory participants and those unable to complete the specific test requirements for other reasons. A retrospective, private hospital-based study limits the generalisability of the results to the greater population of patients with stroke. Our age criteria of a maximum of 70 years, excluded many participants and resulted in a homogeneous age distribution. The pain rating tool used was not able to assess the pain of those with cognitive and communication impairments. We addressed the limitation of the sample size and missing data by reviewing and consolidating our variables once the initial univariate analysis revealed multiple categories with low frequencies. While unable to address the inclusion criteria, we have acknowledged that it was a limitation to ensure that future studies can learn from this.

The limitation in the pain rating scale has been addressed by suggesting clinical practice adopt a more inclusive tool.

6.5 Conclusion

The research question that formed this study was “What are the predictors of functional walking ability of participants on discharge from inpatient stroke rehabilitation at a private sub-acute hospital in South Africa?”. Our results have answered this question with the key findings of the study identifying three significant predictors: cognition measured by the FIM category ‘social cognition’ (p=0.015), balance measured by the Berg Balance Scale (p=0.021), and length of stay in acute care (p=0.030). The predictive model, formed through a multivariate logistic regression, showed excellent discrimination ability (AUC=0.914) and explained 63% of the variance in walking outcomes, providing clinicians with evidence-based predictors of walking ability on discharge from inpatient stroke rehabilitation, within the South African context. With walking consistently reported as the most important rehabilitation goal for patients after stroke and walking ability directly impacting quality of life and community participation, these findings are meaningful for those who have experienced stroke.

The findings provide clinicians with two areas to prioritise in assessment and intervention, cognition and balance, and demonstrate the standardised outcome measures (FIM and BBS) that should be routinely implemented to assess these in post stroke care. Evident from the predictors of cognition and balance is that and interdisciplinary approach is essential to optimise walking ability after a stroke. The knowledge should also be used to guide prognosis, rehabilitation and discharge planning.

Our study highlighted the need for larger studies across multiple regions and healthcare settings in South Africa, with more research needed into walking parameters needed to achieve community participation within the South African context. Pain assessment tools that are more inclusive of those with cognitive and communication impairments need to be considered and more research is needed to determine the impact of comorbidity burden on functional outcomes following stroke.

While our study faced limitations, its strengths included adding to the growing knowledge of predictors of functional outcomes of stroke in South African literature, a comprehensive assessment of multiple predictors and a focus on walking ability which is a meaningful, important outcome after stroke. These strengths culminated in a robust statistical approach with excellent model accuracy and the study was able to meet its aim “To determine the predictors of functional walking ability on discharge from inpatient stroke rehabilitation”.

References

Akinyemi, R. O. *et al.* (2021) 'Stroke in Africa: profile, progress, prospects and priorities', *Nature Reviews Neurology*, 17(10), pp. 634–656. doi: 10.1038/s41582-021-00542-4.

Alghadir, A. H. *et al.* (2018) 'Reliability, validity, and responsiveness of three scales for measuring balance in patients with chronic stroke', *BMC Neurology*, 18(1), pp. 1–7. doi: 10.1186/s12883-018-1146-9.

Australian Institute of Health and Welfare (2024) *MyHospitals Glossary*. Available at: https://www.aihw.gov.au/reports-data/myhospitals/content/glossary (Accessed: 28 March 2025).

Avan, A. *et al.* (2019) 'Socioeconomic status and stroke incidence, prevalence, mortality, and worldwide burden: An ecological analysis from the Global Burden of Disease Study 2017', *BMC Medicine*, 17(1). doi: 10.1186/s12916-019-1397-3.

Bansal, K. *et al.* (2024) 'Speed- and Endurance-Based Classifications of Community Ambulation Post-Stroke Revisited: The Importance of Location in Walking Performance Measurement', *Neurorehabilitation and Neural Repair*, 38(8), pp. 582–594. doi: 10.1177/15459683241257521.

Bertram, M. Y. *et al.* (2013) 'The disability adjusted life years due to stroke in South Africa in 2008', *International Journal of Stroke*, 8(100), pp. 76–80. doi: 10.1111/j.1747-4949.2012.00955.x.

Bland, M. D. *et al.* (2012) 'Prediction of discharge walking ability from initial assessment in a stroke inpatient rehabilitation facility population', *Arch Phys Med Rehabil*, 93(8), pp. 1441–1447. doi: 10.1016/j.apmr.2012.02.029.

Bohannon, R. W., Andrews, W. B. and Smith, M. (1998) 'Rehabilitation goals of patients with hemiplegia', *International Journal of Rehabilitation Research*, 11(2), pp. 181–183. doi: 10.1097/00004356-198806000-00012.

Brown, A. W. *et al.* (2015) 'Measure of Functional Independence Dominates Discharge Outcome Prediction after Inpatient Rehabilitation for Stroke', *Stroke*, 46(4), pp. 1038–1044. doi: 10.1161/STROKEAHA.114.007392.

Bryer, A. *et al.* (2010) 'South African guideline for management of ischaemic stroke and transient ischaemic attack 2010: A guideline from the South African Stroke Society (SASS) and the SASS Writing Committee.', *South African Medical Journal*, 100(11), pp. 747–778. doi: 10.7196/samj.4422.

Chevalley, O. *et al.* (2023) 'Physical functioning factors predicting a return home after stroke rehabilitation: A systematic review and meta-analysis', *Clinical Rehabilitation*, 37(12), pp. 1698–1716. doi: 10.1177/02692155231185446.

Collen, F. M., Wade, D. T. and Bradshaw, C. M. (1990) 'Mobility after stroke: Reliability of measures of impairment and disability', *Int Disabil Stud*, 12(1), pp. 6–9. doi: 10.3109/03790799009166594.

