Exploring Rebound Exercise for Adults with Neurological Disorders

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Abstract

Neurological disorders, a leading cause of morbidity and mortality, often lead to reduced balance, mobility and physical activity. Although the World Health Organisation recommends regular exercise, individuals with neurological disorders face unique challenges in meeting these guidelines. Despite the increasing research on exercise interventions, there remains a significant gap in understanding the feasibility and effectiveness of low-impact, cost-effective exercises for adults with neurological disorders. Rebound exercise offers a promising yet understudied option for this population. This research addresses this gap by exploring whether rebound exercise can increase physical activity and improve health outcomes in the studied population. The thesis involved a systematic review (study one) consisting of five studies, with three eligible for meta-analysis. The outcomes assessed were balance and mobility. This was followed by a feasibility study (study two) involving 53 community-dwelling adults with neurological disorders who engaged in rebound exercise for 30 minutes over 12 weeks. Feasibility was assessed through recruitment, retention, adverse events, and participant feedback. Secondary outcomes included balance, mobility, physical activity levels, quality of life, and blood pressure, which were assessed at baseline, at six and 12 weeks. Study three involved semi-structured interviews that explored participants' perceptions. The systematic review revealed improved mobility (-0.53[-0.94,-0.11],$p=0.01$) but not balance in hospitalised adults with neurological disorders and identified limited research on community-dwelling adults. The feasibility study showed high recruitment (70.6%) and retention (98.1%) rates, no adverse events, and significant improvements in blood pressure ($p<0.001$), balance ($p<0.001$), walking speed ($p<0.001$), physical activity levels ($p=0.000$), and quality of life ($p<0.001$) after 12 weeks. Participants reported the exercise as enjoyable, safe, and effective. This research demonstrates the safety and feasibility of rebound exercise for individuals with neurological disorders in supervised community settings. The alignment between participants' subjective experiences and the quantitative outcomes highlights its potential to improve physical and physiological functions.

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Author’s Declaration

I declare that this thesis and the work presented in it are my own and have been generated by me as the result of my own original research.

I confirm that:

1. This work was done wholly or mainly while in candidature for a research degree at this University.
2. Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
3. Where I have consulted the published work of others, this is always clearly attributed.
4. Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
5. Where elements of this work have been published or submitted for publication prior to submission, this is identified, and references are given at the end of the thesis.
6. This thesis has been prepared in accordance with the Staffordshire University and Buckinghamshire New University regulations.
7. I confirm that if the submission is based upon work sponsored or supported by an agency or organisation, I have fulfilled any right of review or other obligations required by such contract or agreement.

Adaora Okemuo

List of Abbreviations

WHO – World Health Organisation

CDC – Centre for Disease Control and Prevention

UK – United Kingdom

NHS – National Health Service

OHID – Office for Health Improvement and Disparities

NASA – National Aeronautics and Space Administration

PD – Parkinson's Disease

MS – Multiple Sclerosis

GBS – Guillain Barre Syndrome

ALS – Amyotrophic Lateral Sclerosis

HD – Huntington’s Disease

AD – Alzheimer’s Disease

TBI -Traumatic Brain Injury

SCI – Spinal Cord Injury

NIA – National Institute on Aging

NINDS – National Institute of Neurological Disorders and Stroke

MG – Myasthenia Gravis

MND – Motor Neuron Disease

NICE – National Institute for Health and Care Excellence

UCL- University College London

PHE – Public Health England

SA – Stroke Association

CNS – Central Nervous System

NMSS – National Multiple Sclerosis Society

NHGRI – National Human Genome Research Institute

HDA – Huntington's disease association

VDA – Vestibular Disorder's Association

BBS – Berg Balance Scale

TUG – Timed up and Go test

FRT – Functional Reach Test

MET – Metabolic Equivalent

MMSE – Mini-Mental State Examination

MoCA – Montreal Cognitive Assessment

QoL – Quality of Life

SF36 – 36 item Short-Form Health Survey

WHOQoL- World `Health Organisation Quality of Life

IASP – International Association for the Study of Pain

mini-BESTest – Mini- Balance Evaluation system test

OLS – One-Leg Stance

SLST – Single Leg Stance Test

3MBWT – 3-Metre Backward Test

10MWT – 10-Metre Walk Test

4MWT – 4-Metre Walk Test

6MWT- 6-Metre Walk Test

2MWT- 2-Metre Walk Test

COPD – Chronic Obstructive Pulmonary Disease

IPAQ – International Physical Activity Disease

GPAQ – Global Physical Activity Questionnaire

PASE – Physical Activity Scale for Elderly

DLW – Doubly Labelled Water

PDQ – Parkinson’s Disease Questionnaire

MSQoL-54 – Multiple sclerosis quality of life-54

SF-12 -12-item Short-Form Health Survey

WHOQoL-100 – 100 item World Health Organisation quality of life

WHOQoL-BREF – World Health Organisation Quality of life -Brief version

HIFIm – High-Frequency Impulse for Microgravity

G-force – Force of gravity

GRF- Ground Reaction Force

ACSM – American college of sport Medicine

EPE – Elastic Potential Energy

ICF – International Classification of Functioning, disability and health.

TPB -Theory of Planned Behaviour

TRA -Theory of Reasoned Action

PCB – Perceived Behavioural Control

MRC – Medical Research Council

NIHR – National Institute for Health and care Research

AAGR – Average Annual Growth Rate

NAD – National Audit office

PROSPERO – International Prospective regular of systematic reviews

PRISMA – Preferred Reporting Items for Systematic Reviews and Meta-analysis

MESH – Medical Subject Heading

CASP – Critical Appraisal Skill Programme

RCT – Randomised Control Trial

JAMA – Journal of the American Medical Association

CONSORT – Consolidated Standards for Reporting Trials

MMAT – Mixed Methods Appraisal Tool

PICO – Population, Intervention, Comparator, Outcome

CoP – Centre of pressure

SMD – Standardised Mean Differences

ADL – Activities of daily living

CI – Confidence interval

STROBE – Strengthening the Reporting of Observational Studies in Epidemiology.

AHA – American Heart Association

PAL – Physical Activity Level

SB – Sedentary Behaviour

BMI – Body Mass Index

BP – Blood Pressure

BPM – Beats per minute

HEPA – Health Enhancing Physical Activity

COREQ – Consolidated criteria for reporting qualitative studies

RTA – Reflexive Thematic Analysis

CHAPTER ONE

1.0 Introduction

As the world grapples with the alarming rise of chronic diseases[1] and physical inactivity[2], the survival and well-being of humanity depend on innovative solutions that promote sustainable lifestyle changes. The World Health Organisation's projections indicate that physical inactivity will continue to escalate, exacerbating the global burden of chronic diseases, including neurological disorders (Feigin *et al*., 2020; World Health Organisation, 2022, 2024b). In response, public health organisations and stakeholders are urgently seeking evidence-based strategies, such as the one proposed in this research, to reverse this trend and increase physical activity for all (Rigby *et al.*, 2020; Center for Disease Control and Prevention, 2024; World Health Organisation, 2024a). Despite growing efforts, evidence highlights significant barriers to physical activity, particularly among vulnerable populations. Individuals with neurological disorders face unique challenges as their condition often poses additional limitations on mobility and accessibility (The Neurological Alliance, 2020; Ningrum and Kung, 2023).

As a physiotherapist managing patients with neurological disorders and as a researcher committed to improving health outcomes, this thesis is driven by a compelling question: How can physical inactivity be effectively addressed among individuals with neurological disorders who are already disadvantaged by their condition? This research is motivated by the need to identify effective, feasible, safe interventions promoting physical activity among individuals with neurological disorders. This exploratory research is centred around exploring rebound exercise potentials to enhance physical activity and improve health outcomes in people with neurological disorders. The research examined the existing evidence on the effect of rebound exercise in adults with neurological disorders and the context in which rebound exercise was used. Based on the limited evidence revealed by the review, the research investigated the safety and feasibility of rebound exercises in community settings and explored the participants' views and experiences.

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[1] Diseases that persist for more than a year require ongoing medical attention and/or limit activities of daily living (WHO, 2023). 'Chronic diseases' and 'Non-communicable diseases' are usually used interchangeably. They are caused by genetic, physiological, environmental and lifestyle factors. They include neurological disorders, cardiovascular diseases, cancers, obesity, asthma, diabetes mellitus etc

[2] This refers to the inability to meet the approved physical activity levels of 150 minutes of moderate to vigorous exercises weekly (World Health Organisation, 2024b). It is linked to a high risk of chronic diseases.

1.1 Brief Background and Rationale

Neurological disorders represent a considerable and ever-increasing burden on global health. They affect more than 3.4 billion people worldwide and cause several physical, cognitive and psychological impairments (Feigin *et al.*, 2020; Steinmetz *et al.*, 2024). In the United Kingdom (UK) alone, over 16.5 million individuals live with a neurological condition, accounting for approximately 10% of the total disease burden (Neurological Alliance, 2019; Brain Research UK, 2021) and costing the National Health Service (NHS) about 4.4 billion pounds. These disorders, which include conditions like multiple sclerosis, Parkinson's disease, stroke and traumatic brain injury, often result in chronic disabilities that seriously limit one's quality of life, independence, and physical activity levels (The Neurological Alliance, 2020).

Physical inactivity is particularly concerning in this context, as it operates as a double-edged sword: not only can neurological disorders lead to reduced mobility and increased sedentary behaviour, but physical inactivity itself is a well-established risk factor for the development and progression of various neurological conditions (Brawner, Churilla and Keteyian, 2016; Riegel *et al.*, 2017; Anderson and Durstine, 2019). The cycle of inactivity and functional decline exacerbates disability, further complicating rehabilitation efforts. With an ageing population and advances in medical care prolonging life, the prevalence of these diseases is expected to grow sharply by up to 35% in the coming decades (Feigin *et al.*, 2020; Office for Health Improvement and Disparities, 2022; World Health Organisation, 2024a), stressing the urgent need for effective rehabilitation strategies to improve patient outcomes and foster their integration into the community.

Rehabilitation for neurological disorders has traditionally focused on alleviating the physical, cognitive, and psychological impairments associated with these conditions through various therapeutic interventions (Coetzer and Ramos, 2022; Kumar *et al.*, 2023). However, the complexity and degree of heterogeneity of neurological disorders require a more integral and personalised approach to rehabilitation that goes beyond standard therapies. How these disorders affect individuals requires interventions to be tailored to meet each patient's unique needs. Over the past few years, there has been increased attention to non-pharmacological therapies that can complement traditional rehabilitation programs to address the multifaceted nature of neurological impairments (Song, Ang and Lee, 2022; Mortada, 2024). One such intervention is rebound exercise, a low-impact form of physical activity performed on a mini-trampoline. Emerging research suggests that rebound exercise may offer numerous therapeutic benefits, particularly for individuals with neurological impairments, by improving balance, coordination, cardiovascular health, and overall physical fitness (Miklitsch *et al*., 2013; Cugusi *et al*., 2018; Posch *et al*., 2019b)These improvements are particularly crucial for individuals with neurological disorders, who often experience significant mobility challenges.

Despite its potential, there remains a paucity of rigorous research investigating the feasibility[3], effectiveness[4], and acceptability[5] of rebound exercise for individuals with neurological disorders. Understanding these factors is necessary to determine whether rebound exercise can be integrated into community-based neurorehabilitation programs to improve physical activity. As these have yet to be clarified in the literature, this PhD research aims to elucidate the impact of rebound exercise through a comprehensive investigation comprising three interconnected studies: a systematic review, a feasibility observational study, and a qualitative exploration of participants' experiences. Together, these studies explore the practicality of rebound exercise as a public health promotion tool. The concepts of feasibility, effectiveness and acceptability are discussed in Chapter 2 (Section 2.9).

1.2 Research Aim and Objectives

This PhD research aims to explore whether rebound exercise could be a feasible, effective, and well-accepted form of therapy for adults with neurological disorders. By bringing this to the attention of key players like the NHS, the scientific community, and public health organisations, this research hopes to shine a light on how rebound exercise could contribute to better outcomes in neurological rehabilitation. Rebound exercise, described in detail in Chapter 2, has been around for a while but mainly in different contexts. In the late 2000s, it started gaining recognition in healthcare and rehabilitation, though its roots go back much further. The exercise initially gained attention after a National Aeronautics and Space Administration (NASA) study in the 1980s highlighted its health benefits for astronauts, including improved cardiovascular health and fitness (Bhattacharya *et al.*, 1980). Prior to that, it was used in military training and as a fun activity for children. But in the last few years, it's

[3] This is the process of conducting a preliminary study to assess whether a full trial can be successfully completed, whether a project is practical, and, if so, how to proceed. Feasibility studies can help identify the proposed project's strengths and weaknesses, the resources required, and the prospects for success (Pearson *et al*., 2020). Safety, effectiveness and acceptability are key aspects of feasibility.
[4] A measure of how well an intervention works in the real world. It differs from efficacy, which is the performance of an intervention under ideal conditions (Singal *et al*., 2014).
[5] The degree to which an intervention is received by the target population and meets their needs (Ayala *et al*., 2011; Sekhon *et al*., 2017). It is a very key aspect of feasibility studies and plays a huge role in implementation.

been used for a variety of health purposes, from helping athletes (Mohammed and Joshi, 2015), to supporting individuals with obesity (Okemuo *et al.*, 2021), diabetes (Maharaj and Nuhu, 2019), and even children with disabilities (AL-Nemr and Kora, 2024). Despite this widespread use, its use and impact in neurological rehabilitation have not been clarified. Furthermore, the existing studies predominantly focus on quantitative outcomes, with limited exploration of participants' subjective experiences, limiting understanding of rebound exercise's full potential in real-world settings. To address this, the research also aims to explore participants' views and experiences regarding rebound exercise, offering the first formal qualitative investigation into how individuals with neurological disorders perceive this intervention.

The research aim is addressed through the following specific objectives:

a) To synthesise existing evidence on the effectiveness of rebound exercise for improving health outcomes in individuals with neurological disorders. This review identified limitations in the literature and informed the design of the subsequent empirical studies.
b) To assess the feasibility of a 12-week rebound exercise program in a group of community-dwelling adults with neurological disorders. This study evaluated outcomes such as recruitment rates, retention rates, adherence, number of adverse events, balance, mobility, cardiovascular health, cognitive function, quality of life and physical activity level.

c) To explore the experiences, perceptions, and acceptability of rebound exercise among feasibility study participants. This study provided insights into the facilitators and barriers to participation, as well as the perceived impact of the intervention on physical and mental well-being.

1.4 Research Questions

In line with the research objectives, the researcher seeks to answer the following questions:

1. What are the effects of rebound exercise on physical functions such as balance, mobility and grip strength in adults with neurological disorders?
2. Is rebound exercise feasible for adults with neurological disorders in a supervised community setting?
3. Is rebound exercise safe for adults with neurological disorders in a supervised community setting?

4. What are the recruitment, retention, and adherence rates for participating in rebound exercise over 12 weeks?
5. Does rebound exercise improve participants' physical activity levels and other key outcomes over the course of the intervention?
6. How do adults with neurological disorders perceive rebound exercise in terms of enjoyment, motivation, and barriers to participation?
7. What are participants' experiences regarding rebound exercise?
8. Could rebound exercise be a valuable component of public health strategies aimed at increasing physical activity levels in adults with neurological disorders?

Study one (chapter 3) answers the first research question, questions two to five are answered by the second study (chapter 4), questions six and seven are addressed in the third study (chapter 5), and the last research question is addressed in chapter 6.

1.5 Significance of the Research

This research holds important significance, not just within the academic realm, but for the countless individuals living with neurological disorders who face daily challenges in their mobility, independence, and overall well-being. Neurological disorders can drastically reduce the quality of life, making even simple activities difficult (The Neurological Alliance, 2020). While effective for some, current rehabilitation options often fail to provide long-term, community-based solutions that patients can easily integrate into their lives (Pryde *et al.*, 2024). This research offers a glimpse into how rebound exercise, an accessible, low-impact form of physical activity, might serve as a new way to help people regain mobility, improve their health, and reclaim parts of their daily lives that their condition has limited.

One of the key milestones in this research was the publication of the first study, a systematic review that highlighted how rebound exercise improved mobility in hospitalised adults with neurological disorders (Okemuo, Gallagher and Dairo, 2023). This publication in a respected peer-reviewed journal adds credibility to the research and opens new possibilities for its application beyond the clinical setting. It serves as a foundation for translating this intervention successfully in the community, where many people with neurological conditions live and receive care. The second study (Okemuo, Dairo and Gallagher, 2024) has also been published in a reputable peer-reviewed journal, contributing significantly to the field.

What makes this research even more impactful is that it's not just about the numbers or outcomes; it's about the people. By including participants' own voices and experiences, this study paints a fuller picture of how rebound exercise can fit into the lives of those with neurological disorders. Participants shared how the program helped them physically, emotionally, and socially. Their stories add a personal dimension to the findings and provide practical insights into how rebound exercise can be made more inclusive and accessible to everyone.

Furthermore, this research challenges the prevailing assumptions that three times weekly exercise frequency is essential for achieving positive outcomes. The finding that a minimum of once-weekly participation combined with flexibility and social support can lead to significant improvement suggests that adherence and long-term engagement may be more crucial than frequency, particularly in community settings. This has implications for the design and implementation of future community-based exercise programs.

Although the research cannot influence rehabilitation practices at this stage, as more studies are needed to confirm the findings, the insights gained here could shape future health strategies and lead to better support for a population that often feels overlooked. This would ultimately help reduce the burden on healthcare systems and promote a healthier, more active society. Given the growing prevalence of neurological disorders and the role of physical inactivity as both a consequence and risk factor for these conditions, rebound exercise may offer a valuable preventive strategy. Its potential to combat sedentary lifestyles in vulnerable populations makes it a promising candidate for informing future public health strategies and policies.

1.6 Personal Stance

How researchers perceive the world inevitably shapes every aspect of the research process, from the questions posed to the methods selected and the interpretation of findings (Moses and Knutsen, 2007; Moon and Blackman, 2014; Koopmans and Schiller, 2022). Therefore, it is crucial to clearly articulate the philosophical stance that underpins the research. As Creswell (1998) argues, research becomes more refined and meaningful when an explicit philosophical framework is acknowledged, as this helps guide the researcher's decisions throughout the study. This clarity is particularly important in qualitative research, where various approaches and perspectives exist (Creswell, 1998; Moses and Knutsen, 2007). Being transparent about the philosophical viewpoint helps to determine which data should be collected and how best to examine the area of interest (Grix, 2004). It also ensures a consistent and clear path throughout the research process, making it easier to explain the decisions and reasoning that guide the study. This approach enhances the rigour and reliability of the research (Creswell and Poth, 2018). In light of this, the following sections introduce the ontological and epistemological assumptions that inform this research, providing insight into the foundational beliefs that shape the design, methodology, and interpretation of the studies in this PhD thesis.

1.6.1 Ontological Stance

Ontology in research refers to the philosophical study of the nature of being, reality, and the structure of the world as it relates to the phenomena under investigation (Grenon and Smith, 2011). It is the foundation upon which researchers build their understanding of valid knowledge and truth. The ontological stance in this PhD research is grounded in critical realism, which asserts that while an objective reality exists independently of human perception, understanding of it is shaped by social, cultural, and individual perspectives (Koopmans and Schiller, 2022). This perspective is especially relevant in health and illness, where human biology, behaviour, and experience converge. Knowledge of health-related phenomena often arises from direct observation and experience (Alderson, 2021), yet these observable events only represent part of the deeper, often unobservable, mechanisms at play. Critical realism offers a framework well-suited to health sciences, as it allows for the exploration of both the observable and the hidden structures driving those observations. O'Mahoney and Vincent (2014) suggest that while events may be observed and experienced, they are often produced by mechanisms that remain unseen but are nonetheless real. This mirrors the approach commonly adopted by healthcare providers and researchers, who routinely look beyond visible symptoms to understand the root causes of a patient's condition or to assess the actual impact of an intervention.

In the context of this research, the objective reality pertains to the various impairments experienced by adults with neurological disorders that limit mobility, reduce physical activity levels, and negatively affect quality of life. These challenges can be quantitatively and qualitatively measured. However, critical realism acknowledges that individual experiences and engagement with rehabilitation interventions, such as rebound exercise, are shaped by personal, social, and health-related factors. These influences must also be considered to comprehensively understand the intervention's effectiveness. This ontological perspective, therefore, allows for the examination of both the measurable impacts of rebound exercise and the subjective experiences of participants, offering a more nuanced view of its potential in neurological rehabilitation.

1.6.2 Epistemological Stance

The epistemological stance of this PhD research is grounded in pragmatism, a philosophical approach that emphasises the practical application of knowledge and values, both objective and subjective forms of evidence. Epistemology, the study of knowledge and how reality is understood, is crucial in shaping the research design, particularly in determining credible knowledge (Audi, 2010). Pragmatism is particularly well-suited for mixed-methods research as it prioritises practical outcomes and real-world problem-solving over adherence to strict philosophical traditions (Morgan, 2007). Unlike positivism, which exclusively values objective knowledge, or interpretivism, which focuses on subjective experience, pragmatism adopts a flexible approach, integrating quantitative and qualitative methods to address complex research questions (Allemang, Sitter and Dimitropoulos, 2022). Positivism, interpretivism and pragmatism represent distinct paradigmatic stances in research, each with its own epistemological and ontological assumptions. Positivism emphasises objectivity, empiricism and the scientific method, seeking to explain phenomena through causal relationships and laws (Guba and Lincoln, 2005). This paradigmatic stance is appropriate for examining relationships between variables and testing hypotheses (Creswell and Creswell, 2017). In contrast, interpretivism focuses on understanding meaning, context, and subjective experiences, recognising the researcher’s role in shaping knowledge (Denzin, 2017). This approach enables an in-depth exploration of participants’ perspectives and experiences (Merriam, 2009).

In this research, pragmatism provides the framework for exploring rebound exercise's feasibility, effect, and acceptability for adults with neurological disorders. The goal is not to align with a singular philosophical position but rather to focus on what works in practice to improve physical and psychological well-being in this population. This epistemological stance values both forms of knowledge, empirical data that can measure changes in physical function and subjective experiences that capture participants' responses to the intervention (Kaushik and Walsh, 2019). Pragmatism also recognises the need for methodological flexibility (Hothersall, 2019). Rather than privileging one type of knowledge over the other, it promotes an integrative approach, combining the rigour of quantitative data with the depth of qualitative insights (Allemang, Sitter and Dimitropoulos, 2022). This is particularly important in understanding an intervention like rebound exercise, which may have measurable physiological benefits, such as improved balance or mobility, while also impacting psychological and social well-being, as revealed through qualitative insights. Pragmatism supports the view that the practical outcomes of the research, such as the potential for rebound exercise to be incorporated into rehabilitation programs, are of greater importance than strictly adhering to one philosophical tradition. This flexible and outcome-oriented approach is well-aligned with the research goals and its focus on real-world application, thus contributing to a nuanced and holistic understanding of rebound exercise's role in improving health and physical activity.

1.6.3 Methodological Approach

This thesis adopted mixed-method research, recognising that different methods can provide complementary insights into the research question (Morgan, 2007; Creswell and Clark, 2017). The thesis is predominantly a quantitative research followed by a secondary qualitative study. It adopts the explanatory sequential design of mixed methods research. This means that quantitative data is collected and analysed initially, supplemented by qualitative data to contextualise and elaborate on the findings (Creswell, 2011). Although the thesis generally employed mixed methods for the research, the individual quantitative and qualitative studies are presented in separate chapters (see chapters 4 and 5), drawing on both traditions while consistently informed by the overarching critical realist perspective. The mixed-method research is discussed in more detail in Chapter 2.

Using a mixed-method approach for this research was necessary for a holistic understanding of the research subject. The quantitative study data provides the objective measurement of feasibility (recruitment rate, retention rate, attrition rate) and physical health outcomes (balance, mobility, physical activity level), while the qualitative study data reveals personal experiences, challenges, and motivations related to the intervention. Moreover, each method contributes unique insights that complement the other. For instance, quantitative results indicate what changes occurred, such as improvements in mobility, while qualitative feedback explains how and why these changes were meaningful to participants. Additionally, using mixed methods leverages data triangulation to increase the accuracy and dependability of the findings (Creswell, 2011; Timans, Wouters and Heilbron, 2019). When quantitative and qualitative findings converge, they reinforce each other, adding credibility to the research conclusions.

1.7 Researcher Positionality

As a licensed physiotherapist with extensive experience in Nigeria, a middle-income country where access to advanced medical treatments is often limited, this PhD research represents an opportunity to apply both professional expertise and personal insights to the study of rebound exercise in individuals with neurological disorders. Having cared for patients with stroke, spinal cord injuries, Parkinson's disease, and traumatic brain injury, among others, a deep understanding of the challenges faced by these individuals was developed. Additionally, being intimately involved in the rehabilitation journey of loved ones who had suffered strokes provided a personal perspective on the physical and emotional toll these conditions take. This dual experience of caring for both patients and loved ones provided a unique insight into the broader spectrum of physical, psychological, and social challenges that individuals with neurological disorders face.

From these experiences, it became clear that maintaining physical activity in the face of neurological impairments is a struggle, often with negative consequences for mental well-being. This awareness ignited a strong desire to explore interventions to help individuals with these conditions improve their physical health and overall quality of life. While considering various options, rebound exercise emerged as a promising intervention due to its accessibility, low-impact nature, and reported benefits in improving balance, coordination, and cardiovascular health. Although other novel interventions were considered, the potential of rebound exercise to engage this population in physical activity, particularly given its ease of use and the growing evidence of its physical benefits, presented a compelling avenue for investigation. However, the scarcity of robust research exploring its application in neurorehabilitation prompted the decision to focus on this intervention. The aim was not only to contribute to the scientific literature but also to explore an under-researched area that could potentially offer practical benefits for individuals with neurological disorders.

The insights gained from professional practice have significantly shaped the research process, particularly in developing the qualitative interview guide, honing interview techniques, and analysing data. Understanding the contextual challenges participants faced informed the research questions and study design, focusing on the feasibility and acceptability of rebound exercises in community settings. Furthermore, directly supervising participants during rebound exercise sessions fostered a sense of rapport, creating an environment of comfort and trust that likely enriched the quality of the data collected. By adopting an 'insider' perspective, the research benefited from a deeper engagement with participants' experiences, allowing for a richer exploration of how this intervention could fit into their lives.

1.8 Structure of the Thesis

This thesis comprises six chapters, presented below. It adopted the thesis-by-study approach, with most chapters covering each research study. Chapters 3 to 5 report three studies, which can be viewed as two distinct stages summarised in Table 1.1. The findings from Stage 1 informed the research design for Stage 2. The relationship among the studies is illustrated in Figure 1.1.

Table 1.1 Summary of the Research Stages and Their Position in the Thesis

Stage	Objective	Study	Chapter
1	Systematic review to evaluate the effectiveness of rebound exercise in adults with neurological disorders	1	3
2	Observational and qualitative studies to explore the feasibility and acceptability of rebound exercise in community-dwelling adults with neurological disorders.	2	4 &5

Chapter one is the Introduction, which introduces the research objectives, rationale, significance and methodological approach. It also reviews and discusses the scope of the scientific literature in the research domain.

Chapter Two- Literature Review: This chapter comprehensively reviews the literature on neurological disorders, neurorehabilitation, and the emerging role of rebound exercise. It also explores the theoretical frameworks underpinning this research, including the International Classification of Functioning, Disability, and Health, and its methodological approaches.

Chapter three is the preliminary study of this research, titled ‘The Effect of Rebound Exercise on Functional Outcomes among Individuals with Neurological Disorders: A Systematic Review with Meta-Analysis’. This study has been published in PLoS One Journal and can be found here: https://pubmed.ncbi.nlm.nih.gov/37797042/

Chapter four is the second study of the research, titled ‘Investigating the Feasibility of Rebound Exercise in Community-Dwelling Adults with Neurological Disorders: A Prospective Observational Study’. This chapter covers the crux of the research regarding the feasibility of rebound exercises in community settings. This study has been published in Nursing and Health Sciences and can be found here: **https://doi.org/10.1111/nhs.70004**

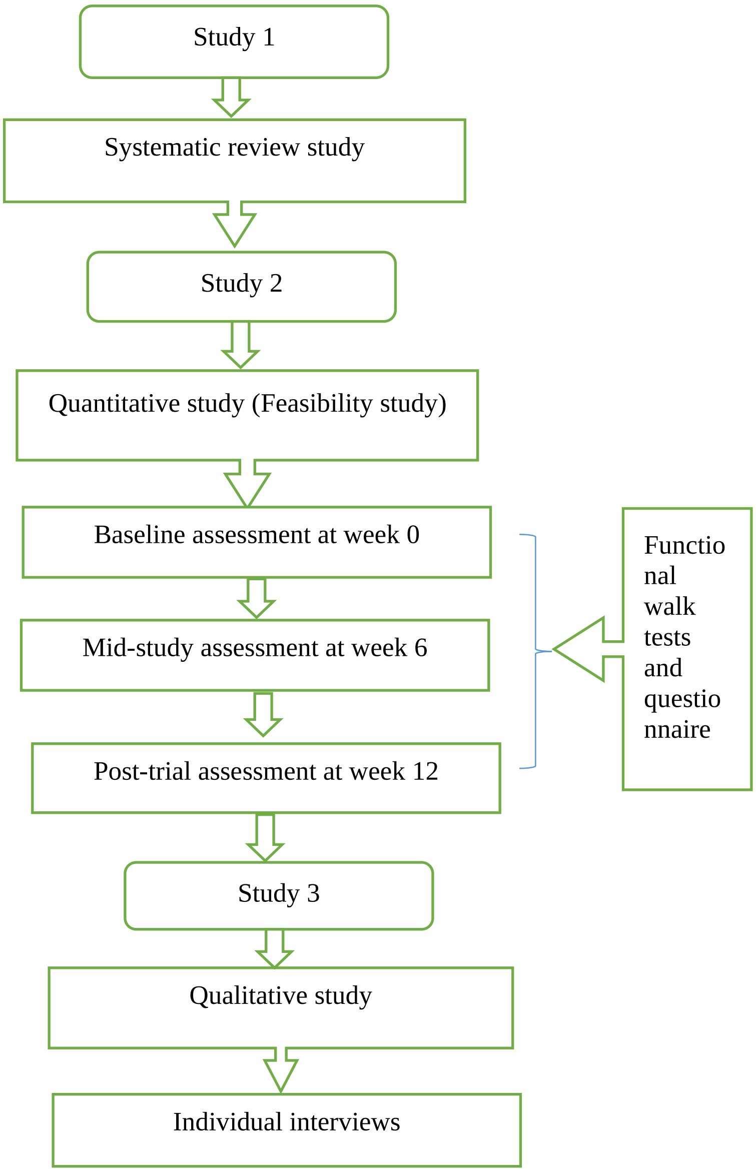

Figure 1.1: Diagram showing the Relationship among the Studies

Chapter five is the third study of the research titled ‘A Qualitative Exploration of Rebound Exercise Training: Perspectives and Experiences of Individuals with Neurological Disorders’. This chapter discusses the qualitative findings, highlighting participants' experiences, perceptions, and the factors influencing their engagement with rebound exercise.

Chapter six is the final chapter, in which data triangulation combines the findings from the individual studies. The chapter summarises the research's findings, contribution to the scientific body, and clinical implications. It also discusses the potential application of the research findings and makes recommendations for future research.

CHAPTER TWO

LITERATURE REVIEW

2.0 Chapter Overview

This chapter provides a review of the literature related to the research topic. It reviews neurological disorders, neurological rehabilitation and rebound exercise. It also describes the theoretical and conceptual frameworks underpinning this research and investigates the various outcome measures and the choice of instruments used. Finally, it looks at the methodological approach of this research study.

2.1 Neurological Disorders

Neurological disorders encompass diverse conditions affecting the nervous system, including but not limited to Parkinson's disease (PD), stroke, multiple sclerosis (MS), Guillain-Barré syndrome (GBS), amyotrophic lateral sclerosis (ALS), Huntington's disease (HD), Alzheimer's disease (AD), traumatic brain injury (TBI), and spinal cord injury (SCI) (Patel *et al.*, 2016; World Health Organisation, 2023a). While often presenting with similar clinical symptoms, these disorders vary significantly in their aetiology, pathology, and progression. A nuanced understanding of these differences is essential, particularly when considering rehabilitation strategies such as rebound exercise.

2.1.1 Acute Neurological Disorders

Acute neurological disorders are characterised by their sudden onset and may be life-threatening. Conditions like stroke, traumatic brain injury, and epileptic seizures fall into this category and are major contributors to global morbidity and mortality, second only to cardiovascular diseases (Moodley, Nitkunan and Pereira, 2017; Subahi *et al.*, 2022). For instance, stroke results from a disrupted blood supply to the brain, leading to rapid onset of symptoms that can vary widely depending on the affected brain region and the timing of intervention (National Institute on Aging, 2023). Similarly, traumatic brain injuries, often caused by external forces such as falls, gunshots or road traffic accidents, can result in significant and sometimes permanent neurological deficits (Ahuja *et al.*, 2017).

Spinal cord injuries, whether traumatic or due to non-traumatic causes like tumours or infections, also represent a major category of acute neurological disorders. These injuries disrupt sensory and motor functions below the level of injury, leading to varying degrees of paralysis (Ahuja *et al*., 2017; National Institute on Aging, 2023). The immediate and severe impact of these conditions highlights the critical need for timely and effective rehabilitation strategies, which are key to improving outcomes and restoring some level of independence for affected individuals.

2.1.2 Chronic Neurological Disorders

In contrast, chronic neurological disorders are progressive in nature, with symptoms that worsen over time (Pan-Montojo and Reichmann, 2014a; Walter *et al.,* 2019). These include neurodegenerative diseases like Alzheimer's disease, Parkinson's disease, and Huntington's disease. Such conditions are marked by the gradual neurone deaths in specific brain areas, leading to significant impairments in motor and cognitive functions (Reddy and Abeygunaratne, 2022).

Parkinson's disease, for example, primarily affects motor function due to the depletion of dopamine, a neurotransmitter crucial for movement. This results in symptoms including rigidity, tremors, postural instability and bradykinesia (Ali and Morris, 2015). In contrast, Alzheimer's disease predominantly affects cognitive functions, leading to memory loss and dementia, although it shares some overlapping symptoms with Parkinson's (Alzheimer's disease facts and figures, 2023). Understanding these distinctions is vital when considering interventions like rebound exercise, which may impact physical versus cognitive symptoms differently.

Huntington's disease presents another unique case within chronic neurological disorders. This genetic condition causes progressive destruction to the basal ganglia and thalamus, resulting in both physical and psychiatric symptoms, including involuntary movements and cognitive decline (Purcell *et al*., 2020; Maiuri *et al*., 2019; Stoker *et al*., 2022; National Institute of Neurological Disorders and Stroke, 2023). Unlike other neurodegenerative diseases, Huntington's is inherited, with a 50% transmission risk to offspring (Li *et al*., 2023; McColgan and Tabrizi, 2018), which raises unique ethical and clinical considerations in its management.

Multiple sclerosis (MS) and myasthenia gravis (MG), while also chronic, differ from other neurodegenerative disorders in their mechanisms and progression. MS, an autoimmune disease, involves the immune system attacking the myelin sheath of neurons, leading to unpredictable symptoms and disease progression (Ghasemi, Razavi and Nikzad, 2017).

Similarly, MG disrupts neuromuscular transmission, causing fluctuating muscle weakness and fatigue (Dresser *et al.*, 2021). These conditions, typically diagnosed in early adulthood (MS Society UK, 2021; NHS, 2022), require long-term management strategies that address physical and cognitive impairments.

2.1.3 Motor Neuron Diseases

Motor neuron diseases (MNDs) are a group of rapidly progressive neurological disorders that primarily affect motor function (Dompenciel, 2021; National Institute of Neurological Disorders and Stroke, 2023). ALS, the most common MND in adults, involves the deterioration of upper and lower motor neurons, leading to muscle atrophy, paralysis, and eventually death (Przedborski, Vila and Jackson-Lewis, 2003; Przedborski, 2017). ALS affects muscles involved in breathing, swallowing, and speaking, making it one of the most debilitating neurological conditions (Mancuso and Navarro, 2015; Brown and Al-Chalabi, 2017). GBS, another MND, differs in that it is an autoimmune disorder leading to acute, ascending paralysis following an infection. While GBS is generally self-limiting, it can cause life-threatening complications if the respiratory muscles are involved (Leonhard *et al.*, 2019). GBS symptoms typically last a few weeks, and most people recover without any long-term severe neurological complications (World Health Organisation, 2023).

