EXPLORING OCCUPATIONAL THERAPISTS' PERCEPTIONS OF THE USE OF FUNCTIONAL ELECTRICAL STIMULATION IN ADULT STROKE REHABILITATION IN GAUTENG, SOUTH AFRICA

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Declaration

I, Sarah Frew, declare this Research Report is my own, unaided work. It is being submitted for the Master of Science in Occupational Therapy (Neurosciences) degree at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

Signature of candidate
Date 20/03/2025

Abstract

Purpose: Stroke is one of the global leading causes of disability, with motor deficits, particularly in the upper limb, being among one of the most common and debilitating consequences. Occupational therapists are crucial members of the multidisciplinary team, working to enhance patients' participation in daily activities by addressing motor impairments through interventions such as Functional Electrical Stimulation (FES). This study aimed to explore occupational therapists' perceptions of using FES in adult stroke rehabilitation and to examine the factors influencing its application in stroke rehabilitation in Gauteng, South Africa.

Materials and Methods: This study employed a descriptive qualitative research design. occupational therapists participated in semi-structured interviews conducted via an online platform. An inductive thematic analysis was used to analyse the data.

Results: Three themes emerged from this research study, namely, ‘A Tug of War’, ‘The Blind Leading the Blind’ and ‘A Puzzle of Practicality. ‘A Tug of War’ encompasses conflicting feelings of understanding the benefits of FES, the ideals held by the participants and holding feelings of caution. ‘The Blind Leading the Blind’ covers the gap in knowledge and skill surrounding the use of FES. Lastly, ‘A Puzzle of Practicality’ demonstrates the multitude of factors that play a role in using FES in context, illustrating client factors, how FES is being used, its frequency, accessibility, and usability in practice. These themes unravel the perceptions of occupational therapists and explore the factors that influence the use of FES in stroke rehabilitation in Gauteng, South Africa.

Conclusion: Many identified perceptions and factors challenge the use of FES in adult stroke rehabilitation. Addressing these challenges is essential for improving evidence-based practices in occupational therapy, especially for motor impairments after stroke.

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List of Abbreviations

ADL	Activities of Daily Living
AOTA	American Occupational Therapy Association
CPG	Clinical Practice Guideline
CRediT	Contributor Role Taxonomy
CDM	Clinical Decision-Making
ES	Electrical Stimulation
FES	Functional Electrical Stimulation
FMA-UE	Fugal-Meyer Assessment for Upper Extremity
GDP	Gross Domestic Product
HREC	Human Research Ethics Committee
MDT	Multidisciplinary Team
NMES	Neuromuscular Electrical Stimulation
OT	Occupational Therapy
OTASA	Occupational Therapy Association of South Africa
PAM	Physical Agent Modality
SCI	Spinal Cord Injury
SDG	Sustainable Development Goal
TENS	Transcutaneous Electrical Stimulation
UTAUT	Unified Theory of Acceptance and Use of Technology

Definitions

Functional electrical stimulation (FES) – Electrically stimulating impaired muscles to produce functional movements during the performance of an activity for improved participation in activities of daily living (Howlett, McKinstry and Lannin, 2018).

Neuromuscular electrical stimulation (NMES) – NMES aims to activate muscle fibres for improved pain, muscle range, and muscle contraction to promote motor re-learning by making use of higher frequencies (15-50 Hz) and longer amplitude widths (200-400 microseconds) to activate muscle fibres for contraction (Zhou *et al.*, 2018).

Occupational therapy is a client–centred profession. It assists clients in engaging in meaningful occupations or therapeutically using occupations to address impairments. This approach aims at gaining health and well-being in the form of functional independence to participate and engage in ordinary daily activities like self-care tasks, domestic tasks, work, and leisure (Rowland, Cooke and Gustafsson, 2008; Gentry *et al., 2024)*.

Stroke – A neurological deficit as a result of an acute focal injury to the central nervous system that is of vascular origin (Murphy and Werring, 2020).

Transcutaneous electrical stimulation (TENS) – TENS does not aim to activate muscle fibres but rather focuses on activating sensory fibres for pain modulation, oedema and wound management using low frequencies (75-100 Hz) and shorter amplitude widths (<200 microseconds)(Zhou *et al.*, 2018).

Overview of the structure of the research report

This research report is constructed in the submissible format of three chapters. This format was chosen to disseminate study findings and is suited to an academic audience via publication. The chapter contents are as follows:

Chapter 1: Introduction, literature review and methods of the study

Chapter 2: Manuscript for a scientific journal - addresses objective 1 of the study

Chapter 3: Synthesis – addresses objective 2 of the study, provides recommendations and conclusions of the study

Chapter 1 Introduction, Literature Review, And Methods

1.1 Introduction

1.1.1 Introduction to the Study

Stroke is a leading cause of death and disability worldwide (Alawieh, Zhao and Feng, 2018; van Niekerk *et al.*, 2021). More than 80% of the burden of stroke occurs in middle to low-income countries, such as South Africa, and incidence rates in these areas continue to rise (Matizirofa and Chikobvu, 2021; Smythe *et al.*, 2022). The burden of non-communicable diseases such as stroke, places a financial and societal load on public and private healthcare systems in South Africa (Maleka, Stewart and Hale, 2012; Badaru, Ogwumike, Adeniyi and Nelson, 2017; Smythe *et al.*, 2022). The total direct costs of stroke management, across public and private health care in South Africa, over 5 years is estimated to be 7.3 trillion rands (Matizirofa and Chikobvu, 2021). Post-stroke care and management is a financial burden that fluctuates based on the severity of disability. The apparent solution to ease the economic and societal burden that comes with disability is to restore function for stroke survivors through rehabilitative measures (Rahman, 2025).

A stroke can be defined as a neurological deficit as a result of an acute focal injury to the central nervous system that is of vascular origin (Murphy and Werring, 2020). A stroke commonly results in a wide range of varied changes in sensation, cognitive, perceptual, and motor deficits of the contralateral upper and lower limb (Juckett *et al.*, 2020). Motor deficits are the most common adverse effects post-stroke (Ullah *et al.*, 2020). A recent study has found that 40-57% of stroke survivors experience acute upper limb weakness (Simpson *et al.*, 2021). Furthermore, only 5-20% of stroke survivors will achieve full recovery of the paretic upper limb (Ullah *et al.*, 2020). It is predicted that 70-75% of stroke survivors will experience residual motor impairments of the upper limb, frequently hindering independence and participation in ordinary activities of daily living (Sousa *et al.*, 2022). Occupational therapists play a crucial role within the Multidisciplinary Team (MDT), focusing on regaining and improving the ability to perform daily activities and improving the overall quality of life for stroke survivors (Juckett *et al.*, 2020). One way occupational therapists support improved engagement in daily activities and participation is by addressing specific body structure and functional deficits that limit stroke survivors. This often involves task-

specific training or goal-directed movements aimed at promoting more independent participation in meaningful activities (Mlambo, Pfavai, R. Chimusoro and Kaseke, 2022). Particularly during earlier stages of rehabilitation, when individuals may lack the motor function needed to perform desired tasks, occupational therapists focus on restoring key functions—such as upper limb strength and muscle tone—to enable the transfer of motor improvements into real-life occupational performance (Mlambo *et al.*, 2022). One of the most disabling deficits concerning activity participation post-stroke is the motor impairment of the contralateral upper limb (Ullah *et al.*, 2020).

Functional electrical stimulation (FES) has the potential to improve upper limb function following a stroke during the rehabilitative phase (Tarkka, Pitkänen, Popovic, Vanninen and Könönen, 2011; Ullah *et al.*, 2020). Although relevant international clinical stroke guidelines — including those from the United Kingdom, Australia, and the United States of America (Winstein *et al.*, 2016; Stroke Foundation, 2022; London: Intercollegiate Stroke Working Party, 2023) — recommend electrical stimulation as a supplementary rehabilitative modality alongside routine care, the evidence supporting its use in occupational therapy remains limited. Current research offers low-grade but promising evidence, with studies suggesting that FES has a small to moderate positive effect (Howlett *et al.*, 2015; Sun *et al.*, 2025). Motor recovery post-stroke is time-sensitive, so early intervention needs to be as efficient and effective as possible. The significance for occupational therapists to incorporate rehabilitative modalities, like FES, into clinical practice to better enhance motor function post stroke is crucial to be able to limit the effects of disability and enhance the quality of life of stroke survivors. Thus, there is a further need for investigation into the role of FES in stroke rehabilitation from an occupational therapy perspective.

1.1.2 Problem Statement

Despite promising findings from FES research and the endorsement of its use in stroke rehabilitation by numerous international guidelines (Winstein *et al.*, 2016; Stroke Foundation, 2022; London: Intercollegiate Stroke Working Party, 2023), FES is a modality that is continually underutilised by occupational therapists in clinical practice (Howlett *et al.*, 2015; Howlett, McKinstry and Lannin, 2018). Translating evidence or research into clinical practice can be challenging for a multitude of reasons, such as

misconceptions, workload pressures, a lack of experience, as well as limited knowledge, appraising or knowledge-seeking behaviours (Auchstaetter *et al.*, 2016; Walker, Fletcher-Smith, Sprigg and Pandyan, 2022). In the case of FES use in stroke rehabilitation from the perspective of occupational therapists, the translation and implementation of FES into clinical practice has been explored in the Global North in countries like Australia and Canada (Howlett *et al.*, 2015; Howlett, McKinstry and Lannin, 2018). However, the reasons for occupational therapists residing in the Global South, specifically in the context of South Africa, are unknown. This gap foregrounds the need to explore and understand occupational therapists' perceptions of FES and further identify influencing factors of its use or non-use in stroke rehabilitation. This problem statement aims to highlight the gap between the theoretical and research-based promise of FES and its practical application in clinical settings, as little is known regarding the use or non-use of FES among occupational therapists in stroke rehabilitation in South Africa. Bridging this gap has the potential to drive research that provides evidence to better inform practice, all in the hopes of working towards optimising the use of FES in achieving functional outcomes in stroke rehabilitation.

1.1.3 Purpose of the study

The purpose of this study was to explore the perceptions of occupational therapists working in public and private healthcare settings regarding FES use in adult stroke rehabilitation, with the intention of understanding their subjective experiences. The aim of investigating the subjective experience was to gain deeper insights into how and why FES is or is not being used among occupational therapists working in adult stroke rehabilitation in Gauteng. The findings of this study can add to the knowledge sources informing clinical programmes regarding adjunctive modalities for neurorehabilitation.

1.1.3 Research question

What are occupational therapists' perceptions of the use of functional electrical stimulation in adult stroke rehabilitation in Gauteng, South Africa?

1.1.4 Aim of the study

This study aims to explore occupational therapists' perceptions of the use of functional electrical stimulation in adult stroke rehabilitation in Gauteng, South Africa.

1.1.5 Objectives

The objectives of this study are:

i. To explore occupational therapists' perceptions of the use of FES in adult stroke rehabilitation in Gauteng, South Africa.
ii. To describe the factors influencing the use of FES in adult stroke rehabilitation by occupational therapists in Gauteng, South Africa.

1.1.6 Justification of the Study

This research study explored the subjective experiences of occupational therapists' use or non-use of FES in adult stroke rehabilitation to understand the evidence-practice gap. The significance of this investigation is that these findings could shed light on how and why FES is or is not being used in the context of activity or occupation-based rehabilitation, and thus hold the potential to inform development of the technology or implementation in practice. Ultimately, the findings of this research study will positively contribute towards three identified Sustainable Development Goals (SDGs), which are health and well-being; industry, innovation and infrastructure; as well as quality education. With regards to health and well-being, understanding how FES is or isn't being used by occupational therapists will assist with informing therapeutic practice so that better health outcomes can be achieved in reducing disability and, essentially, achieving improved well-being among stroke survivors. The accessibility of rehabilitation technologies and practices has been a perpetual challenge within the South African context, specifically when contrasting public and private healthcare settings. The findings of this study will highlight disparities in access to rehabilitation technologies, such as FES, across both public and private healthcare sectors, while also contributing to the advancement of SDG 9. Lastly, this research study will pave the way to better inform training and education programs for occupational therapists, thereby enhancing the quality of FES education and further

highlighting the gap in knowledge and understanding among occupational therapists regarding the use of FES in occupation-based stroke rehabilitation. Along with exploring perceptions, the research study will identify influencing factors when using FES, through the lived experience of each participant, which will assist in guiding education resources and continued professional development. The findings of this study could serve as a starting point to reinforce the knowledge sources informing neurorehabilitation clinical programs, specifically regarding the use of FES in occupation or activities of daily living to reduce physical impairments post stroke.

1.2 Literature review

1.2.1 Introduction to the Literature Review

This section comprehensively reviews and synthesises the most recent literature relevant to answering the research question. Full text journal articles were searched using the databases such as Google Scholar and PubMed using search terms derived from the title of the study. Further relevant articles were found through perusing the reference list of these articles. The literature will begin by describing the resultant impact of a stroke on functional abilities; highlighting the effects of disability post-stroke. The review then explores the role of an interdisciplinary rehabilitation team in managing stroke recovery, focusing on the contributions made by occupational therapists. The final section of the review will investigate the growing body of literature on electrical stimulation, specifically FES, and its significance to stroke rehabilitation.

1.2.2 Stroke

While stroke is a leading cause of fatality, it is also a primary cause of disability worldwide (Alawieh, Zhao, and Feng 2018; van Niekerk et al, 2021). If an individual survives a stroke, the resulting complications can lead to various degrees of disability, significantly hindering their quality of life (Yao *et al.*, 2021). Research shows that 40% of stroke survivors will endure moderate disability, and 15-30% will face severe disabilities (Yao *et al.*, 2021). Common stroke sites include the basal ganglia, parietal, and frontal cortex, which impact the functioning of the motor and sensory control of the face, arm, and leg, as well as cognition with a primary focus on executive functioning, mood and emotion, and communication (Edzie *et al.*, 2021; Bakaeva *et*

al., 2024; Patti., 2024).(Edzie *et al.*, 2021; Bakaeva *et al.*, 2024; Patti., 2024) The identified area of deficits debilitates a person's mobility and participation in daily activities as well as their quality of life, highlighting the need for personalised rehabilitation to aid disability management post-stroke (Alawieh *et al.*, 2018; Gittins *et al.*, 2021).

In 2019, an international systematic analysis found that between 1990 and 2019, the number of incident strokes increased by 70%, with the bulk of strokes occurring in low- to middle-income countries (Feigin *et al.*, 2021). Tiwari *et al.* 2021 conducted a qualitative study in India, a socioeconomic climate similar to South Africa, exploring stroke survivors' and their caregivers' perceptions and experiences. This study found that stroke survivors often experience a diminished quality of life due to physical and financial dependency post-stroke, mental fragility, and perceived social burden, specifically involving their family members, leading to a sense of hopelessness and loss of dignity (Tiwari, Joshi, Rai and Satpathy, 2021). The prevalence of disability among stroke survivors is high and is likely to remain a prominent issue, particularly in low to middle-income countries like South Africa, where inadequate hospital facilities and limited access to post-stroke care exacerbate the problem (Stellenbosch University, 2019; Kuriakose and Xiao, 2020).

A Cochrane review found that stroke survivors who received care from a MDT, with specialised expertise in a stroke unit, were more likely to survive, gain independence in their daily lives, and resume living at home 1-year post-stroke compared to those who received care from a general medical ward (Clarke and Forster, 2015). Post-stroke care by a MDT is critical in reducing the burden on stroke survivors as well as elevating and sustaining their quality of life (Clarke and Forster, 2015). There are three main phases of stroke recovery; the acute phase (first 7 days), subacute phase (first 3 – 6 months) and chronic phase (6 months on)(Grefkes and Fink, 2020). Stroke recovery is not absolute, but rather a complex phenomenon influenced by a multitude of factors such as an individual's comorbidities, severity of deficits, age, mechanism of stroke, lesion size and site (Cassidy and Cramer, 2017; Grefkes and Fink, 2020). Stroke recovery is time-sensitive as the first 4-12 weeks post-stroke are critical in achieving neuroplastic changes through neurological and functional recovery (Teasell and Hussein, 2018; Grefkes and Fink, 2020; Sousa *et al.*, 2022).

Neurological recovery is the spontaneous recovery of body functions and activity post-stroke that is exclusively dependent on time and is most prevalent within the first 3 months post-stroke (Cassidy and Cramer, 2017; Teasell and Hussein, 2018). Neurological recovery typically begins to plateau 6 months post-stroke (Teasell and Hussein, 2018; Grefkes and Fink, 2020). Functional recovery also plays an important role in influencing cortical reorganisation within the first 3 months post-stroke (Cassidy and Cramer, 2017; Teasell and Hussein, 2018). However, functional recovery process differs from that of neurological recovery as it possesses the potential to prolong recovery potential in stroke survivors up to 3 years post-stroke (Teasell and Hussein, 2018). Multidisciplinary rehabilitation interventions are an effective approach to enhancing neurological and functional recovery post-stroke, addressing and reducing the impact of stroke deficits leading to disability (Cabral *et al.*, 2022).

Motor impairments are one of the most common impairments experienced post-stroke as 80% of all stroke survivors will experience weakness of the contralateral face, arm, leg and trunk (Whitehead and Baalbergen, 2019; Cabral *et al.*, 2022). The majority of motor gains occur within the first 3 months post-stroke, this period intersects with the spontaneous biological recovery to allow neuroplastic changes (Cassidy and Cramer, 2017; Chin, Hayward, Chai and Brauer, 2021). Motor recovery post-stroke is challenging and dependent on multiple factors such as the stroke survivor's genetics, pathophysiology, sociodemographic factors, insurance, caregiver support, as well as other therapeutic factors (Alawieh *et al.*, 2018). Research has found that combining neuro-modulatory techniques with conservative stroke management techniques can enhance and facilitate neuroplasticity post-stroke (Alawieh *et al.*, 2018).

Stroke rehabilitation aims to support stroke survivors to return to premorbid functioning within their home, community and work environments, as effectively as possible through means of intervention from a MDT (Whitehead and Baalbergen, 2019). Intervention planning and execution from a MDT in stroke recovery is one of the most effective ways to limit dependency and improve survival post-stroke (Adeniji *et al.*, 2023). A MDT will generally include the physiotherapist, occupational therapist, speech and language therapist, dietitian, nurse and doctor (Stellenbosch University, 2019; Whitehead and Baalbergen, 2019). The MDT is a collection of professionals from different disciplines who take responsibility for a stroke survivor’s quality of life,

through collective care planning, goal setting with the client and decision-making all in attempts to optimize the stroke survivor's functional independence (Clarke and Forster, 2015; Adeniji *et al.*, 2023). There is frequent overlap between each profession within the MDT, supporting a rich understanding of one another's expertise (Clarke and Forster, 2015; Whitehead and Baalbergen, 2019). By embracing these interconnected roles and responsibilities, information exchange can be rapid and efficient; further enhancing early intervention and strengthening the foundation for effective rehabilitation post-stroke (Clarke and Forster, 2015; Whitehead and Baalbergen, 2019).

Occupational therapists play a vital role within the MDT to identify and establish the impact of stroke on the survivor's ability to participate and engage in their daily activities like self-care tasks, domestic tasks, work and leisure (Rowland *et al.*, 2008). A client-centred approach is used to develop a goal-specific program to assist with functional independence (Rowland *et al.*, 2008). Occupational therapy often makes use of various intervention strategies, which include remediation or skill development through occupation-based intervention, the use of compensatory strategies, activity modifications, and environmental accommodations (Wolf, Chuh, Floyd, McInnis and Williams, 2015; Pereira *et al.*, 2020). Occupational therapists possess a profound understanding of the therapeutic use of occupation to enhance or enable activity participation and engagement (Di Tommaso, Isbel, Scarvell and Wicks, 2016; Di Tommaso, Wicks and Isbel, 2019).

There is frequent overlap between physiotherapy and occupational therapy in stroke recovery, however both professions differ based on their philosophies and frameworks used in the treatment of motor impairment (Whitehead and Baalbergen, 2019). The current occupational therapy paradigm centralises health and well-being around occupation (Gentry *et al.*, 2018). Theoretically, occupational therapists view occupation-based practice as being valuable. However, occupation-based practice is not consistently being implemented in practice (Murray, Di Tommaso, Molineux, Young and Power, 2021). To fully comprehend this dilemma, history and context need to be considered (Murray *et al.*, 2021).

Occupational therapy was originally birthed through the moral treatment movement and the emphasis of the proper use of one's time through gratifying activities

(Perryman-Fox and Cox, 2020). However, the profession gained traction and acceptance by the medical community after the First and Second World Wars, in a context heavily powered by the biomedical model, which understood disability through the lens of impairments or biological factors (Murray *et al.*, 2021). However, present-day occupational therapy philosophy does not align with the biomedical model (Gentry *et al.*, 2018). Since the paradigm shift to its philosophical roots, occupational therapy practice is more in alignment with the biopsychosocial model, where the treatment approach provides patient-centred care accounting for more than just the impairments such as contextual factors as well as the mental health of the individual (Gentry *et al.*, 2018). Theoretically, this is where occupational therapy aligns, holistic and patient-centred care, however, in reality, the medical model dominates many clinical practice settings, specifically in acute or hospital-based settings, which limits occupation-based practice due to fast-paced discharge planning, leading to occupational therapists spending more time performing preparatory activities and frequently feeling undervalued and misunderstood within the MDT (Murray *et al.*, 2021).

In reality, occupational therapists, especially in acute care settings, are fostering an impairment-focused approach to address motor deficits post-stroke as a means to improve participation and engagement in daily occupations (Murray *et al.*, 2021). As a result, occupational therapists turn to adjunctive modalities, namely physical agent modalities (PAMs), such as FES, to enhance the neuroplastic window for motor relearning, specifically in the acute phase of stroke recovery (0-3 months post-stroke) (Sousa *et al.*, 2022). Common examples of PAMs that are used with patients with neurological fallout to encourage neural plasticity are constraint-induced movement therapy, mirror therapy and electrical stimulation (Walter and Winston, 2018).

1.2.3 Physical Agent Modalities

Physical agent modalities take the form of heat, cold, water, light, sound and electricity, which are applied to targeted areas of the body to bring about a therapeutic change on a physiological level on biomechanical or neurological systems (Bondoc and Feretti, 2018). According to Bondoc and Feretti (2018), PAMs can be used to address impairments such as pain and inflammation, tissue excitability, range of motion, and muscle activity, as well as modulate activity participation or performance. Electrical stimulation has shown promise in the recovery of motor control and neural circuits for

over half a century with most research occurring in the past decade (Bao, Khan, Song and Tong, 2020). The widely discussed new developments in this technology make it particularly relevant for qualitative inquiry. Understanding the perspectives of rehabilitation regarding its adoption, or lack thereof, can contribute to the wider scholarly discussion and advancement of this modality.

1.2.4 Electrical stimulation

Numerous forms of electrical stimulation are currently described in the literature, which are often described in conflicting ways (Eraifej *et al.*, 2017). However, Bao and colleagues (2020), have managed to create a sense of clarity when it comes to electrical stimulation. Electrical stimulation can be divided into three categories; namely non-invasive brain stimulation, invasive electrical stimulation techniques, and peripheral electrical stimulation. Non-invasive brain stimulation includes transcranial electrical stimulation, transcranial magnetic stimulation, and cerebellar and spinal cord stimulation, which are subcutaneous forms of electrical stimulation that aim to modulate neural plasticity even after the stimulation phase has been completed (Bao *et al.*, 2020). The emerging electrical stimulation techniques are invasive neurostimulation techniques largely based on animal models, such as deep brain stimulation, epidural cortical stimulation, and vagus nerve stimulation. Lastly, peripheral electrical stimulation is the most accessible technology and involves percutaneous forms of electrical stimulation, namely neuromuscular electrical stimulation (NMES), and transcutaneous nerve stimulation (TENS) (Bao *et al.*, 2020).

Peripheral electrical stimulation in neurorehabilitation aims to excite neuronal cells to elicit a response in the affected muscle and sensory fibres, primarily targeting intact fibres (Marquez-Chin and Popovic, 2020). Neuromuscular Electrical Stimulation and TENS, are the two principal forms of peripheral electrical stimulation, with FES classifying as a subcategory of NMES (Bao *et al.*, 2020). The distinction between NMES and TENS is dependent on the device parameters and the goal of its use in addressing impairments (Zhou *et al.*, 2018). The intensity of the electrical stimulation is dependent on three key parameters regarding the pulse (Marquez-Chin and Popovic, 2020). First, the pulse amplitude refers to the magnitude of stimulation measured in milliamps (mA). Second, the pulse width indicates the duration of each pulse measured in microseconds. Lastly, the pulse frequency, measured in hertz (Hz),

determines the rate at which the pulse stimulation is delivered, affecting the strength and quality of a muscle contraction (Marquez-Chin and Popovic, 2020). Pulses used in electrical stimulation can be categorised as monophasic or biphasic (Karamian *et al.*, 2022). A monophasic pulse is unidirectional, whereas biphasic pulses alternate between a positive and negative phase, making them bidirectional (Karamian *et al.*, 2022). Both monophasic and biphasic pulses promote muscle strengthening, however, the biphasic pulses are preferred as they limit damage to the skin (Karamian *et al.*, 2022). Neuromuscular electrical stimulation aims to activate muscle fibres for improved pain, muscle range, and muscle contraction to promote motor re-learning by making use of higher frequencies (15-50 Hz) and longer amplitude widths (200-400 microseconds) to activate muscle fibres for contraction (Zhou *et al.*, 2018). Rather, TENS does not aim to activate muscle fibres but rather focuses on activating sensory fibres for pain modulation, oedema and wound management using low frequencies (75-100 Hz) and shorter amplitude widths (<200 microseconds)(Zhou *et al.*, 2018).

Functional Electrical Stimulation (FES) is understood to be a subcategory of NMES (Bao *et al.*, 2020), what distinguishes NMES and FES is the purpose and utilisation of volitional movement (Hermann *et al.*, 2010; Howlett, McKinstry and Lannin, 2018; Marquez-Chin and Popovic, 2020). There are many different perspectives on defining FES. For example, Marquez-Chin and Popovic (2020), define FES as using electrical stimulation to contract desired muscles to assist in producing purposeful movements that can be used functionally in tasks like bringing a bottle to the mouth (Marquez-Chin and Milos R Popovic, 2020). Similarly, Khan et al., 2023 describe FES as applying electrical stimulation to stimulate paretic muscles for restoring movement, with no mention of activity (Khan *et al.*, 2023). Conversely, Howlett, McKinstry and Lannin, (2018), define FES as electrically stimulating impaired muscles to produce functional movements during the performance of an activity for improved participation in activities of daily living (Howlett *et al.*, 2018). The definitions provided by Marquez-Chin and Popovic (2020) and Khan *et al.* (2023), place limited emphasis on FES use while participating in an activity but rather primarily focusing on the acquisition of motor skills for functional movements. The variation in these definitions suggests that how researchers or clinicians make use of FES is dependent on what definition of FES they best align. Given that this research study focuses on the use of FES among occupational therapists in neurorehabilitation, the definition provided by Howlett,

McKinstry and Lannin (2018), three Australian occupational therapy researchers, will be adopted. This definition emphasizes using FES during activity participation which is better suited to the contemporary occupational therapy paradigm. However, without the use of activity or task orientation when using electrical stimulation, the use of the electrical stimulation device may be better aligned with that of NMES. Therefore, the controversy in the way that FES is defined by different authors creates ambiguity in FES use in stroke rehabilitation.

There are two main types of FES systems: open-loop systems and closed-loop systems as shown in Figure 1 (Karamian *et al.*, 2022; Khan *et al.*, 2023). Open-loop systems are FES devices that are manually controlled by the therapist using fixed electrical current settings that do not provide biofeedback, therefore limiting the ability of the user to self-correct (Karamian *et al.*, 2022; Khan *et al.*, 2023). Whereas closed-loop systems do provide biofeedback where sensors are used to scan the muscle for force contraction and joint position information to send it to a computer as a means to regulate input to the targeted muscles (Karamian *et al.*, 2022). Closed-loop systems involve two types; brain-controlled interface systems, and electromyogram (EMG) controlled systems (Khan *et al.*, 2023). Brain-interfaced controlled systems act as a direct channel between the brain and the peripheral device, using the individual's intent to move through motor imagery (captured through an electroencephalogram) to input data into a computer system to translate that imagery into an action or task. Whereas, EMG systems measure electrical currents in the targeted muscle during contraction and this information provides feedback to the EMG-FES device to adjust and stimulate the muscle appropriately to the task or command (Khan *et al.*, 2023). Despite closed-loop FES systems being more effective than open-loop systems in motor recovery post-stroke, open-loop systems are more widely available on the market and commonly applied in clinical practice (Khan *et al.*, 2023). Closed-loop systems are more frequently applied in the laboratory in research protocols (Khan *et al.*, 2023).