Connor, M. D. *et al.* (2004) 'Prevalence of Stroke Survivors in Rural South Africa: Results from the Southern Africa Stroke Prevention Initiative (SASPI) Agincourt Field Site', *Stroke*, 35(3), pp. 627–632. doi: 10.1161/01.STR.0000117096.61838.C7.

Connor, M. D., Modi, G. and Warlow, C. P. (2009) 'Differences in the nature of stroke in a multiethnic urban south african population the Johannesburg Hospital stroke register', *Stroke*, 40(2), pp. 355–362. doi: 10.1161/STROKEAHA.108.521609.

Corbett, C. *et al.* (2022) 'Prevalence and Characteristics of HIV-Associated Stroke in a Tertiary Hospital Setting in South Africa', *Neurology*, 99(9), pp. e904–e915. doi: 10.1212/WNL.0000000000200780.

Dey, S. *et al.* (2024) 'Exploring the Role of Neuroplasticity in Stroke Rehabilitation: Mechanisms, Interventions and Clinical Implications', *International Journal For Multidisciplinary Research*, 6(2). doi: 10.36948/ijfmr.2024.v06i02.18483.

Elloker, T. *et al.* (2018) 'Factors predicting community participation in patients living with stroke, in the Western Cape, South Africa', *Disability and Rehabilitation*, 41(22), pp. 2640–2647. doi: 10.1080/09638288.2018.1473509.

Farooq, M. U. *et al.* (2008) 'The WHO STEPwise approach to stroke surveillance', *Journal of the College of Physicians and Surgeons Pakistan*, 18(10), p. 665.

Feigin, V. L. *et al.* (2021) 'Global, regional, and national burden of stroke and its risk factors, 1990-2019: A systematic analysis for the Global Burden of Disease Study 2019', *The Lancet Neurology*, 20(10), pp. 1–26. doi: 10.1016/S1474-4422(21)00252-0.

Feigin, V. L. *et al.* (2022) 'World Stroke Organization (WSO): Global Stroke Fact Sheet 2022', *International Journal of Stroke*, 17(1), pp. 18–29. doi: 10.1177/17474930211065917.

Flansbjer, U. *et al.* (2005) 'Reliability of gait performance tests in men and women with hemiparesis after stroke', *J Rehabil Med*, 32(2), pp. 75–82. doi: 10.1080/16501970410017215.

Grau-Pellicer, M. *et al.* (2019) 'Walking speed as a predictor of community mobility and quality of life after stroke', *Topics in Stroke Rehabilitation*, 26(5), pp. 349–358. doi: 10.1080/10749357.2019.1605751.

Green, J. *et al.* (2005) ‘Australian , Finland and South Africa - Delving into Data to Investigate Differences in Stroke Rehabilitation’, *Australasian Rehabilitation Outcomes Centre - AROC*, 3(April).

Groenewald, R. and Rhoda, A. J. (2017) ‘Multidisciplinary rehabilitation outcomes of stroke patients in the Western Cape of South Africa’, *African Journal for Physical Activity and Health Sciences*, 23(4), pp. 267–276. doi: 10.10520/EJC-c2678a93f.

Harrison, R. A. and Field, T. S. (2015) ‘Post stroke pain: Identification, assessment, and therapy’, *Cerebrovascular Diseases*, 39(3–4), pp. 190–201. doi: 10.1159/000375397.

Herr, K. A. *et al.* (2004) ‘Pain Intensity Assessment in Older Adults’, *Clin JPain*, 20(4), pp. 207–219. doi: 10.1097/00002508-200407000-00002.

Hsueh, I. *et al.* (2002) ‘Comparison of the psychometric characteristics of the functional independence measure, 5 item Barthel index, and 10 item Barthel index in patients with stroke’, *J Neurol Neurosurg Psychiatry*, 73, pp. 188–190. doi: 10.1136/jnnp.73.2.188.

Iqbal, A., Bhat, P. and Melam, G. R. (2024) ‘Comparative Analysis of Physical Therapy Outcomes in Acute Ischemic and Hemorrhagic Stroke Rehabilitation’, *International Journal of Physical Therapy Research & Practice*, 3(4), pp. 209–215. doi: 10.62464/ijoprp.v3i4.22.

Johnson, C. O. *et al.* (2019) ‘Global, regional, and national burden of stroke, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016’, *Lancet Neurol*, 18(5), pp. 439–458. doi: 10.1016/S1474-4422(19)30034-1.

Joseph, C. and Rhoda, A. (2013) ‘Activity limitations and factors influencing functional outcome of patients with stroke following rehabilitation at a specialised facility in the Western Cape’, *African Health Sciences*, 13(3), pp. 646–654. doi: 10.4314/ahs.v13i3.18.

Kennedy, C. *et al.* (2021) ‘Factors associated with time to independent walking recovery post-stroke’, *Journal of Neurology, Neurosurgery and Psychiatry*, 92(7), pp. 702–708. doi: 10.1136/jnnp-2020-325125.

Khanittanuphong, P. and Tipchatyotin, S. (2017) ‘Correlation of the gait speed with the quality of life and the quality of life classified according to speed-based community ambulation in Thai stroke survivors’, *NeuroRehabilitation*, 41(1), pp. 135–141. doi: 10.3233/NRE-171465.