2.1.4 Aetiology and Clinical Implications

The aetiology of neurological disorders can be genetic, idiopathic, or related to external factors such as trauma, toxins, or infections (Cannon and Greenamyre, 2011; Pan-Montojo and Reichmann, 2014). Despite their differing origins and courses, these disorders often share similar symptoms, such as pain, mobility issues, cognitive decline, and reduced quality of life, all of which significantly impact the daily lives of affected individuals (Harapan and Yoo, 2021). Understanding these symptoms and their underlying mechanisms is crucial for developing effective rehabilitation strategies. For instance, interventions like rebound exercise could be tailored to address specific mobility, balance and cognitive deficits in neurological conditions like Parkinson’s and stroke, considering the unique cognitive and motor challenges associated with each condition.

Reviewing the broad spectrum of neurological disorders, it becomes evident that while these conditions share some clinical features, they differ markedly in their underlying causes and progression. This understanding stresses the importance of targeted rehabilitation strategies that address the specific needs of each disorder. As the research progresses, a more focused exploration of the neurological disorders most relevant to the study population, such as Parkinson’s disease, stroke, traumatic brain injury, multiple sclerosis and Huntington’s disease, will be crucial. This approach will ensure that the findings directly apply to clinical practice and contribute meaningfully to neurorehabilitation.

2.1.5 Parkinson’s Disease

PD is a debilitating neurodegenerative disorder impacting over 10 million people worldwide, making it the second most prevalent of its kind (Poewe *et al*., 2017; Goldman and Holden, 2023; World Health Organisation, 2023). Currently, there are 153,000 estimated PD patients in the UK, which is likely to increase as the population ages (Parkinsons UK, 2023). The prevalence of PD increases as people age and affects men at a rate 1.5 times higher than women within the same age group (National Institute for Health and Care Excellence, 2023). Living with PD is also expensive, with research estimating that the total cost per patient per year is at least £25,000 (UCL Institute of Neurology, 2018). This creates spatial and health inequalities as those who cannot afford the cost of treatment are unable to properly manage the progression of the disease.

PD primarily affects motor function due to the depletion of dopamine-producing neurons in the substantia nigra, a brain region responsible for movement control (Kalia and Lang, 2016). Dopamine is a vital neurotransmitter that facilitates smooth and coordinated muscle movements. As its levels decline, individuals with PD experience various motor symptoms, including tremors at rest, bradykinesia (slowness of movement), rigidity, and postural instability (Jankovic, 2008). These symptoms impair mobility and significantly reduce quality of life, making everyday tasks increasingly challenging.

Parkinson's disease is a complex condition with a multifaceted aetiology that is not yet fully understood. It is thought to result from genetic and environmental factors (Kalia and Lang, 2016; Funayama *et al*., 2023). While several genetic mutations have been identified in familial forms of PD, most cases are idiopathic, with no clear genetic cause (Day and Mullin, 2021). Environmental risk factors, such as exposure to pesticides, heavy metals, and a history of head injury, have been linked to PD (Shetty *et al*., 2023). Still, the exact mechanisms contributing to neuronal degeneration remain unclear (Ascherio and Schwarzschild, 2016). Aside from the motor symptoms, PD is linked with a range of non-motor symptoms that can come several years before the start of motor dysfunction. These include olfactory dysfunction, sleep disturbances, autonomic dysfunction, and neuropsychiatric symptoms such as depression, anxiety, and cognitive impairment (Chaudhuri, Healy and Schapira, 2006). The presence of these non-motor symptoms adds to the complexity of PD management, as they can be just as disabling as motor symptoms and significantly impact patients' overall well-being (Pontone *et al.*, 2019; Weiss and Pontone, 2019; Hussein *et al.*, 2023).

The course of PD varies greatly among individuals, with some experiencing a relatively slow progression of symptoms while others face a rapid decline (Hähnel *et al.*, 2024). As the disease advances, the effectiveness of pharmacological treatments, such as levodopa and dopamine agonists, diminishes, leading to the emergence of motor complications, including dyskinesias (involuntary movements) and motor fluctuations (Kalia and Lang, 2016). These complications make PD management more challenging, requiring a comprehensive multidisciplinary care approach. PD remains incurable, with current treatments focused on managing symptoms and improving quality of life (Yang *et al.*, 2020; Gouda, Elkamhawy and Cho, 2022). The role of exercise, including novel interventions such as rebound exercise, has gained attention over the years as a potential strategy to enhance mobility and overall physical activity in individuals with PD (Goodwin *et al.*, 2008; Liu *et al.*, 2019). While traditional rehabilitation approaches, such as physiotherapy and occupational therapy, are well-established in PD care, exploring innovative therapies is crucial for addressing the unmet needs of this population.

2.1.6 Stroke

Stroke ranks among the top causes of disability and death worldwide, with significant economic burdens on individuals and healthcare systems (Virani *et al.*, 2020; Feigin *et al.*, 2022). In the United Kingdom, one in every six people is affected by stroke, and an estimated 32,000 people die from stroke-related causes annually (Public Health England, 2018). Stroke hits over 100,000 UK residents yearly, striking every 5 minutes (Tang *et al.*, 2024). Currently, there are an estimated 1.3 million stroke survivors in the UK (Stroke Association, 2020). Stroke survivors require significant healthcare resources, with an estimated 45% of costs attributed to hospitalisations and 33% to recovery and rehabilitation (Luengo-Fernandez *et al.*, 2013). Indirect costs from lost productivity and informal caregiving also add to the economic burden (Ganapathy *et al.*, 2015). The cost impact of stroke rehabilitation on the healthcare system and economy in the UK is substantial, with an estimated economic burden of £26 billion per year (King *et al*., 2020; Patel *et al*., 2020). According to NHS England, stroke rehabilitation costs the NHS approximately £8.6 billion annually (Patel *et al*., 2020).

Stroke is defined as "a clinical syndrome of presumed vascular origin characterised by rapidly developing signs of focal or global disturbance of cerebral functions which lasts longer than 24 hours or leads to death" (National Institute for Health and Care Excellence, 2023). It is a medical emergency that occurs when the blood supply to a part of the brain is disrupted, either by a blockage in a blood vessel (ischemic stroke) or by bleeding within the brain (haemorrhagic stroke) (Benjamin *et al.*, 2019; Center for Disease Control and Prevention, 2024). Approximately 85% of strokes in the UK are ischaemic, and 15% are haemorrhagic (Stroke Association, 2024). The resulting lack of oxygen and nutrients causes brain cells to die, leading to neurological deficits that can vary widely depending on the site and extent of the damage. Ischemic stroke, the most common type, is often caused by a blood clot formation within a cerebral artery (thrombotic stroke) or by an embolus that travels from another part of the body, such as the heart, and lodges in a brain artery (embolic stroke) (Meschia and Brott, 2018). In contrast, haemorrhagic stroke occurs when a blood vessel in the brain ruptures, leading to bleeding within or around the brain. This stroke type is less common but tends to be more severe and is often associated with higher mortality rates (van Asch *et al.*, 2010; Montaño, Hanley and Hemphill, 2021).

Stroke can profoundly change the trajectory of one's life. Depending on the area of the brain affected, a stroke can result in various impairments, including paralysis (hemiplegia) or weakness on one side of the body (hemiparesis), difficulty with speech and language (aphasia), cognitive deficits, and emotional disturbances such as depression or anxiety (Hankey, 2017; Katan and Luft, 2018). The severity and range of these symptoms are influenced by factors including the brain lesion size, the specific brain regions involved, and the promptness of medical intervention (Kuriakose and Xiao, 2020). Stroke rehabilitation is a critical component of recovery, helping individuals regain as much independence as possible (Bindawas and Vennu, 2016). Rehabilitation typically involves a multidisciplinary team approach, including physiotherapists, occupational therapists, speech and language therapists, and psychologists, who work together to address the patient's physical, cognitive, and emotional needs (Langhorne, Bernhardt and Kwakkel, 2011; Li *et al.*, 2024). Early and intensive rehabilitation has been shown to improve outcomes, but recovery can be a long and challenging process, with some individuals experiencing persistent deficits despite rehabilitation efforts (El Husseini *et al.*, 2023; Li *et al.*, 2024).

In recent years, novel rehabilitation interventions that can complement traditional therapies and enhance recovery in stroke survivors have increased (Saraiva *et al.*, 2023; Marín-Medina *et al.*, 2024). Exercise-based interventions, such as rebound exercise, are being explored for their potential to improve motor function, balance, and overall physical activity levels (Billinger *et al.*, 2014). These interventions offer a promising avenue for helping stroke survivors overcome the physical inactivity and sedentary lifestyle that often follow a stroke, which can contribute to further health complications and reduced quality of life. However, while the benefits of physical activity for stroke recovery are well-documented, more research is needed to establish the efficacy of specific interventions like rebound exercise in this population.

2.1.7 Multiple Sclerosis

MS is a chronic, often debilitating neurological disorder that affects the central nervous system (CNS), which comprises the brain and spinal cord. Characterised by an unpredictable and progressive course, MS is marked by episodes of inflammation that damage the myelin sheath, the protective covering surrounding nerve fibres (Faissner *et al.*, 2019). This damage interrupts the normal flow of electrical impulses along the nerves, resulting in various physical, cognitive, and emotional symptoms (Dobson and Giovannoni, 2019). MS is an autoimmune disease, meaning the body's immune system mistakenly attacks its tissues (National Institute of Neurological Disorders and Stroke, 2024). The exact cause of MS is not known, but it is believed to involve a complex interplay of genetic, environmental, and possibly infectious factors (Ascherio, 2013; Bjornevik *et al.*, 2023; Murúa, Farez and Quintana, 2024). Symptoms of MS vary significantly between individuals and can include fatigue, difficulty walking, muscle weakness or spasms, numbness or tingling, vision problems, dizziness, pain, and cognitive issues such as difficulties with memory and concentration (Compston and Coles, 2008; National Multiple Sclerosis Society, 2024). These symptoms can fluctuate, with periods of relapses (worsening of symptoms) followed by remissions (periods of partial or complete recovery). Over time, the disease may progress to a more advanced stage, where symptoms become more persistent and disabling (National Institute of Neurological Disorders and Stroke, 2024).

About 2.8 million people live with MS globally (Walton *et al.*, 2020). In the UK, MS is the most common disabling neurological condition in young adults, with an estimated prevalence of 190 cases per 100,000 people (Public Health England, 2020). It is more prevalent in women than men, with a ratio of approximately 3:1, and it usually occurs between the ages of 20 and 40, although it can occur at any age (Montalban *et al.*, 2018; Walton *et al.*, 2020; MS Society UK, 2021). The UK has one of the highest rates of MS in the world, with Scotland having the highest prevalence within the UK (National Institute for Health and Care Excellence, 2024), a pattern observed in other high-latitude regions, suggesting a possible environmental influence, such as vitamin D deficiency, on the disease's development (Gandhi *et al.*, 2021).

MS can have a devastating and lasting impact on an individual's life. The unpredictable nature of the disease, combined with the wide range of possible symptoms, can make daily life challenging and lead to significant emotional and psychological stress (National Multiple Sclerosis Society, 2024). Many people with MS experience fatigue, which is one of the most prevalent and debilitating symptoms, affecting their ability to work, engage in social activities, and maintain independence (Oliva Ramirez *et al.*, 2021; Johnson, Hooshmand and Hooshmand, 2024). Cognitive impairments, such as difficulties with attention, information processing, and memory, are also common and can contribute to a decline in quality of life (Rocca *et al.*, 2015; Meca-Lallana *et al.*, 2021; Esmaeili, Obeidat and Zabeti, 2023).

Despite the chronic and progressive nature of MS, advances in treatment have significantly improved the management of the disease. Disease-modifying therapies can decrease the occurrence and severity of relapses, slow disease progression, and help manage symptoms (Robertson and Moreo, 2016; World Health Organisation, 2023). Rehabilitation, including physiotherapy and occupational therapy, plays a crucial role in maintaining function and independence, helping individuals manage symptoms and adapt to the challenges posed by the disease (Amatya *et al.*, 2013; Khan and Amatya, 2017; Amatya, Khan and Galea, 2019). Exercise-based interventions, in particular, have gained attention for their potential to improve physical fitness, mobility, and quality of life in people with MS (Motl, Sandroff and Deluca, 2016; Kalb *et al.*, 2020). Regular physical activity can help counteract the physical deconditioning that often accompanies MS and positively affect mood and cognitive function (Motl and Sandroff, 2015). While there is no cure for MS, advances in treatment and rehabilitation offer hope for managing symptoms and improving quality of life. Continued research into innovative therapies, including exercise-based interventions, is essential for expanding the options available to individuals living with MS and enhancing their ability to lead active and fulfilling lives.

2.1.8 Traumatic Brain Injury

TBI is a serious public health issue that occurs when an external force causes damage to the brain. It is defined as "a disruption in the normal function of the brain that can be caused by a bump, blow, or jolt to the head or a penetrating head injury" (Centers for Disease Control and Prevention (CDC), 2015). This injury can result from a variety of incidents, such as road traffic accidents, falls, sports injuries, and assaults, with outcomes ranging from mild concussions to severe brain damage (Jha and Ghewade, 2022; National Institute of Neurological Disorders and Stroke, 2024). The impact of TBI can be immediate and devastating, affecting not only the individual but also their families and communities, given the potential for long-term physical, cognitive, and emotional challenges.

The severity of TBI can vary widely. Mild TBI, often referred to as a concussion, may result in temporary symptoms such as headaches, dizziness, and confusion (National Institute of Neurological Disorders and Stroke, 2024; Obasa *et al*., 2024). Although these symptoms typically resolve within days or weeks, some individuals may experience longer-lasting effects, known as post-concussion syndrome (Quinn *et al.*, 2018; Marshall and van Ierssel, 2022). Moderate to severe TBI can lead to more serious outcomes, including prolonged unconsciousness or coma, significant cognitive impairments, and long-term physical disabilities. In severe cases, TBI can result in permanent brain damage, leading to profound changes in an individual's ability to function independently and dramatically altering their quality of life (Rauchman *et al*., 2023; National Institute of Neurological Disorders and Stroke, 2024).

The consequences of TBI extend beyond physical symptoms. Cognitive impairments, such as memory, attention, and executive function difficulties, are common and can significantly impact daily living, employment, and social relationships (Ruet *et al.*, 2019; Obasa *et al.*, 2024). Emotional and behavioural changes, including depression, anxiety, irritability, and personality shifts, are also frequently reported, adding to the complexity of post-TBI care and rehabilitation (Yeo, 2021; Howlett, Nelson and Stein, 2022; Maas *et al.*, 2022). These challenges highlight the need for a comprehensive and multidisciplinary approach to TBI management that addresses both the physical and psychological aspects of recovery.

In the UK, TBI is a significant contributor to death and disability among young people and adults under the age of 40 (Dinsmore, 2013). Each year, approximately 1.4 million people attend emergency departments in the UK due to head injuries, with around 200,000 of these cases resulting in hospital admissions for TBI (Lawrence *et al.*, 2016; National Institute for Health and Care Excellence, 2023). Males are more commonly affected than females, particularly in the younger age groups, and the incidence peaks in children, adolescents, and older adults, reflecting different causes of injury, such as falls in the elderly and sports-related injuries in younger individuals (Udry, 1998; Gupte *et al.*, 2019). In the UK, the long-term care and rehabilitation of individuals with TBI pose significant challenges for the healthcare system (Li *et al.*, 2021). Rehabilitation services aim to maximise recovery and independence, often involving a combination of physiotherapy, occupational therapy, speech and language therapy, and psychological support. However, access to specialised TBI rehabilitation can be inconsistent, leading to disparities in outcomes based on geographic location and socioeconomic status (Jacob *et al.*, 2020; Johnson and Diaz, 2023).

Emerging research has begun exploring novel interventions that complement traditional rehabilitation approaches. For instance, exercise-based therapies are gaining attention due to their potential to improve physical and cognitive outcomes in individuals with TBI (Gomez-Pinilla and Mercado, 2022; Snowden *et al.*, 2023). Rebound exercise, which involves low-impact, rhythmic bouncing on a trampoline or similar surface, has shown promise in enhancing balance, coordination, and overall physical activity levels (Posch *et al*., 2019; AL-Nemr and Kora, 2024). While the evidence surrounding rebound exercise in neurorehabilitation is still in its early stages, such intervention may offer a valuable addition to the rehabilitation toolkit, particularly for individuals who find traditional exercise regimens challenging due to their injuries.

2.1.9 Huntington’s Disease

HD is a rare, inherited neurological disorder that profoundly affects both the body and mind (Stoker et al., 2022; National Institute of Neurological Disorders and Stroke, 2024b). It is relatively rare in the UK, affecting approximately 12 people per 100,000 (Furby *et al.*, 2022; Stoker *et al.*, 2022; Willock *et al.*, 2023). This translates to around 6,000 individuals living with the condition, though many more are at risk of developing it due to its hereditary nature. HD is caused by a mutation in the huntingtin gene, which produces an abnormal form of the huntingtin protein (McColgan and Tabrizi, 2018; Fodale *et al.*, 2020). This defective protein gradually accumulates in the brain, particularly in regions involved in movement, cognition, and emotion, causing the progressive symptoms associated with the disease (Rüb *et al.*, 2016; Jimenez-Sanchez *et al.*, 2017).

Characterised by a progressive degeneration of nerve cells in the brain, HD leads to severe physical, cognitive, and emotional challenges. The condition is particularly devastating because it typically manifests during the prime of life, with symptoms often appearing between the ages of 30 and 50, though they can start earlier or later (Roth, 2019; Anil, Mason and Barker, 2020). Once symptoms begin, the disease steadily worsens, profoundly altering the lives of those affected and their families (Stoker *et al.*, 2022; National Health Service, 2024). The symptoms of HD are diverse and evolve over time. Early signs may include subtle changes in mood, such as irritability or depression, as well as minor difficulties with coordination or memory (Stoker *et al.*, 2022; NHS Inform, 2024). As the disease progresses, these symptoms become more pronounced. Individuals with HD often develop chorea, a term for the involuntary, jerky movements characteristic of the condition (National Institute of Neurological Disorders and Stroke, 2024). These movements can affect the face, limbs, and trunk, leading to difficulties with walking, swallowing, and speaking (McColgan and Tabrizi, 2018). Cognitive decline is another hallmark of Huntington's disease. Over time, individuals may experience significant impairments in memory, attention, and problem-solving abilities, making it increasingly difficult to manage daily tasks and maintain employment (Jellinger, 2024; National Institute of Neurological Disorders and Stroke, 2024). This cognitive deterioration is often accompanied by emotional and psychiatric symptoms, such as anxiety, apathy, and obsessive-compulsive behaviours. The combination of physical and mental symptoms can make HD particularly challenging to manage, both for those affected and their caregivers (Paulsen, 2011; Gunn *et al.*, 2023).

The hereditary nature of HD adds an additional layer of complexity and emotional burden. Each child of a parent with HD has a 50% risk of inheriting the faulty gene and, consequently, the disease itself (National Human Genome Research Institute, 2011; National Institute of Neurological Disorders and Stroke, 2024). This genetic aspect of the condition raises difficult questions about genetic testing and family planning for those at risk. While some may choose to undergo testing to know their genetic status, others may prefer not to, given the lack of a cure and the inevitability of the disease if the gene is present (Baig *et al.*, 2016). Currently, there is no cure for HD, and treatment primarily focuses on managing symptoms and improving quality of life (Puigdellívol, Saavedra and Pérez-Navarro, 2016; Rüb *et al.*, 2016; Nolan, 2024). A multidisciplinary approach is often employed, involving neurologists, psychiatrists, physiotherapists, occupational therapists, and speech and language therapists.

Medications can help manage specific symptoms, such as chorea or depression, but they do not alter the course of the disease (Nolan, 2024).

Support services for individuals with HD and their families are crucial in the UK. The Huntington's Disease Association provides various resources, including specialist advice, support groups, and advocacy (Huntington's Disease Association, 2024). However, the progressive and complex nature of HD often necessitates long-term care, which can be a significant emotional and financial burden on families. Research into HD is ongoing, with scientists exploring various avenues to slow or halt its progression (Kim *et al.*, 2021; Tabrizi *et al.*, 2022; Conner *et al.*, 2023). These include gene-silencing techniques, which aim to reduce the production of the harmful huntingtin protein and stem cell therapies, which seek to repair or replace damaged neurons and physical activity. While these approaches are still in the experimental stages, they offer hope for future treatments that could alter the trajectory of the disease (Byun, Lee and Kim, 2022).

2.2 Clinical Features Associated with Neurological Disorders.

Neurological disorders include a variety of conditions affecting the central and peripheral nervous systems, leading to various clinical features that can significantly impact an individual's daily functioning (Rahimi *et al.*, 2024). These clinical manifestations often vary depending on the type of disorder, its progression, and the specific areas of the nervous system affected. Common symptoms include muscle weakness, balance and coordination issues, sensory disturbances, pain, cognitive decline, speech difficulties, fatigue and emotional or psychological effects (Hatem *et al.*, 2016). Some of these features emerge suddenly, as seen in acute conditions like stroke or traumatic brain injury, while others develop gradually over time in chronic neurodegenerative diseases such as Parkinson's disease or multiple sclerosis. Understanding and addressing these issues is essential in rehabilitating and managing neurological conditions. Therefore, reviewing these problems in detail is a key aspect of managing these disorders effectively.

2.2.1 Balance Problems

Balance is fundamental to human mobility, allowing individuals to maintain an upright posture and move freely without falling, even when faced with external challenges or environmental changes (Rogers *et al.*, 2013; Marchesi *et al.*, 2022). The complexity of balance control is rooted in a highly coordinated interplay between three key sensory systems:

the visual, vestibular, and proprioceptive systems (Vestibular Disorders Association, 2024). Each system provides critical information to the brain, particularly the cerebellum, which integrates these signals to maintain balance (Figure 2.1). The visual system (the eyes) offers constant details on an individual's surroundings and is crucial to balance. It helps the brain interpret changes in the environment, such as variations in light or surface stability, to adjust posture and movement accordingly. The vestibular system in the inner ear detects changes in head position, motion, and equilibrium, providing the brain with vital spatial orientation cues. Lastly, the proprioceptive system, comprised of sensors in muscles and joints, detects the body's position and movement, contributing to fine-tuned control of posture and balance (Ango, Raphae and Reis, 2019). When any of these systems are disrupted by injury, disease, medication, or the natural ageing process, the result can be balance impairment.

Neurological disorders are a primary cause of such impairments, either at the onset of an acute condition such as stroke or TBI or as a chronic disease like PD, MS, or HD progresses (Perera *et al*., 2018). These disorders interrupt the brain's ability to receive or process sensory information from the visual, vestibular, and proprioceptive systems, profoundly impacting an individual's balance. Evidence highlights the prevalence of balance problems in various neurological conditions. For instance, balance impairments are particularly common post-stroke, affecting mobility and increasing the risk of falls (Vincent-Onabajo, Musa and Joseph, 2018; Xiang, Glasauer and Seemungal, 2018). Individuals with PD also commonly exhibit issues with postural instability, one of the hallmarks of advanced PD (Schoneburg *et al.*, 2013; Wodarski *et al.*, 2023). HD similarly causes a gradual loss of motor control, with chorea and rigidity disrupting balance and gait over time (Medina *et al.*, 2022). MS, characterised by its unpredictable course, often presents with balance dysfunction due to demyelination in the CNS, affecting motor and sensory pathways (Lesinski *et al.*, 2015; Cameron and Nilsagard, 2018; Calafiore *et al.*, 2021).

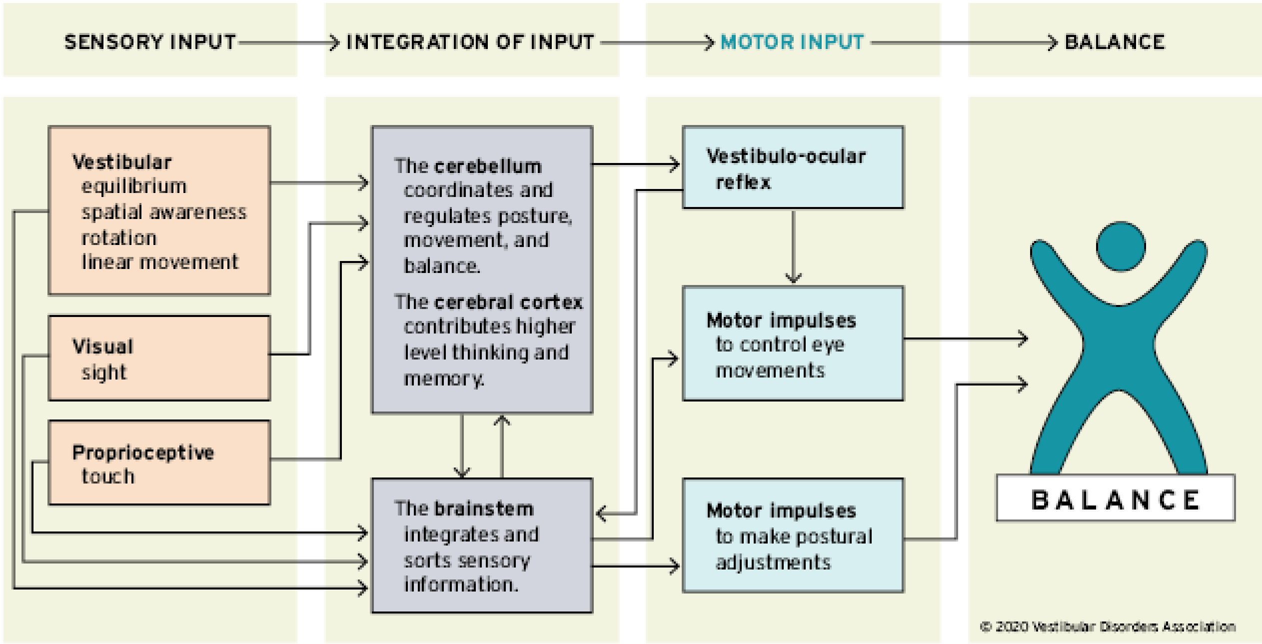

Figure 2.1: The Complex Integration of Sensorimotor Control Systems for Balance

The consequences of balance impairments are extensive and can deeply affect multiple aspects of life. Physically, the most immediate concern is the increased risk of falls, which is significantly higher in individuals with balance issues. Falls can lead to serious injuries, such as fractures, head trauma, and, in severe cases, even death (Schoneburg *et al.*, 2013; Carling, Nilsagård and Forsberg, 2018; Vuong *et al.*, 2018; de Souza *et al.*, 2019). Beyond physical injury, balance problems limit mobility, which restricts an individual's ability to perform daily activities and compromises their functional independence. Psychologically, the fear of falling often becomes a significant issue for individuals with neurological disorders. This fear can lead to self-imposed activity restrictions, creating a cycle of reduced physical activity, social withdrawal, and a sedentary lifestyle. Over time, this contributes to further physical decline, social isolation, and a diminished quality of life (Peterson, Park and Sweeney, 2008; Kalron *et al.*, 2016). The psychological toll of balance impairment extends to increased anxiety and depression, especially as individuals lose their autonomy and ability to participate in social or occupational roles.

The economic burden of balance impairments is another critical consideration. Individuals with neurological disorders often require ongoing healthcare services, such as frequent hospital visits, physiotherapy, and rehabilitation programs, all of which contribute to rising healthcare costs (Jawad *et al.*, 2023). Additionally, many patients require assistive devices (e.g., walking aids or wheelchairs) and home modifications to make their living environments safer and more accessible (Clemson *et al.*, 2019; Sehgal *et al.*, 2021). These adaptations, while necessary, place an additional financial strain on families and healthcare systems.

2.2.1.1 Balance Testing and Training in Neurological Disorders

Given the significant impact of balance problems in neurological conditions, various assessment tools and interventions have been developed to evaluate and improve balance. Balance testing is crucial for diagnosing the extent of balance impairment and tailoring rehabilitation interventions to individual needs. Common balance assessments include the Berg Balance Scale (BBS), the Timed Up and Go (TUG) test, the Functional Reach Test (FRT) and force platform analyses, which objectively measure an individual's postural control and risk of falls. These outcome measures are reviewed in more detail later in the chapter.

Balance training interventions are vital to rehabilitation programs for individuals with neurological disorders. These interventions can range from conventional physiotherapy approaches, such as gait and postural training, to more innovative techniques, like virtual reality-based rehabilitation and balance training with biofeedback (Pandian, Arya and Kumar, 2014; Lee, Lee and Song, 2018; Kim, In and Jung, 2022; Shahid, Kashif and Shahid, 2023). Studies have shown that structured balance training can significantly improve postural control and reduce the risk of falls in individuals with conditions like PD, stroke, and MS (Lesinski *et al.*, 2015; Palmgren *et al.*, 2020). Incorporating balance training into rehabilitation programs is essential for improving physical outcomes, enhancing confidence, and reducing the fear of falling. Evidence supports the use of tailored balance training programs to enhance the mobility and functional independence of individuals with neurological disorders, thereby improving their overall quality of life.

2.2.2 Mobility Impairment

Mobility impairment refers to any limitation or difficulty in movement that affects a person's ability to walk, perform daily activities, or navigate their surroundings independently. It is a broad term that encompasses a range of symptoms such as weakness, poor coordination, spasticity, balance problems, and fatigue, especially prevalent in individuals with neurological disorders (Stolze *et al.*, 2005; Wuehr *et al.*, 2020). For many individuals, mobility is not just about getting from point A to point B, it is deeply intertwined with personal freedom, autonomy, and the ability to engage in everyday activities that give life meaning (Heesen *et al.*, 2008; Attias *et al.*, 2016).

The pathophysiology of mobility impairments varies depending on the specific neurological disorder but typically involves disruptions in the pathways between the brain, spinal cord, muscles, and peripheral nerves. In PD, for example, degeneration of dopaminergic neurons in the basal ganglia leads to difficulties initiating and controlling movement, resulting in symptoms like bradykinesia and gait freezing (Ramesh and Arachchige, 2023). In MS, damage to the myelin sheath of neurons disrupts nerve signal transmission, leading to muscle weakness, fatigue, and spasticity (Filli *et al.*, 2018; National Multiple Sclerosis Society, 2024). In conditions like ALS, the progressive degeneration of motor neurons results in muscle atrophy and loss of motor control, ultimately leading to significant mobility restrictions (Hogden *et al.*, 2017). For those affected, the loss of mobility often translates into a loss of independence, reduced social participation, and diminished quality of life (Mahlknecht *et al.*, 2013; Shafrin *et al.*, 2017; Wuehr *et al.*, 2020).The underlying causes of mobility impairments are often complex, involving multiple systems that govern balance, strength, and coordination.

Mobility impairments manifest differently across neurological conditions. In stroke survivors, unilateral weakness or paralysis (hemiparesis) is common, making walking difficult (Li, Francisco and Zhou, 2018; American Stroke Association, 2024; Stroke Association, 2024). For those with PD, gait is often shuffling, and there is an increased risk of falls due to impaired postural reflexes (Kim *et al.*, 2018) . Individuals with HD experience jerky, involuntary movements (chorea) that can interfere with steady movement (National Institute of Neurological Disorders and Stroke, 2024), while people with MS may struggle with profound fatigue, muscle stiffness, and weakness that vary from day to day (National Multiple Sclerosis Society, 2024). These impairments often increase reliance on mobility aids such as canes, walkers, or wheelchairs.

Mobility impairments are also critical indicators of disease progression and disability, making them key targets for rehabilitation and treatment strategies (Pearson *et al.*, 2004; Pantelaki, Maggi and Crotti, 2021). Identifying the root cause of mobility challenges, whether balance, muscle strength, or other factors, is crucial for tailoring interventions. Beyond the ability to move, the speed of walking itself is an important functional measure. Gait speed is a widely accepted measure of mobility, with slower walking speeds as a marker of disease progression and cognitive decline (Busse, Wiles and Van Deursen, 2006; Rasmussen *et al.*, 2019). Objective tools like the TUG test, 10-metre walk test, or the 6-Minute Walk Test evaluate an individual's ability to rise from a seated position, walk a certain distance, and return, providing insight into their functional mobility. These outcome measures are discussed in more detail later in this chapter (See section 2.3.2). Outcome measures can also be compared to norms or control groups to assess deviations and track changes over time. For example, a person's gait speed may be evaluated at different stages of the disease (early, mid, and late stages) and compared with healthy age-matched individuals. It can also be compared to later reassessments once rehabilitation commences to track progress.

Mobility impairments affect more than just physical movement. Clinically, they may be measured by evaluating muscle strength or balance, but functionally, these impairments impact a person's ability to perform daily tasks, engage in social activities, and live independently (Rosso *et al.*, 2013; Musich *et al.*, 2018). Psychologically, mobility impairments can lead to feelings of frustration, depression, and social isolation. The loss of mobility often forces individuals to rely on others for help with even basic tasks, which can erode their sense of autonomy and self-worth (Mahlknecht *et al.*, 2013; Shafrin *et al.*, 2017). The psychological burden of mobility loss is immense, as it fundamentally alters how individuals perceive themselves and interact with the world.

Rehabilitation for mobility impairments focuses on preserving and restoring function through targeted therapies. Physical therapy is one of the mainstays, incorporating exercises to improve strength, flexibility, and balance (Bhatia *et al.*, 2023). For example, individuals with PD benefit from strategies that focus on maintaining posture and enhancing gait patterns, while MS patients may undergo aerobic training to combat fatigue and stretching to manage spasticity. Assistive devices like walkers or orthotics may also be used to support safe movement (West *et al.*, 2015). Importantly, rehabilitation should be holistic, addressing not just the physical but also the psychological and functional aspects of mobility loss. Emotional support, including counselling or group therapy, may be necessary to help individuals cope with the mental strain of reduced independence. Finally, early and continuous rehabilitation interventions can help halt or slow the progression of mobility impairments, allowing individuals to retain their independence for as long as possible (Maresova *et al.*, 2023).

2.2.3 Physical Inactivity and Sedentary Behaviour

Physical inactivity and sedentary behaviour are increasingly recognised as serious public health concerns, particularly in populations with neurological disorders who face unique challenges in maintaining an active lifestyle (Kinnett-Hopkins *et al.*, 2017; Park *et al.*, 2020). For individuals living with conditions such as stroke, MS, PD, or SCI, engaging in regular physical activity can feel like an insurmountable challenge. As a result, they are more prone to physical inactivity and prolonged periods of sedentary behaviour, which can have profound implications for their overall health and well-being.

The WHO defines physical inactivity as failing to meet the minimum recommendation of 150 minutes of moderate to vigorous physical activity per week (Homer, Owen and Dunstan, 2019). On the other hand, sedentary behaviour refers to any waking activity that involves sitting or lying down with minimal energy expenditure, typically less than or equal to 1.5 metabolic equivalents (METs) (Rawlings *et al*., 2019; Fang *et al*., 2021). While these behaviours may seem harmless, their cumulative effects can be dangerous. A meta-analysis revealed that adults who sit for more than seven hours per day increase their risk of all-cause mortality by 5% for every additional hour of sitting, regardless of how much physical activity they may engage in otherwise (Chau *et al.*, 2013; Harvey, Chastin and Skelton, 2013).

This highlights a critical issue: the fact that even people who meet recommended physical activity levels may still spend a large portion of their day being sedentary, which independently raises their risk for chronic diseases such as cardiovascular disease, diabetes, and certain cancers (Wilmot *et al.*, 2012; Biswas *et al.*, 2015; Akksilp *et al.*, 2023). For individuals with neurological disorders, the situation can be even more concerning. Stroke survivors, for example, often struggle with mobility limitations that make it difficult to remain active. Similarly, people with MS or PD may face fatigue, muscle weakness, or balance problems, all of which can severely limit their ability to engage in physical activity (Billinger *et al.*, 2014; Thivel *et al.*, 2018).