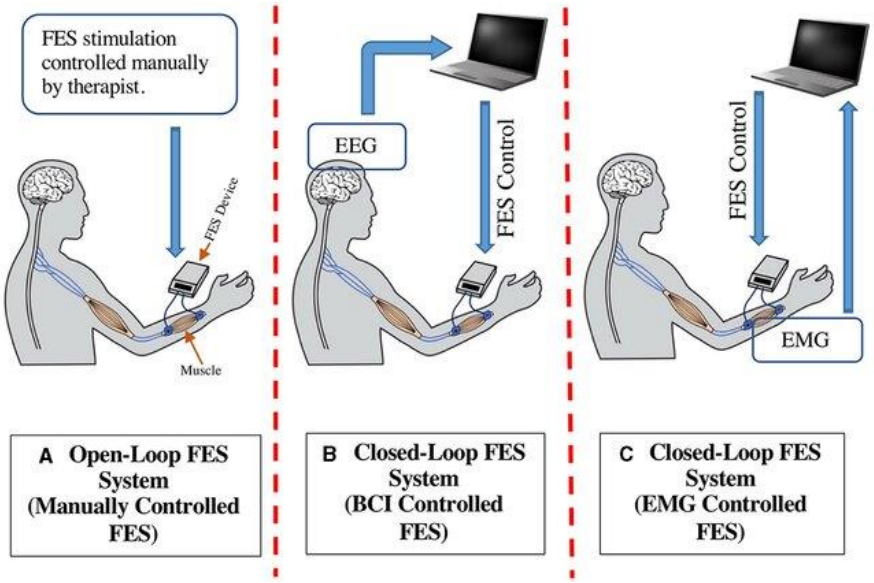

Figure 1. Types of FES systems - open-loop and closed-loop **(Khan *et al.*, 2023, pp 03)**

Open-loop FES systems are routinely used in two ways; to replace or compensate for function through the use of a neuroprosthesis, or to retrain function as a short-term therapeutic intervention modality through the use of percutaneous electrodes (Kapadia, Moineau and Popovic, 2020; Marquez-Chin and Popovic, 2020). The former use refers to devices that are worn throughout the day to aid in functional activities such as walking. The most common FES device used in the form of a neuroprosthesis is a drop foot stimulator which overcomes paralysis of the dorsiflexors and aids in locomotion (Marquez-Chin and Popovic, 2020; Müller *et al.*, 2020). Functional electrical stimulation, as a therapeutic or temporary intervention, is commonly used within clinical practice in the form of transcutaneous electrodes (Marquez-Chin and Popovic, 2020). When FES is used temporarily, this is typically a device like the Compex® electrical stimulator, where transcutaneous self-adhesive electrodes attached to a wire and portable stimulator, can be placed and manoeuvred on the person's skin to activate the nerve-innervating the desired muscle to move during intervention (Cuesta-Gómez *et al.*, 2017; Marquez-Chin and Popovic, 2020). A device such as this involves allowing the patient to attempt the desired functional movement during a functional task with assistance from electrical stimulation in the hopes that the patient will eventually be able to participate in daily tasks and activities without the use of the FES device (Marquez-Chin and Popovic, 2020).

Functional electrical stimulation and neuroplasticity

Neuroplasticity refers to changes in the structure or function of neuronal units in response to experiences or stimuli (Bao *et al.*, 2020). While it occurs spontaneously, it is often enhanced through targeted rehabilitation following a stroke (Cabral *et al.*, 2022). Neuroplasticity is considered the key to stroke rehabilitation because it enables the central nervous system to reorganise cortically, reinforcing disrupted synaptic pathways to recover and re-develop motor abilities (Marquez-Chin and Popovic, 2020). For movement to be produced, motor commands must be generated in the sensorimotor cortex and then transmitted to spinal interneurons, which communicate with efferent pathways to create an action (Popović, 2014; Bao *et al.*, 2020). It is thought that electrical stimulation can promote cortical plasticity by influencing neuronal circuits to improve blood flow to the motor control area of the cortex (Wegrzyk *et al.*, 2017; Bao *et al.*, 2020). This stimulation is delivered through percutaneous means, sending electrical impulses via afferent nerve fibres to the spinal cord, where interneurons are activated to modulate ascending pathways, leading to the activation of the sensorimotor cortex, thus facilitating cortical plasticity (Popović, 2014; Cabral *et al.*, 2022). Neuroimaging has shown that FES can enhance perfusion and excitability in the ipsilesional somatosensory cortex more effectively than passive electrical stimulation modalities like NMES and TENS (Eraifej *et al.*, 2017). Nonetheless, research has shown that electrical stimulation can enhance motor function post-stroke by promoting cortical plasticity (Howlett *et al.*, 2015). However, to counteract this notion, a systematic review published in 2023 confirmed that although FES research findings report on functional improvements achieved among stroke survivors post-FES rehabilitation, there are no studies to date that justify their findings with concrete neuroplasticity outcomes (Khan *et al.*, 2023). Therefore, it is unclear to what degree neuroplasticity occurs as a result of FES intervention (Khan *et al.*, 2023).

1.2.5 Motor control evidence

It is estimated that only about 15% of stroke survivors fully regain motor function post-stroke, while 33-60% experience minimal to no motor recovery in their hemiplegic upper limb (Hendricks, Van Limbeek, Geurts and Zwarts, 2002; Kwakkel and Kollen, 2013; Toh, Chia and Fong, 2022). Upper limb dysfunction significantly impairs stroke survivors' ability to engage independently in Activities of Daily Living (ADL), often resulting in a continued reliance on caregivers or family members (Eraifej *et al.*, 2017).

Therefore, FES is a favourable adjunctive modality to enhance and recover motor impairments post-stroke. This is seen in various recently published systematic reviews. In 2023, Khan et al. published a systematic review finding among 12 different studies, open- and closed-loop FES systems to achieve significant improvements on assessment scales like the Fugl-Meyer Assessment for Upper Extremity (FMA-UE), where all the data was found to be homogenous within each trial (Khan *et al.*, 2023). Khan et al., 2023 also found that when comparing closed and open-loop FES systems to non-FES upper limb stroke rehabilitation, such as physical training, FES upper limb stroke rehabilitation achieved greater gains in upper limb recovery (Khan *et al.*, 2023).

Closed-loop FES systems appear to achieve superior results to open-loop FES systems. However, open-loop FES systems are dominant within clinical settings and continue still achieve promising results (Khan *et al.*, 2023). Kapadia et al., 2020 observed similar benefits, specifically regarding EMG-FES among stroke and Spinal Cord Injury (SCI) survivors (Kapadia, Moineau and Popovic, 2020). When the EMG-FES systems were used in conjunction with conventional occupational therapy and physiotherapy intervention, greater improvements were noted in the Functional Independence Measure and FMA-UE compared to those receiving conventional occupational therapy or physiotherapy in isolation (Kapadia, Moineau and Popovic, 2020). These findings are supported by a scoping review from 2017, which noted significant benefits with a moderate effect size in ADL participation and FMA-UE scores among stroke survivors when transcutaneous FES was applied two months post-stroke (Eraifej *et al.*, 2017). Current research highlights that when FES is used as an adjunctive tool to intervention, FES can be effective in improving upper limb function and ADL participation post-stroke when compared to using conventional therapeutic techniques in isolation (Eraifej *et al.*, 2017; Kapadia, Moineau and Popovic, 2020; Khan *et al.*, 2023). Despite the significant effect that FES has shown to have on functional and motor scales when used alongside conventional therapeutic techniques, it is also important to note that these assessment tools may lack the sensitivity needed to detect subtle motor improvements in upper limb function (Sousa *et al.*, 2022).

1.2.6 Role of occupational therapy and FES application in rehabilitation

There is currently limited evidence specifically examining the application of functional electrical stimulation (FES) within the field of occupational therapy, as the majority of published research has been led by physiotherapists and neuroscientists (Auchstaetter *et al.*, 2016; Eraifej *et al.*, 2017; Brown *et al.*, 2023; Musselman *et al.*, 2024). However, much of this literature investigates areas that are highly relevant to occupational therapy, such as how FES supports improvements in activities of daily living (ADL) participation and upper limb motor recovery following stroke. Notably, two studies directly address the intersection of FES and occupational therapy. Howlett et al. (2015) conducted a systematic review with meta-analysis, concluding that FES had a small to moderate effect on enhancing activity participation when compared to training alone. More recently, Sun et al. (2025) performed a meta-analysis comparing FES combined with occupational therapy techniques to electromagnetic therapy combined with occupational therapy. Their findings showed that FES yielded superior motor improvements, as measured by the FMA-UE (Sun *et al.*, 2025). However, the detail of how FES was applied in the occupational therapy interventions in these studies was not provided.

Although occupational therapy-specific FES research remains scarce, the broader physiotherapy literature consistently addresses upper limb rehabilitation and ADL participation—both central concerns within occupational therapy practice. This overlap underscores the pressing need for more occupational therapy-driven research on electrical stimulation, to better understand and define its role in improving motor outcomes and functional participation post-stroke. This study, therefore, represents a unique and foundational contribution toward enhancing post-stroke rehabilitation practices in occupational therapy, with the goal of improving stroke survivors' quality of life and engagement in meaningful activities.

1.2.7 Infrequent use of FES in clinical practice

Although FES does provide evidence to suggest that when used in conjunction with conventional therapeutic techniques, motor control, specifically in the upper limb, can improve, which has been proved in randomised control trials, demonstrated by motor assessment scales such as FMA-UE (Eraifej *et al.*, 2017; Kapadia, Moineau and Popovic, 2020). Despite the promise in research, healthcare professionals on a global scale are not frequently making use of FES in clinical practice. Qualitative research

conducted in Canada and Australia confirms that among physiotherapists and occupational therapists, FES is rarely made use of in stroke rehabilitation (Howlett *et al.*, 2018; Musselman *et al.*, 2024). These research findings were also noted among physiotherapists working in Canada, where the majority of the survey respondents noted that they rarely make use of FES in stroke rehabilitation (Auchstaetter *et al.*, 2016). It is widely understood that therapists working in physical rehabilitation do not frequently make use of FES. However, it is also important to understand why this may be occurring. The lack of training in FES use appears to be a global crisis and one that is widely cited in FES research (Howlett, McKinstry and Lannin, 2018; Howlett, 2020; Bulley *et al.*, 2021; Brown *et al.*, 2023; Tedesco Triccas *et al.*, 2023; Musselman *et al.*, 2024). Further exploration into therapists' perception of the use of FES in stroke rehabilitation is needed to address barriers to advance the technology and clinical practice.

1.2.8 Lack of Training in FES

A study conducted by Auchstaetter et al., (2016), found that among 298 licensed physiotherapists working in Canada, the majority reported that they rarely or never use FES in clinical practice due to limited training received in FES (Auchstaetter *et al.*, 2016). This is supported by research findings among occupational therapists working in Australia, where FES is not frequently used in clinical practice due to limited undergraduate and post-graduate training (Howlett *et al.*, 2018). Undergraduate programs regarding FES for both physiotherapy and occupational therapy are not sufficient for clinical practice use, although there are postgraduate training programs, they are few and far between, leading to therapists depending on patient feedback, intuition, manufacturer manuals and mentorship from colleagues for skilled use of FES in improving motor or sensory impairments of the upper and lower limb post-stroke (Howlett *et al.*, 2018; Dionne, 2019; Abouzakhm *et al.*, 2022). Information regarding FES training at a postgraduate level in South African universities has not been reported in the literature. Improving access to hands-on training and education and the number of programs to improve the awareness of FES and its application will be an important enabler to improve the use of FES in clinical practice (Abouzakhm *et al.*, 2022). It is recommended that future research focus on informing postgraduate

programmes, courses and resources (i.e. protocols or practical guides) for qualified occupational therapists.

Evidence-based practice empowers clients and occupational therapists to inform their clinically based decisions on high-quality evidence rather than relying on professional experience in isolation (Buchanan, 2017). Evidence-based practice gives each profession credibility (Buchanan, 2017). Most occupational therapists hold a positive attitude toward evidence-based practice and understand the value that it holds (Upton, Stephens, Williams and Scurlock-Evans, 2014). However, many clinicians do not have the knowledge, skill, or resources to be able to translate findings from a research trial and apply them to clinical practice (Lynch, Chesworth and Connell, 2018). There is a scarcity of knowledge on how to deliver evidence-based stroke rehabilitation intervention in clinical practice (Lynch *et al.*, 2018). FES application in stroke intervention among occupational therapists demonstrates that clinical experience and observation substantiate the reasoning behind its use or non-use (Howlett *et al.*, 2018). However, what also complicates the translation of research into practice is that the methodologies used in FES research vary, convoluting the translatability of these findings into practice.

1.2.9 Evidence translation to clinical practice

Methodological variability makes it difficult to understand stimulation parameters in FES research in post-stroke intervention, limiting the replication of research into practice (Eraifej *et al.*, 2017). FES research either provides inconsistent stimulation parameters or does not stipulate stimulation parameters for FES devices used, making it impossible for research to be translated into practice by clinicians. A study conducted by Bhalla and Shergill (2020), found that the use of FES in conjunction with task-oriented training and constraint-induced movement therapy in sub-acute stroke (less than 6 months onset) rehabilitation achieved superior results in improved hand and grip function in comparison to receiving conventional physiotherapy intervention (Bhalla and Shergill, 2020). However, the study did not specify what FES device or what stimulation parameters were used. There was only mention of the duration of treatment, in other words, the intervention was trialled for 30 minutes 5 days a week over 6 weeks (Bhalla and Shergill, 2020). The limited mention of device types and stimulation parameters makes it challenging for healthcare professionals like

occupational therapists or physiotherapists to translate FES research into clinical practice.

FES evidence translation into practice also poses a challenge due to the lack of uniformity between stimulation parameters and intervention structuring when this information is available. A study conducted by Shendkar et al, 2015 and a study conducted by Lee and Kim, 2022 illustrate the challenge of heterogeneity experienced in FES research. Both studies achieved significant improvement in gait and balance using FES in conjunction with conventional physiotherapy intervention in the sub-acute phase of both ischemic and haemorrhagic stroke types, however, their intervention structures were dissimilar (Shendkar *et al.*, 2015; Lee and Kim, 2022). Shendkar et al FES group underwent 30 minutes of FES and 30 minutes of conventional physiotherapy for 5 days a week over 12 weeks using a surface electrode set at a frequency of 40 Hz, a pulse of 0.18 milliseconds and the intensity level was adjusted between the ranges of 20mA and 50 mA to cause dorsiflexion (Shendkar *et al.*, 2015). Whereas Lee and Kim's FES group underwent 30 minutes of FES intervention in conjunction with conventional physiotherapy intervention 5 times weekly over 4 weeks using 4 channel surface electrodes set at a frequency of 33 Hz, a pulse of 0.2 milliseconds and an intensity level of 90mA to cause dorsiflexion (Lee and Kim, 2022). Both studies illustrate a common end goal that FES used in conjunction with conventional physiotherapy intervention in the subacute phase of stroke will improve gait and balance (Shendkar *et al.*, 2015; Lee and Kim, 2022). However, the discrepancies in stimulation parameters and intervention structures make it confusing for clinicians to translate this research into practice. The lack of consistency in stimulation parameters, devices and intervention structures in FES research (Shendkar *et al.*, 2015; Bhalla and Shergill, 2020; Lee and Kim, 2022) limits the translatability of FES research into practice, limiting the knowledge and skill on how to apply FES in post-stroke rehabilitation to achieve improved motor impairments.

Regardless of the limitations noted in current FES research, many occupational therapists and physiotherapists, particularly documented in the Global North, are not aware of current FES findings. Bulley et al., 2021 found that among FES stakeholders, which included healthcare professionals, there is a general lack of awareness around FES among patients and clinical teams, which forces stakeholders to be more

proactive in self-directed learning but hold a preference to understand this knowledge and evidence from healthcare professionals (Bulley *et al.*, 2021). However, research conducted by Auchstaetter et al., 2016 found that among 298 physiotherapists working in Canada, one of the significant barriers to FES use in stroke rehabilitation was that participants lacked or were not certain of FES evidence to substantiate its use in practice (Auchstaetter *et al.*, 2016). Therefore, although FES stakeholders would like to learn and understand FES use in rehabilitation (Bulley *et al.*, 2021), many healthcare professionals lack knowledge and understanding of current FES literature (Auchstaetter *et al.*, 2016; Howlett *et al.*, 2018; Bulley *et al.*, 2021).

1.2.10 Quality of FES research in stroke rehabilitation

Although FES is regarded as a promising therapeutic modality for enhancing motor function post-stroke, several challenges hinder its widespread adoption and translation from research to clinical practice. While FES has demonstrated an impact on improving motor scores and activity participation, as measured by scales such as the FMA-UE and Functional Independence Measure (Eraifej *et al.*, 2017; Kapadia, Moineau and Popovic, 2020), the evidence supporting its efficacy remains low-grade due to various influencing factors (Eraifej *et al.*, 2017; Sousa *et al.*, 2022). Key issues include the heterogeneity of FES parameters across studies, such as variations in current, frequency, stimulation duration, and baseline participant function (Eraifej *et al.*, 2017; Fang *et al.*, 2023). FES research within the stroke population has been criticised for having limited randomised control trials, resorting to feasibility studies, small sample sizes that limit the generalizability of findings as well as a lack of follow-up data (Eraifej *et al.*, 2017; Kapadia, Moineau and Popovic, 2020; Khan *et al.*, 2023). Therefore, regardless of the promise that FES rehabilitation holds in motor recovery post-stroke, current FES research holds several limitations and requires further research to strengthen its conclusions (Khan *et al.*, 2023).

1.2.11 Lack of confidence

FES research presents promising findings to assist in reducing secondary impairments and improving activity performance post-stroke however, it does not contribute positively to therapist confidence and doubt (Howlett *et al.*, 2018; Walker *et al.*, 2022). FES is recommended for best practice in the treatment of motor impairments post-

stroke, as seen in multiple clinical practice guidelines specifically for the treatment of the upper extremity and gait rehabilitation (Hebert *et al.*, 2016; Stellenbosch University, 2019; Teasell *et al.*, 2020; Miyamoto *et al.*, 2022; Stroke Foundation, 2022a). Nonetheless, despite clinical practice guidelines recommending FES as a best practice for treating motor impairment in neurorehabilitation, clinical practice guidelines are frequently critiqued for being vague and lack explicit guidance on how clinicians can successfully implement FES within clinical practice (Dionne, 2019; Dionne, Lenker, Hennessy and Sullivan, 2020; Brown, Street, Adonis, Therese E Johnston, *et al.*, 2023). Occupational therapists lack confidence, on a global scale, in the implementation of FES in clinical practice due to limited training, knowledge and available resources which often limit clinicians from using FES in clinical practice (Howlett, 2020; Brown *et al.*, 2023; Musselman *et al.*, 2024). Healthcare professionals require better access to hands-on training, improved guidelines and resources to better assist with eliminating doubt and improving confidence levels when applying FES in neurorehabilitation (Howlett, 2020; Walker *et al.*, 2022; Musselman *et al.*, 2024).

1.2.12 Time constraints therapy

When it comes to the use of FES in stroke rehabilitation, the aspect of time is frequently mentioned as a barrier in FES literature (Auchstaetter *et al.*, 2016; Howlett *et al.*, 2018; Walker *et al.*, 2022). Time in this regard is quantified in two ways; time used in therapy and experience (Howlett *et al.*, 2018; Abouzakhm *et al.*, 2022). Many practitioners perceive FES as time-consuming, specific to settings where treatment sessions and lengths of stay are shorter, caseloads are higher, as FES is perceived to require lengthy set-ups, which includes altering the stimulation parameters according to the individual's tolerance and time to educate family members for use at home (Auchstaetter *et al.*, 2016; Abouzakhm *et al.*, 2022; Walker *et al.*, 2022). Therefore, due to FES being perceived as time-consuming, therapists are often deterred from integrating this modality into rehabilitation. Improving access to continued education and FES devices that are user-friendly and time-efficient may facilitate the implementation of FES into clinical practice (Auchstaetter *et al.*, 2016). Time constraints regarding the use of FES in neurorehabilitation can be addressed through post-graduate training in attempts to improve knowledge and skill regarding device parameters (Auchstaetter *et al.*, 2016; Howlett *et al.*, 2018; Walker *et al.*, 2022).

1.2.13 Translation gaps in the application of FES in rehabilitation

The use of FES in post-stroke rehabilitation is complex and holds multiple barriers in its application on a global scale, however, these barriers help identify gaps for improved use of FES in occupation-based rehabilitation post-stroke to further enhance the financial, social and healthcare burden that stroke has on a population (Maleka *et al.*, 2012; Badaru *et al.*, 2017; Smythe *et al.*, 2022). For enhanced use and skilled application of FES in practice, there is a need for improved translation of evidence into practice through the development of improved clinical practice guidelines, increased accessibility, education, and stronger evidence to better support therapists applying this modality in post-stroke rehabilitation (Brown *et al.*, 2023). Education and advocacy strategies for rehabilitation post-stroke in occupational therapy are emphasised to achieve improved behaviour change as well as multimodal knowledge translation strategies to improve education access and use of FES in practice (Wolf *et al.*, 2015; Brown *et al.*, 2023). There is a need for entry and expertise level of continuous professional development in the use of FES and the standardisation of clinical practice guidelines to improve the consistency of FES application in post-stroke rehabilitation (Brown *et al.*, 2023). Lastly, clinical decision-making needs to be better supported in the use of FES in post-stroke rehabilitation to enhance therapists' ability to dynamically manipulate and control stimulation parameters based on sound clinical reasoning (Abouzakhm *et al.*, 2022; Brown *et al.*, 2023).

1.2.14 Clinical decision-making tool

Applying FES in clinical practice is a struggle due to limited access to educational opportunities and resources frequently hindering its application in neurorehabilitation (Musselman *et al.*, 2024). For example, in the SCI population, Dionne et al., 2020, found that among 57 occupational therapists working in the United States treating persons with SCI, 43% of the participants reported not adhering to specific treatment protocols when applying FES in practice (Dionne *et al.*, 2020). To bridge the gaps in knowledge, resources and clinical guidance in FES use among neurological populations such as stroke and SCI survivors, a Canadian research team developed the ‘Clinical Decision-Making (CDM) tool’ to support occupational therapists and physiotherapists in selecting appropriate parameters in neurorehabilitation to

counteract the lack of formal guidance (Abouzakhm *et al.*, 2022). This CDM tool has been trialled in Canada and was found to be a valid resource in guiding clinical decision-making for FES applications in neurorehabilitation; however, despite the value of this CDM tool, it does not mitigate all of the barriers to FES implementation (Abouzakhm *et al.*, 2022). Continued research will be necessary to develop a CDM tool that provides enhanced support in clinical decision-making, as well as confidence and clarity among clinicians using FES with the stroke population (Abouzakhm *et al.*, 2022).

1.2.15 The Unified Theory of Acceptance and Use of Technology (UTAUT) Model

With the expansion of computers and information technology seen in the 1900s, many usability models have been developed in an attempt to understand the factors influencing technology acceptance and usage in various organisational contexts in regards to productivity (Venkatesh, Morris, Davis and Davis, 2003). Venkatesh et al. developed the Unified Theory of Acceptance and Use of Technology (UTAUT) Model in the United States in 2003 to create a unified approach to technology adoption and use through integrating eight older usability models (Venkatesh *et al.*, 2003). Because the UTAUT model accounts for the driving forces that influence technology acceptance and has been widely cited in technology literature, this model was selected to assist in synthesising the findings for the second objective of this research study, which will later be expanded on in Chapter 3. Please refer to Figure 2 for the visual representation of the UTAUT model.

The UTAUT Model was designed to focus on populations that are less likely to adopt or utilise the technology (Venkatesh *et al.*, 2003). The UTAUT Model was established based on four main determinants of intention and usage, which are performance expectancy, effort expectancy, social influence and facilitating conditions. Performance expectancy is understood as the perspective or understanding of which an individual will excel using the system. Effort expectancy focuses on the level of convenience when using the system. Social influence is understood to be the degree to which an individual of status believes that another should make use of the system. Lastly, facilitating conditions look at the degree to which an individual believes in the use of the system based on the support provided by the organisational and

technological infrastructure (Venkatesh *et al.*, 2003; Ayaz and Yanartaş, 2020). This model will provide a structural framework in Chapter Three as a means to synthesise all the factors influencing the use or non-use of FES among occupational therapists in Gauteng.

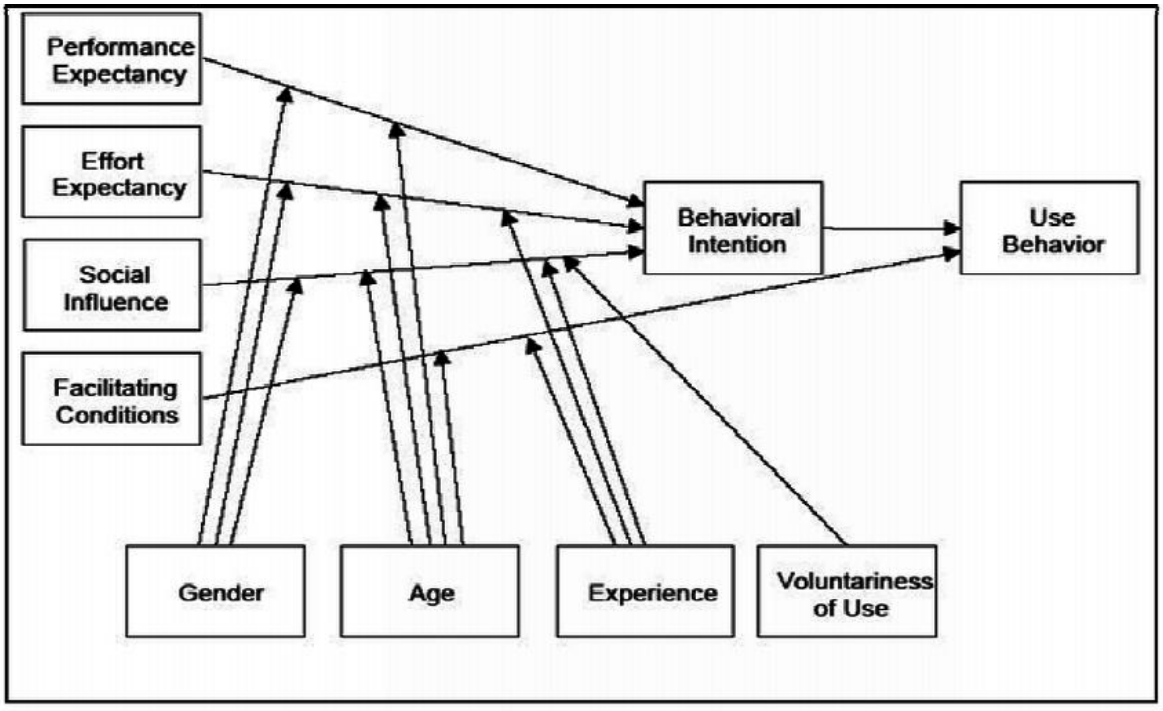

Figure 2. UTAUT model (Venkatesh *et al.*, 2003, pp 443)

1.2.16 Conclusion of the literature review

In conclusion, incorporating FES in clinical practice appears to be complex. Stroke rehabilitation and intervention techniques need to be as effective as possible to optimise motor recovery post stroke. FES presents a promising option for enhancing motor recovery after stroke; however, further research is needed to clarify its specific role within occupational therapy, elevate the quality of existing evidence, and guide advancements in training, education and device development. Although FES research still has a way to go, FES is a therapeutic modality that has the potential to enhance conventional occupational therapy intervention to achieve improved motor outcomes post-stroke. FES is understood to be most effective when implemented in conjunction with conventional therapeutic techniques. Therefore, despite the numerous factors influencing the use of FES in clinical practice, it should not be disregarded by occupational therapists in stroke rehabilitation necessitating the need for this study.