Köseoğlu, B. F. *et al.* (2017) ‘The impact of lower extremity pain conditions on clinical variables and health-related quality of life in patients with stroke’, *Topics in Stroke*

Rehabilitation, 24(1), pp. 50–60. doi: 10.1080/10749357.2016.1188484.
Krishnan, S. *et al.* (2017) 'Patient-centered mobility outcome preferences according to individuals with stroke and caregivers: a qualitative analysis', *Disability and Rehabilitation*, 40(12), pp. 1401–1409. doi: 10.1080/09638288.2017.1297855.
Kuys, S. S. *et al.* (2009) 'Measures of activity limitation on admission to rehabilitation after stroke predict walking speed at discharge: An observational study', *Australian Journal of Physiotherapy*, 55(4), pp. 265–268. doi: 10.1016/S0004-9514(09)70006-6.
Liao, W. L. *et al.* (2021) 'The berg balance scale at admission can predict community ambulation at discharge in patients with stroke', *Medicina (Lithuania)*, 57(6), pp. 1–8. doi: 10.3390/medicina57060556.
Liew, S. L. *et al.* (2023) 'Association of Brain Age, Lesion Volume, and Functional Outcome in Patients With Stroke', *Neurology*, 100(20), pp. 2103–2113. doi: 10.1212/WNL.0000000000207219.
Lingo VanGilder, J. *et al.* (2020) 'Post-Stroke Cognitive Impairments and Responsiveness to Motor Rehabilitation: A Review', *Current Physical Medicine and Rehabilitation Reports*, 8(4), pp. 461–468. doi: 10.1007/s40141-020-00283-3.
Lord, S. E. *et al.* (2004) 'Community Ambulation after Stroke: How Important and Obtainable Is It and What Measures Appear Predictive?', *Arch Phys Med Rehabil*, 85(2), pp. 234–239. doi: 10.1016/j.apmr.2003.05.002.
Louie, D. R. and Eng, J. J. (2018) 'Berg balance scale score at admission can predict walking suitable for community ambulation at discharge from inpatient stroke rehabilitation', *J Rehabil Med*, 50(1), pp. 37–44. doi: 10.2340/16501977-2280.
Maclean, N. *et al.* (2000) 'Qualitative analysis of stroke patients' motivation for rehabilitation', *BMJ*, 321, pp. 1051–1054. doi: 10.1136/bmj.321.7268.1051.
Mandysová, P., Nedvědová, A. and Ehler, E. (2017) 'A comparison of three self-report pain scales in Czech patients with stroke', *Cent Eur J Nurs Midw*, 8(1), pp. 572–579. doi: 10.15452/CEJNM.2017.08.0004.
Mao, H., Hsueh, I. and Tang, P. (2002) 'Analysis and Comparison of the Psychometric Properties of Three Balance Measures for Stroke Patients', *Stroke*, 33(7), pp. 1022–1027. doi: 10.1161/01.STR.0000012516.63191.C5.
Maredza, M. *et al.* (2016) 'Burden of stroke attributable to selected lifestyle risk factors in rural South Africa Global health', *BMC Public Health*, 16(1). doi: 10.1186/s12889-016-2805-7.
Maredza, M., Bertram, M. Y. and Tollman, S. M. (2015) 'Disease burden of stroke in rural South Africa: An estimate of incidence, mortality and disability adjusted life years',

BMC Neurology, 15(1). doi: 10.1186/s12883-015-0311-7.
Markus, H. (2016) 'Stroke : causes and clinical features Key points', *Medicine*, 44(9), pp. 515–520. doi: 10.1016/j.mpmed.2016.06.006.
Markus, H. S. *et al.* (2007) 'Differences in stroke subtypes between black and white patients with stroke: The South London Ethnicity and Stroke Study', *Circulation*, 116(19), pp. 2157–2164. doi: 10.1161/CIRCULATIONAHA.107.699785.
Metreau, E., Young, K. E. and Eapen, S. G. (2024) *World Bank Country Classifications by income level for 2024-2025*, *Data Blog, World Bank Group*. Available at: https://blogs.worldbank.org/en/opendata/world (Accessed: 4 January 2025).
Mong, Y., Teo, T. and Ng, S. (2010) '5-Repetition Sit-to-Stand Test in Subjects With Chronic Stroke: Reliability and Validity', *Arch Phys Med Rehabil*, 91, pp. 407–413. doi: 10.1016/j.apmr.2009.10.030.
National Institute for Health and Care Excellence (2023) *Stroke and TIA - Clinical features*, *CKS [NICE Clinical Knowledge Summaries]*. Available at: https://cks.nice.org.uk/topics/stroke-tia/diagnosis/clinical-features/ (Accessed: 1 March 2025).
Ottenbacher, K. *et al.* (1996) 'The Reliability of the Functional Independence Measure: A Quantitative Review', *Arch Phys Med Rehabil*, 77, pp. 1226–1232. doi: 10.1016/s0003-9993(96)90184-7.
Parekh, I. and Rhoda, A. (2013) 'Functional Outcomes of Stroke Patients Admitted to a Tertiary Hospital in the Western Cape, South Africa', *SA Journal of Physiotherapy*, 69(2). doi: 10.4102/sajp.v69i2.23.
Perry, J. *et al.* (1995) 'Classification of walking handicap in the stroke population', *Stroke*, 26(6), pp. 982–989. doi: 10.1161/01.STR.26.6.982.
Preston, E. *et al.* (2021) 'Prediction of Independent Walking in People Who Are Nonambulatory Early After Stroke: A Systematic Review', *Stroke*, 52(10), pp. 3217–3224. doi: 10.1161/STROKEAHA.120.032345.
Ranganai, E. and Matizirofa, L. (2020) 'An analysis of recent stroke cases in South Africa: Trend, seasonality and predictors', *South African Medical Journal*, 110(2), pp. 92–99. doi: 10.7196/SAMJ.2020.v110i2.013891.
Roy-O'Reilly, M. and McCullough, L. D. (2018) 'Age and Sex Are Critical Factors in Ischemic Stroke Pathology', *Endocrinology*, 159(8), pp. 3120–3131. doi: 10.1210/en.2018-00465.
Saini, V., Guada, L. and Yavagal, D. R. (2021) 'Global Epidemiology of Stroke and Access to Acute Ischemic Stroke Interventions', *Neurology*, 97(20), pp. S6–S16. doi:

10.1212/WNL.0000000000012781.
Salvadori, E. *et al.* (2021) ‘Comparison between Ischemic and Hemorrhagic Strokes in Functional Outcome at Discharge from an Intensive Rehabilitation Hospital’, *Diagnostics*, 11(38). doi: 10.3390/diagnostics11010038.
Schmid, A. *et al.* (2007) ‘Improvements in speed-based gait classifications are meaningful’, *Stroke*, 38(7), pp. 2096–2100. doi: 10.1161/STROKEAHA.106.475921.
Singam, A. *et al.* (2015) ‘Participation in complex and social everyday activities six years after stroke: Predictors for return to pre-stroke level’, *PLoS ONE*, 10(12), pp. 1–12. doi: 10.1371/journal.pone.0144344.
Tasseel-Ponche, S. *et al.* (2022) ‘Walking speed at the acute and subacute stroke stage: A descriptive meta-analysis’, *Frontiers in Neurology*, 13(989622). doi: 10.3389/fneur.2022.989622.
Toglia, J. *et al.* (2011) ‘The Mini-Mental State Examination and Montreal Cognitive Assessment in Persons With Mild Subacute Stroke : Relationship to Functional Outcome’, *Arch Phys Med Rehabil*, 92(5), pp. 792–798. doi: 10.1016/j.apmr.2010.12.034.
Tribelhorn, S., Motara, F. and Lewis, C. M. (2021) ‘Stroke: A retrospective review of the incidence and epidemiology in a South African academic hospital emergency department’, *South African Medical Journal*, 111(12), pp. 1205–1210. doi: 10.7196/SAMJ.2021.v111i12.15682.
Tyson, S. and Connell, L. (2009) ‘The psychometric properties and clinical utility of measures of walking and mobility in neurological conditions: A systematic review’, *Clinical Rehabilitation*, 23(11), pp. 1018–1033. doi: 10.1177/0269215509339004.
Wang, C.-H. *et al.* (2004) ‘Psychometric Properties of 2 Simplified 3-Level Balance Scales’, *Phys Ther*, 84(5), pp. 430–438.
Westerlind, E. *et al.* (2020) ‘Experienced pain after stroke: A cross-sectional 5-year follow-up study’, *BMC Neurology*, 20(1), pp. 1–8. doi: 10.1186/s12883-019-1584-z.
Wolf, S. L., Catlin, P. A. and Robertson, R. (1999) ‘Validity of Measurements of Walking Time Using the Emory Functional’, *Phys Ther*, 79(12), pp. 1122–1133. doi: 10630281.
World Health Organisation (2024) *Rehabilitation*. Available at: https://www.who.int/news-room/fact-sheets/detail/rehabilitation (Accessed: 6 August 2025).

Appendices

Appendix A: Plagiarism declaration

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

FACULTY OF HEALTH SCIENCES

PLAGIARISM DECLARATION TO BE SIGNED BY ALL HIGHER DEGREE STUDENTS

SENATE PLAGIARISM POLICY: APPENDIX ONE

I Maxine Leigh Farr (Student number: 1095688) am a student registered for the degree of Master of Science, Physiotherapy in the academic year 2024.

I hereby declare the following:

- I am aware that plagiarism (the use of someone else's work without their permission and/or without acknowledging the original source) is wrong.
- I confirm that the work submitted for assessment for the above degree is my own unaided work except where I have explicitly indicated otherwise.
- I have followed the required conventions in referencing the thoughts and ideas of others.
- I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this is not my own unaided work or that I have failed to acknowledge the source of the ideas or words in my writing.
- I have included as an appendix a report from "Turnitin" (or other approved plagiarism detection) software indicating the level of plagiarism in my research document.

Signature: ______________ Date: 30/03/2025

Appendix B: 10 Meter Walk Test

Core Measure: 10 Meter Walk Test (10mWT) Overview	• The 10mWT is used to assess walking speed in meters/second (m/s) over a short distance.
Number of Test Items	• 1 item
Scoring	• The total time taken to ambulate 6 meters (m) is recorded to the nearest hundredth of a second. 6 m is then divided by the total time (in seconds) taken to ambulate and recorded in m/s[1,2]
Equipment	• Stopwatch • A clear pathway of at least 10 m (32.8 ft) in length in a designated area over solid flooring[2,3]
Time (new clinician)	• 5 minutes or less
Time (experienced clinician)	• 5 minutes or less
Cost	• Free
Logistics-Setup	• A clear pathway of at least 10 m (32.8 ft) in length in a designated area over solid flooring is required. • Measure and mark the start and end point of a 10-m walkway. • Add a mark at 2 m and 8 m (identifying the central 6 m which will be timed). • Quiet conditions[1]
Logistics-Administration	• Comfortable walking speed: o Have the patient start on the 0-m mark (start line) o Instructions to patient: *"Walk at your own comfortable walking pace and stop when you reach the far mark."* • Fast walking speed: o Have the patient start on the 0-m mark (start line) o Instructions to patient: *"Walk as fast as you can safely walk and stop when you reach the far mark."* • Two trials are administered at the patient's comfortable walking speed, followed by 2 trials at his/her fast walking speed, per the below instructions. The 2 trials, for each speed, are averaged and the 2 gait speeds are documented in meters/second.[1] • Patients may use any assistive device or bracing that they are currently using. The type of device and/or bracing must be documented.

• When administering the test, do not walk in front of or directly beside the patient, as this may “pace” the patient and influence the speed and distance they walk. Instead, walk at least a half step behind the patient.

Appendix C: Berg Balance Scale

1. SITTING TO STANDING

INSTRUCTIONS: Please stand up. Try not to use your hand for support.