The consequences of prolonged inactivity and sedentary behaviour are far-reaching. Beyond the physical health risks, such as increased risk for cardiovascular diseases, obesity, and metabolic disorders, these behaviours can lead to further declines in functional independence and quality of life (Akksilp *et al.*, 2023; Teno, Silva and Júdice, 2024). For individuals with neurological disorders, the cycle of inactivity can be challenging to break, as reduced physical capacity often leads to even greater sedentary behaviour, creating a negative feedback loop that is difficult to reverse. However, addressing these issues is crucial. Promoting even small increases in daily activity, such as engaging in light walking or performing seated exercises, can help break the cycle of sedentary behaviour. Rehabilitation programmes and tailored interventions that focus on movement, even in small doses, can help reduce the long-term impact of inactivity on health and support better outcomes for individuals with neurological conditions.

2.2.4 Cognitive Impairment

Cognitive impairment refers to a decline in cognitive abilities that can significantly disrupt an individual’s ability to perform everyday activities (Roy, 2013). It affects various domains of mental function, including memory, executive function, attention, decision-making, language, and visuospatial abilities (Mitchell and Byun, 2013; Dhakal and Bobrin, 2023). In neurological disorders, cognitive impairment is not merely a mild inconvenience but a common, profoundly debilitating consequence that erodes one's capacity to think, reason, and remember, creating a ripple effect across all areas of life (Mayo *et al.*, 2021). It is a symptom that often leaves individuals feeling isolated, frustrated, and dependent on others for basic tasks.

Cognitive impairment can manifest differently depending on the underlying disorder, ranging from mild cognitive deficits in the early stages to severe dementia in advanced cases (Zhang *et al.*, 2024). For instance, in AD, cognitive decline typically begins with short-term memory loss and progresses to severe disorientation and language difficulties (Porsteinsson *et al.*, 2021), while in PD, it often includes problems with executive function and attention (Degirmenci *et al.*, 2023). In stroke survivors, cognitive deficits may vary based on the brain region affected, with some individuals experiencing language impairments (aphasia) and others facing difficulties with spatial awareness (Gerstenecker and Lazar, 2019; Elendu *et al.*, 2023; American Stroke Association, 2024). In TBI, cognitive impairment can range from mild confusion and forgetfulness to profound memory loss and difficulties in concentration (Whiteneck, Gerhart and Cusick, 2004; Gratwicke, Jahanshahi and Foltynie, 2015; Rektorova, 2019; Koton *et al.*, 2022). This cognitive decline can be isolating and emotionally devastating for individuals. Regardless of the cause, cognitive impairment profoundly impacts an individual’s ability to live independently. Simple tasks like managing finances, cooking meals, or navigating familiar environments can become insurmountable challenges (Torpy, Burke and Golub, 2011; Widera *et al.*, 2011). As cognitive function declines, individuals often lose the ability to manage their personal affairs, creating a sense of helplessness and dependence on family members or caregivers. This decline can lead to a diminished quality of life and place a significant emotional and physical burden on those providing care (Emmady, Schoo and Tadi, 2022).

Cognitive impairment is often assessed through a series of neuropsychological tests, which measure various domains of cognitive function, including memory recall, attention span, problem-solving, and language skills. Standard tools used include the Mini-Mental State Examination (MMSE), Mini-Cog and the Montreal Cognitive Assessment (MoCA), which provide clinicians with a clearer picture of the extent and pattern of cognitive decline (Trzepacz *et al.*, 2015; Salis, Costaggiu and Mandas, 2023). These results can be compared to normative data from healthy individuals or tracked over time to evaluate the progression of cognitive decline or the effectiveness of a rehabilitation intervention. While there is no cure for many forms of cognitive impairment, particularly in neurodegenerative disorders, there are therapeutic interventions that can help slow the progression and improve the quality of life. Cognitive rehabilitation therapies, which involve structured activities to improve specific cognitive domains like memory or problem-solving, can help individuals maintain mental function for longer periods (Kudlicka *et al.*, 2019). In some cases, medications such as cholinesterase inhibitors slow cognitive decline, especially in conditions like AD (Sharma, 2019). Non-pharmacological strategies, such as exercise, mindfulness, and social engagement, have also been shown to help mitigate the cognitive decline associated with neurological disorders by promoting brain plasticity and improving emotional well-being (Remskar *et al.*, 2024).

2.2.5 Muscle Weakness

Muscle weakness is a debilitating and often overlooked symptom associated with many neurological disorders, profoundly affecting an individual's quality of life. It occurs when the communication between the brain, spinal cord, muscles, and nerves is disrupted, leading to a loss of strength and control (Jangra, Bhagat and Takkar, 2019). This loss of muscle strength can rob a person of their independence, making everyday activities like walking, holding objects, or even getting out of bed difficult or impossible.

The impact of muscle weakness goes far beyond the physical struggle. It can strip away a person's confidence and self-reliance, often leading to frustration, helplessness, and anxiety (Yamada *et al.*, 2017; Marques *et al.*, 2020; Cabanas-Sánchez *et al.*, 2022). Depending on the neurological condition, muscle weakness can take many forms. In stroke survivors, weakness is often unilateral, affecting only one side of the body (American Stroke Association, 2024). For those with TBI or SCI, it may be bilateral, affecting both sides of the body, further complicating mobility and balance (Guest *et al.*, 2022). In diseases like MS, weakness can vary in intensity and location, sometimes starting in one limb before gradually spreading to other body parts (National Institute of Neurological Disorders and Stroke, 2024). Each of these variations creates unique challenges for the affected individual, whether it's the difficulty of moving a single limb or the inability to stand or walk. The nature of the weakness often depends on the location and extent of the neurological damage (Nayak, 2017). For instance, in poliomyelitis, the weakness may be localised to one limb, while in conditions like ALS, GBS, or MS, the weakness can become more widespread. As these conditions progress, they can severely weaken the muscles used for movement and those required for essential functions like breathing, swallowing, and coughing (National Institute of Neurological Disorders and Stroke, 2024). In extreme cases, when the bulbar and respiratory muscles are affected, life-threatening complications may arise, requiring respiratory support to assist with breathing (Jangra, Bhagat and Takkar, 2019).

Muscle weakness can make even the simplest tasks, such as opening a jar or lifting a cup, feel insurmountable. Hand grip strength, a seemingly simple measure, has become an important tool in clinical settings to assess muscle function (Bohannon, 2015, 2019). This measurement doesn't just reflect a person's physical strength; it can also provide crucial insights into their overall health. Weak hand grip strength has been linked to an increased risk of falls, functional disability, cognitive decline, and even early mortality (Carson, 2018; Shaughnessy *et al*., 2020). For individuals with neuromuscular disorders, declines in hand grip strength are often due to reduced neuromuscular activation and decreased ability to recruit motor units effectively (Carson, 2018; McGrath *et al*., 2018, 2020).

Muscle weakness also brings with it a loss of freedom, as individuals may no longer be able to engage in activities they once enjoyed. The inability to move quickly or perform simple tasks independently can significantly decrease the quality of life (National Institute on Aging, 2020). Many people facing these challenges experience feelings of sadness or isolation, as their physical limitations make it difficult to participate in social or community activities. Caregivers, too, are affected, often taking on more responsibilities as the individual's physical abilities decline. Despite these challenges, it is essential to remember that muscle weakness is not always permanent. With early intervention, rehabilitation, and appropriate treatment, individuals can regain some strength and functionality, which can help restore a sense of autonomy and, importantly, hope.

2.2.6 Poor Quality of Life

Quality of Life (QoL) captures the lived experiences of individuals facing illness, including those with neurological disorders (Post, 2014). It refers to an individual's self-reported well-being and functioning across various domains of life. This concept reflects the extent to which a person can live well, rather than merely survive, in the presence of health challenges. They encompass a wide range of factors, from the ability to perform daily activities, such as dressing or working, to emotional well-being and feelings of happiness or sadness (Yin *et al.*, 2016; Kaplan and Hays, 2022). 'Functioning' refers to an individual's ability to perform certain activities, including self-care, work, and social functions, while 'well-being' refers to an individual's subjective feelings such as pain, happiness, sadness, depression, and so on (Hays and Reeve, 2008; Sitlinger and Zafar, 2018). Neurological disorders can profoundly impact an individual's quality of life, affecting their physical, psychological, and social well-being (Mitchell *et al.*, 2010). When an individual experiences a 'poor quality of life,' it signifies a substantial decline in both their ability to function and their overall well-being, a reality many people with neurological disorders face daily.

For many individuals living with neurological conditions, the physical symptoms they experience, like pain, muscle weakness, or fatigue, make even the simplest tasks feel insurmountable. A loss of autonomy and change in lifestyle can contribute to frustration and depression, negatively impacting the psychological aspects of QoL. This, in turn, can lead to social withdrawal and isolation, loss of employment, and financial strain, affecting the environmental and social domains of quality of life (Kaplan and Hays, 2022). Financial strain is another invisible weight that many individuals carry. Neurological disorders often cause a loss of employment or reduced work capacity, making it hard for individuals and their families to meet financial obligations. The cost of medical care, rehabilitation, and necessary home modifications can add up, exacerbating stress. The loss of financial independence can also intensify feelings of inadequacy or dependence, further impacting a person’s emotional well-being (Kaplan and Hays, 2022).

Measuring QoL, a complex, multi-dimensional concept, goes beyond assessing physical health. It encompasses an intricate blend of an individual’s physical, psychological, social and environmental well-being; for individuals with neurological disorders, each can be deeply affected (Bullinger and Quitmann, 2014; Estoque *et al.*, 2019). When assessing QoL in individuals with neurological disorders, researchers and clinicians utilise various outcome measures designed to capture these diverse components. However, the extent to which these measures cover each aspect can vary, and understanding their scope is crucial for obtaining a comprehensive picture of a person's lived experience. Most standardised QoL instruments, like Short Form Health Survey-36 and World Health Organisation Quality of Life, strive to assess multiple domains to provide a holistic understanding of an individual's well-being (Den Oudsten and Skevington, 2022). In contrast, disease-specific QoL instruments, such as stroke-specific quality of life, delve deeper into how the disease impacts an individual's life, offering deeper insights that general measures might overlook (Pequeno *et al.*, 2020). These outcome measures are discussed in more detail later in the chapter (section 2.3.4). Selecting appropriate measures requires balancing comprehensive assessment with practicality, so researchers and clinicians often choose tools based on the specific goals of their study or the needs of their patients.

2.2.7 Pain

Pain is more than just a physical sensation; it’s an experience that encompasses both sensory and emotional dimensions. The International Association for the Study of Pain (IASP) defines it as “an unpleasant sensory and emotional experience associated with or resembling that associated with actual or potential tissue damage” (International Association for the Study of Pain, 2020; Raja *et al.*, 2020). For many, pain is a temporary, fleeting occurrence, like a stubbed toe or a headache that eventually subsides. However, when pain persists for over three months, it becomes chronic, embedding itself into a person’s daily life (Inoue *et al.*, 2017). Chronic pain often brings with it additional sensory disturbances such as nociceptive hyperalgesia, increased sensitivity to painful stimuli and tactile allodynia, where even a light touch can trigger intense pain (Borsook, 2012; Inoue *et al.*, 2017; Blanton, Reddy and Benamar, 2023).

Chronic pain is a common, debilitating companion to many neurological disorders. It’s one of the primary reasons people seek medical care because it limits mobility, interferes with daily tasks, and severely impacts quality of life (Blanton, Reddy and Benamar, 2023). This kind of pain doesn’t just affect the body; it also affects the mind, relationships, and overall sense of well-being. When pain becomes a constant presence, it can dominate a person’s life, influencing everything from how they move to how they sleep and even how they interact with others. For people with neurological disorders, this reality is all too familiar (Dueñas *et al.*, 2016).

The pain experienced by individuals with neurological conditions is often neuropathic, meaning it stems from dysfunction in the central or peripheral nervous system. Neuropathic pain can range from mild discomfort to excruciating, unrelenting agony, affecting both the body and mind (Bouhassira and Attal, 2023). Unfortunately, the complex nature of neurological pain means that it is often under-recognised or misunderstood, leaving many individuals suffering in silence (Sabater-Gárriz *et al.*, 2024).

The prevalence of pain across various neurological disorders highlights its wide-reaching impact. It affects 40-60% of people with PD, a condition already fraught with motor impairments and stiffness (Simuni and Sethi, 2008; Ford, 2010). For individuals with AD, 45.8-57% experience pain, which can often go underreported or untreated due to communication difficulties as the disease progresses (Pautex *et al.*, 2006; Blanton, Reddy and Benamar, 2023). Pain is also a frequent and troubling symptom in HD (41%) (Sprenger *et al.*, 2019), stroke survivors (11-66%) (Harrison and Field, 2015), and MS, where as many as 29-83% of individuals report pain as a significant part of their condition (Heitmann *et al.*, 2022). SCI leads to pain in 68.9% of cases (Müller *et al.*, 2017; Hunt *et al.*, 2021), while TBI results in pain for 51% of affected individuals (Nampiaparampil, 2008). Even in ALS, known primarily for its motor neuron degeneration, up to 60% experience significant pain (Hurwitz et al., 2021), and GBS sees rates between 34.5-66% (Ruts *et al.*, 2010; Yao *et al.*, 2018).

Living with chronic pain often feels like carrying an invisible burden. It’s not just the pain itself but the emotional and psychological toll it takes, leading to anxiety, depression, and, in many cases, a sense of hopelessness (Miller and Kaiser, 2018). Managing this pain often requires a multidisciplinary approach: pain medications, physical therapy, psychological support, and sometimes, invasive procedures (Danilov *et al.*, 2020; Connell *et al.*, 2022). However, despite advancements in treatment, chronic pain remains a significant challenge for individuals with neurological disorders, profoundly affecting their daily lives and the healthcare systems that support them.

Unfortunately, this research did not assess pain as an outcome measure. However, since it is a crucial component of the lived experiences of individuals with neurological disorders, participants in the qualitative research reported that the intervention addressed it.

2.2.8 Fatigue

Fatigue is more than just feeling tired after a long day. It is a deep, overwhelming sense of physical or mental exhaustion that can persist even after rest (Penner and Paul, 2017). Fatigue is defined as "a subjective lack of physical or mental energy perceived by an individual or caregiver that interferes with usual and desired activity" (Zwarts, Bleijenberg and van Engelen, 2008; Khan, Amatya and Galea, 2014; Skau, Sundberg and Kuhn, 2021). This distinction is critical because unlike normal tiredness, which is usually the result of physical exertion or lack of sleep and improves with rest, neurological fatigue often relates little to activity levels and may not be alleviated by sleep or rest (Penner and Paul, 2017). Instead, it can feel relentless, weighing down the body and mind and interfering with the simplest daily tasks.

For individuals with chronic neurological disorders, fatigue is a constant and debilitating presence. It affects physical abilities and the very essence of how a person experiences life. Fatigue is a top distressing symptom associated with neurological conditions like MS, MG, poliomyelitis, and stroke (Penner and Paul, 2017). In fact, it is a significant complaint in MS, where up to 90% of individuals experience fatigue that dramatically reduces their quality of life (Walker *et al.*, 2012). This type of fatigue is not just an inconvenience; it can be disabling, leaving individuals feeling disconnected from the life they once knew. Unlike everyday tiredness, neurological fatigue can be disproportionate to activity levels. It might come on after minimal effort or sometimes even without exertion, making it particularly frustrating and unpredictable (Levine and Greenwald, 2009). A person may sleep through the night yet wake up still feeling drained. It's no wonder that fatigue can have profound psychological effects, leading to frustration, depression, and even social isolation as individuals withdraw from activities they once enjoyed (Robinson *et al.*, 2015).

Despite its prevalence, the underlying mechanisms of fatigue in neurological disorders remain poorly understood. This lack of clarity makes it difficult to develop effective, targeted treatments. Current evidence suggests that neurological fatigue is likely a result of complex interactions between the brain, immune system, and energy metabolism (Rudroff, 2024). Still, continued research is necessary to fully understand the underlying mechanisms. Compounding the challenge, limited pharmacological options have been proven to effectively treat this type of fatigue, leaving many individuals searching for ways to cope (Kos *et al.*, 2008; Khan, Amatya and Galea, 2014). Management of neurological fatigue often focuses on non-pharmacological approaches. Exercise, yoga, and mindfulness-based stress reduction are commonly recommended strategies to build resilience and manage fatigue's physical and emotional toll (Zielińska-Nowak *et al.*, 2020; Wender, Manninen and O'Connor, 2022). These interventions may not cure fatigue, but they can help individuals reclaim some sense of control and improve their overall well-being. Exercise, for example, has been shown to improve energy levels and reduce fatigue in people with MS, despite the seeming paradox of physical activity for someone already feeling exhausted (Heine *et al.*, 2015).

2.2.9 Cardiovascular Problems

Cardiovascular problems are prevalent in individuals with neurological disorders and can significantly influence their overall health and quality of life (Benjamin *et al.*, 2019; Khemani and Mehdirad, 2020). The cardiovascular system is crucial for maintaining blood flow to all tissues, including the brain, and its dysfunction can exacerbate or result from neurological conditions (Broughton, 2018). Neurological disorders such as stroke, PD, MS, and SCI can all affect cardiovascular health, leading to issues like hypertension, abnormal heart rates, and reduced cardiovascular endurance (Khemani and Mehdirad, 2020).

Cardiovascular problems refer to a group of disorders involving the heart and blood vessels, which can manifest as hypertension, coronary artery disease, arrhythmias, heart failure, and vascular damage (World Health Organisation, 2021). The mechanisms by which they arise in neurological conditions are multifactorial. In stroke and SCI, for instance, brain or spinal cord damage disrupts the autonomic nervous system, which controls heart rate, blood pressure, and vascular tone (Wulf and Tom, 2023). This can lead to dysregulated blood pressure and a heightened risk of cardiac events (Masenga and Kirabo, 2023). Similarly, PD and MS are associated with autonomic dysfunction, leading to cardiovascular irregularities, including orthostatic hypotension, arrhythmias, and fatigue due to poor circulatory efficiency (Findling *et al.*, 2020; Pfeiffer, 2020; Zhang and Chen, 2020). Individuals with cardiovascular problems may experience various symptoms, including chest pain, shortness of breath, dizziness, and palpitations (Barnett *et al.*, 2017). Autonomic dysfunction, prevalent in many neurological conditions, can manifest as abnormal blood pressure regulation, excessive heart rate variability, and circulatory abnormalities (Zhang and Chen, 2020; Siepmann *et al.*, 2022).

Blood pressure and heart rates were specifically assessed in this study as key indicators of cardiovascular health. Both are important clinical measures for identifying abnormalities in cardiovascular function that may accompany neurological conditions (Muntner *et al.*, 2019).

Blood pressure helps monitor hypertension, hypotension, and other pressure-related disorders, while heart rate can signal arrhythmias or other irregularities (Zaza, Ronchi and Malfatto, 2018; Alugubelli, Abuissa and Roka, 2022). These cardiovascular assessments are crucial in the rehabilitation of individuals with neurological disorders, as unaddressed cardiovascular issues can slow recovery and increase morbidity (Fawzy and Lip, 2021). These measurements are often compared across different stages of disease progression and against control populations to understand the impact of neurological disorders on cardiovascular health (Rumsfeld *et al.*, 2013). Other tests for cardiovascular assessment include electrocardiograms for arrhythmias, stress tests for exercise tolerance, and pulse oximetry for oxygen saturation.

Addressing cardiovascular problems in individuals with neurological disorders is a critical component of comprehensive care. Management strategies typically include a combination of pharmacological interventions and lifestyle modifications to improve cardiovascular health (Ghodeshwar, Dube and Khobragade, 2023; Kolanu *et al.*, 2024). Exercise can enhance heart health, reduce blood pressure, and improve overall endurance when appropriately tailored. Interventions might include aerobic training, resistance exercises, and activities to improve autonomic regulation (Zhang and Chen, 2020).

2.3 Review of Outcome Measures

Outcome measures are standardised tools or instruments used to assess the results of interventions in clinical and research settings. They provide a quantifiable means of evaluating changes in a patient's health, functioning, or quality of life and offer an objective framework for tracking progress over time (Jazieh, 2020). For researchers and clinicians, outcome measures are essential for ensuring studies' validity, reliability, and reproducibility, facilitating meaningful comparisons across studies and patient groups (Coster, 2013). Their importance lies in their ability to translate subjective experiences into data that can guide improvements in care, treatment, and health outcomes (Al Sayah, Jin and Johnson, 2021).

In clinical practice, outcome measures help healthcare professionals make informed decisions about patient care, tailoring interventions based on individual progress (Al Sayah, Jin and Johnson, 2021). They allow for monitoring patient responses, identifying any needs for adjustments, and offering an evidence-based approach to optimise treatment plans. Furthermore, outcome measures support communication between clinicians and patients by providing a clear, measurable understanding of health changes and empowering patients in their care journey (Nelson *et al.*, 2015). In research, outcome measures are essential for validating the effectiveness of treatments, therapies, or interventions, ensuring that results are not based solely on subjective or anecdotal evidence (Nelson *et al.*, 2015). Outcome measures also play a pivotal role in research, providing the foundation for evidence-based practice. This section will review various outcome measures to evaluate the key outcomes in this research and the reason behind the selected choice of instrument.

2.3.1 Outcome Measures for Balance

Balance is the foundation for several functional activities like mobility, self-care, and fall avoidance (Howe, Smajdor and Stöckl, 2012). Numerous tools, as many as 56, are used to measure balance in various populations, reflecting the absence of a gold standard outcome measure for balance assessment (Tyson and Connell, 2009a; Sibley *et al.*, 2015). The most commonly used generic outcome measures for balance measurement include the BBS, mini balance evaluation systems test (mini-BESTest), TUG, FRT and one leg stance (OLS) test, also called single leg stance test (SLST). As the risk of falls is closely linked to balance, most outcome measures used for assessing balance are equally used to predict the risk of falls in a given population (Chomiak *et al.*, 2015; Louie and Eng, 2018). A comparison of these outcome measures is presented in Table 2.1 below.

The reliability and validity of these outcome measures have been widely established and used in community-dwelling adults and people with neurological disorders for BBS (Downs, 2015; Schlenstedt *et al.*, 2015; Claesson, 2018; Taghizadeh *et al.*, 2018), mini-BESTest (Leddy, Crowner and Earhart, 2011; King *et al.*, 2012; Tsang *et al.*, 2013), TUG (Flansbjer *et al.*, 2005; Knorr, Brouwer and Garland, 2010; Sarac, Unver and Karatosun, 2022), OLS (Flansbjer *et al.*, 2005; Chomiak *et al.*, 2015; Sarac, Unver and Karatosun, 2022) and FRT (Steffen and Seney, 2008). Despite having acceptable validity and reliability, the evidence supporting sensitivity and responsiveness has only been reported for TUG (Alghadir *et al.*, 2018; Spagnuolo *et al.*, 2018) and mini-BESTest (Hasegawa *et al*., 2021; Löfgren *et al*., 2014; Phyu *et al*., 2022; Phyu, Wanpen and Chatchawan, 2022) but not for BBS (Winser *et al.*, 2019). This makes TUG and mini-BESTest the recommended options to assess balance for different populations and for clinicians to consider to detect clinically meaningful patient recovery changes over time (Di Carlo *et al.*, 2016).

Table 2.1 Summary of some Balance Outcome Measures Comparison

Outcome measures	Psychometric properties	Pros	Cons
BBS	High inter-rater (0.97) and intra-rater (0.99) reliability and good construct validity. Moderate responsiveness (2.7). (Alghadir *et al.*, 2018)	Comprehensive assessment of static and dynamic balance. High reliability and validity.	Time-consuming, ceiling effects in high-functioning individuals.
Mini-BESTest	High inter-rater (0.95) and intra-rater (0.93) reliability, strong concurrent validity, and highly sensitive to change (2.16). (Phyu *et al.*, 2022)	Detailed dynamic balance assessment, shorter than full BESTest. Sensitive to balance issues.	It takes slightly longer to administer and requires more equipment.
TUG	High (0.98) reliability, good predictive validity for falls, moderate responsiveness (3.2s). (Alghadir *et al.*, 2018)	Quick, easy to administer, minimal equipment required. Strong fall risk predictor.	Focuses on mobility, less effective in detecting subtle balance deficits.
FRT	High test-retest (0.84-0.86) reliability, good criterion validity for fall risk prediction, and moderate (8.28cm) responsiveness. (Soke *et al.*, 2022)	It is simple, quick, and requires minimal equipment. Assesses dynamic balance.	It only assesses forward reach and is not comprehensive for multidirectional balance deficits.
OLS	Moderate to high test-retest (0.88-0.92) reliability, good validity for static balance. (Flansbjer *et al.*, 2012)	Simple, quick, effective for static balance and fall risk assessment.	Focuses on static balance, not suitable for dynamic balance.
3MBWT	High test-retest (0.85-0.97) reliability, good validity, and sensitivity (2.13s) to subtle balance issues. (Kocer *et al.*, 2023)	Quick to administer, backwards walking is sensitive to balance impairments.	Limited to backward walking, challenging for severely impaired individuals, not comprehensive.

The BBS test measures an individual's sitting, standing, and dynamic balance through various tasks. It is more suitable for people with lower functional abilities as it has a known ceiling effect when used in high-functioning individuals (Chou *et al*., 2006; Lemay and Nadeau, 2010; Miklitsch *et al*., 2013). The scale consists of 14 items, including sitting and standing unsupported, standing with eyes closed, feet together, on one foot, with one foot placed in front of the other, turning to look backwards, reaching forward with extended arms, picking up an object from the floor, sitting to standing, standing to sitting, turning around 360 degrees, and placing one foot on a step (Neuls *et al.*, 2011; Park and Lee, 2017; Azuma, Chin and Miura, 2019). Each task is scored between 0-4, with a maximum total score of 56, with higher scores corresponding to better balance.

The BBS was initially developed for use in the geriatric population in 1989 but has since been widely validated and used in other populations, such as neurological disorders (Lemay and Nadeau, 2010; Schlenstedt *et al.*, 2015; Alghadir *et al.*, 2018; Taghizadeh *et al.*, 2018), musculoskeletal conditions (Jogi *et al.*, 2010; Azuma, Chin and Miura, 2019), cardiopulmonary diseases (Jácome *et al.*, 2016), older people (Marques *et al.*, 2016) and learning disabilities (Sackley *et al.*, 2005). Furthermore, the BBS tool evaluates different aspects of balance, including static and dynamic stability, anticipatory postural control, and sensory integration. However, it does not measure reactive postural control, crucial for preventing falls (Sibley *et al.*, 2015). Unlike other tests that require individuals to walk or stand independently, the BBS can be used for those unable to move from a chair, further supporting its recommendation for lower-functioning individuals (Sibley *et al.*, 2015).

On the other hand, the mini-BESTest was developed much later in 2010 and revised in 2013 as a shortened version of the original BESTest to address the time-consuming problem of the original version and make it more clinically friendly (Horak, Wrisley and Frank, 2009; Franchignoni *et al.*, 2010). The mini-BESTest is a 14-item clinical balance test that assesses sensory orientation, dynamic gait, and anticipatory and reactive postural control (Sibley *et al.*, 2015). Unlike BBS, mini-BESTest assesses more aspects of postural control, making it a more comprehensive measure of balance (Sibley *et al.*, 2015). It is valid and reliable and has been reported as a very useful tool for predicting falls in people with PD (Leddy, Crowner and Earhart, 2011; Duncan and Earhart, 2012; King *et al.*, 2012; Duncan *et al.*, 2013). Mini-BESTest has recorded minor ceiling effects in high-functioning neurological patients but less than BBS (Godi *et al.*, 2020).

The TUG test is commonly used to evaluate dynamic balance, functional mobility, and fall risk. It was developed in 1991 as a modified timed version of the Get up and Go test (Mathias, Nayak and Isaacs, 1986; Podsiadlo and Richardson, 1991). The individual is timed as they are asked to rise from an armchair, walk comfortably and safely for 3 metres, turn at the 3-metre marked point, walk back to the chair, and sit back down. A walking aid can be used if necessary, but this is noted. A duration of 13.5 seconds or more is associated with an increased risk of falls in older adults (Barry *et al.*, 2014). The TUG, OLS, and FRT are all single-task measures, meaning they do not evaluate the various components of balance that multiple-task measures like BBS do (Flansbjer *et al.*, 2005; Pollock *et al.*, 2011).

Multiple-task measures are more effective at providing a comprehensive assessment of balance, which helps to focus on treating the specific aspect of balance deficit. However, because they take longer to administer, single-task measures are sometimes preferred in clinical settings (Pollock *et al.*, 2011; Wong, Chen and Welsh, 2013). OLS measures the length of time (in seconds) an individual can stand on one leg. This test can be performed with either open or closed eyes (Flansbjer, Lexell and Brogårdh, 2012). On the other hand, FRT assesses balance by measuring the furthest distance in centimetres that an individual can reach forward beyond arm's length on a fixed base of support (Steffen and Seney, 2008). Some studies have found that OLS and FRT have significant floor or ceiling effects (Blum and Korner-Bitensky, 2008; Tyson and Connell, 2009b). Additionally, it has been found that a shorter time for OLS and a shorter distance for FRT can predict the occurrence of falls (Lin *et al.*, 2004, 2010). TUG is recommended for frailer or mobility aid users, while OLS and FRT suit healthier seniors (Moen *et al.*, 2018).

In contrast to these outcome measures already described, the 3-metre backward test (3MBWT), which is the outcome measure of choice for this research, is a relatively recent outcome measure used to assess balance and risk of falls. It was developed in 2019 as a clinical tool for fall risk evaluation in community-dwelling older adults (Carter *et al.*, 2019). Unlike traditional measures such as BBS, TUG, and mini-BESTest, which primarily evaluate the ability to walk forward, turn around and step, 3MBWT is more challenging because it requires reliance on neuromuscular control, proprioception and protective reflexes (Abit Kocaman *et al.*, 2021).

Backwards walking is essential to performing daily tasks such as walking backwards, backing up a door or chair, and getting out of the way of a sudden obstacle (Carter *et al.*, 2020). Research has shown that walking backwards is more sensitive to identifying health-related changes in mobility and balance than walking forward (Wang, Xu and An, 2019; Maritz *et al.*, 2021). Recent research indicates that backward walking might be a better way to identify the impairment level in gait than forward walking and multiple task measures (Kwon *et al.*, 2019). It has gained increased use as a valid and reliable functional tool for measuring dynamic balance and fall risks in diverse populations, including PD (Kocer *et al.*, 2023), stroke (Abit Kocaman *et al.*, 2021), spinal cord injury (Foster *et al.*, 2016), fibromyalgia (Leon-Llamas *et al.*, 2023), older adults (Maritz *et al.*, 2021), MS (Bilek and Demir, 2022; Kirmaci *et al*., 2022), arthroplasty (Özden, Coşkun and Bakırhan, 2021) and dementia (Chan *et al.*, 2022). Evidence shows that the 3MBWT showed better diagnostic accuracy for falls than most traditional measures (Carter *et al.*, 2020).

2.3.2 Outcome Measures for Walking Speed

Walking speed, also called gait speed, has been labelled the sixth vital sign due to its significance in clinical practice and research (Fritz and Lusardi, 2009). The most used outcome measures for assessing walking speed include the 10-metre walk test (10MWT), 4-metre walk test (4MWT), 6-minute walk test (6MWT) and 2-minute walk test (2MWT). These tests primarily assess individuals' walking speed by recording the time taken to cover a specified distance or the distance covered within a specified time. A comparison of these tools is summarised in Table 2.2 below.

6MWT is a tool first designed in 2002 to measure response to treatment in people with cardiopulmonary conditions (Holland *et al.*, 2014; Kammin, 2022). However, it is now used to measure walking speed, aerobic capacity and endurance in various populations (Kammin, 2022). The validity, reliability and responsiveness have been widely established in different populations, such as those with COPD (Celli *et al.*, 2016; Aalstad *et al.*, 2018), total knee arthroplasty (Ko *et al.*, 2013), post-amputation (Resnik and Borgia, 2011), AD (Ries *et al.*, 2009), SCI (Lam, Noonan and Eng, 2008), Stroke (Flansbjer *et al.*, 2005), COVID-19 (Robinson *et al.*, 2021; Burnfield *et al.*, 2022; Klanidhi *et al.*, 2022), etc. To perform this test, an indoor walking space of over 30 metres is required, and the participant is asked to walk as far as possible for 6 minutes while being timed. They are allowed to slow down, stop or take a rest before continuing. At the end of 6 minutes, the distance covered is recorded in meters (Holland *et al.*, 2014).

Despite its usefulness and clinical relevance, the 6MWT can be logistically challenging in certain situations, which has led to an efficient substitute requiring minimum space and less time to perform (Bhattacharyya *et al.*, 2020). The 2MWT assessment has been developed to evaluate walking ability in individuals with difficulty tolerating the longer 6MWT test due to weakness (Darke *et al.*, 2006; Bohannon, Wang and Gershon, 2015; Vill *et al.*, 2015). This test is considered a promising alternative to the longer version for people who cannot handle the extended test duration. 2MWT has been validated and proven reliable across various populations as a measure of endurance, as demonstrated in studies (Leung *et al.*, 2006; Connelly *et al.*, 2009; Selman *et al.*, 2014; Bohannon, Wang and Gershon, 2015; Witherspoon *et al.*, 2019; Karle *et al.*, 2020).

Table 2.2 Summary of some Walking Speed Outcome Measures Comparison

Outcome measures	Psychometric properties	Pros	Cons
10MWT	High reliability and validity, moderate responsiveness.	Quick and easy to administer, minimal equipment required. Strong measure of gait speed.	It only assesses short-distance walking and does not measure endurance or functional capacity.
4MWT	High reliability, good predictive validity, and moderate responsiveness.	Quick to perform, minimal space and equipment required. Reliable gait speed indicator.	Short-distance walking only, limited scope for assessing endurance or real-world mobility.
6MWT	High reliability, strong validity, and responsiveness to changes in endurance and mobility.	Measures endurance, widely used across multiple populations. A strong predictor of functional capacity.	It requires a long, unobstructed path, time-consuming, and can be physically demanding.
2MWT	Moderate to high reliability, good validity for certain populations, moderate responsiveness.	Quicker and less fatiguing than the 6MWT, appropriate for frail individuals.	It is less comprehensive than 6MWT in assessing endurance, not as widely validated.

On the other hand, 4MWT and 10MWT are also used to assess walking speed by recording the time taken to cover a specified distance. In this research study, the instrument of choice used is the 10MWT. This tool is well tolerated among most patient groups, and it is a simple way to assess gait speed in clinical and research settings for adults and children (Pizzato *et al.*, 2016; Duncan *et al.*, 2017; Niu *et al.*, 2017; de Baptista *et al.*, 2020) with neurological disorders. The test is conducted by asking an individual to walk as much as they safely can over a marked distance of 10 metres while being timed with a valid timing device. If necessary, the individual can use an assistive device, which is then noted. The distance of 10 metres is divided by the time taken to cover the distance in seconds to obtain the walking speed score in metres per second (mls). Studies have shown, through 10MWT, how walking speed declines with age, starting at 50 and decreasing each decade (Bohannon and Williams, 2011; Frimenko, Goodyear and Bruening, 2015).

10MWT has been widely reported to have high validity, reliability and responsiveness in different populations, including people with SCI (Kahn and Tefertiller, 2014; Rini *et al.*, 2018), Down syndrome (Sánchez-González *et al.*, 2023), TBI (van Loo *et al.*, 2004), MS (Paltamaa *et al.*, 2008), stroke (Flansbjer *et al.*, 2005) and older adults (Perera *et al.*, 2006). It is sensitive to minimal changes in comfortable walking speed and indicates clinical progress or deterioration (Flansbjer *et al.*, 2005). However, because it requires a flat, straight hallway of at least 14 metres, this space requirement may be problematic in some clinical settings (Amatachaya *et al.*, 2014; Fernández-Huerta and Córdova-León, 2019). The distance could also be challenging for some individuals who fatigue easily or have severe gait impairments (Cabanas-Valdés *et al.*, 2023).

To address these issues, a shorter 4MWT was introduced initially as part of the Short Physical Performance Battery tool and later used as an independent walking speed outcome measure (Fernández-Huerta and Córdova-León, 2019; Nguyen *et al.*, 2022). The 4MWT has demonstrated reliability and validity in measuring walking speed in different populations (Kittelson *et al.*, 2022; Cabanas-Valdés *et al.*, 2023). Although 4MWT may be preferred for its space and time effectiveness in routine clinical assessments, 10 metres has been reported as the minimum functionally significant distance in independent walking recovery and the typical distance in clinical gait remediation (Watson, 2002).