1.3 Methods

1.3.1 Introduction to the Methods

This section outlines the methodology used to address the research question. Firstly the design of the study along with the setting and population will be described to assist in providing context to the study. Next, the method of sampling and sample size of the study participants will be succinctly conveyed. Finally, a detailed overview of the data collection and analysis procedures including ethical considerations will be provided to clarify the research process.

1.3.2 Study design

The researcher conducted a study following a qualitative descriptive design. The goal of the descriptive qualitative design was to take on a naturalistic understanding of a phenomenon such as understanding the human experience within its unique context (Doyle, McCabe, Keogh, Brady and McCann, 2020; Villamin, Lopez, Thapa and Cleary, 2024), namely the experiences and perceptions of occupational therapists and their use of FES in rehabilitation among stroke survivors in Gauteng, as this research area is not well explored and understood in South Africa. The descriptive qualitative research design aligns well with a pragmatic research paradigm as both underscore the value of real-world experiences and practical outcomes (Doyle, McCabe, Keogh, Brady and McCabe, 2020; Elgeddawy and Abouraia, 2024). Descriptive qualitative research design aims to capture rich descriptions of participants' lived experiences, whereas pragmatism focuses on generating actionable knowledge through varied subjective and objective measures (Doyle, McCabe, Keogh, Brady and McCabe, 2020; Elgeddawy and Abouraia, 2024). The pragmatic approach was evident in the use of the interview guide, which allowed for in-depth discussions and descriptions as well as the reinforcement of research insights to support the lived experiences of each participant. Furthermore, the research process was shaped and guided by the study's aims, objectives and contextual considerations of the study, ensuring relevancy of the methodology throughout (Ormston, Spencer, Barnard and Snape, 2014; Doyle, McCabe, Keogh, Brady and McCabe, 2020). As an occupational therapist working within the neurorehabilitation setting and actively using FES among the stroke population, the researcher's current position within the profession can be used as a

means to identify meaningful insights regarding occupational therapists' perceptions of FES and its use in neurorehabilitation among stroke survivors in South Africa.

1.3.3 Setting

This research study took place in South Africa, specifically in the province of Gauteng. Gauteng is the most populous province in South Africa, with 16 million residents (Stats SA, 2024). Gauteng remains South Africa's economic powerhouse as it is the province that contributes the most to the national Gross Domestic Product (GDP) (Stats SA, 2023). There is a distinct dichotomy in South Africa's healthcare system, where there is a split between public and private healthcare systems. Public healthcare services cover 84% of South Africa's population and are funded through the national budget (Rispel, 2016). Whereas private healthcare is funded through medical schemes as well as the national budget, and has the highest expenditure on healthcare services in the world (de Villiers, 2021). Nearly nine percent of South Africa's GDP is spent on healthcare. However, half of that is invested in private healthcare, servicing South Africa's exclusive minority (Rispel, 2016; de Villiers, 2021). The research study was also conducted in Gauteng as the primary researcher resides in this province, making the study feasible.

A care pathway has been outlined in the South-African Contextualised Stroke Rehabilitation Guideline (SA-CSRG) to ensure appropriate up- and down-referral of stroke survivors to ensure appropriate stroke services and continuity of care (SA-CSRG, 2019). In the public health sector, entry may occur either at the primary, secondary or tertiary level; however, depending on the client's point of entry, severity of the stroke and availability of health services and facilities. If specialised rehabilitation services are required and available post-stroke, then patients may be transferred to a quaternary-level facility, but if not, they may be discharged directly home and managed as an out-patient for long-term care, usually at clinics at the primary level of care (SA-CSRG, 2019). Stroke survivors funded by medical aids are seen in private hospitals and may be transferred to a rehabilitation unit, depending on availability of member benefits and funding. Out-patient rehabilitation is continued at home, in private practices or at the rehabilitation unit.

The research setting was limited to the province of Gauteng as the researcher resides in this province as well as in anticipation that each interview would be conducted in person. On invitation, each participant was given a choice to have the interview conducted online via Microsoft Teams or in person at a time and destination that best aligned with their daily routines and personal schedules. The intention of giving each participant this choice was to ensure that each participant could choose the context that was most comfortable for them. Two out of the twelve participants initially opted for in-person interviews; however, due to scheduling constraints, one of them reverted to an online format.

1.3.4 Population

The research population of this study is occupational therapists working in the neurorehabilitation field in Gauteng, South Africa in the public or private healthcare sector. Since there is no available database of this population, available statistics will be used to deduce an approximate population size. A retrospective record-based review of the Health Professions Council of South Africa (HPCSA) database was conducted between 2002 to 2018, revealing a total of 5180 occupational therapists registered in South Africa (Ned *et al.*, 2020). Of the 5180, 1838 (35.5%) were working in Gauteng, and only 16.5% of occupational therapists working in Gauteng are employed in the public health service (Ned *et al.*, 2020). Whether or not this population currently makes use of FES in clinical practice is not a factor that will be included in the inclusion and exclusion criteria because a non-biased representation of the perceptions that occupational therapists have regarding the use of the FES is desired in this research study. This will further inform the factors influencing the use or non-use of FES as a treatment modality in stroke rehabilitation in Gauteng, South Africa.

1.3.5 Sampling method

Purposive sampling was used in the form of a non-random technique that was based on the study's aims and objectives, ensuring that the five purposively-sampled participants added valuable insights to the findings of the research study (Etikan, Musa and Alkassim, 2016). Snowball sampling was used for further recruitment of seven participants. Table 1.1. outlines the inclusion and exclusion criteria used. Notably,

whether or not the population owned an FES device or made use of it in their clinical practice was not an exclusion criterion because the researcher wanted a non-biased representation of the perceptions that occupational therapists have regarding the use of the FES and rather a true representation of the population.

Table 1.1: Inclusion and exclusion criteria

Inclusion criteria	• Occupational therapists registered with the HPCSA as an independent practitioner (i.e., community service year was completed). • Occupational therapists who were currently working in the field of adult neurorehabilitation with experience of 2 years or more, working in the private and/or public health sectors. • Occupational therapists who were currently working in the field of neurorehabilitation that were treating the adult stroke population at the time of the study.
Exclusion criteria	• Occupational therapists who were working with the researcher during the study. • Occupational therapists who had worked in the neurorehabilitation field for less than 6 months.

1.3.6 Sample selection and sample size

According to Guest, Bunce and Johnson (2006), if the research study aims to explore a common perception or belief regarding a specific topic of interest among a homogeneous participant group, then a sample size of 12 participants will be sufficient to achieve data saturation.

1.3.7 Data collection process

1.3.7.1 Pilot study

Ethical approval was granted by the University of the Witwatersrand Human Research Ethics Committee (HREC-Medical) M221070 MED22-08-145 (Appendix A). The researcher formulated the interview guide, using the study's objectives to guide the question formulation process (Villamin *et al.*, 2024). The initial interview guide (Appendix B) was piloted before the data collection process commenced. The pilot

included three participants who were selected through purposive sampling. They were contacted through mutual connections. All three pilot participants met the study's inclusion criteria. Two pilot interviews were conducted over Microsoft Teams. The recording feature on Microsoft Teams was utilised; however, the video feature on Microsoft Teams was turned off for the duration of the interview. The last pilot interview was conducted in person, and an audio recording feature on the researcher's phone was utilised. This was password-protected. It is important to note that the findings from the pilot interviews were not incorporated into the final findings of this study, but rather, the pilot interviews assisted the researcher in identifying concerns regarding the proposed interview guide, ensuring that the research question would be answered adequately (Shakir and Rahman, 2022). These concerns were identified during each pilot study, and the adaptations were made to the interview guide before commencing the data collection process. For the specific adaptations, please refer to Appendix C.

1.3.7.2 Research instrument

Once the revisions were made and discussed among the researchers following the pilot study and seven questions were finalised for the interview guide with appropriate probing questions (Appendix B). The first three questions in the interview guide assisted with collecting demographic data of the participants. This data were used to produce Table 2.2 in Chapter 2 of this research study. This table describes the demographic information of the participant population and their Electrical Stimulation Devices. Part of the probing questions in questions three and four were questions used to interrogate the use of FES among participants. Questions five, six and seven were used to assist with exploring participants' perceptions around the use of FES and factors influencing its application in practice. It is significant to note that the probing questions in the interview guide, specifically in questions five, six and seven, assisted greatly in collecting rich descriptive data regarding perceptions around the use and application of FES in stroke rehabilitation (Robinson, 2023).

1.3.7.3 Research procedure

Data collection commenced in June 2023 and continued to January 2024 (eight months). The Occupational Therapy Association of South Africa (OTASA) was contacted via email to request distribution of the study's information sheet to find

willing participants to take part in the study; please refer to Appendix D for the dissemination letter sent to OTASA. Once permission was granted by OTASA, an invitation to participate in the study, and the study's information sheet (Appendix E) was distributed via the OTASA member database as well as WhatsApp to recruit possible research participants for the study. The participants who were interested in contributing to the study contacted the researcher via email or WhatsApp. The researcher distributed the consent forms (Appendix F) to the participants once verbal consent to participate in the study had been received. This was conducted before the interview to obtain written consent to participate in the study and to be audio-recorded (Appendix G) during the interview process. Participants were invited to be interviewed online or in person at a venue, time and date that was most convenient to them (DeJonckheere and Vaughn, 2019). Eleven of the 12 participants opted for the interview to be held online, via Microsoft Teams. Whereas, only one participant requested that the interview be held in person at her home. Text messages and emails were used to organise the planning of the semi-structured interviews.

The primary researcher held 12 semi-structured interviews collecting descriptive data using an interview guide involving open-ended as well as probing questions (Appendix B). The semi-structured interviews were used as this study aimed to explore the perceptions, thoughts and personal experiences of participants, which aided in collecting open-ended data, coupled with the topic of interest (DeJonckheere and Vaughn, 2019). Each interview varied between 20-60 minutes in duration (DiCicco-Bloom and Crabtree, 2006). Open-ended questions as well as probing questions were used during the interview process as a means to promote insightful descriptions of each participant's perceptions regarding the use of Functional Electrical Stimulation (FES) in adult stroke rehabilitation (Whiting, 2008). All but one of the semi-structured interviews were held online. Each participant was given the choice to participate online or in person for the interview to ensure comfort.

At the start of each interview, it was also made clear to each participant the purpose, length and format of the interview (DeJonckheere and Vaughn, 2019). It was verbally communicated and pointed out on the consent form that each participant had the freedom to decline any interview question and resign from the study at any point (Whiting, 2008). An interview guide (Appendix B) was made use of during the interview

process as well as the recording feature on Microsoft Teams, allowing the interviewer to actively engage during each interview. At the start of each online interview, the transcription feature was turned on, the participant was reminded of the purpose of the interview, and the researcher shared information about herself as well as why this research topic held interest to create a sense of comfort and ease to the start of the interview (Whiting, 2008; DeJonckheere and Vaughn, 2019). For all the online interviews, the video feature of Microsoft Teams was turned off to save bandwidth. The only in-person interview took place within the participant's home. The start of the interview included making use of an audio recording feature on the researcher's phone, which was password-protected and the same initial process as the online interviews was conducted. All interview audio recordings, including the in-person interview recording, were safely stored on a Google Drive that only the researchers had access to using private login details.

During each interview, probing questions and techniques were used to elicit more detail regarding each participant's point of view (DiCicco-Bloom and Crabtree, 2006). Probing techniques assisted the researcher in achieving in-depth descriptions and involved remaining silent and allowing enough time for each participant to answer each interview question, echoing each participant's answer back to them, clarifying words or descriptions when appropriate, making use of affirming words such as "yes" or "okay" to express interest in the participant's point of view as well as asking each participant to expand or further describe a particular point without the use of echoing (Whiting, 2008; DeJonckheere and Vaughn, 2019). Each interview was concluded with the researcher expressing gratitude towards each participant by thanking them for taking the time to cooperate and take part in this study as well as for the valuable contribution that each participant has made to the study (Whiting, 2008; DeJonckheere and Vaughn, 2019). The researcher made use of a journal to engage in reflexive note-taking and journaling during and after each interview, which aided in the reflection process regarding the content of each interview, thus enhancing the quality of identified ideas and meanings to reduce bias (DeJonckheere and Vaughn, 2019).

1.3.8 Data management

The audio recordings and transcriptions were stored on a secure online access-controlled platform (Google Drive), which was hosted by the University of the

Witwatersrand through the principal researcher's student account. Only the principal researcher, as well as the supervisor, had access to the data. All data collected during the study will be securely retained for two (2) years if a scientific publication arises from the study and six (6) years if there is no publication. Thereafter, it will be destroyed accordingly. Please refer to Appendix H for full details.

1.3.9 Data analysis

Once each interview had been completed, all audio recordings were transcribed verbatim using a transcription program, Transkriptor, in conjunction with the researcher's notes taken in the reflection of each interview (Whiting, 2008). The data analysis was achieved through a thematic analysis where patterns of meaning were identified, described and interpreted from the data set. In parallel, an inductive approach was used to further enrich the analysis (Saldaña, 2013). This process involved continuous familiarisation of the data through continued reading and repetition so that meaning units, and codes could emerge (Hsieh and Shannon, 2005). Manual coding and MAXQDA (Plus) were used to extract meaning units from the transcripts and begin formulating codes as well as develop a coding manual (Appendix I). MAXQDA assisted the researcher in being able to formulate an organised coding system for the benefit of the qualitative research being conducted (Saillard, 2011). In-vivo and descriptive coding were used during code formation, with in-vivo coding allowing for the curation of accurate depictions of the participant's experiences (Saldaña, 2013). The same method of coding was repeated by the researcher over a three to four-month period, allowing comparison of the sets of coded data. Once the coding manual was finalised, with all 12 of the interviews coded, two other coders were given the coding manual and two of the interview transcripts to code independently. To ensure consistency between the researcher's codes, two additional coders were introduced (Morse, 2015). These secondary coders included the research supervisor and an occupational therapy master's student at the University of the Witwatersrand. However, only the primary researcher and the primary second coder, being the research supervisor, met to address inconsistencies in coding and to further simplify code definitions. The following code definitions were then adjusted and refined for clarity: "Carry-over", Difficult to use (in an activity), Lack of training, Unsure and "Activity is key".

Table 1.2: The following code definitions were merged with established codes or split into separate codes to further refine the code book:

Original Code(s)	Action Taken	New Code(s)
High turnover	Collapsed into	Not for acute
Demand plan challenges, Wear and tear	Collapsed into	Scarce resource
FES use	Split into	Rarely, Often
Other	Collapsed into	Rarely
Pros and cons	Split into	Unsure, Game changer
Self-doubt	Collapsed into	Unsure
Therapist dependent	Collapsed and dissolved into	Supervision and mentorship, Game changer, Carry-over
Fear of causing pain, Room for error	Merged into new code	Fear
Muscle activation	Collapsed into	Preparatory exercise
NMES vs FES	Split into	Movement in function, Preparatory exercise
Visual feedback	Collapsed into	Instils hope

Table 1.3: The subsequent codes were renamed

Old Code Name	New Code Name
Physiotherapy modality	Controversial
Motivating factor	Instils hope
Mentorship	Supervision and mentorship
Difficult to use functionally	Difficult to use (in an activity)
Training	Lack of training
Evidence	Not aware of evidence

The renaming and merging of code definitions were completed once both second coders were given a chance to analyse the designated data sets. This allowed for further refinement of the code book, ironing out discrepancies in the codes between the primary researcher and the primary second coder. It was at this point that the refined codes were analysed for patterns and trends for the emergence of final categories and themes (Appendix J)(Saldaña, 2013).

1.3.10 Trustworthiness and rigour of the study

To ensure credibility, the researcher made use of investigator triangulation (Bans-Akutey and Tiimub, 2021). Investigator triangulation was achieved through the use of a secondary researcher as well as having two second coders to assist with refining the codes during the data analysis phase (Krefting, 1991; Bans-Akutey and Tiimub,

2021). Member checking was also done by sending each participant their interview transcription to peruse for errors to assist the credibility of the study. No corrections were made to any of the 12 transcripts. Reflexivity was also used in an attempt to limit bias, and preconceptions and ensure the dependability of the study. This was done through the use of reflexive writing and field notes (Krefting, 1991; Olmos-Vega, Stalmeijer, Varpio and Kahlke, 2023). Thick description was also used to ensure transferability. The researcher ensured that contextual information regarding each participant was accounted for to ensure that the data collected would apply to situations of a similar context. The researcher also ensured that there was a variety in the sample by choosing participants with different demographic factors, where possible (Krefting, 1991; Younas *et al.*, 2023).

1.3.11 Ethical Considerations

Ethical consent was granted by the University of the Witwatersrand HREC-Medical (M221070 MED22-08-145) (Appendix A). To ensure beneficence, the interview guide and probing questions (Appendix B) were designed in such a way as to ensure the exploration of the research participants' use of functional electrical stimulation and not in such a way that would impose guilt, discomfort or upset on the research population. Non-maleficence was promoted by ensuring that the questions posed during the semi-structured interviews were not offensive or harmful (Jelsma and Clow, 2005). If at any point the participant were made to feel uncomfortable or upset, the interview process would have been stopped.

Informed consent was conducted through the use of written, signed and dated documents from each participant before the interview process began (Appendix E and F) (Manandhar and Joshi, 2020). To respect the identity of the participants, de-identification took place, where each participant was issued a participant code (Eungoo and Hwang, 2023). Any data (typed or recorded) was stored on an access-controlled server/cloud platform and will be for 6 years and then be destroyed (Health Professions Council of South Africa, 2022). To ensure justice the data analysis process ensured that the data collected was not manipulated as a means to prevent any exploitation of the participants (Jelsma and Clow, 2005). The distribution of the study's information sheet (Appendix E) assisted in informing participants regarding their voluntary participation in the study. At any point in the study, the participants had

the choice and freedom to withdraw from the study which promoted autonomy among all participants within the study (Jelsma and Clow, 2005).

Researcher positionality

As a white, female occupational therapist with 5 years of clinical experience and postgraduate training in neurorehabilitation, I approach this study with a personal interest in improving functional outcomes in my clients. At the time of data collection and analysis I was working at a private neurorehabilitation unit. Although I have limited experience with FES, my interest in FES as a promising modality may lend to highlighting its benefits rather than its limitations. Therefore bracketing was employed throughout the research process as a means to minimize the researcher's own biases and expectations (Habibullah *et al.*, 2023). Reflections were kept in the researcher's journal and used throughout the research process. Additionally, no colleagues I was working with at the time of data collection, nor had previously worked with, were sampled to prevent any influence of power dynamics.

1.3.12 Risks, burdens and benefits

There are no real anticipated risks or immediate benefits to participants. However, the findings in this study have the potential to contribute to the development of future best practice guidelines and promote the informed use of FES in stroke rehabilitation.

Chapter 2 Submissible Manuscript

This chapter is in the format of a scientific paper that has been submitted to a journal (Appendix K). The journal identified is 'Disability and Rehabilitation: Assistive Technology' because the study's and journal's aims are well-aligned. This journal is an international, multidisciplinary journal that promotes rehabilitation science, specifically assistive technology service delivery and design to assist persons with disability to enable function and participation within their daily lives. This study would align with this journal because the findings of this study provide beneficial insight into the factors affecting service delivery, usability, and product design of FES within stroke rehabilitation. The journal boasts a 1.9 impact factor, enhancing influence for further research. Additionally, this journal is feasible as its article processing fees are waived due to the transformative agreement between the publisher - Taylor & Francis - and

the University of the Witwatersrand. The journal is DHET accredited and open access. The chapter conforms to all author submission guidelines (Appendix L). As this chapter is a stand-alone document, background and methodology information provided in Chapter 1, may be repeated in a condensed form in this chapter. It is important to note in the instructions to authors (Appendix L), that the chosen journal has a 'format-free submission' meaning that there is no word limit, formatting requirements, or a specific referencing style that must be employed. Therefore, the author chose to use a typical article length, with a final draft of 9278 words. The same reference style as Chapters 1 and 3 (Harvard) was used. Please note that the reference list at the end of the chapter pertains only to the references in the manuscript and, therefore likely repeated in the full reference list for the research report.

Manuscript details

The primary researcher in this study is S. Frew with F. Breytenbach as co-author and supervisor. According to the relevant aspects of the Contributor Role Taxonomy (CRediT), the author's contributions to this manuscript are detailed in Table 2.1 (Allen, O'Connell and Kiermer, 2019). The title of the manuscript is "*Exploring Occupational Therapists' Perceptions of the Use of Functional Electrical Stimulation in Adult Stroke Rehabilitation in Gauteng, South Africa.*"

Details of Author Contribution

CRediT terms	**S. Frew**	**F. Breytenbach**
Conceptualization	X	X
Methodology	X	X
Formal analysis	X	X
Funding acquisition	Funding request rejected	
Investigation	X	
Project administration	X	
Resources	X	
Validation	X	X
Data curation	X	X
Writing manuscript- draft	X	
Writing manuscript- reviewing and editing	X	X
Supervision		X

Table 2.1 Details of Author Contributions

Abstract

Purpose: Stroke is one of the leading global causes of disability, with motor deficits, particularly in the upper limb, being among one of the most common and debilitating consequences. Occupational therapists are crucial members of the multidisciplinary team, working to enhance patients' participation in daily activities by addressing motor impairments through interventions such as Functional Electrical Stimulation (FES). This study aimed to explore occupational therapists' perceptions of using FES in adult stroke rehabilitation in Gauteng, South Africa.

Materials and Methods: This study employed a descriptive qualitative research design. Twelve occupational therapists participated in semi-structured interviews conducted via an online platform. An inductive thematic analysis was used to analyse the data.

Results: Three themes emerged from this research study, namely, 'A Tug of War', 'The Blind Leading the Blind' and 'A Puzzle of Practicality'. These themes unravel the perceptions of occupational therapists and explore the factors that influence the use of FES in stroke rehabilitation.

Conclusion: Many identified perceptions and factors challenge the use of FES in adult stroke rehabilitation. Addressing these challenges is essential for improving evidence-based practices in occupational therapy, especially for motor impairments after stroke.

Key words

"Occupational therapy" "Electrical Stimulation" "Functional Electrical Stimulation" "Stroke" "Neurorehabilitation" "Perceptions"

Introduction

Background

Functional Electrical Stimulation (FES) has been labelled a promising modality for improving post-stroke motor deficits for over half a century (Kapadia, Moineau and Popovic, 2020). In the 1960s, FES was a modality developed as a means to correct drop foot in stroke survivors who had been affected by hemiplegia by utilising electrical currents to stimulate the peroneal nerve (Karamian *et al.*, 2022). Since then, electrical stimulation has evolved and advanced into various forms, expanding its use and application in upper limb rehabilitation among persons with neurological deficits (Karamian *et al.*, 2022). Current literature has found FES to be effective in improving upper limb impairments such as shoulder subluxation, pain, spasticity and various grasps when used in conjunction with functional tasks (Thakre, Qureshi and Naqvi, 2020; Silva *et al.*, 2020), as well as improved participation in activities of daily living (Howlett *et al.*, 2015). Despite the promise in FES research, occupational therapists have largely avoided using FES devices in stroke rehabilitation (Auchstaetter *et al.*, 2016; Howlett *et al.*, 2018; Musselman *et al.*, 2024).

Among many influencing factors across FES users, the lack of training and education around FES use in stroke rehabilitation is a global crisis that further widens the evidence-practice gap (Howlett, McKinstry and Lannin, 2018; Howlett, 2020; Taylor *et al.*, 2020; Bulley *et al.*, 2021; Swaffield *et al.*, 2022; Brown *et al.*, 2023; Musselman *et al.*, 2024). However, few of these studies included occupational therapists as participants, which indicates a need for further exploration into their behaviour leading to this evidence-practice gap. An understanding of the development and philosophy of the occupational therapy profession may provide insights into the perceptions and worldview of occupational therapists. Occupational therapy is a profession that originated on the premise that occupation could be used as an integrative approach of the mind, body and environment to regenerate lost function following disability (Matuska, 2010). The profession saw a paradigm shift during the 1950s following interdisciplinary critique, leading to an impairment-focused approach to disability (Matuska, 2010). During the 1960s and 1970s, occupational therapy saw a reversion back to its original orientation, solidifying the profession's focus back to occupation as the centre of health and well-being (Matuska, 2010).

Motor deficits are one of the most common adverse effects experienced post-stroke (Ullah *et al.*, 2020) with stroke being a leading cause of disability worldwide (Alawieh *et al.*, 2018; van Niekerk *et al.*, 2021). A recent study found that 40-57% of stroke survivors experience acute upper limb weakness (Simpson *et al.*, 2021), being one of the most disabling deficits concerning activity participation (Ullah *et al.*, 2020). Stroke rehabilitation aims to support stroke survivors to return to premorbid functioning within their home, community and work environments, as effectively as possible through means of intervention from a Multidisciplinary Team (MDT) (Whitehead and Baalbergen, 2019). Occupational therapists play a crucial role within the MDT, focusing on regaining and improving the ability to perform daily activities and improve overall quality of life for stroke survivors (Juckett *et al.*, 2020). Occupational therapists use activities during therapy as a means to facilitate the restoration of deficit body structures and functions hindering stroke survivors' quality of life (van Niekerk *et al.*, 2023).

Multiple stroke rehabilitation guidelines recommend FES as an adjunctive modality to assist with improving upper limb motor impairments post-stroke (Intercollegiate Working Party for Stroke, 2012; National Stroke Foundation, 2015; Stellenbosch University, 2019). Motor recovery post-stroke is time-sensitive and therefore, early intervention needs to be as efficient, effective and evidence-based as possible (Grefkes and Fink, 2020; Sousa *et al.*, 2022). The need for occupational therapists to incorporate stroke modalities that hold promising evidence, such as FES, into clinical practice to better enhance motor function is pertinent in limiting the effects of disability and enhancing the quality of life of stroke survivors.

Rationale

There is limited research on FES that has been published in the Global South that specifically explores occupational therapists' perspectives on its use in stroke rehabilitation. There have been several studies conducted in the Global North illustrating occupational therapists' and physiotherapists' perspectives on the use of FES in neurorehabilitation. What these studies have found is that FES is a modality that is not commonly utilised in stroke rehabilitation (Auchstaetter *et al.*, 2016; Howlett *et al.*, 2018). The literature suggests that healthcare professionals are more likely to hold negative perceptions surrounding the use of FES in stroke rehabilitation, largely

owing to a lack of confidence, accessibility and educational opportunities (Auchstaetter *et al.*, 2016; Howlett, McKinstry and Lannin, 2018; Howlett, 2020; Bulley *et al.*, 2021; Brown *et al.*, 2023). There are currently no studies that have been conducted in the Global South that can confirm or dispute these findings for occupational therapists working in developing countries. Therefore, this study aims to address the gap in the literature by exploring occupational therapists' perceptions of the use of FES in stroke rehabilitation in Gauteng, South Africa.

Primary aim of the study

This study aims to explore occupational therapists' perceptions of the use of functional electrical stimulation in adult stroke rehabilitation in Gauteng, South Africa.

Methodology

Study design

A descriptive qualitative design was employed to explore occupational therapists' perceptions of using FES in stroke rehabilitation. The study was conducted across both the private and public health sectors in Gauteng, South Africa, from June 2023 to January 2024.

Study population and sampling

The study population included all qualified occupational therapists working in adult neurorehabilitation in Gauteng, South Africa. The inclusion criteria consisted of occupational therapists registered as independent practitioners with the Health Professions Council of South Africa (HPCSA), as well as occupational therapists treating adult stroke survivors at the time of data collection. Four participants were working in the public health sector while the remaining 8 were working in the private health care sector. Whether or not the population owned an FES device or made use of it in their clinical practice was not an exclusion criterion because the researcher wanted a non-biased representation of the perceptions that occupational therapists have regarding the use of the FES.

A total of 12 occupational therapists from both public and private healthcare settings participated in the study. Purposive sampling was used (Etikan, Musa and Alkassim, 2016) based on the study's aims and objectives to ensure that the five selected

participants would add valuable insights to the findings of the research study. Snowball sampling was additionally used for further recruitment of seven participants until data saturation had been achieved (Naderifar, Goli and Ghaljaie, 2017). Permission was granted from OTASA to assist in dispensing the study's information sheet, further supporting the recruitment of suitable participants.