( ) 4 able to stand without using hands and stabilize independently

( ) 3 able to stand independently using hands

( ) 2 able to stand using hands after several tries

( ) 1 needs minimal aid to stand or stabilize

( ) 0 needs moderate or maximal assist to stand

2. STANDING UNSUPPORTED

INSTRUCTIONS: Please stand for two minutes without holding on.

( ) 4 able to stand safely for 2 minutes

( ) 3 able to stand 2 minutes with supervision

( ) 2 able to stand 30 seconds unsupported

( ) 1 needs several tries to stand 30 seconds unsupported

( ) 0 unable to stand 30 seconds unsupported

If a subject is able to stand 2 minutes unsupported, score full points for sitting unsupported. Proceed to item #4.

3. SITTING WITH BACK UNSUPPORTED BUT FEET SUPPORTED ON FLOOR OR ON A STOOL

INSTRUCTIONS: Please sit with arms folded for 2 minutes.

( ) 4 able to sit safely and securely for 2 minutes

( ) 3 able to sit 2 minutes under supervision

( ) 2 able to able to sit 30 seconds

( ) 1 able to sit 10 seconds

( ) 0 unable to sit without support 10 seconds

4. STANDING TO SITTING

INSTRUCTIONS: Please sit down.

( ) 4 sits safely with minimal use of hands

( ) 3 controls descent by using hands

( ) 2 uses back of legs against chair to control descent

( ) 1 sits independently but has uncontrolled descent

( ) 0 needs assist to sit

5. TRANSFERS

INSTRUCTIONS: Arrange chair(s) for pivot transfer. Ask subject to transfer one way toward a seat with armrests and one way toward a seat without armrests. You may use two chairs (one with and one without armrests) or a bed and a chair.

( ) 4 able to transfer safely with minor use of hands

( ) 3 able to transfer safely definite need of hands

( ) 2 able to transfer with verbal cuing and/or supervision

( ) 1 needs one person to assist

( ) 0 needs two people to assist or supervise to be safe

6. STANDING UNSUPPORTED WITH EYES CLOSED

INSTRUCTIONS: Please close your eyes and stand still for 10 seconds.

( ) 4 able to stand 10 seconds safely

( ) 3 able to stand 10 seconds with supervision

( ) 2 able to stand 3 seconds

( ) 1 unable to keep eyes closed 3 seconds but stays safely

( ) 0 needs help to keep from falling

7. STANDING UNSUPPORTED WITH FEET TOGETHER

INSTRUCTIONS: Place your feet together and stand without holding on.

( ) 4 able to place feet together independently and stand 1 minute safely
( ) 3 able to place feet together independently and stand 1 minute with supervision
( ) 2 able to place feet together independently but unable to hold for 30 seconds
( ) 1 needs help to attain position but able to stand 15 seconds feet together
( ) 0 needs help to attain position and unable to hold for 15 seconds

8. REACHING FORWARD WITH OUTSTRETCHED ARM WHILE STANDING

INSTRUCTIONS: Lift arm to 90 degrees. Stretch out your fingers and reach forward as far as you can. (Examiner places a ruler at the end of fingertips when arm is at 90 degrees. Fingers should not touch the ruler while reaching forward. The recorded measure is the distance forward that the fingers reach while the subject is in the most forward lean position. When possible, ask subject to use both arms when reaching to avoid rotation of the trunk.)

( ) 4 can reach forward confidently 25 cm (10 inches)
( ) 3 can reach forward 12 cm (5 inches)
( ) 2 can reach forward 5 cm (2 inches)
( ) 1 reaches forward but needs supervision
( ) 0 loses balance while trying/requires external support

9. PICK UP OBJECT FROM THE FLOOR FROM A STANDING POSITION

INSTRUCTIONS: Pick up the shoe/slipper, which is place in front of your feet.

( ) 4 able to pick up slipper safely and easily
( ) 3 able to pick up slipper but needs supervision
( ) 2 unable to pick up but reaches 2-5 cm(1-2 inches) from slipper and keeps balance independently
( ) 1 unable to pick up and needs supervision while trying
( ) 0 unable to try/needs assist to keep from losing balance or falling

10. TURNING TO LOOK BEHIND OVER LEFT AND RIGHT SHOULDERS WHILE STANDING

INSTRUCTIONS: Turn to look directly behind you over toward the left shoulder. Repeat to the right. Examiner may pick an object to look at directly behind the subject to encourage a better twist turn.

( ) 4 looks behind from both sides and weight shifts well
( ) 3 looks behind one side only other side shows less weight shift
( ) 2 turns sideways only but maintains balance
( ) 1 needs supervision when turning
( ) 0 needs assist to keep from losing balance or falling

11. TURN 360 DEGREES

INSTRUCTIONS: Turn completely around in a full circle. Pause. Then turn a full circle in the other direction.

( ) 4 able to turn 360 degrees safely in 4 seconds or less
( ) 3 able to turn 360 degrees safely one side only 4 seconds or less
( ) 2 able to turn 360 degrees safely but slowly
( ) 1 needs close supervision or verbal cuing
( ) 0 needs assistance while turning

12. PLACE ALTERNATE FOOT ON STEP OR STOOL WHILE STANDING UNSUPPORTED

INSTRUCTIONS: Place each foot alternately on the step/stool. Continue until each foot has touch the step/stool four times.

( ) 4 able to stand independently and safely and complete 8 steps in 20 seconds
( ) 3 able to stand independently and complete 8 steps in > 20 seconds
( ) 2 able to complete 4 steps without aid with supervision
( ) 1 able to complete > 2 steps needs minimal assist
( ) 0 needs assistance to keep from falling/unable to try

13. STANDING UNSUPPORTED ONE FOOT IN FRONT

INSTRUCTIONS: (DEMONSTRATE TO SUBJECT) Place one foot directly in front of the other. If you feel that you cannot place your foot directly in front, try to step far enough ahead that the heel of your forward foot is ahead of the toes of the other foot. (To score 3 points, the length of the step should exceed the length of the other foot and the width of the stance should approximate the subject's normal stride width.)