2.3.3 Outcome Measures for Physical Activity Level

Given the high rates of physical inactivity and sedentary behaviour, there is an increasing emphasis on developing lifestyle interventions to promote physical activity in adults (Silfee *et al.*, 2018). Assessing the impact of these interventions accurately is crucial for research, clinical practice, and public health. Various subjective and objective outcome measures have been validated for this purpose (Tudor-Locke and Myers, 2001). Self-reported questionnaires are widely used due to their practicality, versatility, low cost, and ease of use (Welk, 2002; Demetriou, Ozer and Essau, 2015). Common examples include the International Physical Activity Questionnaire (IPAQ), Global Physical Activity Questionnaire (GPAQ), and Physical Activity Scale for the Elderly (PASE). A comparison of physical activity level instruments is summarised in Table 2.3 below.

Despite their advantages, these tools are subject to measurement errors, recall bias, social desirability bias, and interpretation issues (Prince *et al.*, 2008; Silfee *et al.*, 2018). To mitigate the limitations of subjective measures, objective tools have been developed to directly assess physical activity dimensions such as frequency, intensity, time, and type (Strath *et al.*, 2013). Objective measures include accelerometers, pedometers, doubly labelled water, heart rate monitors, respiratory gas analysis, and direct observation. Research indicates significant discrepancies between activity levels reported by subjective measures and those obtained from objective methods, with self-reports often overestimating activity levels (Arvidsson *et al.*, 2011; Dyrstad *et al.*, 2014; Hukkanen *et al.*, 2018).

Table 2.3 Summary of some Physical Activity Level Outcome Measures Comparison

Outcome measures	Psychometric properties	Pros	Cons
IPAQ	Moderate reliability and validity. Good for large population studies.	Easy to administer, captures physical activity in different domains.	Prone to recall and social desirability bias, limited accuracy for intensity and duration.
GPAQ	Moderate reliability and validity. Specifically designed for global use.	Quick, easy to use, and covers multiple domains.	Similar to IPAQ in limitations; recall bias and limited intensity/duration accuracy.
PASE	High reliability for older adults. Moderate validity.	Tailored for elderly populations, captures light/moderate activity well.	Self-reported, not suitable for younger populations or high-intensity activity.
DLW	Extremely high reliability and validity. Gold standard for total energy expenditure.	Gold standard for energy expenditure, completely objective, highly accurate.	Very expensive, does not provide detailed data on activity type, intensity, or patterns.
Accelerometers	High reliability and validity. Gold standard for objective physical activity measurement.	Accurate, provides detailed information on intensity, duration, and frequency of activity.	Expensive, requires technical expertise, cannot differentiate between activity types.
Pedometers	High reliability for step counts but lower validity for intensity and duration.	Affordable, simple, and provides step count data.	Limited to step counting, does not capture intensity, duration, or other forms of physical activity.

While objective measures directly or indirectly assess physical activity levels, some can only evaluate the intensity of a single physical activity and are unsuitable for monitoring patterns of physical activity over an extended period (Steultjens, Bell and Hendry, 2023). These include respiratory gas analysis, heart rate monitors, and rate of perceived exertion scales, which provide data on oxygen uptake and energy expenditure during specific activities. Conversely, other objective measures, such as doubly labelled water (DLW) and wearable sensors, can track patterns of physical activity and sedentary behaviour over time (Steultjens, Bell and Hendry, 2023). DLW, considered the gold standard for measuring total energy expenditure, involves analysing bodily fluids like saliva, urine, or blood after ingesting isotopes of water (^2H_2O and $H_2{}^{18}O$) to estimate energy consumption over a prolonged period (Hallal *et al*., 2013). Although highly accurate in estimating carbon dioxide production, DLW is expensive and impractical for large studies. It cannot identify specific activity patterns, such as light physical activity or time spent in sedentary behaviour.

To address some of these limitations, body-worn devices like pedometers and accelerometers were developed. Pedometers are simple tilt devices worn on the body that record step counts (Baskerville *et al.*, 2017). There are two main types: spring-levered pedometers, which use a spring to move a horizontal beam with each vertical movement of the hip, and piezo-electric pedometers, which use a beam that compresses a piezo-electric crystal with each acceleration to record steps (Clemes and Biddle, 2013). Studies have shown that both types are valid and reliable for children and adults (Louie and Chan, 2003; McKee *et al.*, 2005; Cardon and de Bourdeaudhuij, 2007). However, spring-levered pedometers are less accurate at slow walking speeds and are affected by the device's tilt angle (Crouter *et al.*, 2003; Le Masurier and Tudor-Locke, 2003; Clemes and Parker, 2009; Feito *et al.*, 2011). Conversely, piezo-electric pedometers are more accurate across all walking speeds and less affected by the tilt angle (Duncan *et al.*, 2007; Hazell *et al.*, 2016). Despite their low cost, simplicity, and practicality, pedometers only measure step counts and cannot capture other physical activity components, such as intensity, duration, and frequency (McNamara, Hudson and Taylor, 2010).

On the other hand, accelerometers, which are more recently developed, use time-based movement sensors to log the time and intensity of activities as well as periods of inactivity (Baskerville *et al.*, 2017). They are worn on the body and can detect acceleration along one axis (vertical plane) or three axes (vertical, frontal, and sagittal planes) (Steultjens, Bell and Hendry, 2023). Although accelerometers are the most accurate and commonly used objective measures of physical activity and sedentary behaviour, they may underestimate activity levels as they do not capture water-based activities or non-locomotor activities like swimming and upper limb exercises (Lee and Shiroma, 2014). They are also susceptible to tampering or data loss from damage or misplacement (Dollman *et al.*, 2009). Despite these advancements in objective measures, self-reported instruments remain advantageous for large-scale studies due to their affordability and practicality (Leggett *et al.*, 2016).

The IPAQ is the most commonly used subjective instrument and the choice outcome measure for this study. It was chosen for its ease of administration, cost-effectiveness and practicality of use for longitudinal studies. It is a standardised, self-report generic instrument developed in 1999 to assess physical activity levels in the population (Cleland *et al.*, 2014). Evidence of its validity and reliability exists in different populations and countries (Tomioka *et al.*, 2011;

Cerin, 2012; Van Holle *et al.*, 2015; Cleland *et al.*, 2018). IPAQ assesses physical activity frequency, intensity, and duration through four domains (work, transport, household and leisure) and sedentary behaviour (Craig *et al.*, 2003; Sember *et al.*, 2020). It can be self-administered and administered through face-to-face interviews or telephone interviews (Craig *et al.*, 2003).

Another generic self-report measure of physical activity level is the GPAQ, which was developed in 2002 by the WHO for surveillance purposes (Bull *et al.*, 2020). It consists of 16 questions designed to estimate an individual's activity level in 3 domains (work, transport and leisure time) and time spent in sedentary behaviour (Bull, Maslin and Armstrong, 2009; Singh and Purohit, 2011). It doesn't measure household activities, unlike the IPAQ. GPAQ has shown evidence of validity and reliability in various countries, including Malaysia, Vietnam and the United States (Bull, Maslin and Armstrong, 2009; Hoos *et al.*, 2012; Herrmann *et al.*, 2013).

2.3.4 Outcome Measures for Quality of Life

Assessing QoL has become crucial in clinical research, public health, and healthcare practices, reflecting a comprehensive approach to health and well-being that encompasses physical, psychological, and social dimensions (Burckhardt and Anderson, 2003; Bullinger and Quitmann, 2014; Estoque *et al.*, 2019). Accurate measurement of QoL is essential for evaluating the impact of diseases, treatments, and interventions on overall well-being and for guiding healthcare policy and clinical decision-making (King *et al.*, 2016; Łaszewska *et al.*, 2022). Objective measurements of QoL typically involve quantifiable data collected through clinical assessments, biological markers, or performance-based measures (Muldoon *et al.*, 1998; de Wit, 2020). These methods provide direct, measurable indicators of an individual's physical health, the presence of symptoms or side effects and changes in functional abilities (de Wit, 2020). However, while objective measures can provide valuable data on certain aspects of health and functioning, they often overlook the equally important psychological and social dimensions (Den Oudsten and Skevington, 2022).

The subjective nature of QoL means that an individual's satisfaction with life, sense of well-being, and personal happiness are central components that objective measures fail to assess accurately (Bullinger and Quitmann, 2014; Wei and Wang, 2020). Therefore, it is unsurprising that objective measures are not commonly used and standardised for QoL assessment in research studies. A recent study has introduced a validated objective tool for

QoL called the bio-functional status assessment tool, comprising 43 test items that assess an individual's physical, psychological, and emotional components of quality of life (Theis *et al.*, 2024). However, this tool is still recent, and there is scarce literature on objective QoL measures. Given these limitations, self-reported measures of QoL are indispensable for capturing the full breadth and depth of an individual's quality of life. These self-reported instruments can holistically assess the multidimensional aspects of QoL, including personal feelings, perceptions, and life satisfaction.

There are various validated self-reported instruments for QoL assessment, which can generally be grouped into disease-specific and generic measures (Łaszewska *et al.*, 2022). Disease-specific QoL instruments are tailored to capture unique aspects and impacts of specific diseases, providing more sensitive and relevant information for those conditions (Pequeno *et al.*, 2020). For example, there are instruments such as stroke-specific quality of life scale, stroke impact scale, Parkinson's disease questionnaire (PDQ-39), Parkinson's disease quality of life questionnaire, multiple sclerosis quality of life-54 (MSQOL-54), Quality of life after Brain Injury scale, etc.

These instruments are validated and widely used to obtain detailed and relevant quality-of-life information for specific conditions. For instance, the PDQ-39 focuses on mobility, activities of daily living, emotional well-being, and social support specific to Parkinson's disease (Opara, 2012; Schönenberg and Prell, 2022), while MSQOL-54 integrates the SF-36 with additional items relevant to multiple sclerosis, addressing symptoms like fatigue, mobility issues, and cognitive impairment (Pittock *et al.*, 2004; Gil-González *et al.*, 2020). Despite their specificity and depth of insights into specific disease QoL, they are unsuitable for comparisons across different diseases and cannot be used across a varied population such as that used in this research. In contrast, generic QoL instruments are designed to be used across various populations and health conditions (Pequeno *et al.*, 2020). This allows for comparisons between different groups and interventions. Some widely used generic QoL measures include the 36-item Short Form Health Survey (SF-36), 12-item Short Form Health Survey (SF-12), World Health Organisation Quality of Life Assessment (WHOQOL-100), and World Health Organisation Quality of Life - Brief version (WHOQOL-BREF). These instruments are summarised in Table 2.4 below.

Table 2.4 Summary of some Quality of Life Outcome Measures Comparison

Outcome measures	Psychometric properties	Pros	Cons
SF-36	High reliability and validity. Widely used and validated.	Comprehensive, covers physical and mental health domains.	Lengthy, may miss nuances for specific populations, limited social and environmental domain coverage.
SF-12	Moderate reliability and validity. The condensed version of SF-36.	Shorter, quicker to administer, captures essential health information.	Less comprehensive and less sensitive than SF-36, reduced precision in some domains.
WHOQOL-100	High reliability and validity. Comprehensive and cross-culturally validated.	Covers broad aspects of QoL, including spiritual and environmental factors.	Very lengthy and time-consuming, not ideal for large or time-sensitive studies.
WHOQOL-BREF	Good reliability and validity. Shorter, practical version of WHOQOL-100.	Easier to administer, cross-culturally validated, covers multiple domains.	Less detailed, particularly in spirituality and independence domains, may miss subtle changes.
EURO-QOL	Moderate to high reliability. Good validity for general health assessments.	Quick and easy to use, it includes a utility score for health economics.	Simplistic, limited detail on psychological and social factors, less sensitive to subtle health changes.

The SF-36 consists of 36 questions that assess eight health domains: physical functioning, role limitations due to physical health problems, bodily pain, general health perceptions, vitality, social functioning, role limitations due to emotional problems, and mental health (Lins and Carvalho, 2016). The SF-36 has been extensively validated and is known for its reliability and sensitivity to changes in health status (Wee, Davis and Hamel, 2008; Bunevicius, 2017). However, some respondents may find its length burdensome, leading to the development of shorter versions like the SF-12, which retains the core components of the SF-36 while reducing respondent burden (Wee, Davis and Hamel, 2008; Wong, 2021). While SF-36 and SF-12 are valid and reliable generic QoL tools, they primarily focus on physical and mental health components, which may not fully capture the social and environmental factors affecting individuals with neurological conditions.

On the other hand, the WHOQOL-100 is designed to provide a broad and comprehensive assessment of the quality of life across multiple domains: physical health, psychological health, social relationships, and environment (Power *et al.*, 1999; Den Oudsten and Skevington, 2022). This holistic approach is particularly relevant for individuals with neurological disorders, who often experience complex and multifaceted impacts on their lives. The WHOQOL-100 and its shorter version, the WHOQOL-BREF, were developed by the WHO through an international collaborative effort and are internationally recognised (Skevington, Lotfy and O'Connell, 2004). They have been validated in numerous languages and cultural contexts, making them suitable for cross-cultural studies (Noerholm *et al.*, 2004; Skevington, Lotfy and O'Connell, 2004; Nejat *et al.*, 2006; Vahedi, 2010).

The WHOQOL-BREF, a 26-item instrument derived from the original longer version, is sensitive to changes over time, making it suitable for longitudinal studies assessing the impact of interventions or the progression of neurological disorders on QoL (O'Carroll *et al.*, 2000; Almarabheh *et al.*, 2023). Studies have demonstrated the validity and reliability of this tool for the general population and various conditions (Bulamu, Kaambwa and Ratcliffe, 2015; Lodhi *et al.*, 2017). The extensive literature supporting the validity, reliability, and applicability of the WHOQOL-BREF in diverse settings and populations as well as its coverage of different QoL components, makes it a suitable choice for QoL assessment in this research (Skevington, Lotfy and O'Connell, 2004; Kalfoss *et al.*, 2021; Almarabheh *et al.*, 2023).

2.4 Neuroplasticity

Neuroplasticity refers to the nervous system's capacity to change its structure and function in response to intrinsic and extrinsic stimuli, including experiences, learning, behaviour, injury and disease (Marzola *et al.*, 2023). This plasticity can occur at various levels, including synaptic plasticity (changes in synaptic strength), structural plasticity (changes in dendritic spines, axons, or even the growth of new neurons), and functional plasticity (reorganisation of brain functions) (Mateos-Aparicio and Rodríguez-Moreno, 2019). Historically, the adult brain was considered largely immutable, with little potential for change after a certain developmental period, often called the Cajal doctrine (Cajal, 1928; Bjorklund and Stenevi, 1979; Colucci-D'Amato, Bonavita and di Porzio, 2006). However, research over the past few decades has overturned this view, demonstrating that the brain retains considerable plasticity throughout life (Merzenich, Van Vleet and Nahum, 2014; Rozo, Martínez-Gallego and Rodríguez-Moreno, 2024).

Neuroplasticity operates through several mechanisms, including synaptic plasticity, neurogenesis, and cortical reorganisation. Synaptic plasticity involves the strength of connections between neurones through long-term potentiation for increased strength and long-term depression for decreased strength (Bliss, Collingridge and Morris, 2014). Another critical aspect of neuroplasticity is neurogenesis, which is the generation of new neurons, particularly in the hippocampus (Ming and Song, 2011). Although neurogenesis is most active during development, it continues to occur in the adult brain, contributing to learning, memory, and the response to injury (Abdissa, Hamba and Gerbi, 2020). Following injury or significant changes in sensory inputs, the brain can reorganise its cortical maps. This cortical reorganisation can involve expanding functional areas into adjacent regions or taking lost functions by adjacent or contralateral brain regions (Nudo and McNeal, 2013).

Neurological disorders, such as stroke, TBI, MS, and PD, often result in significant impairments due to disrupted neural pathways (Feigin *et al.*, 2020). Neuroplasticity offers a basis for recovery in these conditions by enabling the brain to compensate for lost functions or to enhance remaining functions through rehabilitation (Kumar *et al.*, 2023). The ability of the brain to adapt and reorganise in response to injury and therapeutic interventions underpins the success of rehabilitation strategies. Exercise, in particular, emerges as a powerful promoter of neuroplasticity, offering a non-pharmacological approach to enhance functional recovery (Budde *et al.*, 2016; Hwang *et al.*, 2023). This can come in various forms, such as aerobic exercise, resistance training, and task-specific exercises (Erickson *et al.*, 2011; Cassilhas, Tufik and De Mello, 2016). These exercises stimulate a range of neurobiological processes that enhance brain health, such as increased neurogenesis, synaptogenesis, angiogenesis, and the release of neurotrophic factors like brain-derived neurotrophic factor (BDNF) (Voss *et al.*, 2019). While neuroplasticity can occur spontaneously following injury, targeted interventions such as exercise can significantly enhance this process (Johnson and Cohen, 2023). Exercise supports the formation of new neural connections and helps maintain and strengthen existing ones.

After a stroke, the brain undergoes a spontaneous recovery process characterised by neural reorganisation (Mang *et al.*, 2013). Rehabilitation strategies, such as task-specific training, aerobic exercise and constraint-induced movement therapy, can harness this plasticity to improve motor functions (Krakauer *et al.*, 2012; Aderinto *et al.*, 2023). Interventions that promote plasticity, such as cognitive rehabilitation and physical exercise, have been shown to improve cognitive and motor outcomes in people with TBI (Griesbach *et al.*, 2004; Anderson and Durstine, 2019).

In neurodegenerative conditions like PD and MS, neuroplasticity can be a double-edged sword (Cramer *et al.*, 2011; Johansson *et al.*, 2020). While some compensatory plasticity may initially help offset symptoms, maladaptive plasticity can also occur, leading to abnormal neural circuits that contribute to the progression of the disease (Lipp and Tomassini, 2015; Abbruzzese *et al.*, 2016). However, exercise has been shown to induce beneficial plasticity, potentially slowing disease progression and improving motor function in MS (Tomassini *et al.*, 2012; Motl and Sandroff, 2015) and PD (Fisher *et al.*, 2013; Johansson *et al.*, 2020). Emerging evidence, including findings from this thesis, suggests that rebound exercise can be particularly effective in improving balance, mobility, and overall quality of life in individuals with neurological disorders (Miklitsch *et al*., 2013; Daneshvar *et al*., 2019; Okemuo, Gallagher and Dairo, 2023). The rhythmic, low-impact nature of rebound exercise may stimulate proprioceptive pathways and enhance motor coordination, thereby promoting neuroplastic changes that support functional recovery.

2.5 Neurological Rehabilitation

In the physiotherapy management of neurological patients, aerobic exercise is often used to improve cardiovascular fitness, endurance, and overall function (Doyle, Lennox and Bell, 2013; Zhang and Yang, 2019). Some standard modalities commonly used for aerobic exercise in neurorehabilitation include treadmill training, stationary cycling, hydrotherapy, elliptical training, and dance therapy (Zhen *et al.*, 2022; Snowden *et al.*, 2023). The choice of appropriate modalities depends on the individual patient's abilities and goals, and the physiotherapist closely monitors progress. While they provide a range of benefits for patients with neurological conditions, some of these modalities are easily accessible and well-tolerated, while others are not. For instance, treadmill training is used to improve gait and walking ability (Bishnoi *et al.*, 2022), while stationary cycling can be used to improve leg strength, endurance and gait (El-Tamawy *et al.*, 2021), and both can be easily accessible in neurorehabilitation centres. On the other hand, hydrotherapy which improves balance, coordination, muscle tone, pain, mobility and self-confidence in a low-impact environment (Methajarunon *et al.*, 2016; Curcio *et al.*, 2020) is not readily accessible in the community for several reasons, such as cost, maintenance, staff shortage, comorbidities and fear of water (Marinho-Buzelli *et al.*, 2022). Dance therapy is another safe and acceptable form of aerobic exercise used in neurorehabilitation to improve gait and balance (Ares-Benitez *et al.*, 2022). It is reportedly an enjoyable way to exercise, increasing compliance.

However, these modalities may not always be the best option for every patient, and other alternatives may be worth investigating. Rebound exercise is one such alternative that is being increasingly studied in rehabilitation. The instability provided by the compliant rebound surface is thought to promote neuroplasticity and improve balance, coordination, and overall function (Posch *et al*., 2019). It can be argued that the bouncing effect of rebound exercise is so beneficial to the human body that scientists are constantly looking for ways to incorporate or replicate this exercise in diverse fields. For instance, Cleather, Price and Kennett (2022) recently reported the feasibility of a new jumping device called High-Frequency Impulse for Microgravity (HIFIm) exercise device in space by astronauts as a countermeasure against deconditioning due to weightlessness. This device replicates rebound jumping in a horizontal plane on a sledge-based carriage, with resistance from high tensile springs and jumps push from the force plate in the jump plate.

In addition to providing enjoyable exercise options such as dance therapy and low-impact therapies like hydrotherapy and stationary biking, rebound exercise is multidimensional, targeting multiple aspects of rehabilitation simultaneously (Rathi *et al.*, 2024). It is also affordable and time-effective (Şahin, Demir and Aydın, 2016). Although rebound exercise is not the only alternative to the commonly used modalities of aerobic exercise in neurorehabilitation, it is an example of how new research is constantly developing and providing new insights and options for managing people with neurological disorders. Physiotherapists must stay up-to-date with the latest research and be open to exploring different treatment options to find the best approach for each patient. Furthermore, neurological disorders place a significant financial burden on both the public and private sectors in the UK, and finding cost-effective treatment options such as rebound exercise, if proven to be effective, can help to alleviate some of this burden.

2.5 Rebound Exercise

2.5.1 History of Rebound Exercise

Exercises involving the trampoline have been practised for a long time, dating back to pictures discovered in ancient China, Egypt, and Persia (Russell, 2013). Trampolines have been used as a training tool for astronauts and fighter pilots in the past to help them prepare for the physical demands of space travel and high-performance aircraft (Burandt, 2016). For fighter pilots, maintaining balance and coordination during high levels of G-force is crucial. Training on a trampoline can enhance these skills, as well as improve muscular strength and endurance under such conditions (Sovelius *et al.*, 2006). Additionally, trampoline training can help reduce the fear of falling or spinning mid-air, promote aerial awareness, increase confidence, and develop flexibility and agility, essential skills for both soldiers and pilots (Esposito and Esposito, 2009). Trampolines have also been used for recreational and athletic purposes for many decades. Historically, trampolines were primarily used for entertainment and were often found at carnivals, amusement parks, and other recreational facilities. In the 1950s and 1960s, trampolines became more popular as a form of exercise and were often used in gymnastics training and competitive events (Vescia, 2019). Trampolines were also used in special education for children with developmental disorders (Chartered Society of Physiotherapy, 2016).

Early proponents of rebounding noted its ability to improve cardiovascular health, balance, and coordination while minimising stress on the joints and muscles. Albert Carter, a professional gymnast and teacher often regarded as one of the early pioneers and most vocal advocates of rebound exercise, played a crucial role in popularising this unique form of physical activity (Rebound Air, 2021). In the 1970s, Carter began promoting rebounding as a highly effective, low-impact exercise that could benefit people of all ages and fitness levels. His efforts to highlight the health benefits of rebounding resulted in the publication of his influential book, "The Miracle of Rebound Exercise". In the book, Carter outlined the several benefits of rebounding, from improved cardiovascular health and lymphatic circulation to enhanced balance, muscle tone, and overall physical conditioning (Carter, 1979). The book also emphasised the unique gravitational forces involved in rebounding, which he believed stimulated cellular activity throughout the body, making it a "cellular" exercise.

Despite its early popularity, rebound exercise lacked comprehensive scientific backing until the late 1970s, when the National Aeronautics and Space Administration (NASA) began investigating its potential applications for astronauts. In space, astronauts face unique physiological challenges due to the absence of gravity, including muscle atrophy, bone density loss, balance problems and cardiovascular deconditioning (Gaskill, 2024). NASA needed an efficient exercise modality to counteract these effects during extended missions in space. So, NASA researchers, led by Bhattacharya and colleagues, conducted a groundbreaking study to evaluate the effectiveness of various exercises in maintaining astronaut fitness. Their findings confirmed what fitness enthusiasts, including Carter, had long suspected: rebound exercise was remarkably efficient (Bhattacharya *et al.*, 1980). This pivotal study provided the scientific foundation of rebound exercise and opened the door for its broader application in fields such as rehabilitation and fitness. Rebound exercise has since been used in astronaut training because bouncing on a trampoline could help simulate the effects of weightlessness (Rebound Air, 2021). This allowed astronauts to practice moving and navigating in a simulated zero-gravity environment, helping avert the complications associated with weightlessness.

2.5.2 Significance of the NASA Study

Although the NASA study is over 40 years old, it is significant for its landmark findings, which established rebound exercise in the scientific literature. NASA's research revealed that, compared to running, rebound exercise is 68% more effective in promoting physiological gains while requiring less energy expenditure (Bhattacharya *et al.*, 1980). The study highlighted rebound exercise's efficiency in stimulating cellular processes throughout the body. This efficiency arises from the cyclical nature of acceleration and deceleration during rebounding, which creates a unique form of biomechanical loading across all cells (Harper *et al.*, 2022). This process improves lymphatic circulation, enhances cardiovascular fitness, and triggers mechanical signals that promote bone and muscle growth (Wellman, 2024).

One of the key mechanisms behind the effectiveness of rebound exercise is its ability to enhance cellular function through mechanotransduction, the process by which mechanical forces are converted into biochemical signals that lead to cellular adaptation (Dunn *et al.*, 2016). The alternating forces of gravity (G-force) experienced during rebounding stimulate cells to promote musculoskeletal and cardiovascular health without damaging impact forces typically associated with high-intensity exercise like running (Burandt, 2016). The study found that the G-force at the weight-bearing joints was evenly distributed and below the rupture threshold of healthy individuals (Bhattacharya *et al.*, 1980). The gentle oscillations of rebound exercise also aid in venous return and lymphatic drainage, which can reduce swelling and inflammation, which is crucial for maintaining overall health, especially in individuals with neurological disorders (Vairo *et al.*, 2009; Mehrara *et al.*, 2023). Additionally, the rhythmic rebounding motion encourages proprioceptive feedback and balance coordination, which is essential for neuroplasticity (Daneshvar *et al.*, 2019). This aspect is crucial for individuals with neurological disorders, where balance and coordination are often compromised.

Despite this NASA study's notable findings, rebound exercise has not yet become a mainstream practice in healthcare, even 44 years later. One possible reason for this may be a lack of institutional momentum. While the findings benefitted astronauts returning from zero-gravity environments, the direct translation of these benefits into clinical settings for the general population may not have been immediately apparent to many healthcare professionals. It may also be a reluctance or difficulty in changing existing practices (White, Dudley-Brown and Terhaar, 2019; Smith and Johnson, 2023). Another potential reason may be limited research expansion. Although some studies have investigated the benefits of rebounding across various populations, the research may not yet have amassed enough evidence to significantly influence healthcare policy or practice (Ryder and Jacob, 2022). This delay or lack of continued, focused research has created a limitation in understanding how rebound exercise could be integrated into rehabilitation protocols, particularly for patients with neurological disorders, cardiovascular disease, or other chronic health conditions. Finally, misconceptions and scepticism about rebound exercise may have been a barrier, as people don't engage with what they don't understand (Lachman *et al.*, 2018; Okwose *et al.*, 2020). While Carter's enthusiasm helped to bring rebounding to public attention, it may have also made it susceptible to being viewed as a fitness trend rather than a serious therapeutic option. The association with the commercial fitness industry and anecdotal claims of its benefits may have hindered its perception among clinicians, who often prefer evidence-based interventions with large-scale, peer-reviewed backing (Tiller, Maguire and Newman-Taylor, 2023).

With the growing emphasis on preventive health and rehabilitation, particularly in managing chronic diseases, rebound exercise could offer a low-cost, highly effective intervention that aligns with current trends in healthcare delivery. The underutilisation of rebound exercise in healthcare indicates a need for more research, education, and advocacy within the medical community. Just as other exercise modalities have evolved into standard care options over time, rebound exercise has the potential to do the same if time and resources are invested in fully understanding its benefits and applications across diverse patient populations.

2.5.3 Features of Trampolines/ Rebounders

Trampolines have several distinguishing characteristics that make them unique to other aerobic exercise programs and lead to positive health benefits.

2.5.3.1 Low-impact:

This characteristic is derived from the trampoline's design, which absorbs much of the impact that would otherwise be transmitted to the user's joints during exercise activities (Witassek, Nitzsche and Schulz, 2018). During a bounce on a mini-trampoline, the flexible surface moves down with the body, absorbing a significant portion of the impact energy typically absorbed by the knees, hips, and ankles during ground exercises like running or jumping (Burandt, 2016). Additionally, the trampoline mat's elasticity allows for a more extended period of deceleration during the landing, reducing the sudden forces exerted on the body and, consequently, the strain on the joints (van Schoor *et al.*, 2006). The rebounding action distributes the impact forces more evenly across the body. This contrasts with hard surface exercises, where certain joints, particularly the knees and ankles, bear the brunt of the impact (Özdalyan *et al*., 2021).

The low-impact feature of mini-trampolines makes them an excellent exercise tool, particularly for individuals seeking a joint-friendly workout option. It has been widely reported that ground reaction force on elastic surfaces like mini-trampolines is much lower than that observed on hard surfaces, as seen during jogging, running, skipping, basketball etc, making it a safer exercise option to minimise injury risk (Crowther *et al*., 2007; Puddle and Maulder, 2013; Özdalyan *et al*., 2021).

2.5.3.2 Dynamic:

The dynamic feature of mini-trampolines refers to their ability to provide a versatile and engaging workout that activates multiple body systems simultaneously impacting physical components other than strength, including balance, muscle coordination, range of motion and spatial integration (Sukkeaw, Kritpet and Bunyaratavej, 2015; Aragão *et al*., 2011; Wen *et al*., 2018). Mini-trampolines' dynamic feature encompasses their ability to offer a comprehensive workout that is not only effective for physical fitness but also enjoyable, thereby promoting consistent exercise adherence (Crowther *et al*., 2007; Puddle and Maulder, 2013).

Furthermore, mini-trampolines are accessible to a wide range of users, including those who may be limited by joint pain, neurological diseases or other conditions that make high-impact exercises challenging (Aragão *et al.*, 2011; Fricke *et al.*, 2023). They can be used indoors, require minimal space, and provide a safe, low-impact form of exercise when used correctly and with proper safety precautions, such as ensuring a clear surrounding area and using handlebars for stability if needed (Weston *et al*., 2001; Fricke *et al*., 2023). Finally, they offer exercise training of varying intensities and can be used for high-, moderate-, or low-intensity workouts (Tay *et al.*, 2019; Schöffl *et al.*, 2021; Clement, Alexander and Draper, 2022).

2.5.3.3 Time and Energy Efficiency:

Rebound exercise leverages the trampoline's gravitational force and elastic rebound to provide a high-intensity workout that can improve cardiovascular health, muscular strength, and endurance in shorter sessions than traditional exercise forms (Witassek, Nitzsche and Schulz, 2018). The low-impact nature of rebounding results in less stress on the joints and muscles, potentially reducing recovery time and allowing for more frequent workouts. Aerobic activities like rebounding improve the body's ability to utilise oxygen, enhancing cellular metabolism and energy production. However, rebound exercise has been widely shown to be more time- and energy-efficient than traditional exercises.

Unlike in traditional exercises like running, cycling, and swimming, where the energy is fully generated by the body, in rebound exercise, part of the energy is generated by the musculoskeletal system while the rest is provided by the elastic potential energy in the trampoline surface (Moreira-Reis *et al.*, 2020). The increasing energy input from the trampoline surface results in reduced mechanical work done by the body and, consequently, reduced energy costs (Moreira-Reis *et al.*, 2020). Studies have reported that rebounding on a trampoline is approximately 68% more effective than jogging in improving maximum oxygen uptake and yet requires less effort, exerting less strain on the cardiovascular system (Bhattacharya *et al.*, 1980; Şahin, Demir and Aydın, 2016). Rebound exercise promotes the activation of both slow-twitch (Type I) and fast-twitch (Type II) muscle fibres, enhancing muscular endurance and strength while keeping the metabolic cost low (Davies, Riemann and Manske, 2015).

Evidence in the literature shows that individuals report a lower rate of perceived exertion during rebound exercise compared to traditional aerobic exercises at similar intensity levels (Tay *et al.*, 2019). Another study revealed that rebound exercise led to individuals burning 9-12 calories per minute on the trampoline within the American College of Sports Medicine (ACSM) recommended ranges (Heil, 2001; Burandt, 2016). This level of energy expenditure has been equated to running 6 miles per hour on solid ground, biking at 14 miles per hour and playing football or basketball (Burandt, 2016). Regarding time efficiency, research has shown that 10 minutes of rebound exercise is equivalent to 30 minutes of running, suggesting that individuals with time constraints can benefit from rebound exercise (Bhattacharya *et al.*, 1980). Similarly, a recent study showed that 8 minutes of high-intensity rebound exercise weekly was sufficient to improve cardiovascular fitness in adults (Clement, Alexander and Draper, 2022). This indicates that even low doses of rebound exercise performed at the right intensity can likely offer therapeutic benefits, making it a time-efficient form of exercise.

2.5.3.4 Safety:

Trampoline-related injuries have been widely reported and documented in the literature (Nysted and Drogset, 2006; Hurson *et al*., 2007; Eager, Chapman and Bondoc, 2012; Klimek *et al*., 2013; Ashby *et al*., 2015; Cheung *et al*., 2016; Kasmire, Rogers and Sturm, 2016; Potera, 2016; Sharwood *et al*., 2018; Eager *et al*., 2022). However, these injuries all occurred in trampoline parks, backyard trampoline, and gymnastic trampolining, most commonly affecting children and gymnasts. Most of these injuries occur on the trampoline surface, with the victims colliding with another user, falling onto the frame or springs or the mat, while a few of the injuries result from people falling off the trampoline surface (Bhangal, Neen and Dodds, 2006; Nysted and Drogset, 2006; Klimek *et al*., 2013). The severity of trampoline-related injuries can range from mild bruises, sprains and concussions to severe head injuries, fractures and spinal cord injuries (Hurson *et al*., 2007; Ashby *et al*., 2015; Kasmire, Rogers and Sturm, 2016; Sharwood *et al*., 2018).

The high prevalence of these injuries has led to certain recommendations from authors to reduce the potential dangers of trampoline use, particularly for recreational use in children (Klimek *et al.*, 2013; Ibrahim and Okoro, 2019). Top on the list is constant adult supervision, preventing multiple users simultaneously and setting up age restrictions for trampoline use. Other recommendations include installation of safety nets, padding of the springs and safety checks (Sharwood *et al.*, 2018). Multiple users account for the most frequent cause of trampoline injuries, with a recorded prevalence of 57% (Hurson *et al.*, 2007), 74% (Nysted and Drogset, 2006), 80% (Bogacz *et al.*, 2009) and 90% (Klimek *et al.*, 2013). In cases where there are multiple users, studies have shown that the lighter individual is 14 times more likely to be injured than the heavier individual and as such, children under 6 years should be restricted from trampoline use (Hurson *et al.*, 2007; Klimek *et al.*, 2013). This risk factor results in injuries due to the double bounce effect, which refers to a situation where an individual's bounce can influence the bounce of another person on the same trampoline due to mismatched bounces, unpredictable movements and limited space (Eager *et al*., 2022). Studies have shown that in most injury cases, there was no supervision, as only 22-27% of such cases reported parental supervision (Nysted and Drogset, 2006; Klimek *et al*., 2013). This is significant as people, particularly children, tend to attempt risky moves without adult supervision (Wootton and Harris, 2009). However, there are still studies conducted in trampoline parks that have recorded no injuries due to supervision of the sessions (Budzynski-Seymour *et al.*, 2019; Tay *et al.*, 2019), highlighting the critical role supervision plays in trampoline injury prevention.