Data collection

Once ethical approval had been granted, participants were given written consent to participate and be audio-recorded in the study and were made aware that they could withdraw from the study at any point without negative consequences. Confidentiality during the data analysis was ensured through participants being given a participant code (Eungoo and Hwang, 2023). The mentioned measures assisted the study in meeting the principles of the Declaration of Helsinki (The World Medical Association Inc., 2008). The researcher formulated the interview guide, using the study's objectives to guide the question formulation process (Villamin *et al.*, 2024). The initial interview guide was then piloted before the formal data collection process commenced. The pilot included three participants; two pilot interviews took place online over Microsoft Teams, whereas the last pilot interview was conducted in person. The findings noted in each pilot interview were not included in the final findings of this research study, although each pilot interview assisted in addressing concerns regarding the interview guide, which allowed the necessary changes to be made to evoke more in-depth discussions during the formal data collection process.

Once all three pilot studies had been completed and the interview guide had been finalised, candidates were invited to participate in a semi-structured interview via email. After an information letter was sent and written consent was received, each participant was given the option to attend the interview either in person or online. Only one participant chose to engage in the interview in person. The interviews conducted online were held over Microsoft Teams, a video conferencing platform and the in-person interview was audio-recorded using a cell phone app with a passcode. Each interview lasted between 20 and 60 minutes, and an interview guide was used to structure the discussions, ensuring comprehensive participation and facilitating in-depth conversations to gather rich insights (Roberts, 2020).

At the start of each interview, it was made clear to each participant the purpose, length and format of the interview (DeJonckheere and Vaughn, 2019). The audio and transcription feature was turned on, and the cameras were turned off. During each interview, probing questions and techniques were used to elicit more detail regarding each participant's point of view (DiCicco-Bloom and Crabtree, 2006). Once each interview was completed, the researcher made use of a journal to reflect on the process and content of each interview, enhancing the quality of identified ideas and meanings without incorporating bias (DeJonckheere and Vaughn, 2019).

Data analysis

Audio recordings were transcribed using Transkriptor, a transcription program and the transcripts were reviewed by the researcher for accuracy. Transcripts were sent to participants for member checking to ensure the words captured were correct, and no corrections were received. MAXQDA (Plus) was used to develop a hierarchical structure of codes (Saillard, 2011). In-vivo and descriptive coding were employed, with in-vivo coding ensuring an accurate representation of participants' experiences (Saldaña, 2013). The researcher re-coded the data later to compare and ensure consistency. Once the code manual was finalised, two additional coders independently coded three interview transcripts. The discrepancies were discussed and resolved to reach a consensus and clarify code definitions. Finally, codes were analysed for patterns and connections, which were further examined to define the study's key themes (Saldaña, 2013). Data saturation was reached by the tenth interview, with no new codes generated in interviews 11 and 12, see Appendix N for code saturation.

Results and Discussion

Demographic Information

Twelve occupational therapists working in stroke rehabilitation in Gauteng, South Africa, participated in the study. Table 2.2. details participants' demographic information as well as the electrical stimulation devices they owned, if any. Eight were working in a private healthcare setting, whereas four were working in the public sector. Despite the majority of South African occupational therapists working in the private healthcare sector (Ned *et al.*, 2020), this may have been due to the sampling method

employed since the primary researcher works in private healthcare. Of the four working in the public sector, three were working in hospitals at a tertiary level of care, and one was working at a hospital at the secondary level of care. Generally, at the tertiary and secondary level of care, stroke survivors are in the acute or subacute phase of their recovery. Years of experience ranged widely among all participants from two years to 14 years of experience working as an occupational therapist. Notably, half of the participants had or were undergoing their master's degree in occupational. Five therapists interviewed did not own an electrical stimulation device, and the remaining participants used a variety of electrical stimulation devices. Interestingly, all devices were fixed pre-programmed open-loop systems.

Table 2.2 Demographics of Research Participants

Participant Code	Highest Occupational Therapy Qualification	Current healthcare sector	Total Work Experience since qualification	Electrical Stimulation Device Model	Wired or Wireless	Open or Closed Loop System	Waveform	Parameters mA – current intensity Hz - frequency µS – pulse duration
1	Master's degree	Public	9 years	Chattanooga® Wireless Professional 2Ch Standard	Wireless	Open	Symmetrical biphasic	0-120 mA 1-150 Hz 30-400 µS
2	Undergraduate degree	Private	3 years 5 months	R-C4A	Wired	Open	Bi-phasic square-wave pulse	TENS mode : 0-120 mA 2-120 Hz 50-330 µS EMS Mode: 0-120 mA 4-80 Hz 4-80 µS Massage Mode : 0-120 mA 25-100 Hz 100-250 µS
3	Master's degree	Private	2 years 5 months	Does not have access to device in clinical setting				
4	Undergraduate degree	Private	8 years 6 months	Chattanooga® Wireless Professional 2Ch Standard	Wireless	Open	Symmetrical biphasic	0-120 mA 1-150 Hz 30-400 µS
5	Master's degree	Private	6 years 6 months	Does not have access to device in clinical setting				
6	Master's degree	Private	4 years 6 months	NeuroTrac® MultiTENS	Wired	Open	Asymmetrical, rectangular bi-phasic	0-90mA 2-200Hz 50-450µS

				Cefar Physio 4 Electrostimulator	Wired	Open	Symmetrical and asymmetrical biphasic waveforms	0-100 mA 1-150 Hz 50-400 µS
7	Master's degree	Public	14 years 7 months	Does not have access to device in clinical setting				
8	Master's degree	Private	5 years 10 months	Medisana TT 200 3 in 1 Electro therapy device	Wired	Open	Bi-phase rectangular-wave pulse	0 - 120 mA 2 - 120 Hz 55 - 260 µS
9	Undergraduate degree	Private	3 years 10 months	ODSF III	Wired	Open	Nominally square with passive charge balancing	0-100mA Programable 0-330 µS
10	Undergraduate degree	Public	3 years 10 months	Does not have access to device in clinical setting				
11	Undergraduate degree	Private	2 years 11 months	R-C4A	Wired	Open	Bi-phasic square-wave pulse	TENS mode : 0-120 mA 2-120 Hz 50-330 µS EMS Mode: 0-120 mA 4-80 Hz 4-80 µS Massage Mode : 0-120 mA 25-100 Hz 100-250 µS
12	Undergraduate degree	Public	4 years	Does not have access to device in clinical setting				

2

After careful analysis of the data, three themes emerged, giving an in-depth representation of occupational therapists' perceptions of how FES is utilised, namely; 'A Tug of War', 'The Blind Leading the Blind', and 'A Puzzle of Practicality'. The start of each theme begins with an introduction, table and results and discussion to follow.

'A Tug of War' encompasses conflicting feelings of being convinced of the benefits of FES and the ideals held by the participants but also feelings of caution and its misalignment with the occupational therapy profession.

Table 2.3a Theme one: A Tug of War

CATAGORY	CODE	EXAMPLE QUOTES
Cautious	**Unsure**	P3: "…I'm not 100% comfortable with, with using it by myself and knowing exactly where to place the electrodes…" P11: "…I don't feel like I'd be doing my patients any justice if I just kind of wing it, you know, it's more of a lack of confidence from my side."
	Fear of harm	P2: I personally feel that you do just need someone… who knows what they're doing so that you don't end up doing the wrong thing because the wrong thing can have…like negative impacts… or you could actually end up hurting them." P7: "I think we are sort of fearful of doing harm because a stroke patient is already in such pain."
	"Out of sight out of mind"	P5 "when I look back at it and then, yeah, you know, they say and it's out of sight, it's out of mind."
	Plan B	P6 "I prefer to work a lot more manually and trying to get the patient to actively strengthen…so I try to not always use it as…my first port of call."
	"False hope"	P1 "…It kind of gives that patient a little bit of false hope because the patient gets super excited when they see their… fingers or their wrist or whatever it might be moving…then it doesn't always get carried over."

		P7 “So I don't always want to create an impression that you are going to be 100% okay and only this machine is going to help you to do this…I don't want to create like a false impression with them...”
Questioning Professional Alignment	**“Controversy”**	P7: “And also I think the perception of it in my department it's that it's a physiotherapy modality, so physios must use it first or they are prioritized to have one before OT does.” P4: “…but there's a lot of controversy around should OTs be using it like, it's a Physio thing and you know, or a Bio thing and whatnot.”
	Lazy therapy	P6 “I think sometimes it does make therapists lazy because I think some therapists do just end up putting their patients on a stim machine and not even handling or engaging with a patient.”
	“Activity is key”	P2 “… And physio has its place, but you're not a physio, you're an OT. So I think that's the thing is that…we need to be almost nurturing this idea of activity is key and if you're not doing an activity then what are you doing?”
Perceived Benefits	**Instils hope**	P7 “… the moment a patient can see…I want to say a non-functional arm…come to life that almost like brings up hope in that patient…obviously that would encourage them or motivate them more to come for rehab to be more compliant with the home exercise programs or the ward exercise programs or to come to the gym as often as they can.” P6 “I think with the patient being able to see that…movement can happen. I think it is a good one, a good motivating factor and I think it's a good element of hope that something can also change. P4 “So it's getting that whole sort of visual feedback cycle…going, which I thought was quite effective and they could see the hand, you know, you could put a cup there and get them as the as the machine starts working, get them to close the fingers, whether it's them or not, they're seeing the fingers close around the cup and they can actually hold the cup.”
	“Game changer”	P4 “And yeah, I just found it very effective and I saw very nice results with it…” P6 “So I think sometimes when it's you've kind of hit a bit of a wall, it can be something that can really change the game a little bit for your patient and for their rehab.”
	“Neuroplasticity”	P1 “…in terms of encouraging active movement and trying to get that neuroplasticity taking place, I do think it does play a role.”
	“Extra set of hands”	P6: “Sometimes having that stim unit is almost like having an extra set of hands in some ways when you can't facilitate every single movement manually. Sometimes being able to put the stim unit on one muscle group so you can focus your manual facilitation somewhere else gives you a

		nicer way to facilitate participation in a task without being awkward or in your patient's face or feeling like they're not doing anything.”
	“Prognostics”	P10 “…I've always liked it in terms of like prognostics...”
Ideal	**“Prove our use”**	P7 “So I think…the more we use it…we can prove our use in its patient use, then I think departments will be more open to ordering one or fighting more for one.” P4 “You know, if we're not really aware that we can use it, people are going to avoid it.” P5 “And I do think that should we should it be more like a well-known intervention in OT through, you know, while whist in a functional activity, more OTs will probably make use of it.”

9

Theme: 'A Tug of War'

Cautious

Unsure

All participants reported feeling a lack of self-confidence in their use of FES in clinical practice and spoke about it frequently with it being the second most common code - mentioned over 80 times (Appendix M). They expressed feelings of uncertainty about the application of FES in stroke rehabilitation, which contributed to a sense of self-doubt. The perceived lack of confidence is supported by studies conducted in Northern America and Australia among occupational therapists and physiotherapists regarding the use of FES in clinical practice (Howlett, 2020; Brown *et al.*, 2023). Occupational therapists often experience self-doubt when incorporating FES into rehabilitation, feeling unsure of their ability to use the device effectively (Howlett, 2020). The lack of confidence is attributed to a perceived gap in knowledge in the rationale and method for using FES, causing therapists to shy away from using FES in clinical practice (Brown et al, 2023; Howlett, 2020). Musselman et al,. 2024 found that among 23 occupational therapists and physiotherapists, six participants experienced residual confidence issues despite undergoing extensive e-learning modules on FES to modify self-directed learning and improve confidence in FES use (Musselman *et al.*, 2024). As a means to address therapists' lack of self-confidence in the use of FES, hands-on training over consecutive days is recommended (Bulley *et al.*, 2021).

Fear of harm

This study found that among the participants, there was a general sense of fear of causing pain to stroke survivors. Some participants expressed that they were uncertain how FES affects stroke survivors, leading to feelings of anxiety around the potential for causing discomfort or harm during therapy. Research has found that, more often than not, therapists are unsure about the potential effects that electrical stimulation has on patients (Swaffield *et al.*, 2022), fearing it could lead to burns, muscle spasms, or discomfort (Bulley, Shiels, Wilkie and Salisbury, 2011; Bulley *et al.*, 2021). As a result, occupational therapists are hesitant to incorporate FES into treatment (Bulley *et al.*, 2021; Swaffield *et al.*, 2022). Howlett, McKinstry and Lannin, 2018 found among Australian occupational therapists, the added lack of confidence

and competence in FES use remains a deterrent, often increasing the risk of faulty application and cause for harm (Howlett *et al.*, 2018). Musselman et al., 2024 found for healthcare professionals to overcome feelings of fear and doubt, therapists need to embrace being uncomfortable initially and take the plunge into using FES, as the more that FES is applied in practice, the better the chance skill sets can develop (Musselman *et al.*, 2023). Therefore, the only way for occupational therapists to reduce their risk of error and fear in FES application is to consistently commit to the use of FES over time for their skill set to develop.

Out of sight, out of mind and Plan B

Five of the twelve participants in this study noted that FES often slips from consideration when addressing motor or sensory deficits in stroke survivors, leading to a perception of it being "out of sight, out of mind." Instead, conventional occupational therapy techniques are typically prioritised, with FES viewed as a “Plan B” option, particularly when patients begin to plateau in their recovery. Based on the findings of this study, there is a sense of comfort and familiarity in using conventional occupational therapy techniques, as these are the approaches taught at an undergraduate level. When there is a shift away from familiar methods, it often creates a sense of reluctance (Auchstaetter *et al.*, 2016; Taylor *et al.*, 2020). Literature conducted in Australia and Canada suggests that healthcare professionals, namely occupational therapists and physiotherapists, do not prioritise FES use in stroke rehabilitation (Auchstaetter *et al.*, 2016; Howlett *et al.*, 2018). Instead, therapists rely on routine methods or preferred treatment practices for stroke survivors, leaving FES as an afterthought or being dismissed (Taylor *et al.*, 2020). Despite the comfortability of using routine methods of treatment, research has found that FES used in conjunction with conventional therapeutic techniques leads to favourable outcomes in the upper and lower limbs (Hou and Yang, 2022).

False hope

Participants expressed that using FES in stroke rehabilitation holds the potential to create false impressions among stroke survivors during their recovery process. Participants described patients experiencing a surge of excitement when the device is used in the session, thinking that their upper limb may fully recover, however, more often than not, the mobility observed is a result of the electrical stimulation device,

where limited carryover was noted once the device had been removed. These same findings were observed in a qualitative study published in 2013, where stroke survivors, family members and caregivers felt that healthcare professionals were hesitant to use FES in stroke rehabilitation because of the risk of creating false impressions among patients, which could lead to unrealistic expectations of their recovery process (Demain *et al.*, 2013). Therefore, healthcare professionals rather err on the side of caution and hesitate to use FES in stroke rehabilitation as a means to ensure that stroke survivors are not misled in their recovery process. This strategy emphasises the significance of patient understanding and education regarding the application of adjunctive modalities within stroke rehabilitation.

Questioning Professional Alignment

Controversy and Activity is key

Participants perceived FES as a controversial tool to be used in practice, being perceived as a physiotherapy or biokinetics tool rather than a comprehensive rehabilitation modality, further contributing to a sense of caution when using FES within an occupational context. The primary researcher is a practising occupational therapist, this likely created a safe space for the participant to share conflicted feelings. The perception that FES is a physiotherapy modality is not a perception that has been documented in previous research. However, Howlett, 2020 found that professional role and identity influence how FES is used to address motor impairments post-stroke, where occupational therapists will generally focus its use on the upper limb and physiotherapy will focus its use on the lower limb limiting the comprehensive use of FES in rehabilitation (Howlett, 2020). Such misconceptions about the scope of practice often arise in the workplace, reinforcing conventionally accepted methods rather than new modalities, possibly to avoid conflict amongst the MDT.

In addition, the code ‘Activity is key’ captured participant’s perception that to align appropriately with the philosophy of occupational therapy, meaningful activity should be at the core of FES intervention. This code evidences the paradigm shift of the professions focus onto activity and participation. Participants’ viewpoint is supported by AOTA’s 2018 position paper which endorses PAMs such as electrical stimulation to be used by occupational therapists and occupational therapy assistants, simultaneously during occupational-based intervention or as a preparatory method to

support performance skills required for occupational engagement (Amini, 2008; Bondoc, Feretti and Dorsey, 2018). It is when PAMs like FES are used in isolation, without the inclusion of purposeful activity, that scope of practice concerns begin to arise (Bondoc *et al.*, 2018). Therefore, FES appears to be a controversial issue possibly contributing to the feelings of caution amongst occupational therapists. It is recommended that multidisciplinary training on PAMs like FES address and allow for discussion regarding misconceptions regarding the scope of practice.

Lazy therapy

Another perceived barrier to the use of FES as a tool for occupational therapists was the concept of "lazy therapy". Some participants felt that relying on the device might lead to passive involvement from occupational therapists, with patients left to sit while the device is applied rather than engaging in more active, hands-on therapy. This finding shows that occupational therapists have a desire to be perceived as hard-working, and this is perceived as being achieved through being physically “hands-on” in stroke rehabilitation. This possibly stems from neuro-facilitatory approaches like the NDT theory developed by Bobath, which continues to dominate South African neuro-rehabilitative practice (Freeme, 2011), emphasising manual handling for desired normal movement patterns of the trunk, arm and leg (Freeme, 2011). It is further recommended that training on FES also address the misconception that NDT theory is a superior theory to apply in practice.

Perceived benefits

Instils hope

In contrast to the code “false hope”, FES was also seen as a motivating factor for stroke survivors by therapists in the study. Participants expressed that FES provided observable, visual feedback to stroke survivors, specifically in the upper limb, which fostered a sense of hope for improvement and thus supported participation in rehabilitation. These findings are seen in a study conducted by Swaffield et al 2022, who analysed parent perceptions on the use of FES as an upper limb intervention for children with hemiparesis (Swaffield *et al.*, 2022). What this study found was that parents perceived that their child had received results that were “leaps and bounds ahead of regular OT”, which contributed to their interest and motivation in seeking out FES services outside of the clinical trial as a means to continue with this treatment

intervention (Swaffield *et al.*, 2022). Bulley et al 2021, found that motivation and self-management were key indicators for success when receiving FES intervention post-stroke (Bulley *et al.*, 2021). Therefore, when stroke survivors and their families can see the positive effects that FES has on improving motor impairments, this has the power to assist with improving compliance and dedication to therapy.

Game changer

All participants perceived FES as efficacious or "changing the game" supporting its use and viewing it as a favourable tool for improving physical impairments in stroke rehabilitation. This finding is supported by the findings of Musselman et al 2023 where occupational therapists and physiotherapists perceived FES as being a therapeutically valuable adjunct modality in treating children with neurological disorders (Musselman *et al.*, 2023). Among three recent systematic reviews, all suggest that there is clinical significance for FES use in upper limb rehabilitation in improving activity participation (Eraifej *et al.*, 2017; Howlett, McKinstry and Lannin, 2018; Khan *et al.*, 2023). However, the relevance and reliability of this statement are compromised by the limitations found in current FES literature. All three systematic reviews critique FES literature for lacking randomised control trials (RCT), heterogeneity, adequate sample sizes and blinding (Eraifej *et al.*, 2017; Howlett, McKinstry and Lannin, 2018; Khan *et al.*, 2023). Despite these limitations, the concept that FES should be continually applied in stroke rehabilitation is supported (Howlett *et al.*, 2018). Therefore, both participant perceptions in this study and international research findings speak to holding a positive attitude towards using FES to improve motor impairments post-stroke; however, FES evidence needs to be further refined and strengthened.

Neuroplasticity

The potential for neuroplasticity was cited by participants as an important benefit of FES, helping to promote recovery in stroke survivors. It is hypothesised that the affected motor control system can be manipulated by peripheral electrical stimulation, such as FES, to induce neuroplasticity in stroke survivors (Bao *et al.*, 2020; Sousa *et al.*, 2022). This theory postulates that when peripheral electrical stimulation is used, it can activate the contralateral primary motor cortex, somatosensory cortex, supplementary motor area and the prefrontal cortex through neuronal hyperpolarization and depolarization of the spinal interneuron via the extremities

(Sousa *et al.*, 2022). A systematic review published in 2023 found that despite several research studies supporting the notion that FES rehabilitation can improve functional outcomes in stroke survivors, none of these studies are validated with neuroplastic outcomes (Khan *et al.*, 2023). Therefore, current evidence suggests that it is inconclusive as to whether or not neuroplasticity is induced during stroke rehabilitation using open or closed-loop FES devices (Khan *et al.*, 2023). Therefore, it is recommended that further studies in neuroscience investigate the cortical changes following FES use among stroke survivors.

Extra set of hands

Participants in this study viewed FES as a positive addition to therapy, likening it to an "extra set of hands," particularly when focusing on manual facilitation techniques and being more efficient in therapy. Similar results were reported in the study conducted by Musselman et al., 2023 where one of the participants expressed that using FES in therapy was like having “another set of hands” on the muscles to assist therapists with muscle recruitment in children with neurological disorders (Musselman *et al.*, 2023). This perception reinforces that FES is an important modality to assist with intensive input during manual facilitation for increased muscle activation post-neurological injury.

Ideals

Prove our use

Participants in this study believed that occupational therapists should prove themselves in the use of FES in stroke rehabilitation. This viewpoint is that occupational therapists should make better use of FES in stroke rehabilitation, with the idea that greater exposure to the device in occupation-based intervention may grow awareness and skill competence. Although limited literature overtly supports the concept of occupational therapists wanting to “prove their use” of FES within stroke recovery, Musselman et al., 2023 focused on paediatric physiotherapists and occupational therapists’ experiences and perceptions of using FES with the neuropediatric population (Musselman *et al.*, 2023). They found that although many therapists shied away from using FES in clinical practice, participants felt that therapists need to be bolder and get over ‘not knowing’; committing to continued learning and practice in applying FES. The hope that FES could be a well-known modality used by occupational therapists may be in response to the feelings of fear

and controversy. The next theme addresses the gaps and solutions in training and awareness of this modality.

‘The Blind Leading the Blind’ covers the gap in knowledge and skill surrounding the use of FES, the variety in means of guidance that therapists may or may not receive within their contexts as well as the dependence that therapists develop on self-directed learning in figuring out FES use in stroke rehabilitation.

Table 2.3b Theme two: The Blind Leading the Blind

CATEGORY	CODE	EXAMPLE QUOTES
Knowledge and Skill	**Not aware of evidence**	P3 “I'm not really sure what the evidence has to say about its effectiveness yet.” P5 “I think I would really like to see theoretically like or like a journal article on how well it did in like a control group. .”
	“Protocols”	**LACK THEREOF:** P4 “I don't know of any protocols around it actually and if there are any, I haven't seen any. I wouldn't even know where to find one.” P6 “I have to say we don't follow like a specific protocol and I have to say not that I've really ever seen any…” **NEED**: P6 “ I do think like having… and protocols in place would be really helpful.”
	Lack of training	**LACK THEREOF:** P3 “we didn't get specific training on it like at undergraduate level.” P4 “maybe a lack of training... I haven't seen a lot of like courses on it…it's not really touched on in undergrad studies.” **NEED:** P5 “So I really think that more training and more like education about it would be really beneficial specific to the OT scope. Like how theoretically it can be used in OT, what are the benefits of using it, how it can be used and also actually having an education session or training on how to use like functionally, practically. So having a practical-based training session will also be really helpful.”
Guidance	**“Peer mentoring”**	P3 “I think the physios had learned more how to use it, so they were the ones to show us.”

		P6 "…Just from speaking with my boss and my other colleagues on…what they've used and what had worked like what settings they were using and that kind of stuff…peer mentoring from my from my colleagues…"
	Lack of supervision	**LACK THEREOF:** P4 "And then I mean who else trains you if your team doesn't really know how to use it?" P7 "Because I don't have someone who can or someone who can supervise me to use a machine…my supervisors also don't know how to use an FES machine." **NEED:** P6 "Like neuro rehab interest group like maybe utilising something like that… because if there's not formalized training going to be brought about, then it may as well be a collective effort and may as well be a collective knowledge or collective input into maybe giving some guidance for younger therapists on how to do it. Yeah, I like that because…it's something that wouldn't need to be recreated."
	"Masters"	P1 "…from doing masters… after that I've been trying to use it a lot more and trying to incorporate it into function because we reviewed there's good evidence behind using it for improvement in the hemiplegic upper limb." P8 "…during, doing my masters, when we were researching adjunctive techniques, obviously FES was one of them. And I could see the benefits of adding it to practice, not solely just using it, but having it as an addition..."
	Supplier	P4 "…all these big companies.. have reps so…our rep…would come and show us you know how it works.
	"Curiosity"	P5 "So I was very interested in it at that stage, more on observation level rather than actually doing it myself… and it was more from the point of curiosity".
Figuring it out alone	**"Trial and error"**	P6 "Honestly it was a lot from exploration and…I sat with the manual one day and just tried to figure it out on myself…so just…a lot of self-directed learning." P9 "…and half of it comes from trial and error…"
	"Patient tolerance"	P1 "So if the patient says to me that's too much, then I'll reduce it or if they tolerating it well, I can increase it, but again, I totally guess the intensities like when it looks like it's moving a lot and the patient's not complaining, I'll increase it."

		P8 “But a lot of the time, my patients will dictate what they can handle and if it's too much or too little.”
	“Clinical reasoning”	P1 “so it's really just clinical reasoning.” P4 “To be honest, I just think my clinical reasoning.”
	“Contraindications”	P8 “I know the contraindications and things like that. So I make sure that I stick to contraindications, pregnancy, pacemakers, things like that.” P9 “Okay well obviously if the patient has like a pacemaker or something like that then you're not going to use it. So in terms of that like there's somewhat of a protocol but or if they're like pregnant or whatever, you know.”

THEME 2: THE BLIND LEADING THE BLIND

Skill and knowledge

Not aware of evidence

Participants from all sectors of healthcare in Gauteng identified a significant knowledge gap regarding the use and application of FES. There was specific mention of a lack of evidence, established protocols, and training for occupational therapists. Many participants expressed that they feel inadequately informed about the evidence related to FES for stroke survivors. Similarly, Bulley et al. 2021, found that MDT members, such as physiotherapists and occupational therapists, had to be proactive in locating and evaluating information on using FES, which was not currently being achieved (Bulley *et al.*, 2021). These findings were also observable in Auchstaetter et al.'s 2016 study, which found that 40% of Canadian physiotherapy participants were unaware of current evidence supporting the use of FES for stroke recovery (Auchstaetter *et al.*, 2016). Misconceptions and the lack of knowledge frequently limit the use of FES and the translation of current FES evidence into practice (Auchstaetter *et al.*, 2016).

Protocols

While participants in this study indicated a willingness to utilize protocols to enhance their understanding of FES in practice, they were largely unaware of any current protocols in the neuro-rehabilitative context. Although there is limited mention of protocol use of FES in recent literature (Dionne *et al.*, 2020; Abouzakhm *et al.*, 2022), there have been efforts to try to strengthen Clinical Practice Guidelines (CPGs) (Bulley *et al.*, 2021). Despite FES being widely recommended by clinical practice guidelines in reducing motor impairment and improving upper and lower limb function post-stroke (Hebert *et al.*, 2016; Stellenbosch University, 2019; Teasell *et al.*, 2020; Miyamoto *et al.*, 2022; Stroke Foundation, 2022), its use in clinical practice is frequently limited due to limited knowledge, skill and training (Auchstaetter *et al.*, 2016; Howlett *et al.*, 2018; Bulley *et al.*, 2021). A study conducted by Bulley et al 2021 found that 98% of participants (FES stakeholders) viewed CPGs as important for achieving best practice evidence, prompting a willingness to engage with FES in clinical practice (Bulley *et al.*, 2021). However, another study found that despite physiotherapists' awareness of CPGs on FES, the ability to translate best evidence into practice was limited due to

CPGs not being descriptive enough (Brown *et al.*, 2023). It is recommended that CPGs are accessible to clinicians by using simple language and practical examples to narrow the evidence-practice gap.