( ) 4 able to place foot tandem independently and hold 30 seconds
( ) 3 able to place foot ahead independently and hold 30 seconds
( ) 2 able to take small step independently and hold 30 seconds
( ) 1 needs help to step but can hold 15 seconds
( ) 0 loses balance while stepping or standing

14. STANDING ON ONE LEG

INSTRUCTIONS: Stand on one leg as long as you can without holding on.

( ) 4 able to lift leg independently and hold > 10 seconds
( ) 3 able to lift leg independently and hold 5-10 seconds
( ) 2 able to lift leg independently and hold ≥ 3 seconds
( ) 1 tries to lift leg unable to hold 3 seconds but remains standing independently.
( ) 0 unable to try of needs assist to prevent fall

( ) TOTAL SCORE (Maximum = 56)

Appendix D: Timed Up and Go

Timed Up and Go Instructions

General Information (derived from Podsiadlo and Richardson, 1991):

- The patient should sit on a standard armchair, placing his/her back against the chair and resting his/her arms chair's arms. Any assistive device used for walking should be nearby.
- Regular footwear and customary walking aids should be used.
- The patient should walk to a line that is 3 meters (9.8 feet) away, turn around at the line, walk back to the chair, and sit down.
- The test ends when the patient's buttocks touch the seat.
- Patients should be instructed to use a comfortable and safe walking speed.
- A stopwatch should be used to time the test (in seconds).

Set-up:

- Measure and mark a 3 meter (9.8 feet) walkway
- Place a standard height chair (seat height 46cm, arm height 67cm) at the beginning of the walkway.

Patient Instructions (derived from Podsiadlo and Richardson, 1991):

- Instruct the patient to sit on the chair and place his/her back against the chair and rest his/her arms chair's arms.
- The upper extremities should not be on the assistive device (if used for walking), but it should be nearby.
- Demonstrate the test to the patient.
- When the patient is ready, say "Go"
- The stopwatch should start when you say go, and should be stopped with the patient's buttocks touch the seat.

Reference:

Podsiadlo, D. and Richardson, S. (1991). "The timed "Up & Go": a test of basic functional mobility for frail elderly persons." J Am Geriatr Soc 39(2): 142-148.

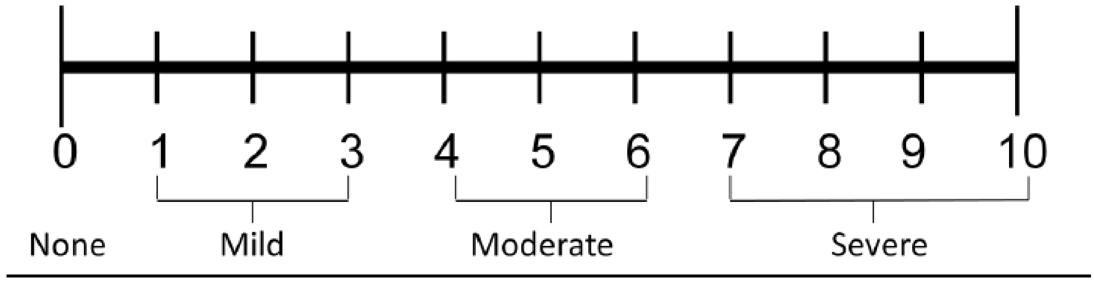
Appendix E: Numerical Pain Rating Scale

The Numeric Pain Rating Scale Instructions

General Information:

- The patient is asked to make three pain ratings, corresponding to current, best and worst pain experienced over the past 24 hours.
- The average of the 3 ratings was used to represent the patient's level of pain over the previous 24 hours.

Patient Instructions (adopted from (McCaffery, Beebe et al. 1989):
"Please indicate the intensity of current, best, and worst pain levels over the past 24 hours on a scale of 0 (no pain) to 10 (worst pain imaginable)"



Reference:

McCaffery, M., Beebe, A., et al. (1989). Pain: Clinical manual for nursing practice, Mosby St. Louis, MO.

Appendix F: 5 Times Sit to Stand

Core Measure: Five Times Sit-To-Stand (5TSTS)

Overview	• The Five Times Sit to Stand Test measures one aspect of transfer skill. The test provides a method to quantify functional lower extremity strength and/or identify movement strategies a patient uses to complete transitional movements.
Number of test items	• 1
Scoring	• The score is the amount of time (to the nearest decimal in seconds) it takes a patient to transfer from a seated to a standing position and back to sitting five times.
Equipment	• Standard height chair (43-45 cm, 17-18 inches) with a backrest. • Stopwatch
Time (new clinician) **Time (experienced clinician)**	• Less than 5 minutes • Less than 5 minutes
Cost	• Free
Logistics-Setup	• The chair should be free-standing • Subjects are allowed to place their feet comfortably under them during testing.1
Logistics-Administration	• One trial is administered • A patient is instructed to sit with arms folded across their chest and with back against the chair. A patient with hemiplegia can have the impaired arm at his/her side or in a sling. • Instruct the patient: "I want you to stand up and sit down five times in a row, as quickly as you can, when I say 'Go'. Be sure to stand up fully and try not to let your back touch the chair back between each repetition. Do not use the back of your legs against the chair." • Time starts when the tester says "Go." • Time stops when the patient's body touches the chair following the fifth repetition. • If individuals are unable to complete the first sit to stand independently, without use of arms, the test is terminated.1,2

Logistics-Scoring	• Document the time in seconds (to the nearest decimal) required to complete the test. If the patient cannot perform five stands to complete the test without use of arms, a score of 0 seconds should be documented. When possible within the medical record it is also recommended to note the reason, such "unable to perform five repetitions." The tester can document the number of stands, time, or compensatory movements for baseline information, but this should not be considered a trial of the 5TSTS Test.
Additional Recommendations	• To track change, it is recommended that this measure is administered a minimum of two times (admission and discharge), and when feasible, between these periods, under the same test conditions for the patient. • Recommend review of this standardized procedure and, on an annual basis, establish consistency within and among raters using the tool.