In contrast to recreational and gymnastic trampolines, mini-trampoline rebounders are relatively safe as there is no evidence of injuries during rebound exercise used for rehabilitation purposes due to close supervision (Hahn, Shin and Lee, 2015; Esposito and Esposito, 2009; Miklitsch *et al*., 2013; Daneshvar *et al*., 2019). Unlike traditional trampolines, mini trampolines typically have enclosed springs and padded frames and are designed for single-user exercises, eliminating the risk of collisions and accidents (Maharaj and Nuhu, 2019). They are often used indoors, providing a controlled environment that eliminates outdoor hazards and weather-related risks, which could affect the trampoline's structural integrity (Maharaj and Nuhu, 2019).

Studies on mini trampolines have shown that they are often used in structured exercise routines that guide users through controlled movements, reducing the possibility of the users attempting risky manoeuvres that could result in injuries (Miklitsch *et al*., 2013; Wen *et al*., 2018; Daneshvar *et al*., 2019; Posch *et al*., 2019). The most appealing safety feature of the mini trampoline is its low-impact nature, which protects the joints from stress and overuse injuries (Fricke *et al.*, 2021). While rebound exercise is inherently safe, certain precautions can further enhance its safety, such as using a well-maintained rebounder with a sturdy frame, secure mat and handlebar and learning proper techniques under the guidance of a qualified instructor.

2.5.3.5 Fun Factor:

This key aspect of mini trampoline exercises contributes to its growing and sustained popularity. This exercise offers a unique and enjoyable experience that goes beyond traditional forms of exercise. Several studies have reported that rebound exercise evokes feelings of excitement, providing a fun way to exercise, as revealed by the participants (Giagazoglou *et al.*, 2013; Burandt, 2016; Shah and Parab, 2018; Budzynski-Seymour *et al.*, 2019). Bouncing on a mini trampoline can evoke childhood memories of jumping on the bed or trampolines, triggering a sense of joy and freedom. Like other aerobic exercises, rebounding can release endorphins, the body's natural mood enhancers. This physiological response contributes to the overall feeling of well-being and enjoyment (Daneshvar *et al.*, 2019).

Music is often incorporated into rebounding sessions, resulting in rhythmic bouncing, which adds a dynamic and enjoyable element to the session (Chow and Etnier, 2017; Witassek, Nitzsche and Schulz, 2018). This makes exercise feel more like a recreational activity than a traditional workout. Furthermore, the low perceived exertion nature of rebound exercise reported by participants may likely make it more appealing to engage in long-term, potentially increasing adherence (Tay *et al.*, 2019).

2.5.4 Current Evidence for Rebound Exercise.

In addition to being used for space training and recreational purposes, trampolines are sometimes used in physical therapy and rehabilitation settings to help improve various health outcomes. The past two decades have seen intense research on the efficacy of rebound exercise as a therapeutic modality in a diverse population. This exercise is reportedly the most potent form of cellular exercise because of its ability to utilise gravity to optimise gains (Burandt, 2016; Şahin, Demir and Aydın, 2016). When rebounding, the gravitational forces are evenly spread across all the body parts so that no joint or bone is over-stressed. Additionally, the soft surface of the trampoline results in low ground reaction force as it absorbs most of the body weight so that there is no stress on the weight-bearing joints (Bhattacharya *et al.*, 1980; Burandt, 2016). Since stress injuries have been consistently linked to the magnitude of ground reaction forces (Pribut, 2010; Tobalina, de Santos and Ramón, 2013), rebound exercise, with its low risk of musculoskeletal injuries, appears ideal for individuals prone to workout injuries and mobility-impaired individuals. Rebound exercise has established benefits for both healthy individuals and those with various medical conditions. In healthy individuals, rebound exercise was reported to enhance physiologic responses such as heart rate, blood pressure, respiratory rate and oxygen capacity (Mohammed and Joshi, 2015; Rodrigues *et al.*, 2018; Clement *et al.*, 2022), muscle strength and balance in young adults (Kong, Tay and Kee, 2018; Tay *et al.*, 2019), vertical and long jump and percentage body fat in high-school male students (Aalizadeh *et al.*, 2016), jump height/ performance and dynamic balance in athletes (Márquez *et al.*, 2010; Atilgan, 2013; Karakollukçu *et al.*, 2015).

On the other hand, this exercise has been reported to be equally effective in diverse populations of individuals with varying disease conditions. For instance, a scoping review by Okemuo *et al*. (2021) revealed that rebound exercise improved body mass index, blood pressure, blood glucose level and quality of life among overweight and obese adults. Similar studies on diabetes mellitus reported remarkable improvement in lipid profile, glycated haemoglobin, insulin resistance and waist circumference following rebound exercise (Maharaj and Nuhu, 2016; Maharaj and Nuhu, 2019). In addition, research has been carried out on the efficacy of rebound exercise in Osteopenia (Posch *et al*., 2019), people with intellectual disabilities (Giagazoglou *et al.*, 2013; Haghighi *et al.*, 2019), children with cerebral palsy (Abd-Elmonem and Elhady, 2018; Kora and Abdelazeim, 2020; AL-Nemr and Kora, 2024), people with spinal cord injury (Sadeghi, Ghasemi and Karimi, 2019) and in the senior citizens (Aragão *et al.*, 2011).

These studies consistently reported beneficial outcomes, which aligns with the tendency towards publication bias where authors are often hesitant to disseminate negative findings and journals frequently reject studies with non-significant results (Joober *et al.*, 2012; Mlinarić, Horvat and Smolčić, 2017; Devito and Goldacre, 2019; Ayorinde *et al.*, 2020). Despite the positive outcomes reported, several critical issues in these studies need addressing. Many were underpowered, with small sample sizes ranging between 11 to 28 participants (Giagazoglou *et al.*, 2013; Mohammed and Joshi, 2015; Aalizadeh *et al.*, 2016; Kong, Tay and Kee, 2018; Rodrigues *et al.*, 2018; Tay *et al.*, 2019; Clement, Alexander and Draper, 2022), increasing the risk of false positive results (Hajian-Tilaki, 2014). Additionally, these studies often failed to calculate the required sample size, compromising their findings and conclusions.

The methodological designs of these studies are also questionable. Only a few reported appropriate randomisation and group allocation processes (Posch *et al*., 2019; AL-Nemr and Kora, 2024), and even fewer presented sample size calculations (AL-Nemr and Kora, 2024). Despite its small sample size, one study used an incorrect statistical test during data analysis (Aalizadeh *et al.*, 2016). It employed repeated ANOVA instead of a paired t-test to compare two-time points, pre-training and post-training. Using the wrong test can produce inaccurate p-values and lead to incorrect conclusions, increasing the likelihood of detecting significant differences when none exist (Forstmeier, Wagenmakers and Parker, 2017). Moreover, some studies did not control for potential confounders, affecting the validity of their results (Tay *et al*., 2019).

Another potential concern is the ‘learning effect’ associated with quick improvements observed in the first few attempts at a new activity (Rhouni *et al.*, 2019). Considering that rebound exercise is a relatively new activity, and most studies reported that their participants had never engaged in the exercise before the study, the possibility of a learning effect cannot be ruled out. The improvements recorded may likely be due to the learning effect phenomenon rather than the intervention, particularly for the short-duration studies (Kong, Tay and Kee, 2018; Rodrigues *et al.*, 2018; Tay *et al.*, 2019) and studies without control groups (Rodrigues *et al.*, 2018). These methodological flaws raise concerns about the reliability of the reported positive findings. Consequently, one could argue that while some of the reported positive outcomes may hold merit, others could be overestimated or even flawed due to these limitations.

Research has found rebound exercise effective and better at enhancing some health outcomes than standard exercise modes. Rebound exercise has been compared to running, jogging, chest physiotherapy, treadmill and cycling, revealing a more considerable improvement in health outcomes. For instance, a study on asthmatic patients found rebound exercise to be better at improving pulmonary functions than traditional exercises (Zolaktaf, Ghasemi and Sadeghi, 2013). Similarly, in their research on cystic fibrosis patients, Kriemler *et al*. (2016) revealed that rebound exercise significantly increased mucus clearance and oxygen saturation compared to routine physiotherapy exercises. Furthermore, compared to chest physiotherapy in people living with HIV co-infected with tuberculosis, rebound exercise leads to more significant sputum production (Maharaj and Dunpath, 2014).

2.5.5 Rebound Exercise in Neurological Disorders

Aside from its reported benefits in cardiopulmonary health, there is evidence of the efficacy of rebound therapy in neurological disorders. Just like other forms of aerobic exercises, such as brisk walking, treadmill, cycling, dancing, etc., with established beneficial effects in the neurological population, rebound exercise has also demonstrated considerable benefits in several health outcomes. These resulting effects can be attributed to the complex sensorimotor stimulation that occurs from constant repetitive movement of the body on an unstable trampoline surface (Márquez *et al.*, 2010). Previous studies have established that rebound exercise improves mobility by decreasing walking time as measured with the timed up-and-go test in people with neurological disorders (Miklitsch *et al*., 2013; Hahn, Shin and Lee, 2015; Okemuo, Gallagher and Dairo, 2023).

Unlike mobility, which is improved by rebound exercise, its effect on balance in people with neurological disorders remains unclear. Whilst some studies have found significant improvement in balance (Miklitsch *et al*., 2013; Sisi, Sadeghi and Nabavi, 2013; Hahn, Shin and Lee, 2015), more recent literature has emerged that offers contradictory findings about the effectiveness of rebound exercise in balance improvement in this cohort (Okemuo, Gallagher and Dairo, 2023). According to the systematic review, rebound exercise did not improve balance in people with neurological disorders. The conflicting results may be a result of certain factors. Firstly, the studies that reported improved balance were underpowered, which could lead to a type 1 error in reporting significant improvement in balance where there is none. If this is the case, the systematic review, which was adequately powered, rightly found no significant improvement in balance. Another factor could be the fact that balance issues are multifactorial and could stem from either or a combination of neurological diseases, vestibular problems, visual impairments, psychological problems and medication side effects (Menant *et al*., 2017; Blodgett *et al*., 2022). As such, rebound exercise alone may not be sufficient to tackle multifactorial balance issues. Amongst other reported benefits of rebound exercise are increased adherence to exercise participation and self-rated enjoyment in children with cerebral palsy (Germain *et al*., 2019) and intellectual disabilities (Giagazoglou *et al*., 2013) and quality of life in people with Parkinson's disease (Daneshvar *et al*., 2019).

2.6 Foundational Concepts of Rebound Exercise

The foundational theories on which rebound exercise training is based include Newton's laws of motion, Hooke's law, energy transformation, and the stretch-shortening cycle. These principles collectively explain the biomechanics and physiology of rebound exercise, providing a comprehensive understanding of the dynamic movements, force production, and energy expenditure involved.

2.6.1 Newton's Laws of Motion

Like other aerobic exercises, rebound exercise is also based on Newton's laws of motion and understanding how these laws relate to rebound exercise is crucial to maximising its full potential. According to the first law of motion, there is a natural tendency for a body at rest to remain at rest and a body in motion to remain in motion except acted upon by an external force (NASA Glenn Research Center, 2023). On the rebounder, the body overcomes the initial state of inertia by pushing off the trampoline surface with the legs, resulting in an upward motion which continues until another force, gravity, acts on the body and sends it downwards. The same law applies to other aerobic exercises like running, swimming or cycling, where the body overcomes inertia by generating that initial force to start the movement, and the skeletal muscles continuously generate this force to keep moving until another force like friction or resistance acts to slow it down or stop it.

Unlike traditional aerobic exercise, where gravity acts downward to provide weight and assist the body in maintaining contact with the ground, this force influences both the upward and downward phases of the rebound exercise. During the initial push off the trampoline surface to initiate a bounce, the body generates enough force to defy the influence of gravity, resulting in upward motion (Pendrill and Eager, 2015). At the peak of the bounce, where the body force matches the force of gravity on the body, the body momentarily experiences a state of 'weightlessness' or 'free fall' as there is no net gravitational force acting on the body at this point. Shortly afterwards, the body descends downward to the trampoline, accelerated by gravity, with the muscles working to control the rate of the descent (Pendrill and Ouattara, 2017).

Newton's second law states that net force is equal to the product of mass and acceleration, which means that the greater the mass of an object or individual, the more force is needed to accelerate or maintain the speed of movement (Pendrill and Ouattara, 2017). This law plays an important role in aerobic exercise, although the nature of the force application and motion differs between rebound exercise and other aerobic exercises. In rebound exercises, the force and acceleration are in the upward direction against gravity on a vertical plane, unlike traditional exercises such as running, where the force and acceleration are applied in the horizontal plane to propel the body forward (Pendrill and Ouattara, 2017).

Finally, the third law states that "for every action, there is an equal and opposite reaction" (NASA Glenn Research Center, 2023). Understanding this law helps to understand how the body generates movement during exercise and how best to improve performance during training or rehabilitation. As the body pushes off the trampoline, the body exerts a downward force on the trampoline. In response to this action, an equal and opposite force propels the body off the trampoline, creating the bouncing effect. This is a key aspect of rebound exercise that is responsible for the sensation of weightlessness at the peak of each bounce. Similarly, other aerobic exercises like running/ jogging, swimming, and cycling involve the primary action of the foot pushing against the ground, water, or pedal (American Heart Association, 2024). This force is instantly followed by an equal and opposite reaction from the ground, water or pedal, which propels the body forward, and this cycle of action and reaction allows for continued movement.

2.6.2 Hooke’s Law and Energy Transformation

Rebound exercise follows the principles of Hooke's law and elastic potential energy concerning the elastic trampoline surface and the energy transformations that occur. Hooke's law states that the force required to extend or compress an elastic material (like a spring) by a certain distance is directly proportional to that distance. Mathematically, it can be expressed as $F = -kx$ where F represents the force applied to the elastic material, k is the spring constant, a measure of the material's stiffness and x is the displacement (stretch or compression) of the material from its equilibrium position (Pendrill and Ouattara, 2017; Eseceli, 2019). When rebounding, the trampoline surface behaves like a giant elastic material like a spring. During a jump or bounce on the trampoline, the body applies a force by compressing the trampoline surface downward. Hooke's law applies to this action, as the force (F) exerted on the trampoline surface by the body is directly proportional to the displacement (x) of the surface from its equilibrium position (Giuliodori *et al.*, 2009). Depending on the amount of force applied, the trampoline surface deforms, storing potential energy according to Hooke's Law.

The potential energy stored in the trampoline because of the compression or stretching is called the Elastic potential energy. It can be calculated using the formula $EPE = (1/2)\ kx^2$ where EPE represents the elastic potential energy, k is the spring constant, and x is the displacement from the equilibrium position. This energy increases as the trampoline surface is further displaced from its original position. When the trampoline surface is released, the stored elastic potential energy is rapidly converted into kinetic energy. As the trampoline springs back to its original shape, it exerts an equal and opposite force, propelling the body upwards. As the body ascends, the kinetic energy is transformed into gravitational potential energy because the body is moving away from the Earth's centre of mass. This increase in gravitational potential energy is directly proportional to the vertical height gained during the ascent, and it is highest at the peak of a bounce. During the descent, the height and the gravitational potential energy decrease (Kuehn, 2016). The decrease in gravitational potential energy is converted into kinetic energy as the downward movement progresses, contributing to the descent's speed and momentum (Demirel, 2012).

2.6.3 Stretch-Shortening Cycle Theory

The stretch-shortening cycle is the core of plyometric exercises, of which rebound exercise can be considered a low-impact form. This cycle describes the muscle-lengthening movement, which is quickly followed by a shortening movement, and these movements provide the force necessary for muscle strengthening. During plyometric activities, such as rebound exercise, the muscle spindle of the muscle-tendon unit along the elastic tissues in the muscles, namely the series and the parallel elastic components, are stretched, resulting in the neurophysiological-biomechanical response (Davies, Riemann and Manske, 2015).

This cycle occurs in three phases: the eccentric, amortisation and concentric phases. The first phase, the eccentric phase, occurs on landing on the trampoline surface, where the leg muscles (quadriceps and calf muscles) are stretched to absorb the kinetic energy from the downward movement. The stretching of the muscles stores potential energy, creating tension in the muscle-tendon complex. Studies have reported that the quality of the subsequent phases depends on this initial stretching phase in terms of the magnitude, rate and duration of the stretch (Ebben, Simenz and Jensen, 2008; Ebben *et al*., 2009).

The second phase, the amortisation phase, also called the “time to rebound phase” is the transition phase between the eccentric and concentric phases (Davies, Riemann and Manske, 2015). This short but critical phase occurs during the momentary pause at the bottom of a bounce, where the stored energy is rapidly converted back to kinetic energy for the last phase. The shorter the transition, the more powerful the movement will be as the energy stored in the eccentric stage is efficiently used up, but if there is a delay, most of this energy is dissipated as heat (Davies and Matheson, 2001).

The final phase is the concentric or shortening phase, which occurs when the trampoline surface is pushed off to initiate the next bounce. This phase results from various interactions, such as the biomechanical response that leverages the elastic properties of pre-stretched muscles. During this phase, the energy stored in the muscles and tendons in the eccentric phase is rapidly released in a powerful contraction, generating the upward force needed for the push-off. This quick transition between muscle lengthening and shortening allows for powerful and efficient movements, contributing to improvements in muscle power, strength, and overall neuromuscular coordination. Additionally, the repetitive nature of rebound exercise enables a continuous stretch-shortening cycle, resulting in a series of micro-cycles that benefit balance, coordination, muscle conditioning, and overall fitness.

2.6.4 Ground Reaction Force

Ground reaction force (GRF) is important in understanding the biomechanics of various exercises and physical activities. In exercise science, GRF is fundamental to analysing movement patterns, assessing injury risk and optimising performance (Jiang *et al.*, 2024).

GRF is the force exerted on the body by the ground or the surface in contact with the body, as described by Newton's third law of motion (Richards, Chohan and Erande, 2013). It is an important concept in biomechanics and exercise science, particularly for activities involving surface interaction, such as walking, jogging, and jumping. When the body is standing still, the GRF is equivalent to the body weight, but when the body is in motion, this force increases due to the acceleration force. Higher GRF is linked to increased energy expenditure and a greater risk of overuse injuries (Ancillao *et al.*, 2018). GRF consists of vertical, horizontal and mediolateral components, with the vertical component representing most of the total GRF and both vertical and horizontal forces increasing with increasing speed (Nilsson and Thorstensson, 1989; Makino *et al.*, 2022; Jiang *et al.*, 2024).

Depending on the activity and surface type, GRF can increase as much as 2-5 times the body weight (Cavanagh and Lafortune, 1980; Nilsson and Thorstensson, 1989). Such activities include fast walking, running, and plyometric exercises like gymnastics, vertical jumping etc. These exercises generate high ground reaction force and loading rates and the magnitude of this force is highest in the landing phase of a jump during 0-25 degrees of knee flexion (Podraza and White, 2010; Özdalyan *et al.*, 2021). Increased knee flexion enhances energy absorption and reduces loading rates on noncompliant surfaces; however, on compliant surfaces, these exercises lead to reduced knee flexion (Crowther *et al*., 2007). Excessive GRF can lead to injuries to the weight-bearing joints. Reducing this force and, consequently, the risk of injury can be achieved by using proper landing techniques and extending the contact (Crowther *et al*., 2007). Strategies targeting lower extremity biomechanical adjustments have been developed to reduce GRF and injury risk during landing (Ericksen *et al.*, 2013). Resistance and explosive exercises performed on the ground requiring both feet in contact with the ground at the same time, including back squats, deadlifts and jumping, produce higher GRF than single-leg stance exercises like lunges, step-ups and running (Ebben *et al*., 2010; Wurm *et al*., 2010). The mechanism for this is believed to be due to the smaller base of support in the unilateral exercises reducing maximal loading (Wurm *et al.*, 2010).

Additionally, increasing the knee flexion (crouch action) on landing lowers the GRF and loading rate by prolonging the contact time (Özdalyan *et al.*, 2021).

Rebound exercise on a trampoline generates a lower peak GRF of approximately 1.2-1.5 times body weight, in contrast to 2.5-4.5 times in running and 3-5 times in vertical jumping (McKay *et al.*, 2005). This reduction in peak GRF decreases impact forces on weight-bearing joints, particularly in the lower limbs, which makes rebound exercise a low-impact activity suitable for minimising injury risks. Unlike exercises on flat surfaces, which often require increased knee flexion during landing to reduce GRF and injury risk, trampolines reduce GRF through the elasticity of the surface, allowing for prolonged contact time without the need for increased knee flexion (Özdalyan *et al.*, 2021). The trampoline's elastic recoil absorbs a portion of the landing forces and subsequently returns this energy to aid in the upward phase of the jump, further minimising stress on the joints (Bhattacharya *et al.*, 1980; Eager *et al.*, 2022). Therefore, rebound exercise provides a joint-friendly alternative that leverages surface elasticity to lower GRF, rather than relying on joint angle adjustments as in traditional plyometric activities on solid ground. Despite the reduced peak GRF, rebound exercise still provides a significant mechanical stimulus for musculoskeletal adaptation. The repetitive vertical movements involve forces that oppose gravity, and while these forces are lower in magnitude than ground-based exercises, they are applied consistently and cyclically.

2.6.5 Movement Kinematics

Movement kinematics in exercises is a vital aspect of biomechanics and refers to the study of the motion of body segments without considering the forces that cause them (Martin, 2023; Fiveable, 2024). Commonly analysed kinematic parameters include joint angles, velocities, distance, acceleration and temporal-spatial parameters like cadence and time. In various exercises, kinematic analysis helps understand the efficiency and effectiveness of human movement patterns. For instance, in resistance training exercises like squats and deadlifts, kinematics involves analysing joint angles and movement velocities to optimise performance and reduce injury risk (Schellenberg, Taylor and Lorenzetti, 2017). These exercises are characterised by specific kinematic profiles, such as the displacement and velocity of joints during eccentric and concentric phases, which are crucial for strength and power development (Wurm *et al.*, 2010).

In contrast, rebound exercises performed on mini-trampolines present unique kinematic characteristics due to the elastic surface (Rathi *et al.*, 2024). These exercises typically involve lower vertical displacements and velocities than ground-based activities, offering a low-impact alternative that can still effectively engage muscles and improve cardiovascular fitness (Crowther *et al*., 2007; Rossato *et al*., 2017). The elastic properties of the rebounder alter the typical kinematic patterns, resulting in more gradual acceleration and deceleration phases, which contribute to reduced joint stress and increased safety for participants (Schellenberg, Taylor and Lorenzetti, 2017). Understanding these kinematic differences is essential for designing effective exercise programs that cater to individual needs and goals.

2.7 Theoretical Frameworks

2.7.1 International Classification of Functioning, Disability and Health

This research is grounded in the theoretical orientation of the International Classification of Functioning, Disability and Health (ICF) (World Health Organisation, 2001). The ICF framework, which adopts a biopsychosocial model of health and disability, categorises the impact of disease at three levels: impairment, disability, and handicap (Leonardi and Fheodoroff, 2021). (Figure 2.2). Impairment refers to symptoms affecting the body's structure and function, while disability describes the resultant limitations in activity. Handicap, on the other hand, describes restricting an individual's participation in social contexts.

The ICF framework comprises two broad parts: functioning and disability and contextual factors (Leonardi and Fheodoroff, 2021). Each of these parts is further divided into two components. The first part includes body structures and functions, which describe the anatomy and physiology of the human body, and activity and participation, which outline an individual's functional status (Cozzi, Martinuzzi and Della Mea, 2021). The second part involves environmental factors, which encompass elements outside the person's control, such as family, laws, culture, and work, as well as personal factors, which describe the individual's demographic characteristics, such as age, gender, and race (McDougall *et al*., 2014; Jaiswal *et al*., 2019).

Activity and participation are influenced by contextual factors, including personal and environmental elements, such as an individual’s sociodemographic characteristics, man-made organisations, rehabilitation, and the physical, social, and attitudinal environment (Teasell *et al.*, 2014). These factors significantly impact individuals' ability to function and participate in the community as they desire (Khan et al., 2009, 2012). This comprehensive framework ensures a holistic understanding of health and disability, essential in neurorehabilitation for evaluating interventions' effects and guiding healthcare policy and practice.

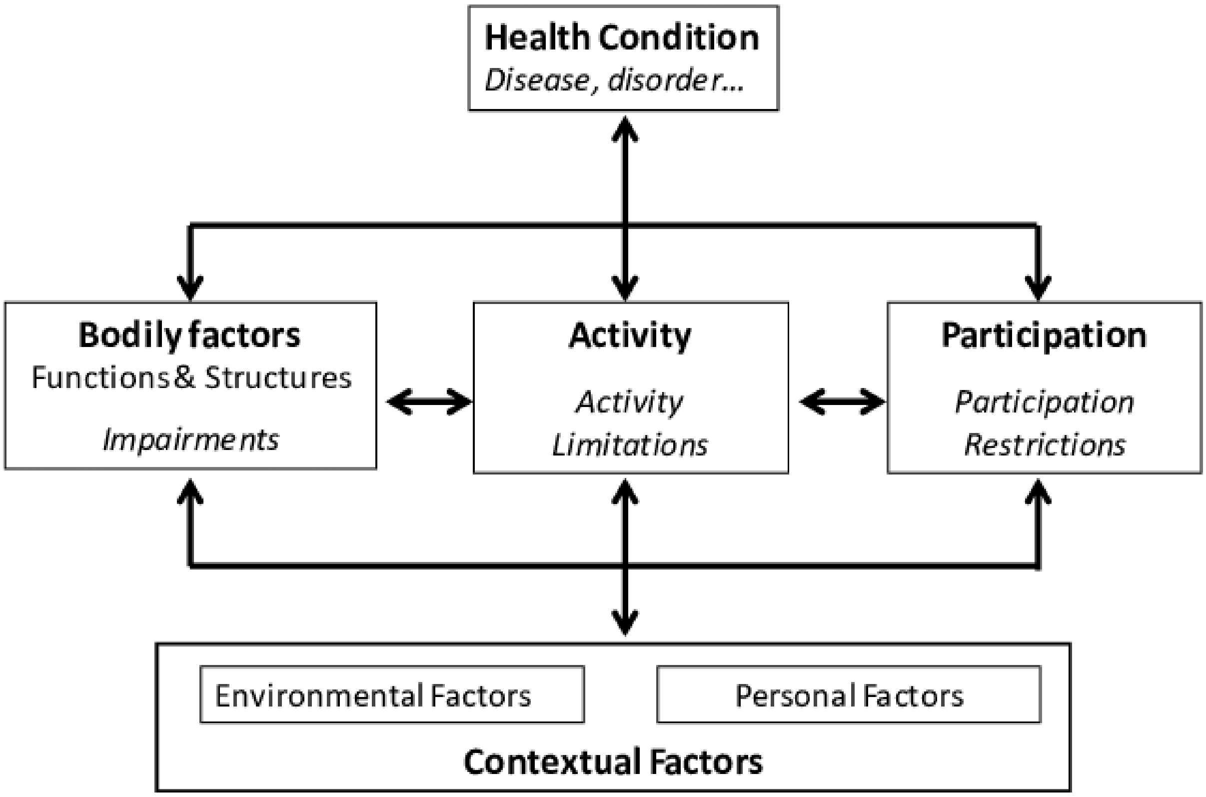

Figure 2.2: International Classification of Functioning, Disability and Health Framework

Neurological rehabilitation helps individuals with disabilities resulting from neurological diseases to achieve and maintain optimal function and health in interaction with their environment. Historically, the philosophy of neurorehabilitation emphasised the individual's disabilities, often viewing them through a negative, illness-focused lens (Barnes, 2003). However, the field has since shifted from this health and illness perspective to the individual's functional abilities within their social and community contexts. In 1998, the ICF framework was updated from its original 1980 version, replacing the terms 'disability' and 'handicap' with 'activity' and 'participation' while maintaining its foundational principles (World Health Organisation, 2001). This shift aimed to emphasise the positive abilities of individuals rather than their limitations. Neurorehabilitation now uses the ICF to evaluate and monitor functional changes following therapeutic interventions, providing a standardised means of describing and quantifying functioning and disability (Huang and Krakauer, 2009; Bjørnshave Noe, Angel and Bjerrum, 2022).

Numerous studies have employed the ICF domains to achieve various goals in neurorehabilitation research. These studies have investigated the effectiveness of rehabilitation techniques for individuals with neurological disorders such as stroke (de Azevedo *et al.*, 2022), cerebral palsy (Huang and Krakauer, 2009), and acquired brain injury (Laxe, Cieza and Castaño-Monsalve, 2015; Beit Yosef *et al.*, 2022). Systematic reviews have used the ICF to establish study inclusion criteria (Hoare *et al.*, 2007) and standardise the outcomes assessed (Huang and Krakauer, 2009). Other studies have utilised the ICF to describe patients' functional status post-surgery (van Egmond *et al*., 2018, 2020), set rehabilitation goals (Laxe, Cieza and Castaño-Monsalve, 2015), design interventions (Patel *et al*., 2020), and monitor functional improvements to gauge the effectiveness of interventions (Martin *et al*., 2008; Marotta *et al*., 2021). Following this approach, the present research employs the ICF domains to measure outcomes and monitor functional changes resulting from rebound exercise training (table 2.5). This methodology ensures a comprehensive assessment of the rehabilitation process, focusing on improving individuals' abilities and community participation.

Table 2.5: Neurorehabilitation with Rebound Exercise and ICF Classification

ICF Components	Goals	Outcome measures	Intervention
Body function Balance Muscle power (grip strength) Cardiovascular fitness Cognitive function	To stimulate neuroplasticity and improve motor control and cognitive and physiological functions.	3-metre backward walk test Handheld dynamometer Digital Blood pressure monitor Mini-cog test	Rebound exercise targets cardiovascular fitness, brain function, balance and muscle strength.
Activity Walking Physical activity	To reduce limitations in mobility and daily activities.	10-metres walk test International Physical Activity questionnaire	Tailored rebound exercise sessions are dynamic, addressing multiple areas like strength and balance training. Regular assessment to track improvements in functional abilities like walking speed.
Participation Quality of life	To enhance participation in the community	WHOQoL-Bref questionnaire	Rebound exercises are designed to improve social interaction and community involvement
Environmental factors Quality of life	To improve individuals' well-being and life satisfaction in their environment	WHOQoL-Bref Questionnaire	The environment for the rebound exercise is safe, and there is access to necessary equipment and support.

2.7.2 Theory of Planned Behaviour

The theory of planned behaviour (TPB) was used in addition to the literature to explain the research findings of the qualitative study. This theory was developed as an extension of the Theory of Reasoned Action (TRA) to address the limitation of behaviours subject to external constraints. TRA assumes that an individual’s intention to engage in behaviour depends on their attitude towards the behaviour and the social norms (Taylor *et al*., 2007). TPB builds upon TRA by incorporating an additional factor, perceived behavioural control, to better explain and predict human behaviour, especially behaviours not entirely under an individual's control.

TPB posits that attitudes, subjective norms, and perceived behavioural control are the key determinants of an individual's intention to perform a behaviour and, subsequently, their actual behaviour (Akaberi and Pakpour, 2012; Khan *et al.*, 2016) (figure 2.3). Attitudes represent the degree to which an individual has a favourable or unfavourable appraisal of the behaviour. Subjective norm refers to an individual's perception of social pressure or the influence of significant others regarding a particular behaviour or action. It encompasses the beliefs about whether people who are important to them think they should or should not engage in the behaviour. Perceived behavioural control (PCB) is the perceived ease or difficulty of performing the behaviour based on past experience and anticipated impediments. PBC is particularly important in TPB because it acknowledges that even when individuals have positive attitudes toward behaviour and perceive that others expect them to perform it, external factors can hinder or facilitate their ability to carry out the behaviour.

An individual's intention to engage in a behaviour is influenced by their attitude, subjective norm, and perceived behavioural control. The stronger these constructs are, the stronger the behavioural intention (Clayton and Griffith, 2008). Ajzen (2005) emphasised that while attitudes significantly shape human behaviour, they are not the sole determinants. Ajzen contended that behavioural intention, which incorporates attitudes, subjective norms, and perceived behavioural control, emerges as a more robust predictor of actual behaviour.

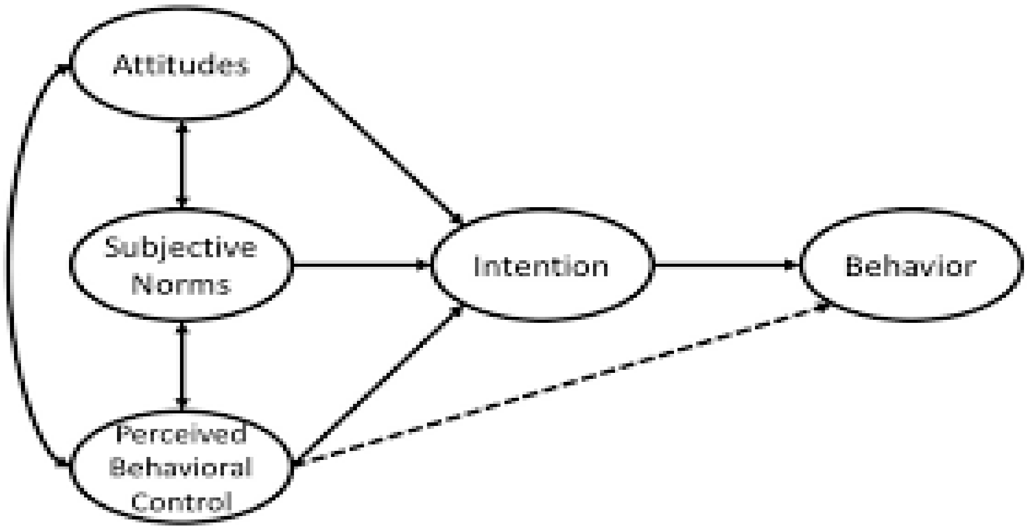

Figure 2.3: Theory of Planned Behaviour (Ajzen, 1985).

Earlier research suggests that TPB can be used to understand the psychosocial factors determining physical activity behaviours (Ajzen, 1980, 1991; Hausenblas, Carron and Mack, 1997; Ajzen and Fishbein, 2000; Hagger, Chatzisarantis and Biddle, 2002). This can consequently serve as a basis for creating interventions to increase physical activity levels (Shafieinia *et al.*, 2016). Various studies have effectively utilised the TPB in different scenarios to encourage physical activity among varied populations (Fateme Saber, Hossein Shanazi and Gholamreza Sharifrad, 2013; Solhi *et al.*, 2014; Ahmadi Tabatabaei *et al.*, 2017; Taghipour *et al.*, 2019).

TPB postulates that a person's intention to engage in a behaviour is linked to their likelihood of adopting it. Research indicates that efforts to encourage physical activity should concentrate on fostering positive attitudes towards physical activity and enhancing perceived behavioural control to influence behavioural intention (Shafieinia *et al*., 2016; Ahmadi Tabatabaei *et al*., 2017). Behavioural intention refers to an individual's readiness and willingness to engage in a specific behaviour in the near or immediate future. Low physical activity levels and poor exercise adherence are common concerns among individuals with neurological disorders, so different options that may improve compliance and physical activity levels must be explored.

TPB provides a suitable framework for exploring this study's participants' intentions towards engaging in rebound exercises. It incorporates the interplay of attitudes, subjective norms, and perceived behavioural control for a holistic understanding of human behaviour. Although TPB has been widely used in most studies to predict behaviours, this study is not focused on prediction. Instead, it aims to explain the constructs that influence participants' experiences and motivations to engage in rebound exercise within the context of neurological disorders.

2.8 Conceptual Framework

Rehabilitation interventions for people with neurological disorders are complex because they are often individualised, have several outcomes of interest, have interconnected elements, and are influenced by contextual factors (Booth *et al.*, 2019). To promote evidence-based practice, it is imperative to conduct rigorous research on new potentially beneficial complex interventions before they are used in neurorehabilitation centres. This research is conceptually poised to investigate the feasibility of using rebound exercise (a complex intervention according to the above definition) guided by the UK's revised Medical Research Council (MRC) framework for developing and evaluating complex interventions.

The initial MRC framework has received criticism for failing to adequately handle the intricacies of complex interventions (Kernick and Reinhold, 2008; Craig and Petticrew, 2013; Booth *et al.*, 2019). Skivington *et al*. (2021) argued that the former MRC framework was centred on intervention effectiveness and didn't address other vital research and clinical priorities. Hence, they developed the revised MRC framework to address the elements necessary when using complex interventions. Such vital research elements are pragmatic considerations for new interventions, including feasibility, acceptability, flexibility, cost-effectiveness and implementability. Since the initial release of the MRC framework in 2000, the emphasis has shifted remarkably away from the sequential cause-and-effect paradigm that was initially used, where the aim was to assess the effectiveness of interventions, and toward a pluralistic and repeatable approach that targets real-world research challenges (Greenhalgh and Papoutsi, 2018)The framework is divided into four phases: development or identification of the complex intervention, feasibility, evaluation, and implementation. This research is focused on phases one and two of the revised MRC framework (figure 2.4).