Lack of training

'Lack of training' was the most frequently used code; mentioned over 90 times and mentioned by all participants (Appendix M). Participants emphasised a notable absence of training opportunities on FES for occupational therapists at both the undergraduate and postgraduate levels. Notably, none of the participants had received formal training in the application of FES for stroke rehabilitation. Surprisingly, the two participants who mentioned the 'lack of training' code most frequently (Appendix M) held postgraduate degrees. This discrepancy is possibly due to their increased awareness of the evidence for the use of FES, but a heightened sense of feeling ill-equipped to apply it in practice. Participants expressed that training would be effective through formal courses as well as informal training in the workplace. The absence of training among occupational therapists and physiotherapists at an undergraduate and postgraduate level for the use of FES is one of the most commonly cited barriers in FES literature (Howlett, McKinstry and Lannin, 2018; Howlett, 2020; Taylor *et al.*, 2020; Bulley *et al.*, 2021; Swaffield *et al.*, 2022; Brown *et al.*, 2023; Musselman *et al.*, 2024). Therefore, there is a drastic need for FES education and training among occupational therapists to improve FES use in clinical practice for neurologically impaired clients (Howlett, 2020; Taylor *et al.*, 2020; Bulley *et al.*, 2021; Brown *et al.*, 2023). However, Howlett, McKinstry and Lannin (2018) found that receiving training in FES does not necessarily lead to FES use in clinical practice. This is illustrated in another study where, despite online training participants had received on FES, some participants still felt that they would require continued guidance to successfully implement FES within clinical practice (Musselman *et al.*, 2024). Rather, emphasis should be placed on the type of education and training to influence how FES is being used in practice (Howlett*, McKinstry and Lannin*, 2018). Gentry et al (2024), found that learning on PAMs was most beneficial when hands-on learning was administered with supervision and feedback (Gentry *et al.*, 2024). This format should be considered in the development and strengthening of accredited courses (Howlett, McKinstry and Lannin, 2018; Brown *et al.*, 2023).

Guidance

Peer mentoring and lack of supervision

Participants who have incorporated FES into their clinical practice with stroke survivors shared that their usage of the device was influenced by various factors. Those interested in incorporating FES into their clinical practice reported facing challenges due to insufficient support, including a lack of supervision and mentorship, which stems from both limited availability and knowledge. They also noted that their approach to FES was shaped by interdisciplinary collaboration, with peers providing informal “crash course” demonstrations. These insights do not directly correlate with current literature. A mixed methods study conducted in the United States on the preparation and use of PAMs, which included electrical stimulation, among the 141 occupational therapists that took part in the study, found that 69% received various PAMs-related training, namely 42.55% received on the job training or mentorship (Gentry *et al.*, 2024). The same occupational therapists were asked which form of training or guidance was most beneficial, and 26.74% of the participant population indicated on-the-job training and mentorship (Gentry *et al.*, 2024). Although the mentioned study indicated that in the US, to a degree, occupational therapists receive some form of on-the-job training and mentorship using PAMs such as electrical stimulation, however, these statistics are still significantly low. Howlett 2020 found that among occupational therapists working in Australia, there is a longing to learn from others in the workplace in the form of hands-on training (Howlett, 2020). As a means of addressing the lack of supervision and mentorship experienced in the context of the Global South, Brown et al 2023 suggested that mentored practice opportunities are the ideal way in which to improve clinicians’ skilled use of FES within clinical practice, using a hands-on approach through role modelling and peer learning (Brown *et al.*, 2023).

Masters and supplier

Six of the twelve participants in this study were either pursuing or had completed their master’s degrees in neurology at the time of data collection and reported having received a brief module on FES during their coursework, which informed their practical application. Contraindications were also cited as an important source of knowledge guiding their decision to use or refrain from using FES generated from self-directed learning. Lastly, participants from both private and public healthcare settings

acknowledged that insights from sales representatives or suppliers of electrical stimulation devices, whose educational backgrounds were rooted in Biokinetics, guided their clinical use. These findings can be related to a study mentioned earlier by Dionne et al., 2020, where 43% of the 57 occupational therapy practitioners working with persons with SCI did not make use of specific, universal treatment protocols, rather sought out alternative means of clinical guidance for FES in with person living with SCI (Dionne *et al.*, 2020). More than half of the participants (57.1%) in the Dionne et al., 2020 study perceived that they were making use of protocols. However, these perceived protocols came from a variety of sources, such as informal, subjective recommendations (41.1%), equipment manuals recommended by manufacturers (33.9%), published evidence (28.6%) and lastly, facility-generated guidelines (21.4%) (Dionne *et al.*, 2020). Although sales representatives appear to play a role in the guidance of FES use among healthcare practitioners such as occupational therapists, Howlett et al., 2020, highlighted a reluctance among physiotherapists to rely on training from non-clinical experts, such as sales representatives due to concerns that their input may not be sufficiently grounded in therapeutic practice (Howlett, 2020). Given the lack of universal use of evidence, protocols and training on a national and global scale, the findings both in this study and international literature demonstrate the discrepancy in guidance that occupational therapists receive around FES in stroke rehabilitation.

Curiosity

Many expressed that their use of FES stemmed from a sense of curiosity sparked by observations and informal conversations with colleagues on the use of FES in stroke rehabilitation. These findings were directly reported by Musselman et al 2024, where over half of the participants indicated that they began incorporating FES in their clinical practice due to interest and curiosity (Musselman *et al.*, 2023). A curious attitude appears to be a catalyst for the use of FES which can be harnessed in marketing appropriate learning opportunities and devices. It is with this mindset that participants needed to overcome their lack of knowledge and “figure it out”.

Figuring it out

Trial and error, Patient tolerance and clinical reasoning

Occupational therapists in this study made use of various methods in figuring out how to clinically apply FES to overcome the shortage of training in their context. Participants described their experience with FES as largely driven by "trial and error," emphasising a process of experimentation rather than a process grounded in established evidence and protocols. Additionally, "patient tolerance" played a crucial role in determining how therapists used the device, as they adjusted their approach and device parameters based on the responses of stroke survivors. One of the significant sources that therapists reported relying on, was their clinical reasoning based on their own clinical experience. This study demonstrates that the therapists who are making use of FES in neurorehabilitation are forced to resort to varied sources of guidance to apply FES in practice, limiting the uniformity of its application. There are a variety of recommended prescriptions across research studies, creating ambiguity for therapists to translate research into practice (Abouzakhm *et al.*, 2022), and novice therapists may have difficulty reasoning without sufficient experience in the field. A Canadian research team developed an FES clinical decision-making tool (CDM) tool to address these challenges (Abouzakhm *et al.*, 2022; Musselman *et al.*, 2024). Abouzakhm and colleagues queried the validity of this tool through qualitative means and concluded that this CDM tool is a helpful guide in using FES in neurorehabilitation (Abouzakhm *et al.*, 2022). Tools such as this offer a feasible solution for the knowledge gap regarding the application of FES for therapists who are not experienced in its use and are practising without supervision (Abouzakhm *et al.*, 2022; Musselman *et al.*, 2024). The researcher believes that occupational therapists will have to continue being adaptable and dependable on their clinical reasoning and experimentation until training and access to more resources, such as context-specific protocols, are readily available.

Lastly, ‘A Puzzle of Practicality’ demonstrates the multitude of factors that play a role in using FES in context, illustrating how FES is being used, its frequency, accessibility, and usability in practice while also considering client-specific factors and targeted interventions.

Table 2.3c Theme three: A Puzzle of Practicality

CATEGORY	CODE	EXAMPLE QUOTES
Application	**Movements in function**	P2 “…there's a specific movement that I want to elicit…for example, wrist extension…we're focusing on the extensors...I would set up a task of reaching for something and basically being able to extend the wrist up so that the hand can then fall over whatever item. Generally it's like a ball or a like a pipe or I've even used rolling pins or something like that where it's extended it the hand then flexes over the item and then is pulled back. But the goal is to when reaching have that wrist extension.”
	Preparatory exercise	P6 “I'd put it on like put the stim unit on that muscle group for like 5 minutes and then get take it off and then let the patient do it more actively within the task...sometimes I use it…more as a preparatory thing than actually within the task itself.”
Frequency	**Rarely**	P7 “So not a lot, but I have used it maybe on a total of max 10 patients.” P3 “…I've I only just tried using it once.” P4 “So yeah, I mean whether like the inpatients, I never really used it on strokes, but I definitely saw the benefit of using it daily on patients like GBS where they need the muscle strengthening and you know then it benefits them daily.”
	Often	P8 “I would say at least once a week, but possibly sometimes then more.” P6 “I would probably say at least twice a week using it with one patient, sometimes more, but not really ever less, so at least twice a week.”
	“One per collective”	P5 “I think that from a in private healthcare specifically we have one device or in our department of which we have many stroke patients and many therapists...” P8 “Oh, just that that not a lot of practice is stuck in abundance of them. So there's definitely only like one per collective, you know, of OTs. So the practice might just have one and then five or so OTs might need to use that one. So it's not that you have easy access to the one that the practice does have, because you have to share it amongst others.”

Access and cost	**Scarce resource**	P2 "…not all …government facilities have that resource available to them." P8 "…I think one of the large reasons why it's not being used enough is one, because they're hard to come by and not a lot of practices will keep many in stock." P7 "We have put it on our demand plan for the past few years, but we're not lucky to get one." P1 "… one of the most frustrating things is that the electrodes obviously lose stickiness." P7 "So the challenge of getting new electrodes on the demand plan ordering systems, those are challenges in government where oh what do we do once these electrodes are worn out or finished, then to order new ones on a regular basis can pose a challenge."
	"Expensive"	P1 "…and like I said, it's a really expensive device…" P4 "And also, let's be honest, these machines are not cheap. So like I would say, a barrier to use it is the cost of the machines itself. I mean, if you're like a little start-up practice… you're probably not going to be able to afford something like that."
	"Carry-over"	P6: "…We can't always get that carry over at home. It's not always reasonable to ask a patient to buy a stim…a lot of those benefits are kind of lived in the session and not necessarily carried over into…a home programme." P1 "…There's little carryover. So there's no way that patients are going to buy a device that costs this much…it's only going to be when they with me in sessions…"
Usability and maintenance	**Time-consuming and technical**	P10 "…the planning and the structuring and the setup of it I think can be quite time-consuming. P2 "…I find FES is quite time-consuming it…there's a lot of fiddling around in a very high-paced inpatient environment."
	Difficult to use (in an activity)	P1 "…I really found it difficult…to be able to use the device within an activity…that's been something that has frustrated me for a long time because I find that…once you've set the programme, you can't really control…how often the muscle contracts…" P6 "And certainly like I can absolutely admit that I don't always use it in an occupation-based task. It's not easy."

		P4 "…Some of the machines are so complex…I actually don't even understand and then you kind of just give up on it." P2 "you've got a short time to when…your contraction is elicited then you've got a short rest period and then you must do it all over again…so the current device that I use…it sets you up for repeating the same movement and doing exercises or doing repeating the same task over and over again with those little rest periods... I feel like an activity takes too long for what the contraction period…allows for…"
	"Pocket-sized"	P8 "Mine's very compact, mine will fit into the palm of my hand. So it makes it much easier for you to travel around with…" P2 "Also it's pocket-sized, it's a very nice size. So in terms of doing home based therapy, it's really nice to take the device."
Client in context	**Not for acute**	P6 "So I sometimes feel that like I mean obviously I'm not going ahead and using, I mean we don't ever use it on our acute patients in hospital or I certainly haven't." P2 "Whereas often you find patients are not really looking for something like that as an inpatient all the time because they more are wanting to like learn how to put their clothes on or brush their teeth again…so I find it's less of a priority as well just to the patient in general because…when you're an inpatient, it's so new that you're still relearning everything. Whereas an outpatient patients have generally gone through all their ADLS." P1 "And in the acute setting, I can tell you now…FES isn't being used… because…a lot of the acute settings their, their motto is assessing and down refer because the patients get discharged so quickly."
	"Patient insight"	P1 "…I don't think it's something that is common… it's just not something that's part of their frame of reference." P8 "But I've had patients just say… we can just put this on and it'll make my muscles work again."
	"Patient-dependent"	P2 "Um…so….it's so patient dependent I feel."
	Patient driven	P11 "I think it's really interesting that this previous patient… it mainly came from her wanting the FES, not myself necessarily thinking that it was the right treatment option."
	"Upper limb"	P1 "So I only…use it on the upper limb."

Targeted interventions	**“Fighting tone”**	P6 “…It did have a spasticity function, but it wasn't my favourite. I felt like it was just fighting tone with more…I don't know how it's like more pull… like you're pulling in the wrong direction, which probably stimulated the tone a little bit…I didn't find it very useful.
	“Shoulder subluxation”	P6 “…I primarily use it for…working on shoulder subluxation.” P7: “…I mainly use it for the severe subluxed shoulders.”
	“Flaccid upper limb”	P2 “We've been using it to try and stimulate any flaccid muscles… or incredibly flaccid arm, we we've been using it for that.”
	“Pain management”	P8 “But with multiple things like even just pain management, it works really, really well for because it gets the circulation going.”

THEME 3: ‘A PUZZLE OF PRACTICALITY’

Application

Movements in function and Preparatory exercise

Interestingly, the focus on ‘function’ in FES, and meaningful activity in occupational therapy appear to be complimentary, however two problems relating to application were revealed in this category. The first problem is the various definitions in FES literature as to what is considered ‘functional’; with some authors considering simple movements to be sufficiently functional (Marquez-Chin and Popovic, 2020). Whereas occupational therapy authors such as Howlett, McKinstry and Lannin (2018), emphasise that FES should “stimulate muscles to contract during the performance of an activity, such as reaching and manipulating objects” (Howlett, McKinstry and Lannin, 2018) which is the definition best aligned for this study. This problem is compounded by current occupational therapy literature that uses the terms ‘occupation’, ‘activity’ and ‘function’ interchangeably, causing conceptual confusion frequently within and outside of the profession (de Oliveira Figueiredo, Gomes, Silva and Simões Martinez, 2020). For example, one participant described using FES whilst a stroke survivor washed their face, another described using FES whilst reaching or grasping for various objects and finally, another participant expressed purely using FES as a preparatory activity to activate the desired muscles to then later participate in the preferred occupation. This demonstrates discrepancies among occupational therapists’ use of FES within function or occupation. Therefore, how occupational therapists use the terms ‘occupation’ and ‘activity’ will remain subjective and interchangeable depending on the context of the individual, creating further ambiguity in how FES is applied to ‘occupation’ or ‘activity’ for improved motor impairments post-stroke by occupational therapists.

During the interviews, participants described their current use of FES in clinical practice. Many reported utilising FES primarily as a preparatory tool, applying the electrical stimulation device to elicit muscle contractions in preparation for function. There is limited qualitative evidence on how occupational therapists are making use of FES in terms of preparatory means to achieve occupational participation in stroke rehabilitation. Nevertheless, according to an American Occupational Therapy Association (AOTA) position paper released in 2018, it is within the occupational

therapy scope of practice to make use of PAMs such as FES as a preparatory means for participation in occupation, however, if FES is used in isolation this is not deemed FES but rather NMES (Bondoc *et al.*, 2018). However, the lack of research on how occupational therapists are using FES in preparation for function draws uncertainty around whether or not the profession's philosophy is being adhered to or if there is confusion regarding the difference between NMES and FES. Conversely, some participants incorporated FES into basic tasks, such as grasp-and-release activities involving the upper limb, which better aligned with the concept of FES. Howlett, McKinstry and Lannin (2018) identified that among occupational therapists and physiotherapists, most therapists used FES to train grasp and release, reach or dexterity through the means of task-orientated activities to increase activity participation of the upper limb (Howlett, McKinstry and Lannin, 2018).

Frequency

Rarely and Often

FES use among occupational therapists in Gauteng reveals a diverse and varied landscape. While the majority of participants (9/12) reported infrequent use of FES, typically employing FES a few times throughout their careers. Additionally, several participants mentioned using FES more regularly in the treatment of other neurological conditions, such as Guillain-Barré Syndrome. Three out of the twelve participants indicated that they incorporate FES into their practice daily or weekly, viewing it as a regular component of their treatment for stroke survivors. Demographic data, as per Table 2.5, suggested that these three participants had between 5-10 years of work experience, and two either had or were completing their master's degree. This finding is associated with research findings in Canada, where it has been found that overall, physiotherapists and occupational therapists rarely make use of FES in stroke rehabilitation (Auchstaetter *et al.*, 2016; Musselman *et al.*, 2024). Howlett, McKinstry and Lannin (2018) also found that FES is not a routine intervention that is being implemented by both occupational therapists and physiotherapists in Australia (Howlett, McKinstry and Lannin, 2018). Therefore, although FES is a modality that is utilised in neurorehabilitation, it is not a common practice among occupational therapists globally. Despite some positive perceptions and ideals, the myriad of barriers mentioned by occupational therapists in this study likely serves as an explanation for the infrequent use.

Access and cost

Expensive

Among participants in private and public settings, they perceived FES to be expensive in its acquisition. Similarly, studies conducted in Canada and the UK found the cost to be a significant barrier to FES use among healthcare professionals and spinal cord injury survivors (Musselman *et al.*, 2023; Triccas *et al.*, 2023). Another study conducted in Vienna also concluded cost to be a barrier to FES use among clinicians, engineers and researchers (Taylor *et al.*, 2020). This could be a potential explanation for the adoption of open-loop systems by occupational therapists in this study, with closed-loop systems on the current global market costing significantly more and not readily available through local suppliers at the time of the study, revealing a gap in the market. “RecoveriX” is the only known commercially available closed-loop system for stroke rehabilitation, whereas many closed-loop systems are mainly used in research protocols in the laboratory (Khan *et al.*, 2023). Interestingly, participants who owned more expensive devices did not report higher use of FES in their clinical practice.

Scarce resource and One per collective

In the same vein, FES was frequently viewed as being a "scarce resource" among participants. This barrier was more commonly cited among occupational therapists working in public healthcare settings, possibly due to the unequal distribution of resources between public and private occupational therapy departments in South African (van Stormbroek and Buchanan, 2016). Participants with access to an FES device reported that there was only one device available for multiple therapists, creating logistical challenges for utilisation. Similarly, Auchstaetter et al 2016 found accessibility to be one of the most commonly mentioned barriers to FES use among Canadian physiotherapists (Auchstaetter *et al.*, 2016). Occupational therapists in public healthcare noted that while FES devices are on tender, efforts to secure these devices have been met with limited success, as they are not viewed as essential. This was also mentioned surrounding the maintenance of the stimulation pads as participants expressed that the electrical pads, which wear out over time, need regular replacement, which can be both costly and difficult to navigate through the public procurement channels. Equipment provision has also been noted as an issue in the

public health sector in the UK as funding through the National Health Service is perceived as unpredictable and relies on negotiations (Bulley *et al.*, 2021).

Carry-over

Despite the issue of accessibility and procurement, participants reported the challenge of poor carry-over. While FES may be utilised during therapy sessions, stroke survivors do not have access to the device at home due to cost. Similar results were reported by a Canadian study, where most physiotherapists reported that many stroke survivors did not have access to the device within their home, limiting translation into their home programmes (Auchstaetter *et al.*, 2016). Specifically in the outpatient setting in public healthcare, patients generally attend therapy less frequently than those in the private sector due to socioeconomic factors. Bulley et al 2021, found that physiotherapists and FES users perceived that access to FES services in the UK was a challenge in that these stakeholders are expected to travel to specialised service providers to access FES devices (Bulley *et al.*, 2021).

Usability and maintenance

Time consuming and technical

Participants highlighted that the application of FES during intervention is challenging. Firstly, FES was found to be time-consuming and technical, requiring considerable effort for training, device setup, and administration during treatment. Lacking time is one of the most frequently cited critiques of FES use among various FES stakeholders globally (Howlett, 2020; Taylor *et al.*, 2020; Bulley *et al.*, 2021; Musselman *et al.*, 2023). FES in stroke and SCI intervention has been critiqued for being time-consuming namely due to the time it takes to don and doff the device during therapy as well as the time it takes to learn to use FES (Taylor *et al.*, 2020; Bulley *et al.*, 2021). Therapists have critiqued FES for being time-poor in its implementation, often taking longer to set up the device than to use it in therapy (Howlett, 2020). Occupational therapists and physiotherapists find it cumbersome and difficult to process FES evidence and implement it into everyday therapy (Howlett, 2020; Stander, Grimmer and Brink, 2021). Musselman et al 2023, found that occupational therapists and physiotherapists critiqued FES devices as being temperamental, frequently requiring technical support and experiencing equipment failures (Musselman *et al.*, 2023). Bulley et al 2021 and Taylor et al 2021 have specifically critiqued FES devices on their low or poor usability

due to complex designs limiting device manipulation as well as wires disrupting therapy participation (Taylor *et al.*, 2020; Bulley *et al.*, 2021).

Pocket-sized and Difficult to use (in an activity)

Participants experienced FES devices as compact and “pocket-sized”, making them easy to transport. However, this benefit was outweighed by the overarching perception that many found FES difficult to integrate into functional tasks due to its singular focus on one muscle group and its rigid, rudimentary programming. Interestingly, no participant expressed rejection of FES as a tool in occupational therapy but rather expressed their frustrations and barriers to using it.

Although FES incorporates the element of ‘function’ which aligns more closely with the philosophy of occupational therapy, electrical stimulation traditionally focuses on singular movements or muscle groups (Marquez-Chin and Popovic, 2020). This impedes the complex combination of movements needed to complete a functional task. This could account for why participants associated electrical stimulation as a physiotherapist or biokinetics tool. For example, an occupational therapist typically uses functional tasks like dressing in therapy. Dressing requires several coordinated movements of the upper limb primarily shoulder flexion and abduction, elbow extension and flexion, wrist extension and finger flexion. The use of an open-loop FES device would be limited to only one of those movements. Activities in occupational therapy are inherently complex - ill-suited to the reductionist view of human movement as isolated, repeated contractions. Therefore, as it stands, FES only seems relevant as a modality to be used in a preparatory or pre-occupational movements (e.g. grasp and release) and not suited to occupation-based tasks in therapy.

Furthermore, all devices that participants in this study owned were open-loop systems, which means that they had fixed pre-programmes with set cycles of contraction and rest periods (Karamian *et al.*, 2022; Khan *et al.*, 2023). Most of the pre-programmed electrical stimulation devices owned by participants detailed in Table 2.2 appear to be marketed to therapists as multipurpose - NMES, FES, and TENS devices. However, if therapists can’t control when a movement should take place in a functional task, pre-programmed cycles of contractions only seem relevant as an NMES device, not FES. Whereas closed-loop systems have access to biofeedback mechanisms allowing the

desired muscles to be manipulated based on sensory feedback (Karamian *et al.*, 2022; Khan *et al.*, 2023). Either closed-loop systems or devices with more control over muscle contraction initiation and duration are recommended for the success of producing timeous movements in a preparatory functional movement. In addition, it is important that therapists are trained to identify key considerations when selecting an FES device, to confirm that it supports functional movements rather than serving only as a means of generating repetitive muscle contractions.

CPGs recommend FES as best practice for improving motor impairments post-stroke (Boulanger *et al.*, 2018; Stellenbosch University, 2019), these guidelines do not guide therapists on how to integrate FES within an occupational context (Brown *et al.*, 2023), often hindering its use among occupational therapists.

Client in context

Not for acute

Participants reported in this study that FES is less suitable for acute care environments and is more effective in rehabilitation or outpatient settings, where the context and available time better facilitates its use. The use of FES in acute public healthcare settings was reported to pose challenges due to limited bed availability and large caseloads, resulting in a high turnover of patients. Participants felt that this environment restricts therapists' ability to address physical impairments during the critically acute phase, as patients are typically admitted for only a few days before being discharged. These findings were also mentioned by participants working in varied care settings in the Auchstaetter et al, 2016 study, who also found that large caseloads, coupled with short treatment sessions and brief lengths of stays hinder the use of FES in varied care settings in Canada (Auchstaetter *et al.*, 2016). Therefore these findings suggest although the ease of FES applicability in acute care settings may not be greatly supported, there is a significant need for a tailored approach to FES use, particularly in rehabilitation or outpatient settings where the benefits of the device can be further maximized.

Patient insight

Participants also mentioned that FES within the public health care context, often does not align with this patient population’s frame of reference, as patients have limited

knowledge of FES, leading to unrealistic expectations of the device, leading patients to believe that the device will solely fix their motor impairments limiting patient insight into its intended use. Similar results were noted in the Swaffield et al., 2022 study, where parents of neurological impaired children reported that they had limited knowledge regarding the use of FES in neurorehabilitation however, where findings differed was on the premise that FES was not perceived to be a “miracle cure” for their child’s upper limb motor impairments but rather realistic expectations were maintained around the purpose and use of the device in neurorehabilitation (Swaffield *et al.*, 2022).

Patient driven

However, among private working occupational therapists, it was reported that some stroke survivors were motivated to push for FES use in their rehabilitation either by their own research or observations and were the ones who prompted the use of FES during treatment. These findings are supported by SCI research by Donovan-Hall et al., 2011, where SCI participants indicated that they frequently initiated the use of FES use in their rehabilitation based on their own observations rather than the therapist promoting its use (Donovan-Hall, Burridge, Dibb, Ellis-Hill and Rushton, 2011). These findings provide layered insights into FES use in rehabilitation, where therapists are not the only advocates for FES use in neurorehabilitation.

Patient dependent

Participants of this study reported that the decision to implement FES is largely dependent on the specific clinical circumstances of the patient and that FES is not clinically indicated for every stroke survivor as contraindications need to be considered. The Auchstaetter et al., 2016 study confirms this notion as physiotherapy participants reported that the use of FES among stroke survivors should be dependent on specific client factors (Auchstaetter *et al.*, 2016). To ensure the safe and appropriate use of FES in stroke rehabilitation, key client factors to account for are the presence of spasticity, poor skin quality, frailty, poor sensation, the presence of a pacemaker and pain (Auchstaetter *et al.*, 2016). Although FES is a modality recommended to improve motor function post-stroke, the individual factors of each potential patient must be carefully assessed to ensure the responsible use of FES in rehabilitation.

Targeted interventions

Upper limb, Fighting tone and Flaccid upper limb

Stroke survivors experience a range of neurological deficits, and FES was viewed as a potential solution for addressing physical impairments. Participants reported using FES to target issues such as muscle tone, pain, and shoulder subluxation following a stroke. Specifically, participants applied FES to manage hypotonicity in the flaccid upper limb as well as to address hypertonicity in the spastic upper limb. Additionally, participants recognised FES as a means to mitigate the effects of spasticity. However, this was also perceived as controversial among some of the participants. The use of FES to address spasticity in the upper limb post-stroke is supported by findings by Yuzer, Dönmez, and Özgirgin in 2017 who conducted a randomised control trial with 30 stroke survivors, finding FES to be effective in reducing wrist and finger spasticity among stroke survivors 3 months post-stroke (Yuzer, Dönmez and Özgirgin, 2017). Occupational therapists and physiotherapists working in the UK with the neuropediatric population reported that they use FES to elicit muscle activation, decrease spasticity and strengthen muscles; however, critiqued the use of FES in addressing spasticity due to a lack of awareness regarding the long-term benefits (Musselman *et al.*, 2023).

Pain management and Shoulder subluxation

Moreover, FES was also perceived as an effective intervention for alleviating post-stroke pain as well as shoulder subluxation. Notably, all participants who reported using FES in their careers indicated that it was exclusively applied for upper limb rehabilitation. Two recent studies found that FES is effective in reducing shoulder subluxation and pain in acute and chronic stroke survivors (Thakre, Qureshi and Naqvi, 2020; Vasconcellos da Silva *et al.*, 2020). These two studies found FES to be effective in reducing shoulder subluxation and pain early after stroke when used in conjunction with functional movements like flexion, extension and abduction of the shoulder or various grasps while simulating functional activities such as combing/washing hair or reaching for objects (Thakre, Qureshi and Naqvi, 2020; Vasconcellos da Silva *et al.*, 2020). Participants in the Musselman et al., 2023 study noted that in addressing upper limb functions like muscle strength and spasticity, FES was sometimes used in functional skills training or with functional skills in mind (Musselman *et al.*, 2023).

Conclusion

The findings of this study underpin the abundance of perceptions surrounding the use of FES in adult stroke rehabilitation within the South African context. When analysing the findings of this study, there appears to be an overwhelming amount of negative perceptions that are hindering occupational therapists' use of FES in neurorehabilitation. Common perceptions inhibiting the use of FES in stroke rehabilitation is the widespread lack of confidence, knowledge, and skill among occupational therapists, compounded by issues related to the device's accessibility and usability in clinical practice. On the other hand, perceptions that support the use of FES in stroke rehabilitation include the belief that it is a game changer, promotes neuroplasticity, and aligns well with functional outcomes, reinforcing its relevance within the scope of occupational therapy.