Common Questions and Variations

1. "What if I don't have a chair that is 43-45 cm (17-18 inches) high?" a. This is the recommended height for completing the test. If the chair used is a different height, the height should be measured, documented and reported as a deviation from this standardized procedure.
b. Using the same chair height is recommended for ongoing assessments to capture change in the patient.
c. Note that this recommended chair height is different from the recommended chair height in the Berg Balance Scale (18-20 inches).

2. "What if the individual's feet don't touch the floor when they have their back against the backrest?" a. In this scenario, it is permissible to allow the individual to move forward in the chair until their feet are flat on the floor. It is recommended that the deviation from standardized protocol be documented as well.

3. "What if the individual is very tall?" a. It would be appropriate to use a taller chair or apply a seat cushion to bring the hip flexion angle to 90 degrees when in the seated position.[3] This condition should be documented as a variation of the standardized procedure.

4. "What if my patient cannot stand without using his/her hands?" a. When following the standardized procedure, it would be appropriate to document 0 for the score. While 0 seconds would be the fastest possible time to complete the test, it is also impossible and therefore would be

clear in any medical record that the patient was unable to perform the test. When possible within the medical record it is also recommended to note the reason, such as “unable; requires use of hands”. At the point in time when the patient is able to complete 5 sit-to-stands without the use of upper extremities, a baseline 5TSTS score can be recorded.
b. Arm and hand position influence the momentum and strategy for the sit to stand transition and influence 5TSTS Test scores.[3] If the patient cannot complete the assessment with arms folded, it is permissible to allow the individual to utilize his or her hands to assist. This deviation from standardized protocol should be documented. The standardized protocol score would still be “unable”.

5. "What if my patient cannot complete five repetitions?" a. If the patient does not complete *five repetitions*, a score of 0 seconds should be recorded. When possible within the medical record it is also recommended to note the reason, such as “unable to perform five repetitions”. The clinician can, however, use his or her clinical judgement to record a time for fewer repetitions or provide physical assistance to help the patient complete the assessment, as this information may be valuable to explore change over time for the individual patient.

6. "What if my patient has a loss of balance and requires physical assistance to prevent a fall?" a. Providing assistance during the test is a deviation from the standardized procedure, however, it may be necessary to prevent patient injury. If physical assistance is provided, the patient should be given a score of 0. When possible within the medical record it is also recommended to note the reason, such “unable to complete test without assistance”.

7. "Should my patient touch their back against the back rest between each repetition of sit to stand?" a. No, the patient should be encouraged to avoid touching his/her trunk to the backrest between each repetition to minimize utilization of momentum to complete the sit to stand.

8. "Should I include a practice session or multiple trials?” a. Yes, a practice session can ensure familiarization with the test.[4] So, if a clinician feels a practice session is warranted then one may be performed.
b. If a patient has limited endurance, consider an abbreviated practice trial of 2 sit to stands to ensure that the patient understands all components of the test.[5]

9. "Does foot position matter?" a. Yes, foot position can impact sit to stand time and has been found to be a limitation in some studies exploring the 5TSTS in neurologic populations.[1,6] A posterior foot position has been shown to have faster sit to stand times in patients with chronic stroke.[3]
b. Foot position should be self-selected by the patient.

References

1. Whitney SL, Wrisley DM, Marchetti GF,Gee MA, Redfern MS, Furman JM. Clinical measurement of sit-to-stand performance in people with balance disorders: validity of data for the Five-Times-Sit-to-Stand Test. *Phys Ther*. 2005;85(10):1034-1045.
2. Duncan RP, Leddy AL, Earhart GM. Five times sit-to-stand test performance in Parkinson’s disease. *Arch Phys Med Rehabil*. 2011;92:1431-6.
3. Kwong PWH, Ng SSM, Chung RCK, Ng CYF. Foot placement and arm position affect the Five Times Sit-to-Stand Test time of individuals with chronic stroke. *BioMed Research International*. 2014; 636530.
4. Møller, Andreas Buch, et al. Validity and variability of the 5-repetition sit-to-stand test in patients with multiple sclerosis. *Disabil Rehabil.* 2012;34(26):2251-2258.

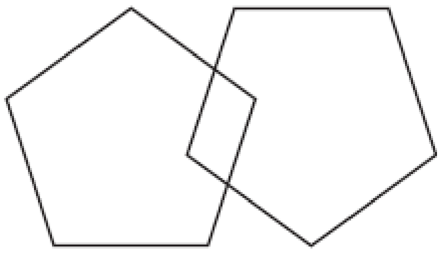
5. Bohannon, Richard W., et al. Sit-to-stand test: performance and determinants across the age-span." *Isokinet Exerc Sci*. 2010;18:4235-240.
6. Mong Y, Teo TW, Ng SS. 5-repetition sit-to-stand test in subjects with chronic stroke: reliability and validity. *Arch Phys Med Rehabil*. 2010;91(3): 407-413.