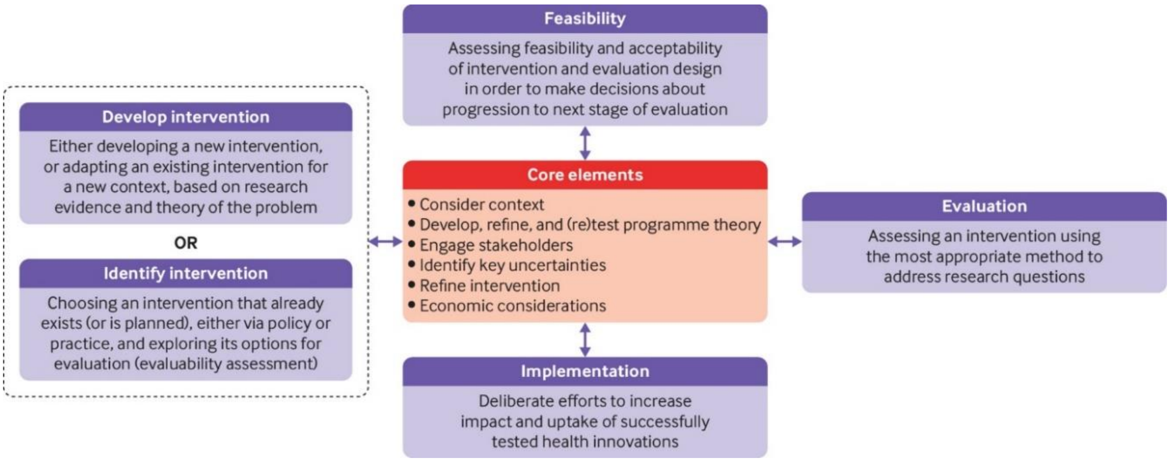

Figure 2.4: MRC Framework for Evaluating Complex Interventions (Skivington *et al.*, 2021)

Phase 1 of the research process is known as the development phase. During this time, researchers focus on three tasks: (1) identifying and reviewing existing evidence; (2) identifying pertinent theory to support the new intervention; and (3) modelling the intervention to understand its components, potential effects, and areas for improvement. Phase 2 involves evaluating the intervention's feasibility using qualitative and quantitative research techniques. The objective is to gain a deeper understanding of logistical issues like the acceptability of the intervention, participant recruitment and retention, and fidelity of the intervention processes. The complex intervention is then improved upon and analysed on a broader scale in Phase 3, emphasising the effectiveness, impact on pertinent outcomes, mechanisms that could underpin findings, and cost-effectiveness of said intervention. Phase 4 entails implementing the complicated intervention into clinical practice through focused knowledge translation and dissemination if Phase 3 is successful. The MRC framework is iterative and cyclical rather than linear since it may be essential to revisit earlier phases in the cycle depending on the results of any given phase (Craig and Petticrew, 2013).

The initial phase of developing/ identifying the complex intervention was completed in study one. The components in this phase largely revolve around compiling the current evidence for the proposed intervention through systematic reviews, identifying underpinning theories and adapting the intervention based on existing evidence (Bleijenberg *et al.*, 2018). The theories guiding the use of rebound exercise for this research study include the principles of Hooke's law, elastic potential energy (Eager *et al.*, 2022) and the stretch-shortening cycle (Azab *et al.*, 2022), which are at work during rebounding. These allow the trampoline to store and release energy and the muscles to generate more force, enabling the user to bounce higher.

In line with phase 1, rebound exercise, typically utilised in the healthy population to train athletes, pilots, astronauts, and children for enjoyment, is adapted for use in individuals with neurological disorders. This population is typically associated with balance and mobility issues (Carmeli, 2017). So, a stability bar is added to the mini-trampoline to ensure safety. The identified limitations in the literature informed the subsequent study design. The next phase, the feasibility testing phase, comprises this research's second and third studies. In agreement with the updated MRC framework guidance (Skivington *et al.*, 2021), this phase investigates recruitment uncertainties, data collection, intervention delivery, acceptability, and adherence. These feasibility studies lay the foundation for future evaluation and implementation phases.

2.9 The Concepts of Feasibility, Acceptability and Effectiveness

Researchers must scrutinise the feasibility, acceptability, and effectiveness of healthcare interventions to ensure their successful translation into practice. This thesis explores these essential interrelated concepts, investigating their role in shaping rebound exercise intervention's potential for real-world application.

2.9.1 Feasibility

When planning to evaluate or implement an intervention, researchers must first demonstrate through a preparatory study that there is convincing evidence to support its potential (National Institute for Health and Care Research, 2023). The preparatory study assesses uncertainties related to conducting a larger study, such as recruitment and retention rates, acceptability of the intervention to the users, adherence to the intervention, willingness of the participants to be randomised, follow-up rates, safety concerns, response rates to questionnaires, practicality of delivering the intervention in the proposed setting and time required to collect, clean and analyse data (National Institute for Health and Care Research, 2023). The language used to describe this preparatory phase for a trial is often inconsistent, decreasing the likelihood of addressing the relevant research questions and ultimately resulting in less efficient trials and interventions (Eldridge *et al.*, 2013).

According to MRC guidance for developing and evaluating complex interventions like rebound exercises, this initial preparatory phase is called the "feasibility and piloting" stage (O'Cathain *et al.*, 2015). While both terms are often used interchangeably, it is essential to distinguish between feasibility and pilot studies. The National Institute for Health and Care

Research (NIHR) defines a feasibility study as “a piece of research done before a main study to answer the question ‘Can this study be done?’” and a pilot study as “a version of the main study that is run in miniature to test whether the components of the main study in many respects”. While pilot studies resemble and focus on the processes of the main study, feasibility studies are used to estimate important parameters needed to design the main study (National Institute for Health and Care Research, 2024). Feasibility studies are crucial in enhancing the conduct and quality of randomised controlled trials by determining whether an intervention is appropriate for future testing, identifying possible adjustment needs to the intervention, testing preliminary intervention effects or addressing uncertainties around the practicality of the intervention (Eldridge *et al.*, 2016).

The distinction between pilot and feasibility studies has sparked debate among researchers. Some researchers consider pilot studies as a subset of feasibility studies (Eldridge *et al*., 2016; National Institute for Health and Care Research, 2023), while others view feasibility studies as a subset of pilot studies (Lancaster and Thabane, 2019). Consistent with the former view, this thesis adopts the perspective that pilot studies are a subset of feasibility studies. Pilot studies adopt the main study’s design on a smaller scale, whereas feasibility studies assess broader uncertainties potentially impacting the main study. Feasibility studies can employ diverse methodologies (quantitative, qualitative or mixed-methods) and designs (observational, experimental, randomised or non-randomised) (O’Cathain *et al*., 2015; Teresi *et al*., 2022). This thesis uses the term ‘feasibility’ to describe the practicality of an intervention, specifically rebound exercise, in community-dwelling adults with neurological disorders. It adopts observational and qualitative feasibility studies to evaluate the feasibility of rebound exercise among these adults, focusing on uncertainties regarding recruitment, retention, safety concerns, adherence, experience and acceptability.

2.9.2 Acceptability

The concept of acceptability plays a vital role in research, particularly in clinical trials, public health interventions, and implementation studies. Although its significance is evident, its definition remains ambiguous; in fact, the concept of acceptability in research has been criticised as “extremely vague” (Macdonald, 2017). The Cambridge Dictionary defines acceptability as “the quality of being satisfactory and able to be approved of” (Cambridge Dictionary, 2024). The Oxford Advanced Learner’s Dictionary defines it as “the degree to which somebody agrees that something is good enough to use or allow" (Oxford University Press, 2024).

In research studies, acceptability refers to people's attitude towards, willingness to engage with, actual engagement with, and satisfaction after engaging with the intervention (Nadal, Sas and Doherty, 2020). Sekhon *et al*. (2017) define acceptability as "a multi-faceted construct that reflects the extent to which people delivering or receiving intervention consider it appropriate based on anticipated or experienced cognitive and emotional responses to the intervention." The theoretical framework for acceptability (TFA) outlines the multi-faceted constructs of acceptability that can be assessed prospectively and retrospectively. These core components include affective attitude, perceived burden, ethicality, perceived effectiveness, intervention coherence, and opportunity costs (Sekhon, Cartwright and Francis, 2017). Gooding *et al*. (2018) define acceptability as "a perception among invited participants that the research design is, to varying extents, favourable, agreeable, palatable and satisfactory". This definition reflects this thesis's stance on the acceptability of rebound exercise intervention to the participants as ethical, satisfactory and effective based on their experience.

Acceptability is a core aspect of feasibility, evaluation and implementation studies as it influences participant adherence, retention and overall study outcome (Perski and Short, 2021). The MRC framework recommends assessing acceptability in the feasibility phase to gain insights into the stakeholders' view of the complex intervention (Skivington *et al*., 2021). Historically, acceptability in research studies has often been inferred from participant behaviour (frequency of attendance, adherence, engagement) rather than direct measurements (via questionnaires and interviews) (Sekhon, Cartwright and Francis, 2018). For instance, a systematic review reported that only 26% of studies assessed acceptability through direct subjective measures, and even a smaller proportion (19%) used both self-report and objective measures of behaviour (Sekhon, Cartwright and Francis, 2017). While self-report measures capture participants' personal experiences, perceptions and opinions, they are prone to recall and social desirability bias. Similarly, objective observations provide direct evidence of behavioural changes, are less susceptible to bias and are more generalisable. However, they focus only on observable behaviours, neglecting complex psychological or social factors and may overlook participants' personal experiences and motivations.

Integrating both self-report and objective measures provides a more comprehensive understanding of the acceptability of the intervention. This thesis employed a mixed-methods approach, combining self-report measures (interview exploring participant experience, perceived effectiveness, and satisfaction) with objective observation (frequency of attendance, retention rate, adherence) to assess the acceptability of rebound exercise among community-dwelling adults with neurological disorders. This triangulation approach may reveal factors influencing research findings, distinguishing between intervention acceptability and external factors affecting participation. For instance, low retention and adherence rates may not necessarily indicate poor intervention acceptability but may result from research burden (lengthy questionnaires, frequent assessments), logistic challenges (transportation issues, scheduling conflicts) or intervention delivery (inadequate training, insufficient resources, therapist-participant mismatch) (Sanders *et al*., 2012; Sekhon, Cartwright and Francis, 2017).

2.9.3 Effectiveness

The term "effectiveness" refers to the degree to which something successfully achieves the intended result (Cambridge Dictionary, 2024). In healthcare interventions, effectiveness encompasses the intervention's ability to produce meaningful, measurable and sustainable improvements in participants' overall well-being (Singal, Higgins and Waljee, 2014). It is an essential concept for evaluating healthcare interventions. In research, effectiveness is often used interchangeably with efficacy despite their unique roles. Rather than a dichotomous relationship, a continuum-based perspective illustrates a gradual progression from efficacy trials establishing intervention potential in controlled environments to effectiveness trials examining pragmatic implementation and outcomes in naturalistic settings (Fritz and Cleland, 2003; Singal, Higgins and Waljee, 2014). In contrast to efficacy, which focuses on intervention potential under optimal conditions, effectiveness evaluates the intervention's performance in real-world contexts, accounting for external factors like heterogenous population, implementation variability and environmental factors. The design of effectiveness studies involves a strategic trade-off, relinquishing some internal validity (e.g. through pragmatic sampling and minimal exclusion criteria) to attain greater external validity, facilitating the translation of findings to diverse populations and contexts (Fritz and Cleland, 2003).

The MRC framework for complex interventions provides a structured approach to evaluating effectiveness, particularly relevant in the evaluation and implementation phases (Skivington *et al*., 2021). This thesis, focusing on rebound exercise for adults with neurological disorders, aligns with the MRC framework. The systematic review (study one) investigated the effect of rebound exercise in adults with neurological disorders in the hospital setting. Despite their structured environments (better access to resources and increased monitoring in line with efficacy), this thesis contends that hospital settings represent real-world contexts for effectiveness research. Hospital settings reflect actual clinical healthcare delivery, involve diverse patient populations, and address complex real-world health issues. Efficacy trials typically employ a placebo-controlled randomised design, whereas, in effectiveness trials, the intervention is compared to standard care (Singal, Higgins and Waljee, 2014). The included studies of the systematic review all compared rebound exercise to usual physiotherapy care, echoing real-world scenarios. Furthermore, the qualitative research (study three) also explored participants' experiences and perceived benefits of rebound exercise, providing insights into the effectiveness of rebound exercise, participant-centred perspectives and real-world implementation challenges.

2.10 Research Methodology

This research is exploratory in nature. Its objectives are to investigate the effect of rebound exercise in adults with neurological disorders and provide insight into its acceptance and perceived effectiveness by the participants. A mixed-method approach was employed to address the research question effectively. The mixed-method approach, which combines qualitative and quantitative research techniques, has gained significant traction in social sciences, healthcare, and education over the past few decades (Timans, Wouters and Heilbron, 2019). This approach leverages the strengths of both qualitative and quantitative methodologies to provide a more comprehensive understanding of research phenomena. By integrating numerical data with rich, contextual narratives, mixed-method research addresses the limitations inherent in using either approach alone and enhances the validity and depth of the findings (Teddlie and Tashakkori, 2009).

Mixed-method research (MMR) has emerged as a significant methodological approach in social science research, bridging the longstanding divide between quantitative and qualitative paradigms. The concept of MMR was born out of the need to reconcile the epistemological differences between quantitative and qualitative research. Early proponents such as John Creswell and Abbas Tashakkori championed this integrative approach in the 1990s, highlighting its ability to produce more comprehensive and nuanced research outcomes (Tashakkori and Creswell, 2007). MMR sought to leverage the strengths of both paradigms, addressing their respective limitations and offering a more holistic understanding of research phenomena.

Since its inception, MMR has faced challenges related to its terminology and definitions. Initially, it was referred to by various names, including multimethod research, mixed methods, mixed methodology, mixed research, and integrated research (Teddlie and Tashakkori, 2009). Over time, a consensus emerged, establishing "mixed-method research" as the standard term. Similarly, defining MMR proved contentious, prompting Johnson, Onwuegbuzie and Turner (2007) to review 19 existing definitions and propose a composite definition: “the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purposes of breadth and depth of understanding and corroboration.”

The formal recognition of MMR in the 1980s and 1990s built upon earlier informal practices where researchers intuitively combined quantitative and qualitative methods (Creswell, 2011). Pioneers like Sieber (1973) used terms like ‘interplay’ and ‘concurrent scheduling’ to describe the collection of multiple data types, though they did not explicitly address the integration of data sources or the rationale behind it. Subsequent scholars such as Bryman (2006), Creswell and Clark (2007), Creswell (2011) and Greene *et al*. (1989) refined these ideas, providing detailed methodologies for data integration and articulating the benefits of combining different data sources. MMR occupies a unique position between the positivist paradigm, favouring quantitative methods, and the constructivist/interpretivist paradigm, which relies on qualitative methods (Denscombe, 2008). This middle ground allows researchers to draw on the strengths of both paradigms, addressing complex research questions that single-method approaches might miss.

Despite ongoing debates and criticisms, MMR is now widely recognised as a legitimate third research paradigm (Tashakkori and Teddlie, 2002; Creswell *et al*., 2003; Creswell and Clark, 2007; Johnson, Onwuegbuzie and Turner, 2007). The defining characteristics of MMR include the simultaneous use of quantitative and qualitative methods within the same study, a research design that clearly delineates the sequencing and priority of these methods, and an explicit explanation of how these methods relate to each other (Denscombe, 2008). Crucially, MMR emphasises using triangulation to enhance the validity and reliability of findings.

Pragmatism serves as the philosophical underpinning of MMR, advocating for the practical application of research to address real-world problems (Morgan, 2014). As a philosophical movement, pragmatism originated in the late 19th and early 20th centuries, primarily in the United States. Key figures such as Charles Sanders Peirce, William James, and John Dewey developed and propagated this philosophy (Maxcy, 2003; Ormerod, 2006). Peirce introduced the concept of pragmatism as a method for clarifying ideas through their practical consequences. William James expanded on this, advocating for a philosophy that evaluates theories based on their practical utility and experiential outcomes. John Dewey further refined pragmatism by emphasising the interplay between experience, action, and inquiry, particularly in educational and social contexts (Morgan, 2014).

Compared with positivism, which defines an object based on what it is, and interpretivism, which defines the same object based on what it is used for, pragmatism defines an object based on how it would help achieve the researcher’s purpose (Goles and Hirschheim, 2000). Pragmatism is characterised by several core principles that distinguish it from other philosophical traditions, including practical consequences, anti-foundationalism, contextuality, pluralism and flexibility (Kaushik and Walsh, 2019). Pragmatism evaluates the truth and meaning of ideas based on their practical effects and applications (Wiggins, 2009). It rejects the idea of absolute truths or foundations of knowledge (Sanches de Oliveira, 2020). Instead, it sees knowledge as provisional and subject to change based on new experiences and evidence (Peirce, 1905; Dewey, 1916). Pragmatic research considers the specific context in which phenomena occur. It acknowledges that findings are often context-dependent and that generalisations should be made cautiously (Patton, 2014). Finally, pragmatism embraces methodological pluralism, recognising that different research methods can provide valuable insights. Researchers are encouraged to use multiple approaches to address complex problems (Creswell, 2011).

Overall, MMR represents a significant advancement in social science research methodology, offering a robust framework for integrating quantitative and qualitative approaches. Its development has resolved many early challenges related to terminology and definition, establishing it as a valuable third paradigm. Pragmatism's flexibility allows researchers to choose methods that best address their research questions rather than being constrained by strict methodological allegiances (Kaushik and Walsh, 2019). This approach aligns with the growing recognition that complex social phenomena often require diverse perspectives and multiple forms of evidence to be fully understood.

Despite its strengths, MMR is not without criticisms. One major critique is the complexity involved in designing and executing MMR studies. Researchers must be proficient in both quantitative and qualitative methods, which can be challenging and resource-intensive (Bryman, 2006). Additionally, integrating data from different paradigms can be methodologically complicated, sometimes leading to superficial or forced integration rather than a genuine synthesis of findings (Freshwater, 2007). Another criticism is the potential for methodological bias, where the emphasis on one method may overshadow the other, leading to an imbalance in the research findings (Greene, 2007). Critics also argue that the philosophical underpinnings of MMR, pragmatism, can be seen as a convenient but superficial reconciliation of fundamentally different epistemological stances (Giddings and Grant, 2006). This may lead to the perception that MMR lacks a coherent philosophical foundation, weakening its credibility in the eyes of purists from either paradigm (Maxcy, 2003). Furthermore, the logistical demands of conducting MMR can be prohibitive. Coordinating multiple data collection and analysis phases requires substantial time, funding, and effort, which may not be feasible for all research projects (Fetters, Curry and Creswell, 2013). This complexity can also lead to difficulties in publishing MMR studies, as the comprehensive nature of such research often exceeds the standard length and scope of many academic journals (Bazeley, 2009).

2.11 Data Triangulation

The term ‘triangulation’ originated from navigation, where it was used to pinpoint an unknown location of a ship by using the angles from two known locations (Heale and Forbes, 2013; Valencia, 2022). This concept was first introduced into qualitative research in the late 1950s to address the inherent subjectivity and potential biases that could compromise the validity and reliability of qualitative findings (Williamson, 2005; Heale and Forbes, 2013). Despite the distinct contributions of qualitative and quantitative research in addressing research problems, experts argue that neither approach, when used in isolation, provides a comprehensive understanding of a research phenomenon (Cowman, 1993). Thus, reconciling the paradigmatic assumptions inherent in both approaches can yield rich and comprehensive data, especially when the goal is to deeply understand a phenomenon (Cowman, 1993). Consequently, Campbell and Fiske first employed triangulation in research in 1959 (Valencia, 2022).

Triangulation in research refers to combining two or more theories, data sources, research methods, or researchers to enhance the robustness of findings (Denzin, 1970; Kimchi, Polivka and Stevenson, 1991). Recognising its potential for ambiguity and misinterpretation, Kimchi *et al*. (1991) elucidated the different types of triangulation to provide clarity. Denzin (2017) described four main types of triangulation: The first is data source triangulation, which involves collecting data on the same phenomenon at different times (time), from different sites (space), and different people (person), ensuring a broad and nuanced understanding. Second is theoretical triangulation, which involves using multiple perspectives to study the same phenomenon, thereby enriching the analysis through diverse theoretical lenses. Next is the researcher triangulation, which involves multiple researchers studying the same phenomenon, reducing individual biases and enhancing the reliability of the findings. Finally, methodological triangulation involves combining multiple methods to study a phenomenon, either within the same qualitative or quantitative approach (within-method) or across different approaches (among-method), such as using surveys and interviews (Valencia, 2022) . This form of triangulation is also referred to as mixed methods.

Employing mixed methods, or methodological triangulation, can result in one of three outcomes (Tashakkori and Teddlie, 2002): 1) Convergence: Results lead to the same conclusions, thereby increasing the validity of the findings. 2) Complementarity: Results relate to different aspects of the phenomenon, highlighting various dimensions and providing a more holistic understanding. 3) Divergence: Results are contradictory, potentially leading to new insights and a better explanation of the research phenomenon. Triangulation enhances the validity and credibility of research findings through verification and quality assurance (Patton, 1999; Noble and Heale, 2019). Furthermore, triangulation ensures a more comprehensive and accurate portrayal of the research phenomenon by minimising the shortcomings and biases associated with any individual method, theory, researcher, or data source (Tobin and Begley, 2004).

CHAPTER THREE

THE EFFECT OF REBOUND EXERCISE ON FUNCTIONAL OUTCOMES AMONG INDIVIDUALS WITH NEUROLOGICAL DISORDERS: A SYSTEMATIC REVIEW WITH META-ANALYSIS.

3.0 Chapter Overview

Systematic reviews and meta-analyses are described as the highest level of evidence in scientific research. Thus, through a systematic review, this chapter extensively reviews the literature to explore the available evidence on the effects of rebound exercise in adults with neurological disorders and identify knowledge deficits. It also presents the meta-analysis of included studies, results and discussion of the findings.

3.1 Background of the Study

Neurological disorders encompass a wide range of diseases affecting the nervous system, including but not limited to traumatic brain injury, stroke, epilepsy, Parkinson's disease, amyotrophic lateral sclerosis, multiple sclerosis, Guillain-Barre syndrome, and spinal cord injury (World Health Organisation, 2016). These disorders affect about 3.4 billion people globally, with an estimated 9 million deaths yearly (World Health Organisation, 2006, 2023). In addition to the increasingly ageing population, there is an equally significant increase in the burden of neurological disabilities in advanced and emergent nations, particularly in countries with a large proportion of older adults (Carroll, 2019). Neurological disorders are the principal root of morbidity and the second major cause of mortality across the globe after cardiovascular diseases, accounting for between 7% and 16.5% of deaths annually (Johnson *et al.*, 2019), and this number is likely to increase (Luo *et al.*, 2021). According to the Neurological Alliance (2019), one in every six people in the UK is affected by neurological disorders, and there are about 600,000 newly diagnosed cases annually, contributing to 25% of all disabilities in the country.

The financial cost of neurological disorders in the UK can be significant, as these conditions often require ongoing medical treatment, rehabilitation, and assistive devices, which can be costly (World Health Organisation, 2006, 2023). Additionally, individuals with neurological disorders may also experience reduced/lost productivity and reduced quality of life, which can add to the financial burden (Shimizu *et al.*, 2021). The NHS disburses a substantial part of its budget on treating and managing neurological disorders. In 2012/2013, the NHS spent over £4.4 billion on people with neurological disorders, representing 4.2% of the total budget (Neurological Alliance, 2019). The trend of NHS expenditure on neurological disorders from 2003/2004 to 2009/2010 shows an average annual growth rate (AAGR) of approximately 6.3% (National Audit Office, 2011). Assuming a conservative 5-6% AAGR and considering the steadily increasing prevalence of neurological disorders, advances in treatment/diagnostic technologies and inflation, NHS spending on neurological disorders is projected to reach £7.8-£8.5 billion by 2023/2024. This growth trajectory emphasises the need for sustained investment in neurological disorders management.

Neurological disorders are linked to various problems, including but not limited to muscle weakness, movement impairments, balance, low quality of life and diminished functional independence (Carmeli, 2017). Movement and balance dysfunction and fear of falling pose psychological risks to patients' overall quality of life, and they can act as barriers to physical activity participation (Ellis *et al.*, 2013; Lindholm *et al.*, 2014). These impairments can lead to physical deconditioning, functional dependency and extreme disability if left unmanaged, creating the need for prompt treatment. For instance, approximately 75% of people with Parkinson's disease experience balance and movement disturbances, out of which approximately 70% report limited engagement in physical activity due to fear of falling (Brozová *et al.*, 2009; Nilsson *et al.*, 2012). To combat and reduce the fear of falling, balance and mobility restoration ought to be the primary target of rehabilitation (Nilsson *et al.*, 2012).

Neurological rehabilitation aims to assist individuals with disabilities in achieving and maintaining optimal health, interacting with their environment, and becoming self-sufficient (Gbiri and Shittu, 2014; Collett *et al.*, 2021). Most people with neurological disorders identify walking as essential and place it as a significant goal in their recovery journey (Tamburin *et al.*, 2019). Regular physical activity has been recommended for adults to maintain health and prevent chronic diseases (World Health Organisation, 2016; Bull *et al.*, 2020; Gualdi-Russo and Zaccagni, 2021). It has also been established as a vital non-pharmacological therapy for people with neurological disorders to improve functioning and prevent further decline in health (Gualdi-Russo and Zaccagni, 2021). Adults with neurological disabilities are most likely to gain from frequent exercise, but the physical impairments and mobility limitations associated with these disabilities tend to pose an obstacle to the performance of aerobic exercise (McDonnell, Smith and Mackintosh, 2011), thus making them less physically fit.

Rebound exercise is one such physical activity medium which is rapidly becoming popular in the healthcare industry despite being previously used solely as a training tool for astronauts (Bhattacharya *et al.*, 1980; Cugusi *et al.*, 2018). This exercise is performed on a mini-trampoline, resulting in the vertical movement of the body aided by the bouncing effect of the mini-trampoline. Fitted handlebars prevent the risk of fall injuries on the mini-trampoline and provide support and safety to the individuals.

Studies have revealed the attributes and outcomes of rebounding on the human body, even when exposed to a non-gravity environment (Bhattacharya *et al.*, 1980; Şahin, Demir and Aydın, 2016). These studies depict rebounding as the most efficient form of cellular exercise, utilising gravity to maximise gains while conserving efforts. NASA reported it to be 68% more effective than running (Bhattacharya *et al.*, 1980). Based on the established effects of rebound exercise on the human body (Şahin, Demir and Aydın, 2016; Rodrigues *et al.*, 2018; Clement, Alexander and Draper, 2022) as well as some of its peculiar characteristics lacking in other traditional modalities, it would be helpful to investigate the effect of this modality on people with neurological disorders. For example, rebound exercise provides equal gravitational force in all body parts, so there is no added stress to the heart, bones or joints, and it is thus a low-impact exercise (Bhattacharya *et al.*, 1980; Burandt, 2016). Because it is a low-impact exercise that minimises stress on the weight-bearing joints, there is a low risk of injury, making it an ideal activity for individuals with neurological disorders. Furthermore, bouncing on a mini-trampoline makes exercise a fun and exciting experience such that the individuals do not realise how intensely they are working (Burandt, 2016; Shah and Parab, 2018). In addition, it is a suitable exercise tool to promote adherence as its fun and enjoyable nature makes it easier to engage in regularly compared to some traditional exercise tools that may feel like a task. Considering these benefits of rebound as a training and recreational tool, it is essential to investigate its effect in the neurological population as it could offer a potentially suitable adjunct in neuro-rehabilitation. Thus, this research examined the effect of rebound exercise in people with neurological disorders.

3.2 Review Questions

- What are the effects of rebound exercise in people with neurological disorders?
- What functional outcomes does rebound exercise improve in people with neurological disorders?
- How were these functional outcomes measured?

3.3 Study Design

The study was a systematic review designed to rigorously evaluate the existing literature on the effects of rebound exercise on functional outcomes in people with neurological disorders. The review protocol was pre-registered with PROSPERO, the International Prospective Register of Systematic Reviews (registration number: CRD42021298030), ensuring transparency and adherence to best practices in systematic review methodology. The review was conducted and reported strictly per the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. These guidelines provide a structured framework that enhances the clarity, transparency, and reproducibility of systematic reviews (Page *et al.*, 2021). By following the PRISMA guidelines, this review aimed to minimise bias and provide a comprehensive synthesis of the available evidence.

3.4 Searches

The search strategy employed for this study involved using medical subject headings (MeSH terms), titles, abstracts and keywords relating to or describing rebound exercise. With the help of the librarian, the terms were initially combined on PubMed and the most specific and sensitive terms were selected. The search terms were adjusted to be used on different electronic databases such as SportDiscus, PsycINFO, ProQuest, and Cochrane Library Trials. An example of the search strategy in SportDiscus is presented in Figure 3.1 below. Database-specific filters for controlled trials were applied as per requirement. Additionally, pertinent research studies were searched on grey literature repositories like open thesis, clinicaltrials.gov and Google Scholar. Email inquiries were sent to leading experts in the field to solicit information on ongoing or unpublished studies. ‘OR’ and ‘AND’ Boolean operators were used to connect terms within and between concepts, respectively, while truncation (*) was used to capture substitute terms. In addition to the identified studies, a manual search of journals and reference lists was conducted. Searches were re-run just before the final analysis to ensure no newly included studies were missed. There were no restrictions on publication dates. Only original peer-reviewed studies published in the English language were considered for inclusion.

3.5 Search Strategy

The URL links to the search strategy used on the different databases are presented in Appendix 1. Several searches run on Medline via the Ovid interface yielded no results. The first search was conducted in November 2021. The search was re-run on the 28th of February, 2022, and then again on the 8th of March, 2023. Few additional studies were identified and screened. However, none of these newly identified studies were relevant to the review question.

Wednesday, March 08, 2023, 1:12:04 AM

#	Query	Limiters/Expanders	Last Run Via	Results
S6	TX (Rebound therapy or trampoline or trampolining) AND AB (neurological disorders or neurological disease or disability)	Limiters - Language: English; Publication Type: Academic Journal Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - SPORTDiscus with Full Text	32
S5	TX (Rebound therapy or trampoline or trampolining) AND TX (neurological disorders or neurological disease or disability)	Limiters - Language: English; Publication Type: Academic Journal Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - SPORTDiscus with Full Text	267
S4	TX rebound exercise OR TX mini-trampoline exercise AND TX neurological disorders	Limiters - Language: English; Publication Type: Academic Journal Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - SPORTDiscus with Full Text	151
S3	TX rebound therapy OR TX trampoline therapy AND TX (neurological disorders or neurological disease or neurological disability or neurological condition)	Limiters - Language: English; Publication Type: Academic Journal Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - SPORTDiscus with Full Text	32
S2	TX rebound therapy OR TX mini-trampoline exercise AND AB neurological disorders OR AB neurological disease	Expanders - Apply equivalent subjects Narrow by Language: - english Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - SPORTDiscus with Full Text	506
S1	TX rebound therapy OR TX mini-trampoline exercise AND AB neurological disorders OR AB neurological disease	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - SPORTDiscus with Full Text	529

Figure 3.1: Example of Search Strategy on Sports Discus

3.6 Eligibility Criteria

3.6.1 Participants

Studies involving participants with neurological disabilities aged 18 years and older were included, while studies involving non-human participants and children/teenagers under 18 with non-neurological disorders were not eligible for participation (table 3.1). The search was not restricted by publication year.

3.6.2 Intervention

Studies in which rebound exercise was used as an intervention. There was no restriction on rebound-only exercise, as there may be studies that include other forms of intervention in addition to rebound exercise. These studies were included only if the effects of the rebound exercise intervention could be ascertained.

3.6.3 Comparison Group

Only studies with control/comparison group(s) were eligible for inclusion. The control group included people with neurological disorders receiving the standard physiotherapy care that all participants receive but without the rebound exercise. Comparator group included other type of intervention such as treadmill training, Pilates practices, other balance exercises.

3.6.4 Outcome

Studies to be included must report on any of the following: Primary outcome includes Balance and quality of life. Secondary outcomes include mobility and activities of daily living. Standard, objective, valid, and reliable instruments were used to assess outcomes without any restrictions on outcome measures.

3.6.5 Study Type

Only experimental trials conducted to assess the beneficial effects of rebound exercise therapy were found and included. The aim of this review is to assess the effect of rebound therapy on functional outcomes of this patient population, and the best way to establish causality is through experimental trials. Although observational studies can potentially only show an association between variables and cannot infer causation, they would have been a useful addition to the review if any were available. Unfortunately, no observational studies on rebound exercise in neurological disorders were found.

3.6.6 Context of Included Studies

There were no restrictions on the study setting as studies that were conducted in the hospital, rehabilitation centres or in the community were eligible for inclusion. Every study on rebound exercise in people with neurological disorders in any country in the world was included.

Table 3.1: Eligibility Criteria

S/N	Inclusion criteria	Exclusion criteria
1	Studies on adults with neurological disorders	Non-scientific reports, letter to editor, commentaries, opinion papers
2	Scholarly journal and peer-reviewed articles	Studies that are written in languages other than English.
3	Intervention as mini trampoline/rebound exercise either alone or in combination with another therapy	Studies on children or teenagers not up to 18 years.
4	Experimental and quasi-experimental studies	Studies on non-human participants (animals).
5	Functional outcomes include balance, mobility, activities of daily living and quality of life.	

3.7 Extraction of Results (Selection and Coding)

The results of the literature search were systematically managed using Mendeley, a reference management software, to identify and remove any duplicate studies. The initial screening process was conducted independently by two review authors, who assessed the titles and abstracts of all articles identified from the databases and manual reference searches. Studies that appeared potentially eligible based on this preliminary screening were then subjected to a more thorough evaluation. For this second phase, the full texts of the selected articles were reviewed independently by the same two reviewers, applying the pre-defined eligibility criteria. In instances where there was a disagreement regarding the inclusion of a study, the reviewers engaged in discussion to reach a consensus. If an agreement could not be reached, a third, impartial reviewer was consulted to arbitrate and make the final decision.

To facilitate the systematic extraction of relevant data, the authors designed standardized data extraction tables using Microsoft Word. These tables were piloted on a small subset of studies to ensure they effectively captured all necessary information. The data extracted included key details such as the study setting, characteristics of the study population, participant demographics and baseline characteristics, descriptions of the intervention and control conditions, study methodology, outcome measures, periods of assessment, and evaluations of the risk of bias. Data extraction was performed independently by two authors to ensure accuracy and reliability. Any discrepancies in the extracted data were discussed between the authors, and unresolved issues were referred to a third author for resolution. In cases where essential data was missing from the published articles, the review authors contacted the study authors via email, as listed in the journal publications, to request the missing information. The entire study selection process was transparently documented and presented in a PRISMA flowchart, which also detailed the reasons for excluding certain studies at various stages of the review process (Figure 3.2).

3.8 Risk of Assessment of Bias

3.8.1 Description of the Risk Assessment Tool Used

Two independent researchers conducted the assessment of study quality for the systematic review using the Critical Appraisal Skills Programme Randomised Controlled Trial checklist [CASP RCT] (CASP, 2020). The CASP RCT checklist is a rigorous and widely recognised tool designed to critically appraise the validity, reliability, and relevance of randomised controlled trials (RCTs). Originating from the JAMA user's guides to medical literature (Guyatt *et al.*, 1994) and later updated in line with the CONSORT 2010 guidelines (Schulz, Altman and Moher, 2010), the CASP RCT checklist is particularly suited for this review, as it provides a detailed assessment of the methodological robustness of RCTs, which were the primary study designs included. The decision to use the CASP RCT checklist was based on its specificity and precision in evaluating RCTs compared to more generic appraisal tools like the Downs and Black checklist or the Mixed Methods Appraisal Tool (MMAT). These other tools, while useful across various study designs, may lack the nuanced focus necessary to critically assess the methodological intricacies of RCTs.