Many of the perceptions identified and discussed in this chapter are prevalent in the existing literature of FES in stroke rehabilitation among healthcare practitioners. Therefore, this research study is significant in depicting the multitude of perceptions contributing to the use and non-use of FES in adult stroke rehabilitation. To work towards the successful and skilled use of FES in adult stroke rehabilitation, these findings need to be continually addressed, researched and communicated to further promote its integration into clinical practice. After all, these efforts are to allow stroke survivors a better chance at living a meaningful and fulfilling life, which could be achieved through enhanced rehabilitation techniques and modalities such as FES. The final section of this study, Chapter 3, will synthesise and conclude the findings of this study as well as recommendations for further research.

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Data availability

The raw data of this study is not publicly available.

Disclosure statement

The authors want to make it clear that there are no competing interests to proclaim involving this study.

Declaration of Interests

An application was made to the desired research committee for an individual research grant in 2024. However, the application was unsuccessful. Therefore, the additional costs regarding the purchase of MAXQDA were all at the expense of the author.

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Chapter 3 Synthesis

3.1 Introduction to the chapter

The primary objective of this research study was to explore occupational therapists' perceptions of FES use in adult stroke rehabilitation in the public and private healthcare sectors in Gauteng, South Africa, an objective that was focused on in-depth in Chapter 2. In addition to exploring these perceptions, the second objective of the study was to investigate the factors influencing the use of FES in adult stroke rehabilitation. Findings not captured in Chapter 2 are discussed in this chapter, followed by a synthesis of the findings related to all of the second objective of the study. It then addresses the implications for practice, education and future research and concludes with a discussion regarding the limitations of the study.

3.2 Synthesis

Although it was not included in the original research protocol, the researcher felt it would be beneficial to answer the second objective using a structured framework due to the volume and nature of data that emerged in Chapter 2. Since the second objective focuses on factors influencing the use of a technological device, a well-established usability model could strengthen the validity and relevance of the findings. This study found that the majority of occupational therapists working in stroke rehabilitation in South Africa do not frequently use FES in their clinical practice. The UTAUT model will bring to light challenges to the adoption and use of FES in stroke rehabilitation, providing areas for further development for rehabilitation technology designers, engineers, educators and researchers.

Each determinant will be explored to understand and depict the current factors influencing occupational therapists' intention and use of FES in stroke rehabilitation. One of the themes emerging from the data was 'A puzzle of practicality' which explored the category of 'frequency'. What this theme discovered was that FES is not being used universally, which is reinforced by the nature of the participants in that only three of the twelve participants mentioned using FES on a daily or weekly basis. Years of experience or work setting did not appear to influence frequency of use, but the few that reported using it were interested in research or were pursuing postgraduate

degrees. Therefore, through the lens of the UTAUT Model, occupational therapists' "Use Behaviour" around FES in stroke rehabilitation is limited, as it appears that FES is an underutilised modality within this context. There appears to be a formidable amount of negative factors hindering occupational therapists' "Behavioural Intention" and "Use Behaviour" around FES in stroke rehabilitation.

Table 3.1 represents a summary of negative and positive factors across each domain of the UTAUT model, highlighted in red and green respectively. These factors influence occupational therapists' job performance, usability, beliefs as well as context in relation to the use of FES in stroke rehabilitation. By identifying these limiting and facilitating factors, usability recommendations are provided as a foundation for future studies and FES technology development. Therefore, this table is not intended to create a new deductive framework for this study but might suggest a deductive framework for future studies.

Table 3.1 UTAUT Model applied with recommendations

PERFORMANCE EXPECTANCY		
Code	**Interpretation into improved job performance**	**Usability recommendations**
Unsure Lack of Evidence Fear of harm	• Feeling uncertain about device or evidence of efficacy – uncertainty leading to fear of causing harm	• Training regarding variety of devices, features and contraindications to mitigate fear of harm • Further research into neurophysiological changes that occur due to FES use
"Activity is key" "Game changer" "Neuroplasticity" "Masters" "Prove our use"	• Positive attitude or perceived as beneficial for motor recovery.	• Promote benefits and practical applicability in stroke rehabilitation
"Shoulder subluxation" "Fighting tone" "Pain management" "Flaccid upper limb"	• Believed to be best suited for treating severe deficits, e.g. paresis.	
"Instils hope" "Visual feedback"	• Found to instil hope in client during rehabilitation.	

“Extra set of hands”	• Helpful, supports therapist to be more efficient.	
EFFORT EXPECTANCY		
Code	**Interpretation into usability**	**Usability recommendations**
“Pocket-sized”	• Small and compact, easy to transport.	• Promote user-friendly features of devices
“Difficult to use (in an activity)”	• Electrodes hinder ability to use it in occupation-based activities (e.g., dressing). • Poor adaptability of device – therapist unable to control when contractions occur in an activity. • Complex and technical device to navigate.	• Advancement of wireless or discrete electrode systems • Avoid pre-programmed cycles of contractions – parameters should remain to prevent harm however therapist should have autonomy over when muscle contraction should be triggered.
Time-consuming and technical	• Complex and technical set-up and use of device. • It takes time to train therapists on how to use device.	• FES devices should focus on functional movement, not individual muscle groups. Preplaced electrodes, for example on a sleeve, and a focus on the group of muscles used to perform a movement (e.g., reach) would be more readily available for therapists and does not limit the therapist to two muscles but rather a combination of muscles.
SOCIAL INFLUENCE		
Code	**Interpretation into others beliefs**	**Usability recommendations**
“Controversy” “lazy therapy” “Peer mentoring” or “lack of supervision”	• Negative social influence – perceived as controversial or makes a therapist "lazy"	• Harnessing constructive and positive networks of supervision and mentorship is essential to promoting confidence and skill in FES use. • Joint trainings with other professions to discuss misconceptions regarding scope of practice and advocating for FES as a rehabilitative tool.
“Patient driven”	• Encouraged by patient to use device in their rehabilitation	• Promote educated and informed decision making by patients for the use of closed and open loop devices.
FACILITATING CONDITIONS		
Code	**Interpretation into contextual factors**	**Usability recommendations**
“Not for acute”	• Poor accessibility due to limited funding hindering procurement, correct number of devices per therapist and integration of home programmes. • Acute care environments (i.e. high turnover/severity of stroke)	• Funding structures should be reviewed in assisting accessibility and awareness. • Should be viewed as an essential rehabilitation equipment item.
“Carry-over”		

"Scarce resource"	hinder FES application at an acute inpatient level	
"One per collective"		
"Protocols"	• Not knowing due to limited knowledge and guidance	• Postgraduate programmes or CPD courses should focus on practical hands-on training for FES use.
"Lack of training"		

Before understanding the determinants contributing to the lack of behavioural intention to use FES, contextual factors around the use of FES need to be described. This will further explain why occupational therapists' "Use Behaviour" regarding FES is limited in stroke rehabilitation. Therefore, factors relating to performance expectancy, effort expectancy, social influence and facilitating conditions will now be explored.

Performance Expectancy

From the perspective of performance expectancy**,** many of the occupational therapists in this study held a positive view on the use of FES in stroke rehabilitation with many believing that FES is a valuable tool in addressing motor impairments post-stroke to promote recovery, adding an element of efficiency to intervention as well as providing hope for patients, encouraging greater participation in therapy. However, factors that are heavily hindering performance expectancy are that most occupational therapists lack confidence in using FES due to limited education, training and awareness of current findings in FES research. Therefore, although occupational therapists hold a positive attitude towards FES in stroke rehabilitation, the lack of confidence and understanding of current FES research frequently prevents them from making use of FES, as this lack curates a sense of doubt in many occupational therapists, leading to fear of causing harm. Table 3.1 includes recommendations to address performance expectancy primarily through training. FES Training should include (i) information on the variety of devices and their features so that therapists buy FES devices that will best serve their practice; (ii) contraindications to mitigate the fear of harm, (iii) the benefits and practical applicability of FES in stroke rehabilitation.

Effort Expectancy

Besides a small portion of participants perceiving FES as easy to use from the perspective of it being small and compact thus making it easy to transport, FES is currently not convenient to use in stroke rehabilitation. This is as a result of the fact that FES requires technical skill, and is time-consuming as it requires time to set up and use the device as well as to educate or train an individual on its use. What significantly hinders its ease of use is the fact that occupational therapists find FES challenging to translate into activity or function due to electrode interference, limited adaptability of the open-loop systems as well as the devices being technical to navigate which are all significant factors contributing to the burden of using FES in stroke rehabilitation, limiting its ease of use. FES designers and manufacturers should prioritise advancing the technology to utilize discrete electrode systems and devices that offer therapists more control over the timing of when muscles should contract. Most devices allow for a maximum of two muscle groups to contract – since FES inherently requires functional movements, manufacturers should ensure functional movements are achievable with possibly more muscle groups recruited in a task.

Social Influence

With regard to the behavioural intention to make use of FES, occupational therapists' motivation appears to be low. Specific to social influence, this study found that as an occupational therapist, there are no significant overarching social influences that promote FES use, as it was apparent in the findings that occupational therapists in the South African context lack mentoring and guidance so much so that even experienced or senior therapists in clinical settings are not promoting its use limiting the intent to use it. In the same regard, given that FES is a device that is intended to address motor impairments, there appears to be a generalised fear hindering its use, as occupational therapists in this study expressed concern for overstepping their scope, causing harm and developing into a lazy therapist with FES use. Therefore, there are limited notable positive social influences within the occupational therapy context that are pushing for the use of FES in stroke rehabilitation other than on occasion, its use is motivated and promoted by the patient based on the patient's observations and informal research. Harnessing constructive and positive networks of training and supervision is therefore needed. Joint occupational therapy, physiotherapy and biokinetics FES workshops should be held to allow for opportunity to discuss misconceptions and differences in

scope of practice, simulate real-world practice on stroke clients, and promote peer learning and mentorship or communities of practice.

Facilitating conditions

When referring to Table 3.1, it is apparent that there are no facilitating conditions regarding FES use among occupational therapists in Gauteng. This is a result of the fact that education and training opportunities on FES in South Africa are virtually non-existent. Although a Canadian research team has developed the CDM tool (Abouzakhm *et al.*, 2022) for FES, South African occupational therapists are unaware of this tool, and, aside from this, there are no current universal protocols or guidelines readily available to occupational therapists working in stroke rehabilitation. Accessibility is a massive issue in the South African stroke rehabilitation context, as FES is frequently viewed as a scarce resource, with many government-run facilities lacking access to FES devices, compared to private care facilities. However, FES devices are frequently shared between professionals or departments, thus limiting access when needed. The overarching context of acute care facilities does not bode well for FES use due to the nature of having a high turnover of patients and large volumes of patients thus leading occupational therapists to prioritise ADL participation over movement quality. Lastly, given the sociodemographic background of the population majority that the South African health care system serves, many stroke survivors do not have access to an FES device within their home, limiting the ability to carry over this modality within their home programs. Therefore, occupational therapists lack the knowledge, skill and resources to be able to maximise the use of FES within the South African healthcare context. Training has been previously recommended, but in addition accessibility needs to be addressed. Designers and manufacturers should provide entry-level devices at a low cost as technologies advance, and funders should view devices as essential equipment in rehabilitation settings.

Before FES use can advance in stroke rehabilitation, several hindering factors need to be addressed to better support occupational therapists' intent and use of FES. Firstly, training and education at both postgraduate levels need to be strengthened to better align with practical-based learning, which could be further improved by well-established mentorship and supervisory networks. Improved mentorship and practical-based learning will assist in enhancing occupational therapists' confidence, self-doubt

and skilled application of FES in clinical practice. Through amplified education and training, occupational therapists could be better informed on how to appropriately integrate FES within their scope of practice. Future research needs to better support the accessibility and use of open-loop and closed-loop FES devices within the rehabilitation context.

This chapter has revealed a multitude of factors that hinder the use and clinical application of FES in stroke rehabilitation, further perpetuating negative perceptions around the use of FES in stroke rehabilitation among occupational therapists. The findings and resulting recommendations provide a foundation for future research aimed at addressing the research aim as well as enhancing both the behavioural intention and actual use of FES among occupational therapists. Such advancements have the potential to reduce post-stroke motor impairments and, in turn, promote greater participation in daily activities and improve overall quality of life.

3.3 Limitations to the study

The study findings should be interpreted in light of its methodological limitations described below. Although these limitations impact the transferability of the findings, they do not negate the fact that there is promise in the use FES post stroke in improving physical impairments for improved activity or occupational engagement post stroke. However, for the efficacy of FES use to improve, increased emphasis needs to be placed on educational opportunities at a postgraduate level, enhancing the usability of the device by the therapist and within activity, promoting support structures as well as addressing contextual factors. Despite FES being an important tool in an occupational therapist's toolbox, there were limitations noted in the study that will be discussed below.

Eleven out of the 12 interviews were conducted online without video to conserve bandwidth; however this limited the researcher's ability to observe and analyze nonverbal communication. This may have hindered the accuracy of interpreting participants' responses and reduced the richness of the data collected. Another limitation relates to the study context, as many of the research participants were based in tertiary-level public or private hospitals in Gauteng. This concentration of

participants runs the risk of creating a skewed understanding of how functional electrical stimulation (FES) is, or is not, used in other settings such as regional hospitals or clinics in the province.

The prolonged data collection period, spanning from June 2023 to January 2024, also posed potential risks. With such an extended timeframe, the researcher may have unintentionally developed bias from earlier data, which could have influenced how later data was collected or interpreted. Furthermore, although transcripts were sent back to participants for verification, the findings and interpretations were not discussed with them in detail. This left room for possible misinterpretations or bias in analysis, though efforts were made to mitigate this by involving two second coders to help ensure that codes were accurately derived.

Another limitation lies in the absence of visual aids during interviews. Providing images or representations of different FES devices could have enabled participants to give more precise descriptions. This might have reduced the need for prompts during interviews and enhanced the researcher's understanding of how devices were being used. Lastly, the study did not include an in-depth exploration of whether participants perceived benefits or observed evidence of effectiveness when using FES with stroke patients, which represents a further gap in the findings.

3.4 Recommendations

This study provides a solid foundation for further research, particularly in the Global South, where a modality like FES could be better promoted. There are a multitude of valuable recommendations from this study to continue promoting further research regarding FES, and so they will be presented in three different sections below, namely recommendations for further research, recommendations for further education and training and lastly, recommendations for practice.

3.4.1 Recommendations for further research

This study only explored the perceptions of occupational therapists working in Gauteng, South Africa, which creates a gap for further research to be conducted in other provinces. Such studies would allow for comparisons to be made to determine whether perceptions and influencing factors differ among occupational therapists

working in different parts of the country. Beyond South Africa, this research also opens further opportunities in other countries within the Global South, where similar healthcare and financial contexts exist. Comparative research in these settings could expand understanding of FES and strengthen its promotion across diverse contexts.

Continued research is recommended to clarify the definition of FES and the use of “functional activity” in the literature, with the aim of reaching a unified understanding of FES in rehabilitation. Further investigation into the mechanisms through which FES operates is also needed to improve knowledge of motor control, particularly given the uncertainty around whether neuroplasticity is induced during or after the use of FES in post-stroke recovery.

At a national level, an audit or survey of the devices currently available to FES stakeholders in South Africa is recommended. This would help establish the extent to which open-loop and closed-loop FES systems are accessible, as it is suspected that closed-loop devices are either rare or unavailable in the country. Addressing this gap could create opportunities for local rehabilitation technology suppliers, particularly for stroke survivors with higher incomes.

In addition, future research should support manufacturers and engineers in designing and producing open-loop FES systems that can be more readily applied to functional tasks and activities. Such developments would help reduce the burden of effort expectancy on healthcare professionals during rehabilitation. Similarly, future research should also assist in the development of closed-loop FES systems that are not only practical but also affordable and accessible for use in clinical settings, rather than being limited to research or laboratory environments.

3.4.2 Recommendations for further education and training:

A key recommendation is the revision of postgraduate curricula in South African universities to place greater emphasis on effective adjunctive modalities such as functional electrical stimulation (FES) in stroke rehabilitation. Strengthening this focus would help occupational therapists across all levels of healthcare feel more competent and guided in applying FES in practice. While it is important to emphasize the theoretical foundations and evidence base of FES, students at a postgraduate levels should also be provided with meaningful practical experiences using FES with stroke

survivors. Incorporating discussions around scope of practice and occupational therapy philosophy is equally essential, as this may help address feelings of fear, uncertainty, or controversy that are often associated with its use.

This study has also highlighted the urgent need for greater education and training in the use of FES. It is therefore recommended that postgraduate learning opportunities be developed, either as Continued Professional Development (CPD) courses or through in-service training at therapists' respective workplaces. Such initiatives would allow occupational therapists to integrate current evidence and research into practice, while also gaining valuable hands-on, practical learning experiences with FES.

Finally, nurturing mentorship and practical training opportunities is strongly recommended, as many participants in this study noted the existing gap in this area. Established education networks, such as neurorehabilitation interest groups, could be leveraged to strengthen connections across multidisciplinary teams and create dedicated mentorship pathways for occupational therapists. Such support structures would enable therapists to apply FES in clinical practice more skilfully, confidently, and effectively.

3.4.3 Recommendations for practice

With further research, relevant guidelines and protocols can be developed in the hopes of achieving a unified approach to FES use in stroke rehabilitation—one that is contextually relevant not only to the Global North but also to countries like South Africa in the Global South. To achieve this, discussions need to be held and facilitated with relevant policymakers and FES stakeholders, including researchers, engineers, and healthcare professionals such as occupational therapists, physiotherapists, and speech therapists. These collaborative discussions would support the development of protocols and guidelines that reflect the realities of practice across different contexts while working toward a shared and unified approach.

In addition, it is recommended that strategies be implemented across all levels of healthcare, both private and public, to improve accessibility to FES devices. This could be supported by revising budgeting frameworks and processes, specifically those

related to medical schemes and tender systems, in order to promote increased awareness, equitable access, and sustainable funding for FES.

3.5 Conclusion

This study demonstrates the multifaceted perceptions and practical realities occupational therapists face when considering the use of FES in adult stroke rehabilitation in Gauteng, South Africa. While therapists acknowledged FES as a potentially transformative tool for promoting motor recovery and enhancing participation in daily activities, there appears to be widespread uncertainty, limited training, and contextual barriers that hinder its consistent use in practice. The findings—captured through the themes ‘A Tug of War’, ‘The Blind Leading the Blind’, and ‘A Puzzle of Practicality’—underscore the urgent need for targeted education, accessible resources, and clearer clinical guidance to support occupational therapists in confidently and effectively integrating FES into their “tool box”. Ultimately, this research marks a foundational step in advancing FES knowledge and application within occupational therapy, contributing to more inclusive, evidence-informed, and functional stroke rehabilitation strategies that prioritise quality of life and meaningful participation for stroke survivors.

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Appendices

Appendix A: Ethical Clearance Certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG	HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

Office of the Deputy Vice-Chancellor (Research and Innovation)

TO:	Ms S Frew School of Therapeutic Sciences Department of Occupational Therapy Medical School University E-mail: SarahFrew3@gmail.com
CC:	Supervisor: Mesdames F Breytenbach and J van der Linde <Fiona.Breytenbach@wits.ac.za> and <HREC-Medical Research Office@wits.ac.za>
FROM:	Mr Iain Burns Human Research Ethics Committee (Medical) Tel: 011 717 1252 E-mail: Iain.Burns@wits.ac.za
DATE:	2023/03/27
REF:	R14/49
PROTOCOL NO:	**M221070** (This is your ethics application reference number. Please quote it in all enquiries, oral or written, relating to this study.)
PROJECT TITLE:	*Exploring occupational therapists' perceptions of the use of functional electrical stimulation in occupation-based stroke rehabilitation in Gauteng, South Africa.*

Please find attached the Clearance Certificate for the above project. I hope it goes well and that an article in a recognized publication comes out of it. This will reflect well on your professional standing and contribute to Government funding of the University.

MSWorks2000/Iain0007/Clearscan.wps

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R49 Ms S Frew

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M221070

NAME: (Principal Investigator)	Ms S Frew
DEPARTMENT:	School of Therapeutic Sciences Department of Occupational Therapy Medical School University
PROJECT TITLE:	*Exploring occupational therapists' perceptions of the use of functional electrical stimulation in occupation-based stroke rehabilitation in Gauteng, South Africa.*
DATE CONSIDERED:	2022/10/28
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:	Mesdames F Breytenbach and J van der Linde
APPROVED BY:	Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	2023/03/27

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

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office secretariat on the 3rd floor, Phillip Tobias Building, Parktown, University of the Witwatersrand, Johannesburg.

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated from the research protocol as approved, I/we undertake to submit details to the Committee. **I agree to submit a yearly progress report**. When a funder requires annual re-certification, the application date will be one year after the date when the study was initially reviewed. In this case, the study was initially reviewed in **October** and therefore reports and re-certification will be due in the month of **October** each year. Unreported changes to the study may invalidate the clearance given by the HREC (Medical).

Signature of Principal Investigator

14/01/2025

Date

Appendix B: Interview guide

Intro – *Summarise at the start make them feel comfortable. Start with an information letter and recap – disclaim (anonymity/no risk or harm/can drop out of the study at any time).*

1. *Please describe where you work and your clinical setting.*

    - *Do you work in a government or private care facility? What level of care?*
    - *Inpatient or outpatients? Or a mixture?*
    - *How long (years) have you been working as an OT post your community service year and how long have you worked in a neuro setting?*

2. Please describe the type of neurologically impaired patients that you see.

    - How frequently do you see stroke patients – daily/weekly/monthly?
        - Its hard to quantify – do you say some/few/majority
    - Are your clients in the acute or chronic phase or a mixture?

3. As you may know, I am exploring OT's perceptions of functional electrical stimulation (FES) in my study.

    So let me start by asking whether your practice or department owns any electrical stimulation devices. *Some have and some don't – seems like a mixed picture of some have and some

        - If yes – can you describe the device?
        - What type of electrical stimulation device is it or what is it used for?
        - Is it pre-programmed /what programs do you use?
        - Do you find yourself using specific programs more than others?
        - What do you prefer? Is there a certain program you like?
        - *If no – Why is it do you think that your practice does not own an electrical stimulation device?*
        - *If no – if you did have one at your practice do you think you would make use of it or not and why? (linked to barrier and facilitators) – is it something that you've considered before?*

4. Do you or have you used FES in your clinical practice, specifically with your stroke population?
    - If yes – what led you to make use of FES in your practice?
        - Where does your knowledge source come from?
    - If yes – describe how you would use it in a typical treatment session.
        - Why is that?
    - If yes – how frequently do you make use of it?
        - Why is that? Could you quantify that for me?
    - If yes – do you make use of a protocol when using FES
        - What would you say guides your use?
    - *If not – why do you not make use of FES in your clinical practice?*

5. *What do you perceive are some of the barriers to the use of this device in OT stroke rehabilitation? with your stroke population? i.e. what factors do you think count against the use of this modality in OT stroke treatment sessions in South Africa?*
    - *Probe: Why? Anything else you want to add? What else would you say prevents OTs from using FES?*
    - *What would you suggest is still needed in the area of electrical stimulation?*

6. *What do you perceive are some of the facilitators of the use of this device in OT stroke rehabilitation? in OT stroke rehab in South Africa? i.e. what factors do you think weigh in favour of using this device in OT stroke rehab in South Africa?*
    - *Probe: Why? Anything else you want to add?*
    - *What else do you think helps support OT's use of FES in stroke rehabilitation? what helps you feel confident in using -paraphrase*

7. *What is your perception or view – are you for or against or unsure of its use in occupation-based stroke rehabilitation by occupational therapists and why?*
    - *Do you feel that FES is beneficial to occupation-based stroke rehabilitation?*

Appendix C: Adaptations made to the Interview Guide based on Pilot Studies

Concern Identified	Adaptation Made	Details / Probing Questions
Concerns identified during each pilot study	An introduction to the interview guide was included	Intro – Summarise at the start to make them feel comfortable. Start with an information letter and recap – disclaim (anonymity/no risk or harm/can drop out of the study at any time).
Pilot question one	Divided into question one and question two. Further probing questions added to new question two	a. Please describe where you work and your clinical setting. b. Please describe the type of neurologically impaired patients that you see. • How frequently do you see stroke patients – daily/weekly/monthly? o It's hard to quantify – do you say some/few/majority • Are your clients in the acute or chronic phase or a mixture?
Pilot question two	Became interview guide question three with added probing questions	a. Is it pre-programmed /what programs do you use? b. Do you find yourself using specific programs more than others? c. What do you prefer? Is there a certain program you like? d. Why is it do you think that your practice does not own an electrical stimulation device? (linked to barrier and facilitators) – is it something that you've considered before? e. Is it pre-programmed /what programs do you use?
Question three in pilot study	Became question four in the interview guide. Rephrased and two probes added	a. Do you or have you used FES in your clinical practice, specifically with your stroke population? • Where does your knowledge source come from? • Why is that? Could you quantify that for me?
Question five in pilot study	Split into questions five and six in the interview guide	—

Interview guide question five	Probing question added	a. What would you suggest is still needed in the area of electrical stimulation?
Interview guide question six (merged from pilot question five)	Probing question added	a. What else do you think helps support OT's use of FES in stroke rehabilitation? What helps you feel confident in using FES?
Interview guide question seven	Rephrased and additional probing question included	a. What is your perception or view – are you for or against or unsure of its use in occupation-based stroke rehabilitation by occupational therapists and why? • Do you feel that FES is beneficial to occupation-based stroke rehabilitation?

Appendix D: Letter for requesting dissemination of information sheet

Good day,

My name is Sarah Frew. I am currently doing my Master of Science in Occupational Therapy (Neurosciences) at the University of the Witwatersrand. My research aims to explore occupational therapists' perceptions of the use of functional electrical stimulation in adult stroke rehabilitation in Gauteng, South Africa. The study is aimed at occupational therapists registered with the HPCSA, who are currently working in neurorehabilitation specifically with the adult stroke population in Gauteng.

This letter serves to kindly request your assistance in the distribution of the studies information sheet (please see attached information sheet) to potential participants for this study across your relevant electronic platforms.

This study has been approved by the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg ("Committee") (please see attached ethical clearance certificate). If you have any concerns over how the study is being conducted, please contact the Chairperson of this Committee, Professor Clement Penny, who may be contacted by telephone number 011 717 2301, or by e-mail at Clement.Penny@wits.ac.za. The telephone numbers for the Committee secretariat are 011 717 2700/1234 and the e-mail addresses are Zanele.Ndlovu@wits.ac.za and Rhulani.Mukansi@wits.ac.za.

Should you require any further information or have any questions or concerns, please don't hesitate to contact me at 2611750@students.wits.ac.za or one of my supervisors, Mrs Fiona Breytenbach or Dr Janine van der Linde at fiona.breytenbach@wits.ac.za or Janine.vanderlinde@wits.ac.za (tel: 011 717 3701) respectively.

Thank you for your consideration.

Kind regards,

Sarah Frew
Department of Occupational Therapy, Faculty of Health Sciences
University of the Witwatersrand

Appendix E: Information Sheet for participants

Good day,

My name is Sarah Frew. I am currently doing my Master of Science in Occupational Therapy (Neurosciences) at the University of the Witwatersrand. I would like to invite you to participate in my research which aims to explore occupational therapists' perceptions of the use of functional electrical stimulation in stroke rehabilitation in Gauteng, South Africa. The study is aimed at occupational therapists registered with the HPCSA, who are currently working in neurorehabilitation specifically with the adult stroke population in Gauteng.

The process of data collection

Participants will take part in face-to-face or online one-on-one interviews (MS Teams). The venue (online or in-person), time and dates will be determined based on the convincing of participants. The interview will be audio-recorded and used for data analysis once transcribed. Interviews will be set between April – October 2023. Before the commencement of the semi-structured interviews, participants will be asked to complete consent forms to participate in the study and audio-recorded. Refreshments will be provided if the interview is held in person. The researcher will guide the discussion with open-ended questions about your views on functional electrical stimulation in rehabilitation.

The risks and benefits of participating in the study

There are no risks involved in participation in this study. Participants can withdraw from the study at any point without any consequences. Participation is completely voluntary. There are no direct benefits from participating in this study, however, participation provides the opportunity to be involved in furthering and enhancing the efficacy and understanding of a rising assistive device within the field of neurorehabilitation in occupational therapy.

How will confidentiality be maintained?