Appendix G: Mini-Mental State Examination

The Mini-Mental State Exam

Patient________________________ Examiner ___________________ Date________

Maximum	Score	
		Orientation
5	( )	What is the (year) (season) (date) (day) (month)?
5	( )	Where are we (state) (country) (town) (hospital) (floor)?
		Registration
3	( )	Name 3 objects: 1 second to say each. Then ask the patient all 3 after you have said them. Give 1 point for each correct answer. Then repeat them until he/she learns all 3. Count trials and record. Trials _______
		Attention and Calculation
5	( )	Serial 7's. 1 point for each correct answer. Stop after 5 answers. Alternatively spell "world" backward.
		Recall
3	( )	Ask for the 3 objects repeated above.Give 1 point for each correct answer.
		Language
2	( )	Name a pencil and watch.
1	( )	Repeat the following "No ifs, ands, or buts"
3	( )	Follow a 3-stage command: "Take a paper in your hand, fold it in half, and put it on the floor."
1	( )	Read and obey the following: CLOSE YOUR EYES
1	( )	Write a sentence.
1	( )	Copy the design shown.



____ Total Score

ASSESS level of consciousness along a continuum ________

Alert Drowsy Stupor Coma

"MINI-MENTAL STATE." A PRACTICAL METHOD FOR GRADING THE COGNITIVE STATE OF PATIENTS FOR THE CLINICIAN.*Journal of Psychiatric Research*, 12(3): 189-198, 1975. Used by permission.

Appendix H: Data extraction tool

Data		**Patient code**		**Patient code**	
Date of stroke					
Date of admission	Acute Hospital				
	Sub-acute facility				
Date of discharge					
Age					
Sex					
Area of stroke					
Comorbidities					
		Admission	**Discharge**	**Admission**	**Discharge**
10MWT					
BBS					
TUG					
NPRS					
5TSTS					
MMSE					
FIM	Self-care				
	Sphincter control				
	Transfers				
	Locomotion				
	Communication				
	Social cognition				

Appendix I: Ethical Clearance Certificate

UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG

R49 Ms ML Farr

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M210805

NAME: (Principal Investigator)	Ms ML Farr
DEPARTMENT:	School of Therapeutic Sciences Department of Physiotherapy Medical School University
PROJECT TITLE:	*Predictors of functional walking ability on discharge from inpatient stroke rehabilitation*
DATE CONSIDERED:	2021/08/27
DECISION:	Approved unconditionally
CONDITIONS:	
NOTE:	If contact information regarding student study participants is required, please contact the Registrar's office - <Nicoleen.Potgieter@wits.ac.za>
SUPERVISOR:	Ms N Comley-White
APPROVED BY:	CB Penny Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	2021/12/22

This Clearance Certificate is valid for 5 years from the date of approval. An extension may be applied for.

Appendix J: Consent Form

CONSENT TO ACCESS HEALTH RECORDS AND INFORMATION FOR A RESEARCH REPORT

TO: ClaytonCare Group Directors

My name is Maxine Leigh Farr and I am a physiotherapist working for the ClaytonCare Group (CCG) at Care@Midstream Sub-Acute Rehabilitation Hospital. I am completing a research report for my master's degree in Physiotherapy (Neurology) at the University of Witwatersrand and I would like to ask for permission to access medical records from the period of June 2017 to June 2021.

My research topic is **'Predictors of functional walking ability on discharge from inpatient stroke rehabilitation'.** It is a retrospective record review study that will aim to determine the predictors of functional walking ability on discharge from inpatient stroke rehabilitation. To be able to predict a patient's expected walking ability on admission to a rehabilitation facility would not only aid in setting realistic goals with the patient but would also assist with treatment plans, anticipating equipment needs, possible home modifications, carer education and training, and discharge planning.

To be able to conduct this study, I will require access to the following information from medical records (admission and discharge reports):

- Date of stroke
- Date of admission and discharge
- Age
- Sex
- Side of brain lesion
- Comorbidities
- Complications
- Results of outcome measures

- 10 Meter Walk Test, Berg Balance Scale, Timed Up and Go, Numeric Pain Rating Scale, 5 Times Sit to Stand, Mini-Mental State Examination, Functional Independence Measure.

Privacy and Confidentiality

The privacy of the ClaytonCare Group and the patients will be of utmost importance and all reasonable efforts will be made to protect the information. Patients' data will be recorded under allocated codes to de-identify data and ensure confidentiality. There will be no risks involved for the ClaytonCare Group or for the patients whose data will be included in this study.

Ethics approval

Ethical clearance will be applied for from the University of the Witwatersrand Human Research Ethics Committee and a copy of ethical clearance will be sent to the hospital as soon as it is received. No data will be extracted until ethical clearance is received.

I thank you for your time.

Maxine Leigh Farr
maxinefarr@gmail.com
083 307 5582

If permission is granted, please sign below:

Dr Theresa Geeker

Name of director

Signature

09/07/2021

Date

Appendix L: Title Approval

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Private Bag 3 Wits, 2050
Fax: 027117172119
Tel: 02711 7172076

Reference: Ms Sandra Munesar
E-mail: Sandra.munesar@wits.ac.za

16 January 2025

Person No: 1095688
PAG

Miss ML Farr
50 Ripon Road
WR5 1HU
United Kingdom

Dear Miss Maxine Farr **Master of Science in Physiotherapy: Approval of Title** We have pleasure in advising that your proposal entitled Predictors of functional walking ability on discharge from inpatient stroke rehabilitation has been approved. Please note that any amendments to this title have to be endorsed by the Faculty's higher degrees committee and formally approved.

Yours sincerely

Ms Sandra Munesar
Faculty Registrar
Faculty of Health Sciences

100 1922 2022

Appendix N: Turnitin Report

As supervisors, we acknowledge this Turnitin report.

N. Comley-White and A. Harrison

31 March 2025

Research Report 1095688

ORIGINALITY REPORT

11%	6%	8%	2%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Bijl, Thea. "Predictors of Patient Length of Stay Post-Stroke in a Sub-Acute Rehabilitation Setting in Gauteng", University of the Witwatersrand, Johannesburg (South Africa), 2025 Publication	1%
2	wiredspace.wits.ac.za Internet Source	1%
3	www.mdpi.com Internet Source	<1%