The CASP RCT checklist was preferred over the PEDro scale, another commonly used tool for RCTs, for several reasons. Although the PEDro scale is highly regarded in the field, particularly for physiotherapy-related studies (Armijo-Olivo *et al.*, 2015; Paci, Bianchini and Baccini, 2022), it has a significant limitation: it assesses whether studies report randomisation but does not delve into the quality or effectiveness of the randomisation process. This oversight is crucial, as improper randomisation can introduce selection bias and undermine the validity of the trial's findings (Berger *et al.*, 2021)In contrast, the CASP RCT checklist offers a more comprehensive evaluation by requiring a detailed description of the randomisation process. This allows reviewers to determine whether the allocation of participants to different groups was truly random and free from bias.

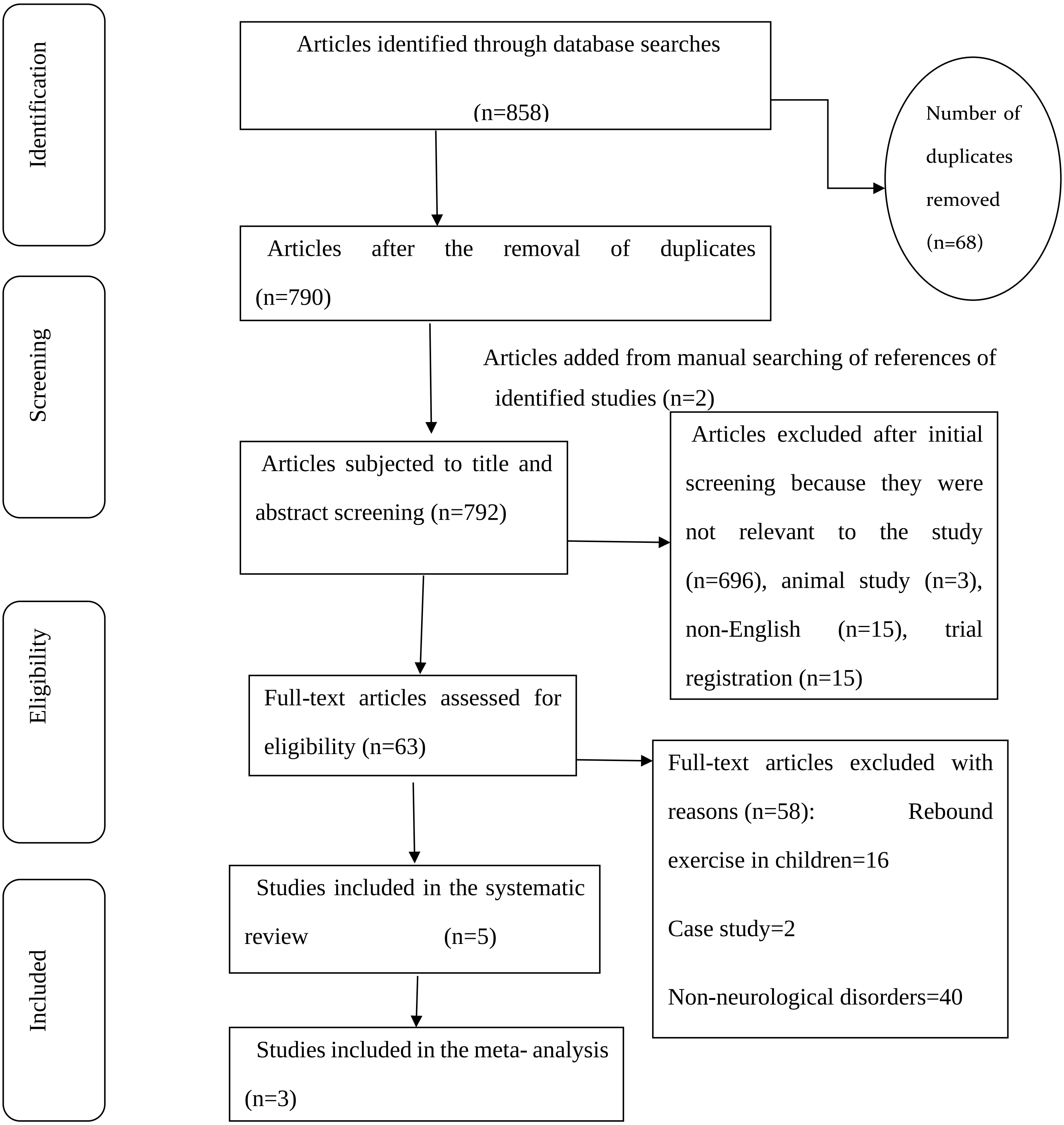

Figure 3.2: Prisma Flow Diagram for the Systematic Review Process

The CASP RCT checklist consists of 11 items broadly split into four sections that assess different aspects of the study (CASP, 2020; Long, French and Brooks, 2020). Section A includes two initial questions designed to quickly assess whether the study addresses a focused research question that aligns with the PICO framework (Participants, Intervention, Control/comparator, Outcome) and whether the study was appropriately randomised, including the concealment of allocation sequence. It also checks whether all participants who entered the study were properly accounted for at its conclusion, thereby addressing potential attrition bias. Section B delves into the methodological rigour of the study, examining the blinding of participants, researchers, and outcome assessors to the intervention, which is crucial in preventing performance and detection bias. It also assesses whether the baseline characteristics of the groups were similar, ensuring that any differences in outcomes can be attributed to the intervention rather than pre-existing differences between groups. Additionally, it evaluates whether the intervention was consistently applied across all groups, except for the intervention under investigation, thereby ensuring the study's internal validity.

Section C focuses on the reporting and interpretation of the study's results. It assesses whether the study included a power calculation to determine the sample size, whether appropriate statistical tests were used and correctly reported, and whether outcome measures were clearly specified. Furthermore, it evaluates how the study handled missing or incomplete data, attrition rates, and whether it reported p-values and confidence intervals, which are essential for understanding the precision of the estimated treatment effects. The section also examines whether the study adequately reported on the potential benefits and harms of the intervention, providing a balanced view of the findings. Section D evaluates the external validity of the study, considering how the findings can be applied to the local population or broader settings. It assesses the practical significance of the study's findings, the acknowledgment of study limitations, and the recommendations for future research. This section is particularly important in healthcare research, where the relevance and applicability of findings to real-world clinical settings are critical.

The CASP RCT checklist does not employ a scoring system, which aligns with the recommendations from the Cochrane Handbook (Noyes *et al.*, 2021). Instead, it encourages a more qualitative assessment of the studies, focusing on the detailed evaluation of each criterion to form a holistic judgment about the study's quality. This approach is advantageous because it avoids the oversimplification that can occur with numerical scores, where the complexity and nuances of study quality might be lost. By using the CASP RCT checklist, this review ensures a thorough and critical appraisal of the included studies, allowing for a more informed interpretation of the results and their implications for clinical practice.

3.9 Results

Six databases and manual bibliographic searches yielded a total of 858 studies (figure 3.2), of which five studies were included in the systematic analysis. Sixty-eight (68) duplicates were found and removed after the de-duplication process. 729 and 58 studies were eliminated following abstract and full-text screenings, respectively. Most excluded studies were irrelevant to the review aim (n=696). Other reasons for the exclusion of studies included studies not published in the English language (n=15), studies on children (n=16), studies on non-neurological disease populations (n=40), and trial registrations (n=15), among others. Only three of the five included studies could be pooled in a meta-analysis. The two excluded studies did not meet the criteria for meta-analysis as they assessed balance and mobility using different measures from the other studies, making it difficult to compare. One study assessed balance using a Kistler force plate (Sadeghi, Ghasemi and Karimi, 2019), while the other study assessed mobility in terms of joint range of motion using a universal goniometer (Daneshvar *et al.*, 2019).

3.9.1 Appraisal of Quality of Included Studies

The CASP tool was utilised to evaluate the quality of the included studies (Table 3.2). The tool provided three possible responses - 'yes', 'no', and 'can't tell'. The percentage risk of bias was calculated based on the total number of 'yes' answers. A score below 30% indicates a high risk of bias or low-quality study, while scores between 30% and 70% represent a moderate risk of bias. Scores above 70% indicate a low risk of bias or high-quality study (Abbaspur-Behbahani *et al.*, 2022). As a result of this rigorous assessment, the included studies demonstrated moderate to high methodological quality with a corresponding moderate to low risk of bias, which reassures the reliability of the systematic review's findings.

3.9.2 Study Characteristics

Five studies, published between 2013 and 2019, were included in this systematic review (Table 3.3). Among these, four were randomised controlled trials (RCTs), and one was a quasi-experimental study (Daneshvar *et al.*, 2019). The majority of the studies (four out of five) utilised a two-arm trial design, while one study (Sisi, Sadeghi and Nabavi, 2013) employed a three-arm trial involving rebound exercise, Pilates, and a control group. In the two-arm trials, two studies compared rebound exercise directly with a control group (Hahn, Shin and Lee, 2015; Sadeghi, Ghasemi and Karimi, 2019). The remaining two studies used an active comparison group rather than a traditional control group, with rebound exercise being compared to balance training (Miklitsch *et al*., 2013) and treadmill exercise (Daneshvar *et al.*, 2019).

In all studies, interventions were administered by qualified physiotherapists, ensuring that participants received professional guidance during the exercise protocols. Geographically, most of the studies were conducted in Iran, except for one study from Germany (Miklitsch *et al*., 2013) and another from Korea (Hahn, Shin and Lee, 2015), respectively. The study settings were explicitly mentioned in only three out of the five studies, all of which took place in hospital environments (Miklitsch *et al*., 2013; Hahn, Shin and Lee, 2015; Daneshvar *et al*., 2019). For the two studies where the settings were not initially disclosed, efforts were made to contact the corresponding authors for clarification. One author responded, confirming that their study was conducted in a spinal cord rehabilitation centre (Sadeghi, Ghasemi and Karimi, 2019).

The intervention and follow-up durations varied considerably among the studies, ranging from three to twelve weeks. Despite this variation, the frequency of the interventions was consistent across all studies, with participants engaging in 30-minute sessions three times per week. Outcome assessments were uniformly conducted at two time points: at baseline and end of trial, across all five studies.

Table 3.2: A Quality Appraisal of Studies

S/N	Questions	Miklitsch *et al*, 2013	Sisi *et al*., 2013	Hahn *et al*., 2015	Daneshvar *et al*., 2019	Sadeghi *et al*., 2019
1	Did the study address a clearly focused research question? (PICO addressed?)	Yes	Yes	Yes	Yes	Yes
2	Was the assignment of participants to interventions randomised? (Was randomisation done appropriately and concealed from the participants and investigators?)	Yes	Cannot tell	Cannot tell	Cannot tell	Cannot tell
3	Were all participants who entered the study accounted for at its conclusion? (Loss to follow-up, intent-to-treat analysis?)	Yes	Yes	No	Yes	Yes
4	Were the participants, investigators and outcome assessors blinded to the intervention given?	Yes	Cannot tell	Cannot tell	Yes	Cannot tell
5	Were the study groups similar at the start of the randomised controlled trial?	Yes	Yes	Yes	Yes	Yes
6	Apart from the experimental intervention, did each study group receive the same level of care (that is, were they treated equally)?	Yes	Yes	Yes	Yes	Yes
7	Were the effects of the intervention reported comprehensively? (power calculation, clear outcomes, p-values reported)	Yes	Yes	No	Yes	Yes
8	Was the precision of the estimate of the intervention or treatment effect reported? (Confidence intervals reported)	No	No	No	No	No
9	Do the benefits of experimental intervention outweigh the harms and costs? (Harms or unintended effect of intervention reported)	Yes	Cannot tell	Yes	Yes	Cannot tell
10	Can the results be applied to your local population/ in your context? (Was the right population used, and proper outcomes assessed?)	Yes	Yes	Yes	Yes	Yes
11	Would the experimental intervention provide greater value to the people in your care than any existing interventions?	Yes	Yes	Yes	Yes	Yes
	Total number of YES responses	10 (91%)	7 (64%)	6 (55%)	9 (82%)	7 (64%)

Table 3.3: Characteristics of Included Studies

Study (Country)	Disease	Sample size (I/C)	Mean age (x±sd)	Sex (% m/f)	Setting	Duration of intervention
1. Miklitsch *et al*., 2013 (Germany)	Stroke	20/20	58.0±12	62.5/ 37.5%	Hospital	3 weeks
2. Sisi *et al*., 2013 (Iran)	Multiple sclerosis	15/15	31.32±7.67	100/ 0%	Not reported	8 weeks
3. Hahn *et al*., 2015 (Korea)	Stroke	12/12	54.48±10	58.3/ 41.7%	Hospital	6 weeks
4. Daneshvar *et al*., 2019 (Iran)	Parkinson's disease	10/10	56.4±7.45	Not reported	Hospital	8 weeks
5. Sadeghi *et al*., 2019 (Iran)	Spinal cord injury	8/8	36.15±6.05	68.75/ 31.25%	Rehabilitation centre	12 weeks

I/C- Intervention/control, x±sd- mean±standard deviation, m/f- male/female

3.9.3 Participants Characteristics

One hundred and thirty (130) participants aged 31.32±7.67 to 58±12 years participated in the five included studies (table 3.3). Only three studies disclosed the sex of the participants (Miklitsch *et al*., 2013; Sisi, Sadeghi and Nabavi, 2013; Hahn, Shin and Lee, 2015), and these studies reported the majority of the participants as men, with one study having 100% male participants (Sisi, Sadeghi and Nabavi, 2013). The authors of both studies with missing data were contacted to provide the information, but only one study author responded, reporting a higher percentage of male participants, 68.75% (Sadeghi, Ghasemi and Karimi, 2019). So, the studies consisted primarily of male participants (72%). Two studies focused on stroke survivors (49%), while others focused on patients with multiple sclerosis (24%) (Sisi, Sadeghi and Nabavi, 2013), Parkinson's disease (15%) (Daneshvar *et al.,* 2019) and spinal cord injury (12%) (Sadeghi, Ghasemi and Karimi, 2019), respectively. Except for one study by Daneshvar *et al*. (2019), all other included studies assessed balance as an outcome. Additional outcomes assessed by the included studies are mobility, activities of daily living, gait endurance, fall efficacy, range of motion, proprioception and quality of life.

3.9.4 Outcome Measures

BBS assessed static balance in three of the four studies that evaluated balance in people with neurological disorders (Miklitsch *et al*., 2013; Sisi, Sadeghi and Nabavi, 2013; Hahn, Shin and Lee, 2015) (table 3.4).

The fourth study (Sadeghi, Ghasemi and Karimi, 2019) used the Kistler force plate for assessing centre of pressure (COP) parameters, which have been accepted as a valid means of evaluating balance in adults (Li *et al.*, 2016). Based on reports from Li *et al*. (2016), moderate to good validity and correlation were found between COP-based parameters obtained with the force platform and Berg balance scale.

The TUG test was used to assess dynamic balance as well as mobility in three of the studies (Miklitsch *et al*., 2013; Sisi, Sadeghi and Nabavi, 2013; Hahn, Shin and Lee, 2015). A fourth study assessed the joint range of motion in degrees using a goniometer, so it could not be compared with TUG scores recorded in seconds (Daneshvar *et al.*, 2019). Only one study assessed the activity of daily living outcomes and used the Barthel index as the outcome measure (Miklitsch *et al*., 2013). Another different study evaluated the quality of life

(Daneshvar *et al.*, 2019), and they used a disease-specific quality of life measure, the Parkinson’s Disease Questionnaire-39, to assess it.

3.9.5 Data Synthesis

The Cochrane Collaboration's Review Manager (RevMan) statistical software (version 5.3) was utilised to synthesise the data in this systematic review. Results of the four studies that reported balance were imputed into RevMan to test for heterogeneity and the possibility of pooling the results in a meta-analysis. Of the four studies that assessed balance, only one reported the outcome values using the summary statistics of median and inter-quartile ranges (Miklitsch *et al*., 2013), while the rest reported mean and standard deviation. To ensure uniformity across studies, the median and interquartile ranges were transformed to mean and standard deviation employing the following formulae developed by (Wan *et al.*, 2014).

Mean= (q1 + m + q2) ÷ 3

Standard deviation = (q3-q1) ÷ ŋ(n)

Where q1= first inter-quartile range, m= median, q3= third inter-quartile range, n= sample size, values for **ŋ(n)** can be found in a table provided in the same study, which is to be used for smaller sample sizes when Q ≤ 50. n= 4Q+1, with n=20 per group in the study by (C Miklitsch *et al.*, 2013), Q= (n-1)/4 = 19/4 ≈5 The corresponding ŋ(n) value for Q= 5 on the table is 1.26, which was used to calculate the standard deviations from the inter-quartile ranges (see Figure 3.3).

Table 2 Values of *η* (*n*) in the formula (12) and the formula (15) for *Q* ≤50, where *n* =4 *Q* +1

From: Estimating the sample mean and standard deviation from the sample size, median, range and/or interquartile range

Q	η(n)	Q	η(n)	Q	η(n)	Q	η(n)	Q	η(n)
1	0.990	11	1.307	21	1.327	31	1.334	41	1.338
2	1.144	12	1.311	22	1.328	32	1.334	42	1.338
3	1.206	13	1.313	23	1.329	33	1.335	43	1.338
4	1.239	14	1.316	24	1.330	34	1.335	44	1.338
5	1.260	15	1.318	25	1.330	35	1.336	45	1.339
6	1.274	16	1.320	26	1.331	36	1.336	46	1.339
7	1.284	17	1.322	27	1.332	37	1.336	47	1.339
8	1.292	18	1.323	28	1.332	38	1.337	48	1.339
9	1.298	19	1.324	29	1.333	39	1.337	49	1.339
10	1.303	20	1.326	30	1.333	40	1.337	50	1.340

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Figure 3.3: Table of Values for Calculating the Mean and Standard Deviation from the Median

Table 3.4: Main Findings

Study ID	Outcome measures	Intervention	Control	Key findings
Miklitsch *et al*., 2013[r]	Mobility-TUG, Balance-BBS, Activities of daily living-Barthel index	Rebound exercise: 10 sessions with 30 minutes per session for 3 weeks. TUG-14.2±8 (P=0.347)*, BBS-52.66±3.97 (P=0.004)*, ADL- 83.66±23.81(P=0.157)*	Balance training: 10 sessions with 30 minutes per session for 3 weeks. TUG- 21.5±11, BBS- 47±7.94, ADL-72.66±25.4	Significant increase in balance and increase (but not statistically significant) in the mobility and ability to perform activities of daily living in the rebound group compared to the control
Sisi *et al*., 2013[r]	Dynamic balance/ mobility-TUG, Static balance-BBS	G1: Rebound exercise: 24 sessions with 30 minutes per session for 8 weeks. TUG-11.43±2.37, BBS- 36.06±2.12 G2: Pilates exercises: 24 sessions with 30 minutes per session for 8 weeks. TUG-11.72±3.01, BBS- 38.43±2.87	Routine exercises TUG-12.23±1.81(P=0.01)* BBS-31.0±2.49 (P=0.01)*	Both rebound and Pilate exercises significantly improved balance compared to the control, but the rebound was more effective in improving dynamic balance, while Pilate was more effective in improving static balance.
Hahn *et al*., 2015[r]	Dynamic balance- TUG, Static balance- BBS	Rebound exercise: 3 times a week with 30 minutes duration per session for 6 weeks + routine physiotherapy TUG-26.3±11, BBS-44.3±7.5 (P<0.05)*	Routine physiotherapy: 3 times weekly with 30 minutes per session for 6 weeks. TUG-30.7±11.2, BBS- 41.8±6.3	Compared to the control, balance, dynamic gait and falls efficacy significantly improved in the rebound group.
Daneshvar *et al*., 2019[q]	Quality of life- PDQ-39	Rebound exercise: 3 sessions a week with 20-45 minutes per session for 8 weeks 147.6±13.22 (P<0.001)*	Treadmill training with body weight support: 3 sessions a week with 20-45 minutes per session for 8 weeks. 118.38±12.48	Although both exercises improved function in participants, rebound exercises showed more significant improvement in range of motion, proprioception and quality of life compared to treadmill exercises.
Sadeghi *et al*., 2019[r]	Kistler force plate for COP-based parameters	Rebound exercise: 3 sessions a week with 10-30 minutes per session for 12 weeks	Traditional exercises	The rebound group significantly improved static balance/ stability compared to the control group.

r- randomised controlled trial, q-quasi-experimental, values presented as mean±standard deviation, ()*-significance level between rebound and control groups.

Wan *et al*. (2014) recommend using formulae to estimate mean and standard deviation from the median and interquartile range. This method is preferable over Hozo or Bland's because it considers the sample size. Moreover, interquartile ranges are less sensitive to outliers compared to minimum and maximum range values, resulting in more stable estimates.

As the Cochrane Handbook (Higgins *et al.,* 2011) stated, "Two studies is a sufficient number to perform a meta-analysis provided that those two studies can be meaningfully pooled and provided their results are sufficiently similar". Some studies have successfully conducted systematic reviews and meta-analyses with as few as three or four studies. For instance, (Abaraogu *et al.*, 2017) performed a meta-analysis on only three studies that were eligible to be combined out of four included studies. Similarly, Arora *et al*. (2020) systematically reviewed only three studies that met their inclusion criteria. Also, (Abaraogu, Tabansi-Ochiogu and Igwe, 2016) and (Feliciano-Alfonso *et al.*, 2021) successfully pooled four studies in a meta-analysis out of the eight and ten included studies of their respective systematic reviews.

3.9.6 Outcome Results

Every study included in this systematic review reported significant improvements in functional outcomes following rebound exercise training (Table 3.5). Four studies recorded significant increases in mobility, balance, and activities of daily living performance, while the remaining study disclosed a significant increase in the quality of life of people with Parkinson's disease (Daneshvar *et al.,* 2019).

3.9.6.1 Subgroup Analysis

Four out of the five included studies of the systematic review satisfied the assumptions of homogeneity for the assessment of static balance and were thus subjected to a formal heterogeneity test using the Chi-squared and I^2 (Miklitsch *et al.*, 2013; Sisi, Sadeghi and Nabavi, 2013; Hahn, Shin and Lee, 2015; Sadeghi, Ghasemi and Karimi, 2019). The random effects model was used with the assumption that any observed differences across the studies could be attributed to sources of heterogeneity other than random chance. Summary statistics of standardised mean differences (SMD) were initially used because the four studies used different scales (Berg balance scale and force platform) to measure static balance.

Table 3.5: Main Findings continued

Study ID	Balance	ADL	Mobility	QoL	Statistical tests
Miklitsch *et al*., 2013	Significant increase in balance from baseline value of 39(36-45) to 53(50-55) at 3 weeks, $p<0.0004$ [BBS (0-56) median (25-75th percentile)]	Significant increase in the ability to perform ADL from 55(45-80) to 85(68-98) at 3 weeks, $p<0.0004$ BI (0-100)	Significant decrease in WT from 24.4±13 to 14.2±8 at 3 weeks, $p<0.0004$	—	T-tests, Chi^2 test, ANOVA
Sisi *et al*., 2013	Significant increase from baseline values of 31.71±2.52 to 36.06±2.12 at 8 weeks, p=0.01	—	Significant decrease in WT from 13.07±0.99 to 11.43±2.37 at 8 weeks, p=0.00	—	T-tests, ANOVA
Hahn *et al*., 2015	Significant increase from baseline value of 33.8±8.2 to 44.3±7.5 at 6 weeks, $p<0.05$	—	Significant decrease in WT from 31.7±13.2 to 26.3±11.0 at 6 weeks, $p<0.05$	—	T-tests
Daneshvar *et al*., 2019	—	—	—	Significant increase in QoL from 105.66±10.46 to 147.60±13.22 at 8 weeks, $p<0.001$	T-tests, ANOVA
Sadeghi *et al*., 2019	Significant improvement in COP parameters from baseline value of 766.6±374.6 to 454.9±301.5 at 12 weeks, $p<0.05$	—	—	—	Repeated measures ANOVA

The heterogeneity test revealed substantial heterogeneity (I^2- 90%) among studies, indicating that meta-analysis cannot be carried out concerning static balance as an outcome (figure 3.4). However, the results were subjected to further testing through sensitivity and subgroup analysis to identify the possible sources of the variations. Subgroups such as force plate versus BBS (outcome assessment tool), <8 weeks versus ≥8 weeks (duration of intervention), < 50 years versus ≥50 years (age of participants), moderate versus high (quality of the studies) and < 30 versus ≥30 participants (sample size) all still revealed significant levels of heterogeneity between subgroups, with I^2 > 50% (figures 3.5-3.9). In terms of the type of neurological disorder, a sensitivity analysis was done, considering only studies conducted among stroke survivors since stroke was the only condition that was studied more than once. A low heterogeneity was observed between the two studies with a p-value of 0.01 and I^2 =2%, indicating considerable homogeneity (figure 3.10).

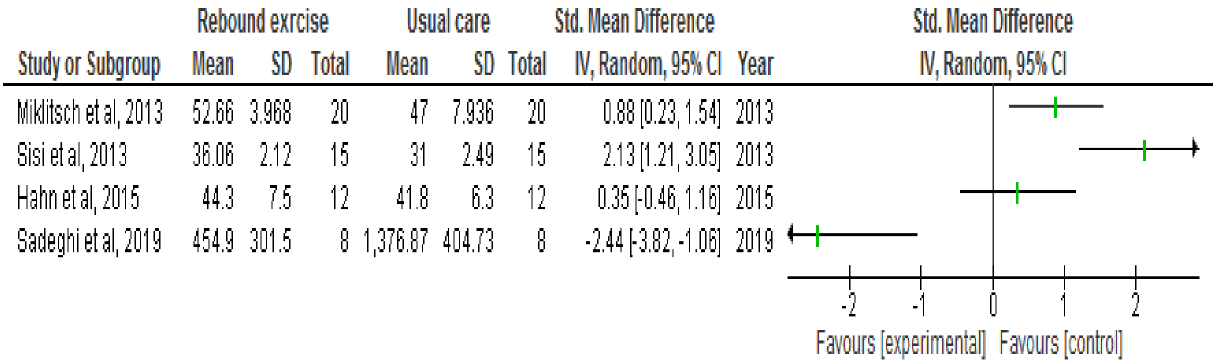


Figure 3.4: Heterogeneity Testing of Studies

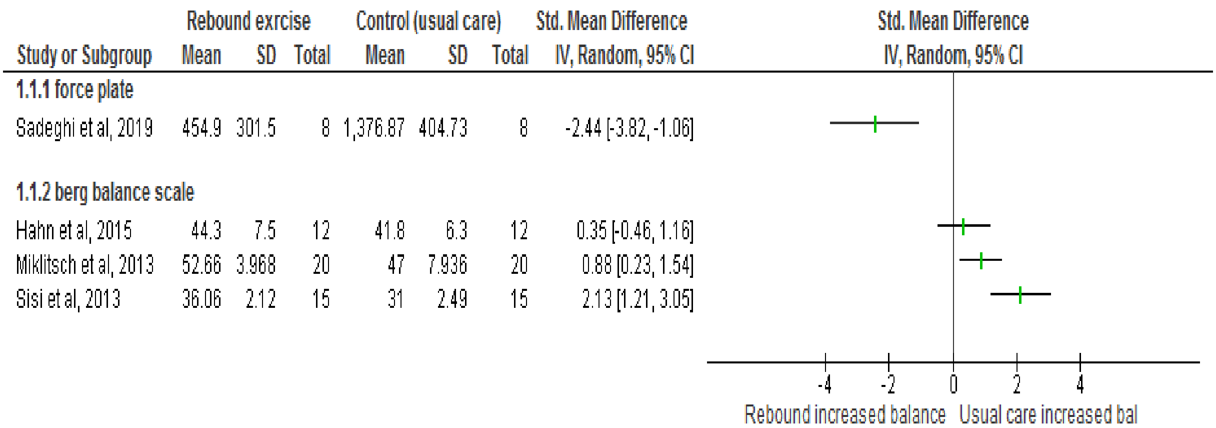


Figure 3.5: Subgroup Testing based on Outcome Assessment Tool used

Study or Subgroup	Rebound exrcise Mean	SD	Total	Control (usual care) Mean	SD	Total	Std. Mean Difference IV, Random, 95% CI
1.1.1 8 weeks or more							
Sadeghi et al, 2019	454.9	301.5	8	1,376.87	404.73	8	-2.44 [-3.82, -1.06]
Sisi et al, 2013	36.06	2.12	15	31	2.49	15	2.13 [1.21, 3.05]
1.1.2 less than 8 weeks							
Hahn et al, 2015	44.3	7.5	12	41.8	6.3	12	0.35 [-0.46, 1.16]
Miklitsch et al, 2013	52.66	3.968	20	47	7.936	20	0.88 [0.23, 1.54]

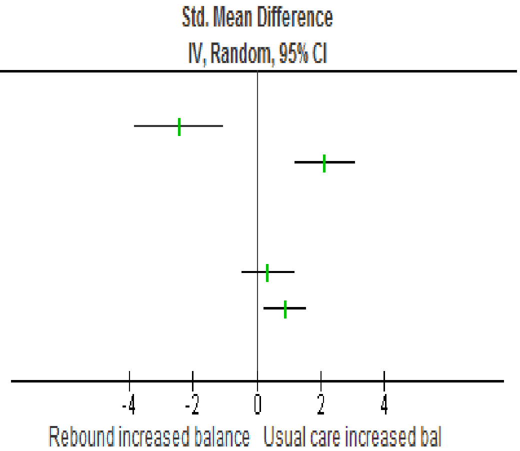


Figure 3.6: Subgroup Testing based on the Duration of the Study Intervention

Study or Subgroup	Rebound exrcise Mean	SD	Total	Control (usual care) Mean	SD	Total	Std. Mean Difference IV, Random, 95% CI
1.1.1 50 years or more							
Miklitsch et al, 2013	52.66	3.968	20	47	7.936	20	0.88 [0.23, 1.54]
Sisi et al, 2013	36.06	2.12	15	31	2.49	15	2.13 [1.21, 3.05]
1.1.2 less than 50 years							
Sadeghi et al, 2019	454.9	301.5	8	1,376.87	404.73	8	-2.44 [-3.82, -1.06]
Hahn et al, 2015	44.3	7.5	12	41.8	6.3	12	0.35 [-0.46, 1.16]

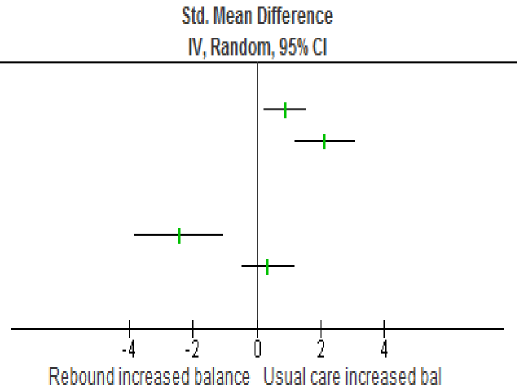


Figure 3.7: Subgroup Testing based on Age of Participants

Study or Subgroup	Rebound exrcise Mean	SD	Total	Control (usual care) Mean	SD	Total	Std. Mean Difference IV, Random, 95% CI
1.1.1 30 participants or more							
Miklitsch et al, 2013	52.66	3.968	20	47	7.936	20	0.88 [0.23, 1.54]
Sisi et al, 2013	36.06	2.12	15	31	2.49	15	2.13 [1.21, 3.05]
1.1.2 less than 30 participants							
Sadeghi et al, 2019	454.9	301.5	8	1,376.87	404.73	8	-2.44 [-3.82, -1.06]
Hahn et al, 2015	44.3	7.5	12	41.8	6.3	12	0.35 [-0.46, 1.16]

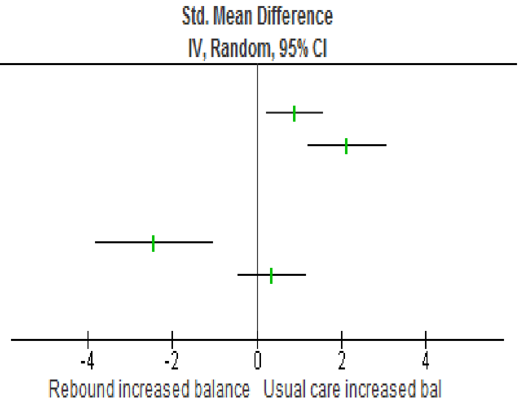


Figure 3.8: Subgroup Testing based on Sample Size of Studies

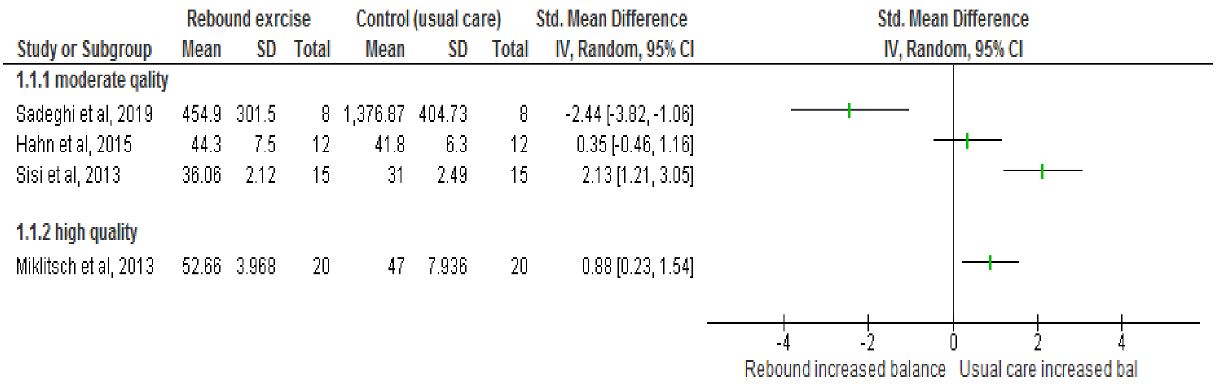


Figure 3.9: Subgroup Testing based on Quality of Studies

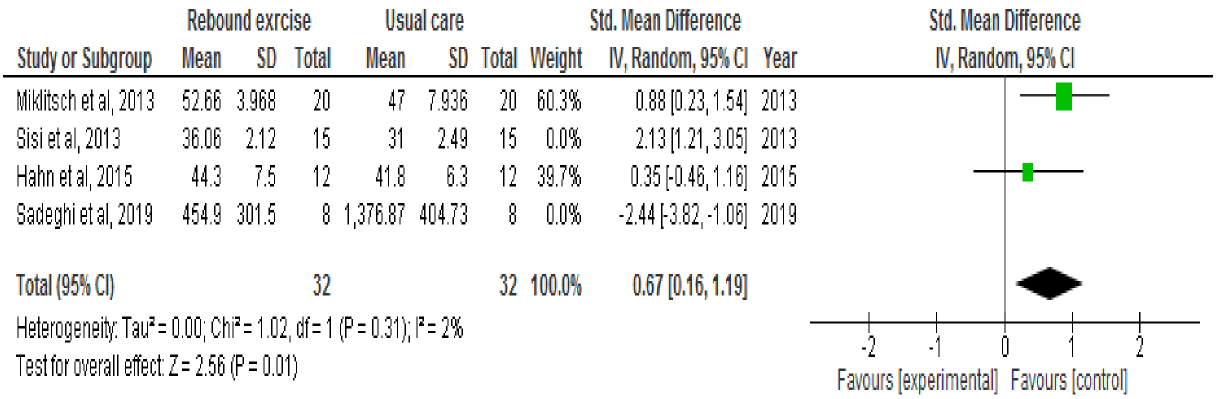


Figure 3.10: Sensitivity Analysis based on Disease Type (stroke-only studies)

3.9.6.2 Effect of Rebound Exercise on Balance

Given the high heterogeneity among the four studies included in the analysis, the one study that did not use the BBS for assessing balance was excluded. This exclusion allowed for a more accurate reassessment of heterogeneity among the remaining three studies, using their mean differences. The reassessment revealed an I^2 value of 0%, indicating that the studies were homogenous enough to be combined in a meta-analysis. The resulting forest plot, shown in Figure 3.11, clearly illustrates that usual physiotherapy care was favoured over rebound exercise. The point estimates for all studies lie on the right side of the line of null effect, suggesting a consistent advantage for the control group. This advantage is further substantiated by the positive mean difference values reported in each study, all greater than 0. The pooled estimate, represented by the diamond on the forest plot, has a mean difference of 4.97, with confidence intervals ranging from 3.50 to 6.43. These values indicate a statistically significant improvement in balance as measured by the Berg Balance Scale in the control group compared to the rebound exercise group.