Participants will be assigned a participant code throughout the study to remain anonymous during analysis, within the results of the study, as well as if the study undergoes any form of publication. This means that your name, surname and any

other identifying information will not be captured, rather you will be assigned a number. Once data analysis is complete, the audio recordings and transcriptions will be stored in a safe location for 6 years, according to HPCSA regulations. The participant will be given all relevant information required while participating in the study. Results of the study once completed can be issued to participants upon request (participant codes only given, not participants' names). Results will remain anonymous if they are published in the form of a journal article or presented at a conference or seminar. Member checking will be used. Therefore, the analysis and interpretation of data will be checked and evaluated by the participants, through the researcher distributing a hard copy of the analysis to participants at their workplace, and will be collected by the researcher on completion.

This study has been approved by the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg ("Committee"). If you have any concerns over how the study is being conducted, please contact the Chairperson of this Committee, Professor Clement Penny, who may be contacted by telephone number 011 717 2301, or by e-mail at Clement.Penny@wits.ac.za. The telephone numbers for the Committee secretariat are 011 717 2700/1234 and the e-mail addresses are Zanele.Ndlovu@wits.ac.za and Rhulani.Mukansi@wits.ac.za

Should you require any further information or have any questions or concerns, please don't hesitate to contact me at 2611750@students.wits.ac.za or my supervisor, Mrs Fiona Breytenbach at fiona.breytenbach@wits.ac.za respectively.

Thank you for your consideration.

Kind regards,

Sarah Frew
Department of Occupational Therapy, Faculty of Health Sciences
University of the Witwatersrand

Appendix F: Informed consent for participation in the study

"Exploring occupational therapists' perceptions of the use of functional electrical stimulation in adult stroke rehabilitation in Gauteng, South Africa."

I_____ (full name) I have been given a participant information Sheet which explains the nature and processes involved in this study, which is attached hereto;

1. I was given time to read it, or had it read to me, in the language I best understand.
2. I was given time to ask any questions I wanted to and found any answers given to me to be reasonable and satisfactory.
3. I believe I fully understand why the study is being conducted and what the intended outcomes will be.
4. I understand that there will be no immediate benefit to me, should I agree to participate, nor will I receive any payment; conversely, participation will not cost me anything but my time.
5. I understand that, even if I initially consent to take part in the study, I may subsequently withdraw at any time and would not be required to give any reasons; if that happened, any data collected about me for the purposes of the study would immediately be destroyed, unless I give consent for it to be retained.
6. I have been given a range of contact details, listed below. If I require further information or become concerned about any aspect of this study I am free to speak to any of these contacts.

Contact details:

Sarah Frew, the principal investigator can be contacted on 0823022232, or by e-mail at sarahfrew3@gmail.com

Fiona Breytenbach, the research supervisor, can be contacted on 0760485478, or by e-mail at fiona.breytenbach@wits.ac.za

Professor CB Penny, Chairperson of the Human Research Ethics Committee (Medical) at the University of Witwatersrand, on telephone no. 011 717 2301, or by e-mail at Clement.Penny@wits.ac.za.

Ms. Z Ndlovu or Mr Rhulani Mkansi, Committee Secretariat, telephone nos.: 011 717 2700 or 1234, or by e-mail at: Zanele.Ndlovu@wits.ac.za or Rhulani.Mkansi@wits.ac.za

Name of Participant: _____

Date:_____

Place: _____

Signature or mark_____

Witnessed by:

Name of Witness: _____

Signature: _____

Date: _____

Appendix G: Informed consent to be audio recorded

"Exploring occupational therapists' perceptions of the use of functional electrical stimulation in adult stroke rehabilitation in Gauteng, South Africa."

I hereby consent to the audio recording of the interview. I understand that:

- The recording will be stored in a secure location (a locked cupboard or password-protected computer) with restricted access to the researcher and the research supervisor.
- The recording will be transcribed and any information that could identify me will be removed,
- The recordings will be erased within either (a) two (2) years of the publication of the research findings, or (b) six (6) years if no publications arise from this research.
- Anyone wishing to access this information in the future will first have to obtain the approval of the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg.
- Direct quotes from my interview, without any information that could identify me, may be cited in the research report or other write-ups of research.

Name of Participant: _____

Date:_____

Place: _____

Signature or mark_____

Witnessed by:

Name of Witness: _____

Signature: _____

Date: _____

Appendix H: Data Management Plan

1. Description of the data
1.1 Type of study The researcher will be conducting a qualitative study using an interpretive phenomenological approach using narrative interviews. 1.2 Types of data Data will be captured through audio recording of semi-structured, in-depth individual interviews.
2. Data collection / generation
2.1 Methodologies for data collection / generation Data will be captured through audio recording of semi-structured, in-depth individual interviews. After the audio-recording, the audio file will be transferred to the principal researcher's password-protected personal computer and Google Drive (student account). 2.2. File formats The audio-recording will be in .mp4/.mp3 format and uploaded to Google Drive through the Wits student account (access-controlled).
3. Data management, documentation, and curation
3.1 Managing, back-up and storing data An information letter will be provided, and consent will be required from each participant Google Drive requires an account to be created (provided through the University of the Witwatersrand) and is password-protected. Data will not be stored on hard drives or proprietary software. Google Drive password-protected online platform and therefore does not carry the risk of loss/theft/damage as hard drives. After the study has ended and the student has submitted the research report for examining, all data will be handed over to the Department of Occupational Therapy to be stored in its digital research repository. All data collected in the course of the study will be securely retained for two (2) years, if a scientific publication arises from the study and six (6) years if there is no publication. Thereafter it will be destroyed accordingly.
4. Data security and confidentiality of potentially disclosive information

4.1 Formal information/data security standards

The University of the Witwatersrand is a public university and is compliant with the International Organisation for Standardisation (ISO) ISO 27001 Information Security. Data will be stored in Google Drive which is an access-controlled storage cloud. Data will not be destroyed unless required for ethical or legal reasons in which case the University of the Witwatersrand's Central Records Office will be consulted for advice on expertise.

4.2 Main risks to data security

No names, surnames, contact details or other identifiers will be captured on the audio-recordings. Pseudonyms and Codes will be used for participants to ensure anonymity of data. The real names and codes will be stored only in hard documents, stored in a locked cupboard. The video and audio recordings will not be uploaded. We do not foresee risks to data security related to this project.

5. Data sharing and access

5.1 Policies for re-use and restrictions to sharing

If a researcher wishes to re-use the data in future, they will need written permission from the principal researcher and Department of Occupational Therapy, University of the Witwatersrand. Ethical clearance must be obtained before data is shared.

5.2 Governance of access

The principal researcher and co-supervisors of the research project will have access to the raw data. Anyone requesting access to raw data must obtain permission from HREC

6. Responsibilities

The primary researcher, Sarah Frew, is responsible for the data management, and data security as no formal, paid data management services are currently available.

Appendix I: Codebook

CODE	CODE DEFINITION
1. "Patient-dependent"	• Includes appropriateness of use. • Not always appropriate for every patient depending as it is dependent on their clinical picture and needs. • Some patients may respond well to the use of the device where others may not (find it uncomfortable or painful). • Any reference to "not one size fits all" referencing that the use the device will be dependent on the patients clinical picture (stroke severity/movement available/understanding/ muscle strength/tone etc). • Includes the desired goal the device will serve for the patient and their functioning.
2. "Not for acute"	• Preferred use of the device in a rehabilitation or outpatient setting as these settings accommodate more for set up of device. • The perception that FES is more of a priority in the subacute or chronic phase of a stroke where the quality of movement or impairments are focused on more whereas in the acute inpatient setting ADLs are more likely prioritized over quality of movement. • Time for healing - Transition from acute to outpatient setting or a sub-acute setting allowing swelling of the brain to go down and so therapists are able to get a clearer picture of the patient and their needs. • The perception that it is not ideal to be used in the ward i.e. transporting to and from the ward as well as it being challenging to use it in the ward. *This code also speaks to high turnover in hospital settings* • Fast discharges or short length of stays due to lack of bed space specifically in an acute setting. • Any mention of getting a patient "up and going" owing to Doctors needing bed availability due to high patient numbers.
3. "Carry-over"	• Benefits are lived in the session as the patients don't have devices to make use of at home. • This also includes consistency of the device being used between sessions as well as the dilemma of patients coming for irregular follow ups, limiting consistent use each week. • Includes poor compliance. • Especially in the out-patient setting or high turnover settings the patients don't have an electrical stimulation device to make use of at home. • Any reference to transferability being tricky. • The limited carry-over into other MDT sessions. FES being used in OT sessions but not being carried over into other sessions within the team.
4. "Patient insight"	• Includes the cognitive abilities of the patient. • The patient educational background. • Mention of electrical stimulation not being part of their frame of reference or contextual background especially in the government setting.
5. Patient driven	• Push from patients to make use of FES in the session as a result of doing their own research on google or via informal conversations with a variety of current therapists or previous therapists.

6. Often	• Includes the current frequency of FES use being regular or often. • Expressing the fact that they use the device “a lot”. • The frequency of FES use is measured on a daily or weekly basis.
7. Rarely	• Current use of the device is rare or infrequent. • Expressing that they have only used the device once or twice in their career. • Being able to count the number of patients that they have used the device with (range from 0-10) over their whole OT career. • Mentioning that they have used the device before but don’t use it a lot or not frequently. • Includes never having used it with any patient before – only trialling it on other therapists or on themselves. • Includes therapists having used FES more frequently at their previous practices (private or government settings) but not currently using FES very frequently at their current practice or current setting. *This code also speaks to using the device with diagnoses other than stroke* • Expressing that they have used the device with other neurologically impaired patients Guillain Barre Syndrome/Motor Neuron Disease/Spinal Cord Injury and not necessarily stroke patients.
8. Controversy	• The device has been labeled or perceived as physio territory or that it’s a “physio thing” where physiotherapists are the only healthcare professionals expected to use this device. • The perception that physios should be using the device, and the assumption is that OTs are not or should not be using the device. • Physios having the device in their departments and not OTs.
9. Unsure	• Lacking confidence. • Not feeling 100% confident when thinking using the device or even when using the device. • Expressing not feeling comfortable when using the device. • Senior therapists expecting younger therapists to know how to use the device and younger therapists feeling lost or just feeling like they don’t know what they are doing. • Perceiving the use or understanding of the device as “grey area”. • Seeking reassurance during the interview. • Just not knowing, making comments of “I don’t know”. • Having the opinion of feeling “unsure” about being for or against the use of FES in occupation-based rehabilitation for stroke patients. • Querying what the evidence says or not being sure on what the evidence says. Having mixed feelings. Feeling weary of device. • Includes experiencing a pro and con pulley system. • Never having used the device before also includes initially not knowing what electrical stimulation was during the interview. • Feeling uncertain about what the machine is or even having heard of it initially.

10. "Activity is key"	• In order to stay true to the profession the device needs to be used functionally. • The perspective that it has a place in OT if its used functionally or within activity/occupation. • Speaks to the philosophy of the profession. • The premise that it needs to be used functionally or in an occupation for it to be appropriate to the occupational therapy scope. • Goal orientated – want to encourage a functional goal with FES use. • Using FES can feel like exercise-based therapy if activity/occupation is not incorporated into the session. • Feeling like a physio and not OT – focusing mainly on impairments rather than function.
11. Fear	*This code speaks to therapist fear on inflicting pain on patients when using FES* • Shying away from using this modality because you might cause pain or further harm to the patient especially as a result of not feeling certain or confident in its use. • Includes being cautious or trying to avoid fatiguing muscles. *This code speaks to therapist fear around creating errors or mistakes* • Variability in use or not always knowing how to use it which results in a lack of uniform use of the device within neuro rehabilitation. • Not knowing what its actually doing to the patient. • The perception that things can go wrong if you don't know what you're doing in the event of causing adverse effects. • Perception that you need to be trained in order to make use of the device in your practice.
12. Lazy therapy	• Creates lazy therapists. • Includes descriptions of therapists placing the electrodes on the patient and leaving them for the session.
13. "Neuroplasticity"	• Perceived to achieve neuroplasticity with its use
14. "Prognostics"	• Indicator of severity of the upper limb. • Used to guide treatment regarding compensation.
15. "Upper limb"	• Includes only making use of the device with the upper limb. • Includes not using on lower limb because it would be like "stepping on toes".
16. Shoulder subluxation	• Using it to treat a subluxed shoulder.
17. "Fighting tone"	• Making use of FES for a spastic/hypertonic upper limb in working against the overriding muscle group to allow for movement. • Perception that it feels like making use of FES/electrical stimulation worsens "tone" or spasticity. • Preferred not to make use of the device with patients with severe spasticity or increased tone.
18. Pain management	• Used to treat pain.
19. Flaccid upper limb	• Used to stimulate flaccid muscles.
20. Scarce resource	• Perceived that not a lot government settings have the device.

	• Therapists in the government sector rarely make use of the device or are exposed to the device or even know about the device. • More regularly seen and used in private practice. • Therapists lack exposure to the device especially in their community service or while working in a government setting. • Includes limited accessibility. *This code also speaks to challenges experienced with demand plans in public hospital settings:* • Unaware of being able to motivate for electrical stimulation devices through the demand plan in a government setting. • Uncertain why the device has never been motivated for in the past. • The assumption that it wouldn't be on Tender/demand plan. • Motivating for the device through the demand plan but having it be rejected each year. • Perceived to be a "nice to have" item by hospital management alluding to reasons why it has been rejected before as other equipment items are deemed more important. *This code also speaks to the general wear and tear of devices and electrode replacement not being easy* • Maintenance and expense of replacing new electrodes. Challenge to order new electrodes especially within a government setting. • Therapists being forced to bandage electrodes as stickiness has been lost from repeatedly using the same electrodes. • Speaks to the expense and logistics of maintaining the device. • Includes hygiene, specifically a lack in hygiene when having to reuse electrodes.
21. Game changer	• Perceived as beneficial, "I think its beneficial". • Perceived to provide good motor recovery based on own use of the device as well as others observed use of the device. • Perceived to provide good motor recovery based on colleagues' experiences having limited experience of your own. The therapist hasn't always achieved results themselves or hasn't used it long enough to be able to experience that desired motor recovery. • Observed others achieving good results and thus believes its beneficial. • Sounds good on paper or sounds good theoretically. • Positive attitude towards using device in therapy. • Opinion on the use of FES in occupation-based stroke rehab specifically having the opinion of "Definitely for it" or "cautiously for it". • Having the opinion of being "cautiously for it", cautiously for the use of FES in stroke rehab among OTs. • Includes – "for it" if you know what you are doing or when used properly.
22. Time-consuming and technical	• Time taken to train or expose therapists to the machine • Time taken to educate therapists (attending courses/practical sessions).

	• Time taken to set the patient up in the allocated session which includes having to "fiddle" and manipulate the device. This includes electrode accuracy - finding the right place – don't always get the desired muscle groups. • It is time consuming having to sit and be with the patient, can't just be set up and left. Includes time taken to position and facilitate movement of the affected limb to achieved desire movement. • Time taken to administer the device, use and train therapists which includes the pressure when patient caseloads are high.
23. "One per collective"	• Only having one device to many therapists • Only having one device to many patients • This includes within the MDT or just amongst the OTs.
24. "Out of sight out of mind"	• Electrical stimulation not being at the forefront of therapeutic practice. • Focus on conventional occupational therapy rather than additional adjunctive therapies. • Passively forgetting about FES. • Forgetting about using the device even though the department has access to one. • Getting stuck in your approaches or ways. • Sticking to what you know and not expanding or seeking. Just going with what you have. • Not fighting for new treatment modalities especially in government – sticking to old habits and not trying new things. • Includes older therapists being hesitant or reluctant to change when commserves come in and change things despite the need for young therapists to come in and change old ways of thinking/habits.
25. Preparatory exercise	• Focuses on the description of how the device is used in therapy specifically focused on using the device as a preparatory technique to stimulate movement before removing the device and participating in a functional task. • Includes physio based exercises to activate the muscles in prep for function or prepping for movement. • No functional tasks are involved during use of the device. • Includes any mention of muscle activation or stimulation in isolation. • Using electrical stimulation for activation or stimulation of a particular muscle group and then taking the device off for participation in a functional task. • Using the electrical stimulation device for sensory stimulation and muscle stimulation.
26. Movements in function	• Description of how the device is used and applied while the patient is participating in a functional task or occupation. • The description of the simultaneous use of the device and patient participation in a functional task or occupation. • Any mention of making use of the device in basic activities or functional tasks. • Includes the application of electrical stimulation with the inclusion of basic activities/tasks (e.g. grasp and

	release of objects/tapping/switching a light on and off etc.).
27. "Plan B"	• Made use of electrical stimulation to enhance normal movement after conventional methods were no longer working. • Manual facilitation techniques were made use of first and only then was electrical stimulation used. • Not being their first port of call
28. "Extra set of hands"	• Focus on manual facilitation. The device allows therapists to be more effective in sessions especially in trying to enhance movement with stroke patients who are time sensitive. • Achieving more efficiency in sessions. • Assists in getting results quicker.
29. Instils hope	• Helps patients be hopeful in their recovery process which is a positive in motivating the patient to participate in therapy. • Patients become hopeful that something can change. • Includes "buy in" to therapy *This code also includes mention of visual feedback contributing to patient motivation* • Benefit of its use – gives that visual feedback to the patient. • Draws the patient's attention to the affected limb.
30. "Expensive"	• Speaks to the perception that the device is expensive.
31. "Pocket sized"	• Easy to transport especially for home visits.
32. Supervision and mentorship	Includes: Currently not receiving any supervision or mentorship. o Experienced therapist being busy or unavailable to assist with supervision when younger or other therapists want to make use of electrical stimulation. o Therapists also not knowing how to use the device appropriately to provide guidance or supervision to other or less experienced therapists. Also includes the need for: o Neuro interest groups o Cluster meetings o Better support networks Mentorship is especially needed among novice therapists.
33. "Curiosity"	• Sparking interest based on their context to use and buy electrical stimulation in their own practice. • Includes feeling uncertain as to why they may have wanted the device or started using the device in practice. • "Why not?" mentality. Having an open-minded or adventurous attitude towards the use of FES even though the participant may seem unsure, nonetheless shows willingness. • The "why not mentality". • If the therapist had the device they feel that they would want to try and use the device with stroke patients. • Includes plans for FES clinics or future plans to make use of it more, "I would use it".
34. Difficult to use (in an activity)	• Not knowing how to use the device functionally or finding it challenging to incorporate the device into activity.

	• Feasibility of using it every time the therapist or the patient want to perform an occupation outside of the gym setting (in the ward). • Perceived as not being able to be generalised or incorporated into occupation. • Electrodes hindering ADL participation (e.g. dressing). • Just not using it in an occupation-based tasks. *This code also speaks to the lack of variation experienced between devices* • Device variations challenge the use of FES within functional based tasks or activities. • Mention of being limited by the actual device and its settings. • There is a vast variability in the type of devices available – some are easy to use and some are more complex. • Need for the device to be easier to use and manipulate, ease of use. • Need for the device to be more adaptable. • Includes that it is difficult to use functionally because of device variability and adaptability.
35. Lack of training	• Lack training and exposure. Need for theoretical and practical training and education. • Lack training across disciplines or between disciplines. • The perception that there is an unwillingness to teach OTs on the use of the device from PT side within a practice setting. • Seeking courses and training and coming out unsuccessful. • "Brain drain" - one therapist becomes skilled with its use and then once they leave, no one else knows how to use it. One skilled among many unskilled in its use. • Not being exposed to electrical stimulation at an undergraduate level, theoretically and practically. • Includes no current OT specific training, need for OT specific workshops to assist with its functional use in stroke intervention. • Includes having limited courses available to attend and the ones that are available are led by physiotherapists not occupational therapists. • There is a need for training and education (postgrad or undergraduate level).
36. Not aware of evidence	• Not knowing what the current evidence says about FES. Limited knowledge. • Not interested in seeking out knowledge on device. • Includes lack of exposure to research. • Needing further research to better support OTs use of FES in occupation-based rehabilitation.
37. "Peer mentoring"	• Speaks to learning from colleagues and their experiences and knowledge. • Learning from colleagues, being shown it by colleagues, mimicking colleagues as well as receiving guidance from colleagues. • "Crash course" demonstrations • Device being explored during OT orientations. • Good working relationship with the physiotherapist • Doing joint sessions with physiotherapist using the device, asking for their input or assistance during sessions (individual and joint).

	• Includes physio guidance, stating that a physiotherapist demonstrated its use or that the OT learnt from observing a physiotherapist using it. • Includes asking for help, seeking out courses and information from colleagues.
38. "Trial and error"	• Includes trialing out the device on yourself or another therapist first before the patient. • Includes self-directed learning – experimenting with device, being a "guessing game". • Includes consulting with the instruction manual as a guide.
39. "Clinical reasoning"	• Reliant on own clinical reasoning when choosing to make use of the device and when actually making us of the device. • Using clinical reasoning as a guide on how to use FES.
40. Supplier	• Trained or guided by a supplier of the device.
41. "Patient tolerance"	• Patient response and tolerance is used as a guide. • Therapists are guided by the patient's response to the machine's stimulation. • Includes anything to do with observing or seeing the patient responses to guide own treatment.
42. "Masters"	• Motivated to make use of electrical stimulation as a result of doing a Masters in Neuro. • Includes adding to confidence through use and knowledge.
43. Contraindications	• Using contraindications as a means to guide use of electrical stimulation.
44. "Protocols"	• Most therapists are unaware of any current protocols in practice whereas other have come across protocols in their practice, however, still no use of protocols in practice. • Includes the need for protocols or guidelines to better guide therapists use of electrical stimulation in practice.
45. "False hope"	• Direct mention of creating a false sense of hope with FES use. • Speaks to immediate gratification with patients while using the device in a therapy session, however, when the device is removed, they experience a limited translation of mobility in the upper limb. • Mention of patient feeling such as becoming despondent or disappointed when the device is used in therapy, and limited progress in upper limb function is achieved. • Creating false impressions with patients, when the device is applied to their upper limb for mobility, they frequently believe that their upper limb will recover fully (at 100%), however, are frequently let down or disappointed when they don't achieve the results they think they will.
46. "Prove our use"	• The perception that FES is not well known to OTs or rather many OTs are not aware that they are able to use the device which hinders its use within the profession. • The perception that OTs have limited exposure to FES which hinders its use within the profession. • The perception that OTs have a fear of overstepping their scope at the idea of using the device which hinders its use in the profession.

	• Despite the hinderance there is also the perception that OTs should be using the device because they have a role to play in improving function. • Its perceived that OTs should make use of FES more frequently in order to prove their use and role with the device.

Appendix J: Thematic analysis

THEME	CATAGORY	CODE
A TUG OF WAR	Cautious	Unsure
		Fear
		“Out of sight out of mind”
		Plan B
		“False hope”
	Questioning Professional Alignment	“Controversy”
		Lazy therapy
		“Activity is key”
	Perceived Benefits	Instils hope
		Game changer
		“Neuroplasticity”
		“Extra set of hands”
		“Prognostics”
	Ideals	“Prove our use”
THE BLIND LEADING THE BLIND	Knowledge and Skill	Not aware of evidence
		“Protocols”
		Lack of training
	Guidance	“Peer mentoring”
		Supervision and mentorship
		“Masters”
		Supplier
		“Curiosity”
	Figuring it out alone	“Trial and error”
		“Patient tolerance”
		“Clinical reasoning”
		“Contraindications”
A PUZZLE OF PRACTICALITY	Application	Movements in function
		Preparatory exercise
	Frequency	Rarely
		Often
	Access and cost	“One per collective”
		Scarce resource
		“Expensive”
		“Carry-over”
	Usability and maintenance	Time-consuming and technical
		Difficult to use (in an activity)
		“Pocket-sized”
	Client in context	Not for acute
		“Patient insight”
		“Patient-dependent”
		Patient driven
	Targeted interventions	“Upper limb”
		“Fighting tone”
		“Shoulder subluxation”
		“Flaccid upper limb”
		“Pain management”

Appendix K: Proof of submission to Journal

Taylor & Francis
Taylor & Francis Group

Dear Sarah Frew,

Thank you for your submission.

Submission ID	**258422296**
Manuscript Title	**Exploring Occupational Therapists' Perceptions of the Use of Functional Electrical Stimulation in Adult Stroke Rehabilitation in Gauteng, South Africa.**
Journal	**Disability and Rehabilitation: Assistive Technology**

If you made the submission, you can check its progress and make any requested revisions on the Author Portal

Thank you for submitting your work to our journal.
If you have any queries, please get in touch with IIDT-peerreview@journals.tandf.co.uk.

Kind Regards,
Disability and Rehabilitation: Assistive Technology Editorial Office

Appendix L: Journal Instructions to Authors

About the Journal

Disability and Rehabilitation: Assistive Technology is an international, peer-reviewed journal publishing high-quality, original research. Please see the journal's Aims & Scope for information about its focus and peer-review policy.

Please note that this journal only publishes manuscripts in English.

Disability and Rehabilitation: Assistive Technology accepts the following types of article: research articles, reviews, research on products and devices, case reports, perspective, protocol papers and letters to the editor.

For submissions to *Disability and Rehabilitation: Assistive Technology* authors are given the option to remain anonymous during the peer-review process. Authors will be able to indicate whether their paper is 'Anonymous' or 'Not Anonymous' during submission, and should pay particular attention to the below:

- Authors who wish to remain anonymous should prepare a complete text with information identifying the author(s) removed. Authors should upload their files using the 'double anonymous peer review' article types during submission. A separate title page should be included providing the full affiliations of all authors. Any acknowledgements and the Declaration of Interest statement must be included but should be worded mindful that these sections will be made available to referees.
- Authors who wish to be identified should include the name(s) and affiliation(s) of author(s) on the first page of the manuscript. Authors should upload their files using the 'authors made known to the reviewers' article types during submission.

Structure

Manuscript sections: Introduction (background and rationale for the study, primary and secondary aims/objectives, relevant hypotheses, description of trial design); Methods (participants, assignment of interventions/randomization methods, intervention, description of data collection, equipment, data management, data analysis, monitoring and auditing); Ethics (informed consent, research ethics approval,

confidentiality, role of the funding agency), and Discussion (potential impact and significance of study, strengths and weaknesses, potential contributions to the field).

Authors are strongly encouraged to follow the Standard Protocol Items.

Submitting the article: When you go to the online submission page, you will see the heading "Step 1: Type, Title, & Abstract." Under article type, select "Method". A Method article is the description of a method or protocol to be used in the design and execution of an experiment or study.

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Appendix M: Code frequency table

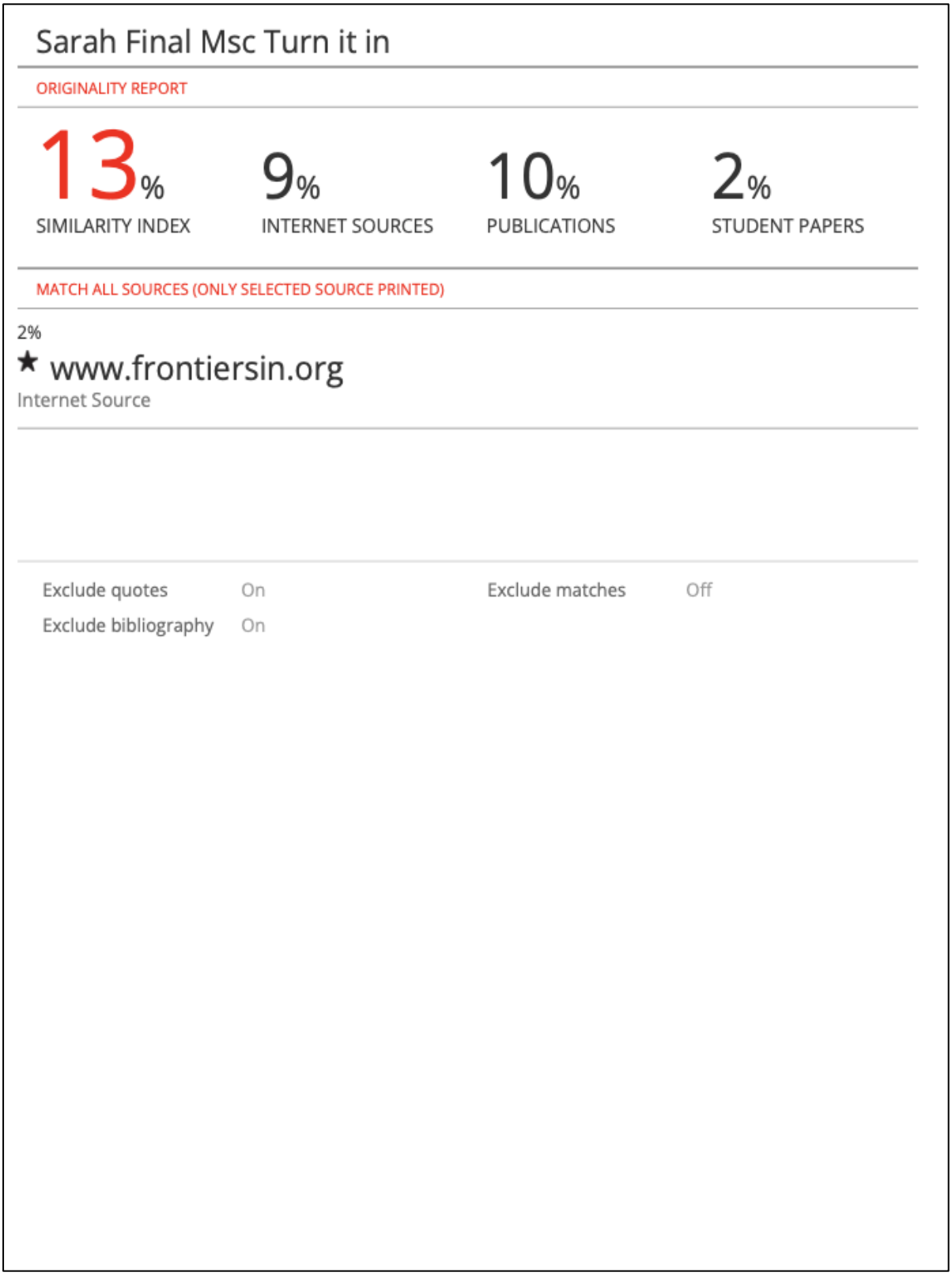
CODE	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	Total
Unsure	12	3	15	8	6	5	3	6	5	3	5	10	**81**
Fear	10	2			2		3	2	7		6		**31**
"Out of sight out of mind"	1	2			5		2					1	**11**
Plan B						4			3	2	1		**10**
"False hope"	4					1	2		1		6		**14**
"Controversy"				3	2		5				3		**13**
Lazy therapy	3					3		2	1				**9**
Instils hope	4	1		4		3	2	7	1				**22**
Game changer	2	3	4	7	3	5	5	1	5	7	2	4	**48**
"Neuroplasticity"	2	4	1									3	**10**
"Extra set of hands"				6		1							**7**
"Prognostics"										2	1		**3**
"Activity is key"	1	4	1	3		1	1	2	1				**14**
"Prove our use"	1			1	2		1			1	1		**7**
Not aware of evidence		1	3		3				3	1	4		**15**
"Protocols"	10	2	2	2	1	5	1	2	1	1			**27**
Lack of training	14	4	4	7	7	7	12	4	11	8	11	2	**91**
"Peer mentoring"	3	5	7	2	5	3	3		6	8	2	3	**47**
Supervision and mentorship		4		1	1	3	1	2	2		4	3	**21**
"Masters"	3						6	4					**13**
Supplier	1			3									**4**
"Curiosity"	3				3		1			1			**8**
"Trial and error"	8			4		7	3		2	1	1		**26**
"Patient tolerance"	1	1						4	3				**9**
"Clinical reasoning"	1			2		3			2	2	2		**12**
"Contraindications"		1				1		1	1		2		**6**
Movements in function	4	1		1		3	3	3	5	3			**23**
Preparatory exercise	2	4		1	5	2		1	4	2			**21**
Rarely	1	3	2	2	2		3		5	3	4	5	**30**
Often				1		1		2					**4**
"One per collective"				1	1			3		1	1	2	**9**
Scarce resource	6	2		1	1	2	8	1	2	2		14	**39**
"Expensive"	2			1				3					**6**
"Carry-over"	8	1		2		4	3		1	2			**21**
Time-consuming and technical	8	5			1				1	8		2	**25**
Difficult to use (in an activity)	11	3	3	1	4	3		6	2				**33**
"Pocket-sized"		1			1	1		1					**4**
Not for acute	1	3		1		2	1			6			**14**
"Patient insight"	4	3						2	1	1	3		**14**

“Patient-dependent”	2	4		3	1	1		4	1		1		**17**
Patient driven								2			3		**5**
“Upper limb”	3					1	1	1	2	1			**9**
“Fighting tone”		2		2		1							**5**
“Shoulder subluxation”	1		1	1		1	3						**7**
“Flaccid upper limb”		3	1	1							1		**6**
“Pain management”								3	3				**6**

Appendix N: Code frequency graph to detect code saturation

Figure 3. Frequency of new codes generated for each interview

Appendix O: Turn it in report



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CURRENT QUALIFICATIONS: BScOT (WITS)					
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DEGREE FOR WHICH PROTOCOL IS BEING SUBMITTED: MSc OT (Neurosciences)					
PART-TIME/FULL-TIME: PART-TIME				Sex : F ✓ M	
DISSERTATION/RESEARCH REPORT: RESEARCH REPORT				50% contribution towards degree	
FIRST REGISTERED FOR THIS DEGREE:	TERM : 1			YEAR: 2022	
DEPARTMENT: OCCUPATIONAL THERAPY					
TITLE OF PROPOSED RESEARCH: Exploring occupational therapists' perceptions of the use of functional electrical stimulation in occupation-based stroke rehabilitation in Gauteng, South Africa.					
CANDIDATE'S SIGNATURE:				DATE: 28/06/2022	
SUPERVISOR'S NAME/QUALIFICATIONS: FIONA BREYTENBACH, MScOT (Neurosciences)				70 % Supervision	
SUPERVISOR'S DEPARTMENT: Occupational Therapy					
SUPERVISOR'S ADDRESS / TEL / E-MAIL: fiona.breytenbach@wits.ac.za					
SUPERVISOR'S NAME/QUALIFICATIONS: JANINE VAN DER LINDE, PhD				30% Supervision	
SUPERVISOR'S DEPARTMENT: Occupational Therapy					
SUPERVISOR'S ADDRESS / TEL / E-MAIL: janine.vanderlinde@wits.ac.za					
SYNOPSIS OF RESEARCH: [Use reverse side of this page if more space is required] **See overleaf**					

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As supervisor, we confirm that I have read the protocol which has been submitted for assessment

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PROTOCOL ACCEPTED BY HEAD OF DEPARTMENT	..... SIGNATURE	19 July 2022 ..... DATE
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1. Background and need for the study

1.1 Introduction to the literature review

Stroke is defined by the World Health Organization (WHO) as “an acute neurological dysfunction of vascular origin with symptoms and signs corresponding to the involvement of focal areas in the brain” (Gillen, 2018, p 810). In South Africa, stroke is the second leading cause of death and the leading cause of disability (Maredza et al, 2016). A stroke leads to an upper motor neuron dysfunction that results in paralysis or weakness of the contralateral upper and lower limb, otherwise known as hemiplegia (Gillian G, 2018). This significantly impairs stroke survivors' ability to engage in meaningful occupations or activities within their daily life (Howlett, Mckinstry and Lannin, 2015). Engagement and participation in daily occupations are crucial goals in occupational therapy intervention (Nhunzvi and Galvaan, 2017). Electrical stimulation has the potential to be able to improve motor ability post-stroke and thus promote activity engagement and participation (Howlett et al, 2015).

1.1.2 What is electrical stimulation and the different types?

Numerous different forms of electrical stimulation are currently described in clinical practice, which are often described in conflicting ways (Eraifej et al, 2017). These relate specifically to Neuromuscular Electrical Stimulation (NMES), Functional Electrical Stimulation (FES) as well as Transcutaneous Neuromuscular Electrical Stimulation (TENS) (Maffiuletti et al, 2018). Electrical stimulation in neurorehabilitation aims to excite neuronal cells to elicit a response and is only applicable when the desired muscle and its innervation are intact (Marquez-Chin and Popovic, 2020). NMES and TENS involve the passive use of transcutaneous electrodes that are frequently used as preparatory techniques before active or activity-based rehabilitation in reducing impairment such as pain, muscle strength, tone as well as shoulder subluxation (Bellew, 2016 (a); Bellew (b), 2016). Functional electrical stimulation (FES) involves the application of single or multiple low voltage transcutaneous electrodes aimed at actively stimulating muscle groups, specifically their motor neurons, to produce a controlled, purposeful movement while engaged in an activity (Demir et al, 2018; Marquez-Chin and Popovic, 2020; Eraifej et al, 2017). FES is routinely used in two ways, one, to replace or compensate for function through the use of a neuroprosthesis or, two, to retrain function by using it as a short-term therapeutic intervention modality (Kapadia, Moineau and Popovic, 2020; Marquez-Chin and Popovic, 2020). FES as a therapeutic intervention is most common within clinical practice (Marquez-Chin and Popovic, 2020). It involves allowing the patient to attempt the desired functional movement with assistance from FES until the patient can produce the desired functional movement and participation in daily tasks meaningfully after which the use of the FES device will be reduced and eventually terminated (Marquez-Chin and Popovic, 2020).

1.1.3 Why is functional electrical stimulation (FES) beneficial to occupation-based neurorehabilitation?

The occurrence of a stroke commonly leads to paralysis or paresis of one side of the body, limiting motor control, which has severe limitations to an individual's independence and quality of life within their everyday life (Marquez-Chin and Popovic, 2020). The World Federation of Occupational Therapists (WFOT, 2013) indicated that "occupational therapy is a health profession concerned with promoting health and well-being through occupation. The primary goal of occupational therapy is to enable people to participate in activities of everyday life" (Nhunzvi and Galvaan, 2017, p 103). Occupational therapists frequently make use of physical agent modalities (PAMs) to further enhance impairments so that individuals are better able to participate in the activities of daily living that they deem most meaningful (Walter and Winston, 2018). Examples of PAMS that are used with patients with neurological fallout to encourage neural plasticity are constraint-induced movement therapy, mirror therapy and FES (Walter and Winston, 2018).

Neural plasticity is essential in stroke rehabilitation as the central nervous system can cortically reorganise as well as strengthen interrupted synaptic pathways to produce new or learnt motor abilities (Marquez-Chin and Popovic, 2020). As previously mentioned, electrical stimulation has the potential to improve motor ability post stroke (Howlett et al, 2015), however, it has been found that FES has considerable potential to induce neural plasticity in comparison to NMES and TENS (Eraifej et al, 2017). Improved perfusion and excitability to the ipsilesional somatosensory cortex were identified using neuroimaging in response to the use of FES in comparison to passive modalities of electrical stimulation such as NMES and TENS (Eraifej et al, 2017). Somatosensory input to the central nervous system post-stroke is key to motor learning and regaining motor control (Vidoni et al, 2010; Pan et al, 2018). Therefore FES in combination with conventional occupational therapy techniques has a greater potential in eliciting neural plasticity in stroke survivors thus a greater potential in promoting improved motor learning and meaningful engagement in activities of everyday life (Kapadia et al, 2020; Eraifej et al, 2017).

1.1.4 What are the factors influencing the use of functional electrical stimulation (FES) in stroke rehabilitation?

On a global scale, occupational therapists are hesitant to make use of functional electrical stimulation within a neurological setting as a result of the discrepancy in research findings, leading to a perceived uncertainty of its beneficial use (Demain et al, 2013). It has been found that there is a lack of confidence in the understanding and application of FES in a neuro rehabilitative setting among occupational and physiotherapists (Walker et al, 2020). This can be attributed to therapists mainly receiving on-the-job training more so than formalised training (Howlett et al, 2018). Healthcare practitioners have become dependent on their intuition, colleagues' knowledge and manufacturer manuals when making use of this modality (Dionne, 2019; Howlett et al, 2018). Many practitioners perceive this modality as time-consuming regarding the education of its use to patients as well as the time that it takes to set up, thus hindering its use (Howlett et al, 2018; Auchstaetter, 2016).

1.2 Problem Statement

There is evidence to suggest that functional electrical stimulation (FES) in conjunction with conventional occupational therapy rehabilitation holds benefits in promoting neural plasticity and improving participation in meaningful activities of daily living post stroke (Kapadia et al, 2020; Eraifej et al, 2017). The researcher is an occupational therapist currently working within the stroke neurorehabilitation field in Gauteng, South Africa and thus can confirm that FES is being used by occupational therapists in the neurorehabilitation setting among the stroke population. International studies have been conducted on the use of FES by healthcare practitioners and the factors influencing its use (Howlett et al, 2018). It was found that occupational therapists are predominantly making use of FES in clinical practice (Howlett et al, 2018), however, factors influencing its use in practice relate to personal experience, confidence, time, workload pressures, limited research appraising abilities as well as information-seeking behaviours (Bennet et al, 2003; Walker et al, 2020). No such studies have been conducted within a South African context therefore it is unclear how occupational therapists in South Africa are translating the research evidence of FES into clinical practice to achieve occupation-based outcomes (Howlett, 2018). There is a need for occupational therapists within the South African neurorehabilitation setting to further explore occupational therapists' perceptions regarding the use of FES in occupation-based stroke rehabilitation as this phenomenon has only been explored on an international scale in developed countries.

1.3 Research question

What are occupational therapists' perceptions of the use of functional electrical stimulation in occupation-based stroke rehabilitation in Gauteng, South Africa?

1.4 Aim

This study aims to explore occupational therapists' subjective perceptions of the use of functional electrical stimulation in occupation-based stroke rehabilitation in Gauteng, South Africa.

1.5 Objectives

The objectives of this study are:

iii. To describe occupational therapists' perceptions of the use of FES in adult stroke rehabilitation in Gauteng, South Africa.
iv. To explore factors influencing the use of FES in adult stroke rehabilitation by occupational therapists in Gauteng, South Africa.

1.6 Significance of Study

The significance of this research study is to explore occupational therapists' perceptions of the use of functional electrical stimulation in occupation-based rehabilitation among adults affected by stroke in Gauteng. This is to explore occupational therapists' perceptions, specific to how and why functional electrical stimulation is being made use of within occupational-based stroke rehabilitation. The information found during this study will contribute to strengthening the knowledge of this treatment modality within the context of occupational therapy neurorehabilitation specific to the stroke population in South Africa.

2. Methodology

2.1 Study design

The researcher will be conducting a study following a descriptive qualitative design. The goal of the descriptive qualitative approach is to recount certain events or phenomena experienced by individuals or groups of individuals (Lambert and Lambert, 2012). The reasoning behind the use of the descriptive qualitative study design will be to provide genuine descriptions of experiences and perceptions within the field of occupational therapy and the use of functional electrical stimulation in occupation-based rehabilitation among stroke survivors in Gauteng as this research area is not well explored and understood in South Africa (Sandelowski, 2010). Rather than needing a deep theoretical context in which this study is conducted, the main focus that the researcher aims to achieve will be to understand the individual human experience within their unique and natural context (Doyle et al, 2019). Descriptive qualitative

research aligns with pragmatism as the research process is guided by the study's aims, objectives as well as the context of the study (Ormston et al, 2014).

As an occupational therapist working within the neurorehabilitation setting and actively using functional electrical stimulation (FES) among the stroke population, the researcher's current position within the profession can be used as a means to identify meaningful insights regarding occupational therapists' perceptions of FES and its use in occupation-based neurorehabilitation among stroke survivors in South Africa.

2.2 Research population

The research population will include all occupational therapists working in the neurorehabilitation field in Gauteng, South Africa. Whether or not this population currently makes use of functional electrical stimulation (FES) in clinical practice is not a factor that will be included in the inclusion and exclusion criteria because a non-bias representation on the perceptions that occupational therapists have regarding the use of the FES is desired in this research study. This will further inform the factors influencing the use or none use of FES as a treatment modality in occupation stroke rehabilitation in Gauteng, South Africa.

2.2.1 Sampling method

Purposive sampling will be used, a non-random technique (Etikan, Musa and Alkassim, 2016) that will be based on the study's aims and objectives to ensure that the selected participants will add valuable insights to the findings of the research study. Snowball sampling will be used for further recruitment of participants (Glen, 2014).

2.2.2 Sample selection and sample size

According to Guest and Bunce (2006), if the research study aims to explore a common perception or belief regarding a specific topic of interest among a homogenous participant group then a sample size of 12 participants will be sufficient in achieving data saturation. Therefore 12 participants are expected to take part in the study.

Inclusion criteria	• Occupational therapists that are currently registered with the Health Professions Council of South Africa (HPCSA) as independent practitioners and have completed their community service year. • Occupational therapists working in the field of neurorehabilitation in both the private and public health sectors. • Occupational therapists working in the field of neurorehabilitation that are currently treating the adult stroke population.
Exclusion criteria	• Occupational therapists currently working with the researcher. • Occupational therapists that have worked in the neurorehabilitation field for less than 6 months.

2.3 Data collection

If ethics approval is granted, data collection can commence. The researcher will be collecting descriptive data by conducting semi-structured interviews with interview guides involving open-ended as well as probing questions (Appendix B). The interview guide will be formulated by the researchers, using the study's objectives to guide the question formulation process. An invitation to participate in the study, which will include the study's information sheet (Appendix A), will be dispensed via the Occupational Therapy Association of South Africa (OTASA) to recruit possible research participants for the study (Appendix H). The participants who are interested in contributing to the study will receive communication from the researcher via email or text message. This will involve the distribution of the consent forms to the potential participants before the study to obtain written consent to participate in the study (Appendix B) and to be audio-recorded (Appendix C) during the interview process. Text messages or emails will be used to organise the planning of the semi-structured interviews.

Semi-structured interviews will be used as this study aims to explore the perceptions, thoughts and personal experiences of participants to collect open-ended data and couple that with the topic of interest (DeJonckheere and Vaughn, 2019). Each interview will be expected to take 45 minutes in duration (DiCicco-Bloom and Crabtree, 2006). The participants will be invited to each interview by a venue, time and date that is most convenient to them (DeJonckheere and Vaughn, 2019). The interview guide (Appendix D) will be piloted before the data collection process. This pilot will include 3 or more participants that meet the study's inclusion criteria to

identify significant issues regarding the proposed interview guide. If problem areas are identified during the pilot study, adaptions will be made to the interview guide before commencing the data collection process. Open-ended questions as well as probing questions will be used during the interview process as a means to promote insightful descriptions of each participant's perceptions regarding the use of functional electrical stimulation in occupation-based rehabilitation among the stroke population (Whiting, 2008).

2.4 Procedure

The semi-structured interviews will be held in a quiet and private room of which the participants will make the choice according to their preferred location or online if that is also their preference (DeJonckheere and Vaughn, 2019). Refreshments will be provided in an attempt to create a comfortable environment for each interview if conducted in person (DeJonckheere and Vaughn, 2019). Before the start of each interview, each participant will have the opportunity to sign the study's consent forms to participate in the study (Appendix B) and be recorded (Appendix G). At the start of each interview, it will be made clear to each participant the purpose, length and format of the interview (DeJonckheere and Vaughn, 2019). It will be verbally communicated and pointed out on the consent form that each participant has the freedom to decline any interview question and resign from the study at any point (Whiting, 2008). An interview guide will be made use of during the interview process as well as a small digital recorder to allow the interviewer to actively engage during each interview (Adams, 2015, p 373). At the start of each interview, the audio equipment will be turned on, the participant will be reminded of its purpose and to alleviate any tension, the researcher will share information about themselves as well as why this research topic holds interest to them (Whiting, 2008; DeJonckheere and Vaughn, 2019).

During each interview, probing questions and techniques will be used to elicit more detail regarding each participant's point of view (DiCicco-Bloom and Crabtree, 2006). Probing techniques that will assist the researcher in achieving in-depth descriptions will involve remaining silent and allowing enough time for each participant to answer each interview question, echoing each participant's answer back to them, clarifying words or descriptions when appropriate, making use of affirming words such as yes or okay to express interest in the participant's point of view as well as asking each participant to expand or further describe a particular point without the use of echoing (Whiting, 2008; DeJonckheere and Vaughn, 2019). Each interview will be concluded with the researcher expressing gratitude towards each participant by thanking them for taking the time to cooperate and take part in this study as well as for the valuable contribution that each participant has made to the study (Whiting, 2008;

DeJonckheere and Vaughn, 2019). Once each interview is completed, the researcher will make use of a journal to reflect on the process and content of each interview to enhance the quality of identified ideas and meanings without incorporating bias (DeJonckheere and Vaughn, 2019).

2.5 Data management

The audio recordings and transcriptions will be stored on a secure online access-controlled platform (Google Drive) which is hosted by the University of the Witwatersrand through the principal researcher's student account. Only the principal researcher, as well as the two co-supervisors, will have access to the data. All data collected in the course of the study will be securely retained for two (2) years if a scientific publication arises from the study and six (6) years if there is no publication. Thereafter it will be destroyed accordingly. Please refer to Appendix F for full details.

2.6 Data analysis

This process will occur in conjunction with the data collection process to ensure that data saturation is reached. Once each interview has been completed, all audio recordings will be transcribed verbatim in conjunction with the researcher's notes taken in the reflection of each interview (Whiting, 2008). A thematic conventional content analysis will be most appropriate for this study, where an inductive approach will be used in parallel to a deductive approach (Hsieh and Shannon, 2005). This approach limits preconceived categories, however, allows for names and categories to materialize out of the data (Hsieh and Shannon, 2005). The inductive process will be directed through the use of Braun and Clarke's (2006) 6-phase process to thematic analysis, indicated by the table below. This process involves repeated reading and familiarisation of the data so that initial codes can begin emerging (Hsieh and Shannon, 2005). Exact words or texts will be taken from the data set for the researcher to highlight key concepts and begin attaching labels, which is the coding process (Hsieh and Shannon, 2005). Manual coding will be done in this study making use of a coding manual (Hsieh and Shannon, 2005). This process will continue and lead the researcher in being able to draw links and connections between the identified codes so much so that categories will be able to begin to emerge from the coding system (Hsieh and Shannon, 2005). Previous research findings or theories will be contrasted will these findings in the study's discussion, which is how the deductive approach will be used in parallel (Hsieh and Shannon, 2005). To ensure that the quality of analysis is checked, the researcher will work collaboratively with two additional researchers involving the thematic analysis and coding cooperation during the analysis phase to ensure inter-coder agreement (Linneberg and Korsgaard, 2020).

The 6 stages of thematic analysis as per Braun and Clarke (Braun and Clarke, 2006)	
1. Familiarising yourself with your data	Initially, it will be important to actively engage with the data by reading it repeatedly and thoroughly, searching for meanings and patterns to assist the coding process. During this phase, it will be important to make notes to guide ideas for the coding process.
2. Generating initial codes	Once familiarity has been achieved with the data, specific features will be identified and labelled within the data in order to begin formulating codes on which themes can be built. The data will be coded using coloured pens to indicate possible patterns. Computer programs identified below will be used to assist this phase.
3. Searching for themes	The identified codes will then be categorised into broader themes, namely main themes or subthemes. Tables and mind maps will be made use of in order to assist with the categorisation of potential themes.
4.Reviewing themes	Possible themes are refined. This phase follows a two-step, sequential process. Step one involves the continued reading of the data to ensure that the patterns identified are consistent. Once this has been achieved step two involves, recoding from the data set in order to ensure that the identified themes correlate with the data set.
5. Defining and naming themes	This phase includes naming and defining the main and sub-themes of the data once continued analysis of the data has taken place to ensure a congruent relationship between the data set and the emerging themes.
6. Producing the report	The final phase involves a written report of the analysed data set, which will include extracts from the raw data to ensure the prevalence of each theme.

2.6.1 Programs to be used for Data Analysis

To assist with the data analysis process specific to generating codes as well as searching for themes regarding each interview, MAXQDA (plus) will be used to assist in the coding and analysis of the data. This program will aid the researcher to be able to formulate a categorized coding system for the benefit of the qualitative research being conducted (Saillard, 2011).

2.7 Trustworthiness and rigour of the study

In order to ensure credibility, the researcher will make use of triangulation. This will be achieved through the use of different sources and methods like semi-structured interviews, research journal note-taking, and audio recordings (Krefting, 1991). Member checking will also be used. The researcher will conduct feedback sessions with all the participants to consolidate the data collected and interpret accuracy once the data collection and analysis phase is complete (Birt et al, 2016). Reflexivity will be used in an attempt to limit bias, and preconceptions and ensure the dependability of the study. This will be done through the use of reflexive journaling (Krefting, 1991). Thick description will be used to ensure transferability. The researcher will ensure that contextual information regarding each participant will be accounted for to ensure that the data collected will apply to situations of a similar context. The researcher will also ensure that there is a variety in the sample by choosing participants with different demographic factors, if possible (Krefting, 1991).

3. Ethical Considerations

The University of Witwatersrand's research ethics guidelines will be followed throughout the research process. In order to ensure beneficence the interview guide and probing questions will be designed in such a way as to ensure the exploration of the research participants' use of functional electrical stimulation and not in such a way that would impose guilt, discomfort or upset on the research population. Non-maleficence will be promoted by making sure that the questions posed during the semi-structured interviews are not offensive or harmful in any way (Jelsma and Clow, 2005). If at any point the participant is made to feel uncomfortable or upset, the interview process will be stopped.

Informed consent will be conducted through the use of written, signed and dated documents from each participant before the interview process begins in order to promote respect for each participant (Manandhar, Kumar and Joshi, 2020). To respect the identity of the participants de-identification will take place. Any data (typed or recorded) will be stored on an access-controlled server/cloud platform for 6 years and then be destroyed (HPCSA, 2016). To ensure justice the data analysis process ensures that the data collected will not be manipulated as a means to prevent any exploitation of the participants (Jelsma and Clow, 2005). At any point in the study, the participants have the choice and freedom to withdraw from the study which will promote autonomy among all participants within the study (Jelsma and Clow, 2005).

3.1 Risks, burdens and benefits

Participants may become irritable during the interview process possibly as a result of confusion or misunderstanding a question, however, the most prevalent burden of this study is the time that participants will have to set aside when engaging with the interview process. An important benefit of this study is promoting evidence-based practice as well as the efficacy of functional electrical stimulation within South Africa.

4. Time frame of the project

Second reader submission	01 July 2022
Protocol submission	19 July 2022
Protocol assessment	17 August 2022
Ethics submission	7 September 2022
Literature first draft	November 2022 - March 2023
Data collection (includes pilot study)	November 2022 – May 2023 (Aim is 2x interviews per month)
Data Analysis and results	June 2023 – November 2023
Discussion	December 2023 - May 2024
The first draft of research	June 2024 - October 2024
Final hand in	November 2024

5. Budget

Funding for this research will be applied for through the Medical Research Endowment Fund, the National Research Foundation, and the Ruth Watson OTASA Research Grant in 2023. The researcher will be responsible for funding the research if the funding is not approved by the suggested funds or grants.

Cost Item	Calculation of cost	Final cost
Dictaphone	Philips Dictaphone = R1999 (x2) and Memory card: 16GB = R100.00 (x 2) and AAA Batteries (x6)= R49.00 for two batteries	R4345
Transcription fees with Top transcriptions	Standard rate: R12.5 per audio minute. 45 min x 12 participants = 540 minutes of recordings. Therefore = 12.5 x 540	R6750
Refreshments (in person interviews)	250g Coffee: R43. 95 - 200g Biscuits: R18.99 x 6 = R 113.94 - Sugar: R24.99/ 1 kg - 1 litre Milk: R14.99 x 6 = R 89.94 - Five roses teabags (26 bags): R21.99 Rooibos teabags (20 tea bags): R19.99 - Polystyrene cups (need 20): R18.99 x2 = R37.98	R352.78

Communication	12 participants each receiving 10-12 messages = 144 messages (MTN SMS R0.50 each)	R72
Data for online interviews	12 participants, 45 minute interviews. 1GB to be used per interview using a Vodacom server. 1GB = R85. Therefore 12GB x 85	R1020
Books	X2: research journal and coding manual. Each Croxley 96 page books= R16.00	R32
Writing items	Pens (x10)= R40	R40
Analysis program	MAXQDA (plus) 6 month subscription= R868,39	R868,39
Travel	38km (WITS to various hospitals, includes round trips) rate R3.82 p/km = R145,16 x12 trips	R1742
TOTAL		R15 222,17

6. Dissemination and translation

It will be significant to distribute the results and findings of this study to the wider health care community on a national and international level. A google scholar profile could potentially be made use of to allow for online access. It could be possible that conferences or courses be held to distribute this study's findings and promote evidence-based practice when using functional electrical stimulation in occupation-based stroke rehabilitation.