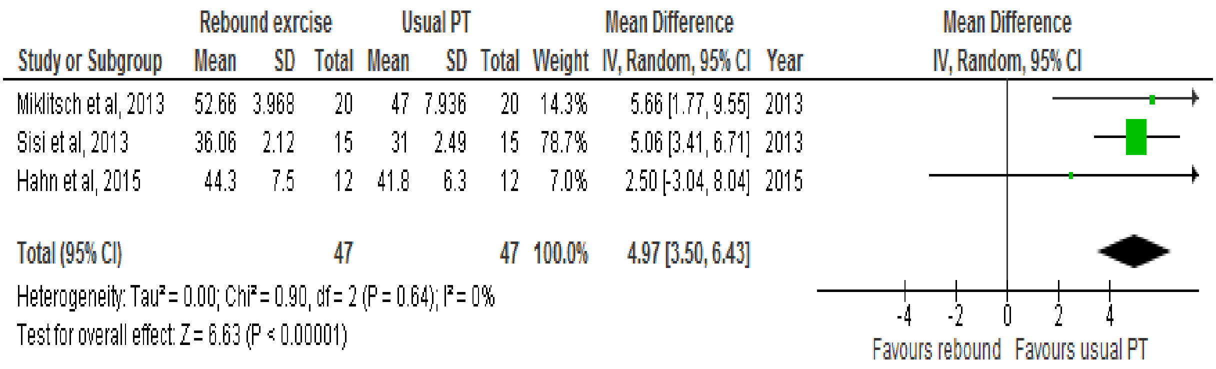


Figure 3.11: Forest Plot showing pooled estimate for Static Balance

3.9.6.3 Effect of Rebound Exercise on Mobility

Three studies assessed mobility using the TUG test. However, due to differences in the time-measuring devices employed—one study used a chronometer (Sisi, Sadeghi and Nabavi, 2013), while another used a stopwatch (Miklitsch *et al*., 2013), the SMD was utilised to account for any potential discrepancies arising from these instrumental variations. The heterogeneity test conducted for these studies indicated an I^2 value of 0%, confirming that the studies were sufficiently homogenous to be pooled in a meta-analysis. The results from the included studies demonstrated a significant reduction in TUG times for both the rebound exercise group and the control group. For the rebound exercise group, the baseline TUG time of 23.39 ± 9.06 seconds decreased to 17.31 ± 7.12 seconds post-intervention. Similarly, the control group's TUG time improved from 24.64 ± 9.35 seconds at baseline to 21.48 ± 8 seconds post-intervention. Participants in the rebound exercise group showed an average reduction of 6.08 ± 6.08 seconds in their walking time over three to eight weeks, with one study reporting as much as a 10.2 ± 8-second decrease in walking time (Miklitsch *et al*., 2013).

The forest plot presented in Figure 3.12 reveals a distinct advantage for the rebound exercise group over the control group, as all point estimates are positioned to the left of the null effect line, indicating that all studies, as well as the pooled effect, favour rebound exercise. This advantage is further illustrated by the reported standardised mean difference values, which are all negative and less than 0. The pooled result, represented by the diamond, shows an SMD of

-0.53 with a 95% confidence interval ranging from -0.94 to -0.11. This indicates a statistically significant improvement in dynamic balance and mobility, as measured by the TUG, for the rebound exercise group compared to the control group, as the diamond does not intersect the line of null effect. The SMD of -0.53 suggests that rebound exercise is 53% more effective in improving mobility than usual physiotherapy care for individuals with neurological disorders. Additionally, the overlapping 95% confidence intervals across all individual studies point to minimal heterogeneity between them. Due to the limited number of studies (fewer than 10) included in this meta-analysis, a funnel plot could not be utilised to test for publication bias. The small number of studies means that the power of such a test would be too low to effectively distinguish between random chance and genuine asymmetry (Higgins *et al.*, 2011).

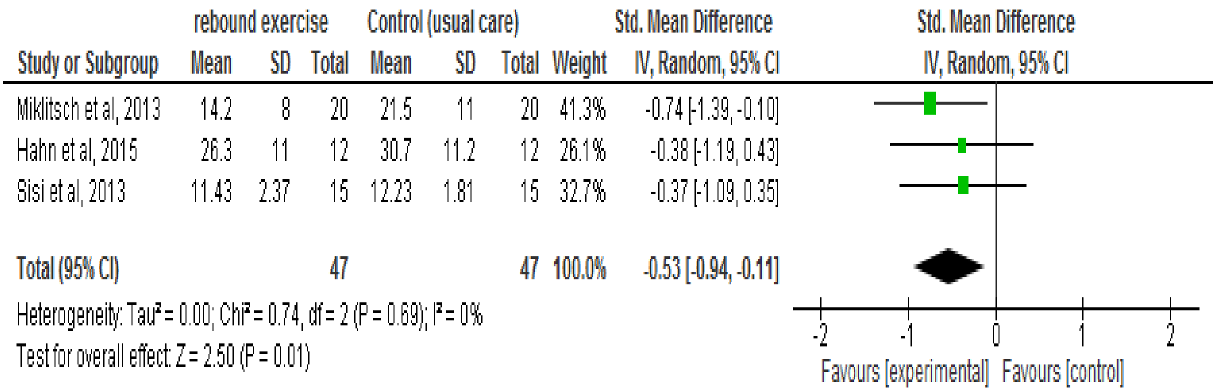


Figure 3.12: Forest Plot showing the Pooled Results of Studies for Mobility

3.9.6.4 Activities of Daily Living

Just a study by Miklitsch *et al*. (2013) measured the activities of daily living outcomes in people with neurological disorders. Their findings show that although there was a significant increase in ADL of both rebound and control groups after 3 weeks of intervention ($p< 0.0004$), this improvement was not statistically significant when the two groups were compared ($p=0.157$).

3.9.6.5 Quality of Life

Only one study assessed the quality of life among patients with neurological disorders and reported that rebound exercise significantly improved the quality of life of patients with Parkinson’s disease ($p< 0.001$) compared with the use of treadmill exercise (Daneshvar *et al.*, 2019).

3.10 Discussion

This study was a systematic review and meta-analysis investigating the effect of rebound exercise on functional outcomes of people with neurological disorders. Out of the five studies examined in this systematic review, only three were similar enough to be combined in a meta-analysis. Two of the studies were on stroke survivors, while the other was on people with multiple sclerosis, so their results could be combined as both conditions are upper motor neurone lesions. Despite the few studies, the meta-analysis shows significant mobility improvement with rebound exercise.

3.10.1 Balance

Contrary to previous literature that documented considerable improvements in balance across various age groups following rebound exercise (Kidgell *et al*., 2007; Márquez *et al*., 2010; Aragão *et al*., 2011; Atilgan, 2013; Posch *et al*., 2019), this systematic review did not find any significant increase in balance among individuals with neurological disorders. This discrepancy is particularly intriguing, given that the individual studies included in this review also reported a significant improvement in balance (Miklitsch *et al*., 2013; Sisi, Sadeghi and Nabavi, 2013; Hahn, Shin and Lee, 2015; Sadeghi, Ghasemi and Karimi, 2019) findings that align with those reported in the general population. Several factors could be responsible for these conflicting findings. Notable among them is the potential for a type 1 error within the individual studies, as many had relatively small sample sizes. This limitation may have increased the likelihood of falsely detecting significant improvement in balance where none truly existed, a common issue in studies with limited statistical power (Button *et al.*, 2013). The small sample sizes might not adequately represent the broader population, thereby skewing the results and leading to overestimations of the intervention's efficacy.

Additionally, the BBS, utilised to assess balance in these studies might not have been sensitive enough to detect clinically relevant changes in the studied population despite its widespread use and general acceptance for measuring balance (von der Malsburg and Angele, 2017). The instrument has been critiqued for its varying reliability and ceiling effects, particularly in populations with higher functional levels, which could result in an underestimation of subtle but meaningful improvements in balance (Downs, Marquez and Chiarelli, 2012). This ceiling effect could mask the potential benefits of rebound exercise, especially in patients who may have already reached a plateau in their balance abilities at the start of the intervention.

Finally, the fact that all the included studies of the review were conducted in hospital settings could have further influenced the outcomes. Hospital environments often lack the diverse and dynamic challenges necessary to adequately stimulate and improve balance (Geerligs *et al.*, 2018; Cowie *et al.*, 2020). Participants in these settings might not have had sufficient opportunities to engage their balance in the same way they might in more varied, real-world environments. This restricted exposure to balance-challenging situations could explain why this systematic review did not observe significant improvements, suggesting that the context in which the exercise is performed plays a crucial role in its effectiveness.

3.10.2 Mobility

The ICF defines mobility as "an individual's ability to move about effectively in their environment" (World Health Organisation, 2001). Mobility is a critical aspect of daily life, and its impairment can have profound consequences for individuals, particularly those with neurological disorders. According to Pearson *et al*. (2004), among various limitations that patients with neurological disorders may experience, the loss of movement ability is often regarded as the most significant. This loss of mobility not only limits an individual's functional independence but also significantly impacts their social participation, increases the risk of falls, and diminishes their quality of life (Mahlknecht *et al.*, 2013; Shafrin *et al.*, 2017).

Given the critical role mobility plays in an individual's overall health and well-being, the accurate measurement and evaluation of mobility function are essential. Identifying patients at risk of falls is particularly important, as it enables healthcare providers to implement timely and effective interventions to mitigate these risks. One widely recognised tool for assessing functional mobility and fall risk is the TUG test. The TUG test is a highly sensitive and specific measure that has proven effective in older adults as well as individuals with neurological disorders (Beauchet *et al.*, 2011; Nocera *et al.*, 2013; Van Uem *et al.*, 2016; Wuehr *et al.*, 2020). The TUG test primarily measures walking speed, a crucial parameter for assessing an individual's ability to perform outdoor activities and navigate their environment. Walking speed has been referred to as the "sixth vital sign" due to its strong correlation with an individual's current health status and its predictive value for future health outcomes, including functional decline and mortality (Fritz and Lusardi, 2009; Vitório *et al.*, 2022).

According to the TUG test results from this review, the group that did rebound exercises showed a decrease in test time of 6.08 seconds compared to the control group, which only showed a decrease of 3.18 seconds. The ratio of these results (1.92:1) indicates that the rebound exercise group improved nearly twice as much as the control group. This highlights the greater effectiveness of rebound exercise in enhancing functional mobility. The reduction in TUG test duration reflects a notable improvement in multiple aspects of mobility, including the ability to rise from a chair more quickly, walk with better speed and balance, turn more efficiently, and sit down with greater control. The observed improvements likely result from a combination of factors such as strength, balance, coordination, and biomechanics, although the studies did not detail these specific mechanisms.

Rebound exercise may have contributed to increased lower limb strength by engaging key muscle groups through repetitive movements against gravitational forces, promoting both muscle endurance and functional power (Rathi *et al.*, 2024). Although balance did not show statistically significant improvement as an outcome, enhanced postural control on the trampoline's unstable surface could have indirectly improved walking performance (Hahn, Shin and Lee, 2015). Additionally, rebound exercise may have improved neuromuscular coordination, facilitating smoother and more efficient synchronisation of movements between the lower limbs and trunk. This, in turn, likely contributed to the reduced time required to complete the TUG test. Finally, the vertical forces generated during rebounding might have positively influenced walking biomechanics by improving proprioception, resulting in better posture, alignment, and gait efficiency (Yılmaz *et al.*, 2024).

The included studies showed improved mobility between three to eight weeks. Two included studies, Hahn, Shin and Lee (2015) and Sisi, Sadeghi and Nabavi (2013) found significant improvement in mobility in the rebound group after six and eight weeks of intervention, respectively. In the third study by Miklitsch *et al*. (2013), both the rebound and control groups showed improved mobility after engaging in exercise for only three weeks. However, there was no significant difference between the two groups. It is plausible that the brief trial duration may have precluded the complete manifestation of the effects of rebound exercise.

Other studies have also reported increased mobility through aerobic exercise, such as treadmills, stationary cycling and walking. A systematic review encompassing nine randomised controlled trials corroborated these findings, indicating a significant improvement in mobility among stroke survivors through such exercises (Kendall and Gothe, 2015). Similarly, Koop, Rosenfeldt and Alberts (2019) demonstrated an enhancement in functional mobility among individuals with Parkinson's disease following an eight-week regimen of high-intensity aerobic exercise conducted on a stationary recumbent bicycle, augmenting the cadence by 30%.

While traditional aerobic exercises have demonstrated clear benefits, rebound exercise offers an alternative approach with its own unique mechanisms and potential advantages. Unlike high-intensity aerobic activities, which predominantly focus on sustained cardiovascular output, rebound exercise engages essential muscle groups across the trunk, upper, and lower limbs through a consistent vertical motion that opposes gravitational forces (Atikovic *et al.*, 2018). This vertical motion, unique to rebound exercise, helps strengthen muscles and improve overall body coordination. Moreover, the soft and unstable surface of the trampoline adds a distinctive element of sensorimotor stimulation that is required to maintain balance and muscle strength during the activity (Hahn, Shin and Lee, 2015; Kanchanasamut and Pensri, 2017). This additional challenge may offer benefits that are less emphasised in traditional aerobic exercises, particularly in improving balance and neuromuscular coordination, which are crucial for individuals with neurological disorders.

3.10.3 Quality of Life and Activities of Daily Living

Regarding the quality of life, only one study (Daneshvar *et al.*, 2019) assessed this outcome, reporting a significant improvement in QoL among patients with Parkinson's disease who participated in rebound exercise compared to those who engaged in treadmill exercise. While this finding is promising, the fact that it comes from a single study limits the ability to generalise this outcome. Therefore, while the evidence suggests that rebound exercise may have a positive impact on QoL, more studies are needed to confirm this effect across different neurological populations. Similarly, only one study by Miklitsch *et al*. (2013) examined ADL, and their results indicated a significant improvement in ADL scores within both the rebound exercise and control groups. However, when comparing the two groups, this improvement was not statistically significant. This suggests that while rebound exercise may have potential benefits for ADL, the evidence is inconclusive due to limited studies.

3.10.4 Other Findings

A notable drawback is evident in the literature concerning rebound exercise and its influence on neurological disorders. The studies primarily rely on experimental trials and lack observational or cohort studies to examine its broader effects. The existing research primarily focuses on measuring intervention effectiveness, neglecting other crucial factors such as acceptability, adherence, and participants' perceptions (Skivington *et al.*, 2021). Recognising that low acceptability or adherence can greatly diminish the overall effectiveness of an intervention (Sekhon *et al.*, 2021), conducting observational and qualitative studies is essential. These studies will help thoroughly explore rebound exercise's full potential for individuals with neurological disorders.

The review uncovers a dearth of information regarding the feasibility of engaging in rebound exercises for individuals with neurological disorders within a community setting. While the reviewed studies were carried out in hospital settings, where participants engaged in rebound exercises thrice weekly, the sustainability of this frequency beyond a hospital environment remains uncertain. Furthermore, additional research is warranted to determine how effective rebound exercise is in improving other functional aspects. To assess the practicality of introducing rebound exercise as a treatment option for adult community members suffering from neurological disorders, it is vital to consider their personal experiences, perceived effectiveness of the treatment, and willingness to participate in the exercise regimen. These factors greatly influence motivation and adherence to exercise programs.

3.10.5 Methodological Quality

Although none of the included studies were classified as low quality, the majority exhibited significant weaknesses in critical methodological areas, raising concerns about their findings' robustness. A primary concern lies in the inadequate reporting of the randomisation process. Several studies failed to detail how patients were randomly assigned to intervention or control groups. This omission makes it difficult to confirm whether true randomisation and allocation concealment were implemented correctly, thus casting doubt on the internal validity of these studies. Without clear documentation of the randomisation process, the risk of selection bias increases, which could lead to systematic differences between groups that might influence the outcomes.

Furthermore, blinding, essential to mitigate bias in clinical trials, was poorly addressed across the studies. Only two studies explicitly mentioned that participants and investigators were blinded to the intervention (Miklitsch *et al.*, 2013; Daneshvar *et al.*, 2019). The lack of blinding in the other studies could lead to performance and detection bias, where participants' or researchers' knowledge of group assignment might influence their behaviour or assessment of outcomes. This is particularly problematic in studies involving exercise interventions, where participants' expectations and the placebo effect can significantly impact reported outcomes such as balance, mobility, or quality of life.

Additionally, none of the included studies reported confidence intervals (CIs) for their results. CIs are crucial as they provide a range within which the true treatment effect is likely to fall and offer insight into the precision and reliability of the estimated effects (Hemming and Taljaard, 2021; Heitmann *et al.*, 2022). The absence of CIs in these studies limits the ability to assess the robustness of the findings and hampers the interpretation of the statistical significance of the reported outcomes. Reporting only p-values, as many of these studies did, is insufficient as p-values do not convey the magnitude or precision of the treatment effect.

The absence of these methodological details significantly undermines the credibility of the findings presented in the studies and, by extension, the overall conclusions of this review. It highlights a broader issue within the research field: the necessity for rigorous adherence to established reporting standards. For instance, the CONSORT (Consolidated Standards of Reporting Trials) guidelines provide a comprehensive framework for reporting randomised controlled trials, ensuring transparency and reproducibility. Similarly, appropriately reporting sample size calculations is vital to determine whether the study was adequately powered to detect a meaningful difference between groups. Without this, the risk of type I and type II errors increases, potentially leading to false positives or negatives (Hajian-Tilaki, 2014; Forstmeier, Wagenmakers and Parker, 2017). Given these methodological shortcomings, the results of this systematic review should be interpreted with caution.

Future studies should adhere to rigorous methodological standards to strengthen the evidence base in this area, ensuring clear and detailed reporting of key aspects such as randomisation procedures, blinding, confidence intervals, and sample size calculations. Furthermore, adopting and consistently applying appropriate checklists or guidelines tailored to the specific research design, such as the CONSORT guidelines for RCTs or the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines for observational studies, can substantially enhance the quality and transparency of research outputs. By embedding these practices into the research culture, the scientific community can significantly improve the reliability and validity of findings, thereby contributing to more robust and actionable evidence.

3.10.6 Study Limitations and Strengths

While this inaugural systematic review delves into the effectiveness of rebound exercise in individuals with neurological disorders, the breadth of evidence is constrained by the paucity of included studies. Moreover, the studies in the review exhibited divergent intervention durations and outcome measures, posing an additional limitation. However, to mitigate the impact of this limitation, the heterogeneity test was used to combine only homogenous studies. Another limitation of this review is the lack of specificity of the neurological disorders under study. Acknowledging that the clinical manifestations and progression of diverse neurological disorders vary significantly, potentially impacting the observed outcomes is imperative. Additionally, individuals may find themselves at distinct stages of their respective diseases, rendering comparisons arduous. Subsequent reviews would benefit from focusing on specific neurological disorders to provide more conclusive findings, accounting for each disorder's distinctive characteristics and requirements. Lastly, the influence of publication bias on the results cannot be overlooked, as most studies reported favourable effects of rebound exercise. At the same time, insufficient data precluded the calculation of asymmetry using the funnel plot test.

3.10.7 Clinical Implications

The findings from this systematic review suggest that rebound exercise could be a valuable addition to the therapeutic options available for individuals with neurological disorders, particularly for enhancing mobility. While the evidence highlights significant improvements in walking time, it's essential to consider that this enhancement could result from a combination of factors, including improvements in balance, coordination, and even the use of the upper limbs during walking. Although balance may not have shown statistically significant improvements, it likely played a crucial role in facilitating the observed gains in mobility. Thus, rebound exercise may contribute holistically to functional improvements, addressing multiple aspects of motor control. This multidimensional approach could make it an effective intervention for improving overall mobility and quality of life in individuals with neurological disorders.

Clinicians could consider incorporating rebound exercise into standard rehabilitation programs, particularly for patients who struggle with mobility. However, given the mixed findings on balance, it would be prudent to combine rebound exercise with other interventions specifically targeting balance improvements. Additionally, the variability in the outcomes across studies suggests that individual patient factors, such as the severity of the neurological disorder, baseline functional status, and specific rehabilitation goals, should guide the implementation of rebound exercise. Clinicians should tailor rebound exercise programs to each patient's unique needs, potentially adjusting the frequency, intensity, and duration of the exercise to optimise outcomes. Finally, the potential benefits of rebound exercise highlighted in this review suggest a need for greater awareness and education among healthcare providers about its application in neurorehabilitation. Training programs for physical therapists, occupational therapists, and other rehabilitation professionals should consider including modules on the use of rebound exercise, its potential benefits, limitations, and the best practices for its implementation.

3.11 Conclusion and Recommendation for Future Studies

This systematic review provides evidence suggesting that rebound exercise has the potential to improve mobility in individuals with neurological disorders, particularly by enhancing walking time in a hospital setting. The positive outcomes observed in individual studies shows the promise of rebound exercise as a component of neurorehabilitation. However, these findings must be interpreted cautiously due to several methodological limitations.

While individual studies reported significant improvements in balance, this review suggests that these results may be overestimated. Contributing factors include small sample sizes, which increase the risk of type I error, and the use of assessment tools, such as the Berg Balance Scale, that may lack the sensitivity to detect clinically meaningful changes in this population. Moreover, the context in which these studies were conducted, predominantly in hospital settings, may have limited the extent to which participants could fully engage in activities that challenge balance. Hospitals often provide controlled environments with fewer opportunities for dynamic, real-world balance challenges, crucial for improving balance in everyday life. This contextual factor likely influenced the outcomes and highlights the need for caution in generalising these findings to other settings, such as community-based environments.

Although this review included a limited number of trials, it nonetheless highlights the potential effectiveness of rebound exercise as an adjunctive therapy in neurorehabilitation. The evidence suggests that rebound exercise could be valuable in improving certain aspects of physical function in individuals with neurological disorders. However, to fully establish its efficacy, further research is needed. Future studies should aim to explore the benefits of rebound exercise in community settings, where participants are more likely to encounter diverse and unpredictable balance challenges.

Additionally, research should focus on other functional outcomes that significantly impact quality of life and independence, particularly those related to physical activities beyond walking, such as upper body strength, endurance, and overall physical activity levels. This broader exploration is essential to determine whether the observed benefits of rebound exercise extend beyond the controlled hospital environment and whether they translate into meaningful improvements in daily functioning and long-term independence for individuals with neurological disorders. Future studies could also explore the participants' views, experiences, and acceptance of rebound exercises. Finally, the limited number of studies evaluating ADL and QoL highlights a significant knowledge deficit in the current literature.

Given the importance of these outcomes in the overall well-being and functional independence of individuals with neurological disorders, future research should focus on these areas. More robust and well-designed studies are needed to understand better the potential benefits of rebound exercise on balance, QoL, and ADL. Specifically, RCTs with larger sample sizes, more sensitive balance assessment tools, and a focus on community settings may provide a clearer understanding of the effectiveness of rebound exercise.

CHAPTER FOUR

INVESTIGATING THE FEASIBILITY OF REBOUND EXERCISE IN COMMUNITY-DWELLING ADULTS WITH NEUROLOGICAL DISORDERS: A PROSPECTIVE OBSERVATIONAL STUDY

4.0 Chapter Overview

Existing evidence suggests that providing rebound exercise to people with neurological disorders three times a week in the hospital setting improves mobility. However, it remains unclear whether these benefits can be replicated in real-world community settings. Given this limitation in the literature, it was important to investigate the feasibility of implementing rebound exercises for community-dwelling adults with neurological disorders. This chapter outlines the feasibility study conducted in a community context, detailing the process from the initial literature review to participant recruitment, data collection, and analysis.

4.1 Background of the Study

Neurological disorders present a significant global health challenge, contributing to high levels of morbidity, mortality and disability (World Health Organisation, 2023). Globally, neurological disorders are the leading cause of disability and the second leading cause of death, affecting approximately 3.4 billion people and resulting in an estimated 9 million deaths annually (Feigin *et al*., 2020; World Health Organisation, 2023; Steinmetz *et al*., 2024). These complex disorders often require long-term, multifaceted care approaches, including neurorehabilitation services that aim to improve patient’s quality of life and functional independence (Feigin *et al.*, 2020). Neurorehabilitation is essential due to the intricate needs and high dependency levels associated with neurological conditions, which can severely impact a person’s ability to carry out daily activities and participate in society (Feigin *et al.*, 2020). However, the financial burden of neurological disorders can be significant to both individuals and the national healthcare systems and economies. The ongoing need for specialised medical treatments, rehabilitation services, and assistive devices significantly contributes to healthcare costs, making neurological disorders among the world's most financially demanding health conditions (World Health Organisation, 2023). The societal costs are further compounded by lost productivity and the reduced quality of life experienced by individuals with these conditions (World Health Organisation, 2023). In the context of community-based interventions, especially in feasibility studies like this one, it is important to consider both the financial and logistical implications (Glenn *et al.*, 2021). Community-based programs that are accessible, cost-effective, and feasible for broad implementation are essential to reduce the strain on healthcare systems while ensuring individuals receive adequate support (Nadkarni *et al.*, 2024). Evidence from feasibility studies in community settings highlights the importance of designing interventions that not only align with WHO guidelines but also address real-world challenges, such as limited access to resources, the need for affordable treatments, and the integration of care into everyday life.

Regular physical activity is recommended for all adults, including those with neurological disorders, as a key strategy to maintain health (Bull *et al.*, 2020). However, individuals with neurological conditions often face significant barriers, such as impaired balance, mobility, and overall quality of life, which limit their ability to engage in physical activities. Exploring cost-effective rehabilitation strategies that can help increase physical activity levels in this population is crucial. Exercise is a vital, cost-effective neurorehabilitation approach that offers numerous benefits for physical and cognitive function (Zhang *et al.*, 2022). However, traditional exercise programs often encounter barriers, such as limited accessibility, time constraints, and lack of enjoyment, which can hinder participation, particularly among individuals with neurological disorders (Collado-Mateo *et al.*, 2021).

To address these challenges, rebound exercise, a low-impact, trampoline-based activity, has emerged as a promising intervention (Bereza *et al*., 2024; Rathi *et al*., 2024). It is also accessible and cost-effective, making it easier to address health inequalities (Bhattacharya *et al.*, 1980; Burandt, 2016). This form of exercise is time-efficient and can be incorporated easily into daily routines, addressing the need for sustainable and equitable health interventions (Bhattacharya *et al.*, 1980; Burandt, 2016). Rebound exercise is ideal for individuals who may not participate in more physically demanding activities due to its low-impact nature (Márquez *et al*., 2010; Aragão *et al*., 2011; Miklitsch *et al*., 2013; Sadeghi, Ghasemi and Karimi, 2019). The trampoline surface reduces stress on weight-bearing joints, making it safer for those prone to injuries or with mobility impairments.

Research has demonstrated that rebound exercise can significantly improve balance, gait, and mobility in various populations, including those with neurological disorders (Daneshvar *et al*., 2019; Rathi *et al*., 2024). A recent systematic review has also suggested that engaging in rebound exercise three times a week can improve mobility in individuals with neurological disorders in hospital settings (Okemuo, Gallagher and Dairo, 2023). However, the controlled environment of a hospital does not fully reflect the challenges individuals face in community settings (Kreuter *et al.*, 2020). While hospitals offer structured environments with immediate access to multidisciplinary care, the realities of community living often present barriers that can hinder rehabilitation efforts (Jamshidi, Parker and Hashemi, 2020; Blakeney *et al.*, 2021). Moreover, the more frequent exercise dose of three times weekly may not be practical in real-world community settings. Patients may face challenges such as limited access to rehabilitation facilities, transportation difficulties, and reduced social support, all of which can impede their ability to maintain consistent exercise regimens (Bock *et al*., 2014; Lachman *et al*., 2018; Kreuter *et al*., 2020). This discontinuity can lead to further diminished health outcomes, including reduced mobility and balance, increased risk of falls, and decreased quality of life (Mahlknecht *et al.*, 2013). The loss of a structured environment often leads to decreased exercise adherence, which can result in the regression of functional gains made during hospital-based rehabilitation (Spiering *et al.*, 2021).

Therefore, it is crucial to investigate whether the effects of rebound exercise observed in hospitals can be replicated in the community, where patients may encounter various obstacles to regular exercise. Given the uncertainties surrounding the applicability of rebound exercise in community-dwelling individuals with neurological disorders, a prospective observational study is a logical and necessary next step. This study design allows for the observation of patients over time in their natural environments, providing valuable insights into the feasibility, safety, and effect of rebound exercises outside the structured confines of a hospital (Carlson and Morrison, 2009; Lu, 2009; Gail *et al*., 2019). Unlike randomised controlled trials (RCTs), where strict control over variables is essential, this prospective observational study offers insights into how participants can engage with rebound exercise in the context of their daily lives (Rezigalla, 2020; Wang and Kattan, 2020; Cappili 2021).

The primary aim of this observational study was to investigate the feasibility of implementing rebound exercise as a community-based intervention for adults with neurological disorders. Feasibility in this study refers to the practicality of rebound exercise use in community neurorehabilitation and the identification of potential evaluation/ implementation problems. Specifically, the study focused on assessing key feasibility indicators such as recruitment rates, retention rates, incidence of adverse events, adherence, attrition, and acceptability of rebound exercise intervention. These metrics are essential to understanding how practical rebound exercise can be when integrated into the daily lives of individuals in community settings, particularly those with neurological conditions. The study explored whether rebound exercise influenced various health outcomes over the 12-week intervention period as a secondary objective. These outcomes included blood pressure, balance, walking speed, cognitive function, grip strength, physical activity level, and quality of life. Assessing the potential effects of rebound exercise on these physiological and physical outcomes was crucial, as there is growing evidence suggesting that exercise interventions can have a wide range of health benefits for individuals with neurological disorders. Moreover, as mobility, strength and balance improve with exercise, people often become more confident in engaging in daily activities, further increasing their physical activity levels. So, it is necessary to explore if rebound exercise can increase physical activity levels in this population.

Capturing both feasibility and outcome data in this study offers a comprehensive view of the potential for rebound exercise to be adopted in community settings. Measuring whether it influences key health outcomes alongside assessing practical aspects of its implementation contributes significantly to understanding the potential effectiveness and real-world applicability. The data gathered from this feasibility study provides a foundation for future research, potentially informing larger, more rigorous trials that explore the broader applicability of rebound exercise as an intervention to enhance physical activity levels and manage health outcomes in community-dwelling adults with neurological conditions. Therefore, this study seeks to address the following research questions:

- Is rebound exercise safe and feasible for adults with neurological disorders living in the community?
- What will be the recruitment/retention rate of the individuals invited to participate?
- Will there be any significant change in physiological and physical outcomes in this group after 12 weeks of rebound exercise?

4.2 Research Objectives

a) To determine the feasibility of introducing rebound exercise into the lives of community-dwelling individuals with neurological disorders.

b) To evaluate the influence of rebound exercise on the physiological and physical functions of individuals with neurological disorders.

4.3 Research Methods

4.3.1 Study Registration and Report

This study was registered on Clinical Trials.gov and given the study ID of NCT05526508. It was reported following the guidelines for the STROBE statement (Cuschieri, 2019). The STROBE checklist consists of 22 items designed to ensure that observational studies are presented clearly and transparently (Cuschieri, 2019). It includes items related to the introduction, study objectives, methods, results, and discussion sections. Eighteen items on the checklist are applicable to all three observational study designs (cohort, cross-sectional, and case-control), while the remaining four items have specific variations based on the study design (Vandenbroucke *et al.*, 2007).

4.3.2 Epistemology

Quantitative research in social sciences often aligns with the positivist paradigm, which emphasises the use of rigorous and standardised methods to obtain objective, generalisable knowledge (Babones, 2016; Bonell *et al.*, 2018). This paradigm is rooted in the empiricist tradition, where knowledge is acquired through systematic observation, measurement, and experimentation (Bonell *et al*., 2018). In line with this approach, the current study adopts the positivist paradigm to investigate the rebound exercise's feasibility and potential effect on the physical and physiological functions of adults with neurological disorders living in the community. The positivist paradigm's emphasis on objectivity and empirical validation supports the study's use of quantitative methods, including the comparison of mean outcomes to determine the significance of the findings (Park, Konge and Artino, 2020). By focusing on measurable variables and employing structured data collection tools, the study ensures that the results are not only objective but also reliable and replicable. This methodological rigour allows for the control of potential biases and confounding factors, enhancing the study's internal validity.

Furthermore, the use of pre-and post-intervention assessments allows for a clear comparison of outcomes over time, offering valuable insights into the potential relationship between rebound exercise and changes in mobility, balance, and overall quality of life in the target population. This study draws from the positivist tradition, contributing to a broader understanding of how structured physical interventions can be effectively implemented in community settings, offering potential pathways for evidence-based practices in neurorehabilitation

4.3.3 Research Design and Setting

This study employs a prospective observational design, focusing on a sample of individuals with neurological disorders residing in the Buckinghamshire community. The study was conducted between January and September 2023 at two Buckinghamshire New University campuses, Aylesbury and High Wycombe. The participants were observed over a 12-week period as they engaged in rebound exercises to assess the intervention's feasibility and potential impact. Unlike more controlled experimental designs, this study was pragmatic and observational, allowing participants to attend rebound exercise sessions at their discretion. This approach reflects a real-world setting, where participants' naturalistic behaviour was not manipulated, ensuring that the findings reflect how rebound exercise might be adopted and utilised in a community context (Pinquart, 2021). Using a prospective observational design rather than an RCT was intentional and strategic. As a preliminary study, this research aims to explore the feasibility and potential effect of rebound exercise in a community-dwelling population with neurological disorders, a context where such interventions have not been extensively studied.

The observational nature of the study allowed for the collection of data in a setting that mirrors everyday life, providing insights into how often and under what conditions individuals choose to participate in rebound exercise. This pragmatic approach is particularly important in feasibility studies, as it helps to identify potential challenges and barriers to participation that might not be evident in a more controlled trial environment. The findings from this observational study are intended to serve as a foundation for future research, particularly if the results indicate that rebound exercise is both feasible and potentially beneficial in this population. A more resource-intensive RCT could then be justified, building on the preliminary evidence gathered here. This stepwise approach is crucial, as it minimises the risk of investing significant resources into a study design that may not be viable. Indeed, the literature highlights that up to 20% of RCTs are prematurely terminated due to challenges such as recruitment difficulties, leading to wasted resources and incomplete data (Morgan *et al.*, 2018). By first conducting a feasibility study, this research not only informs the potential for a larger trial but also contributes to the efficient allocation of research resources, ensuring that subsequent studies are both necessary and methodologically sound (Pearson *et al.*, 2020).

4.3.4 Sampling Technique and Sample Size

Recruiting participants with neurological disorders, especially those who are willing to engage in a 12-week rebound exercise program and possess specific characteristics, can be quite challenging. The necessity of participants having a defined level of disability inherently limited the potential participant pool. Furthermore, the commitment required for a 12-week intervention requires finding individuals both willing and physically capable of sustained participation. To address these challenges, this research employed a combined approach of convenience and purposive sampling techniques. Initially, convenience sampling was used to establish a practical and accessible pool of potential participants. While convenience sampling may introduce some selection bias, it provides practical access essential for efficient initial recruitment. Subsequently, purposive sampling was applied to this initial pool to ensure all participants met the specific criteria relevant to the research question. Specifically, participants were required to have a neurological disorder and a Modified Rankin Scale of 3 or less, indicating mild to moderate disability. Participants with more severe disabilities were excluded due to potential safety concerns and practical limitations of performing the exercise. The combined use of convenience and purposive sampling is a recognised and justifiable strategy in research, particularly when studying specific populations (Creswell, 2012). By combining these two sampling techniques, this research was able to strike a balance between practicality and relevance in recruiting participants for this observational study.

The researcher employed G-power software (v3.1) to conduct an a priori power analysis, ensuring that the study was adequately powered to detect statistically significant differences. The analysis indicated that detecting a small effect size of 0.3 (Kang, 2021), with a power of 0.90 and a significance level of 0.05 required a sample size of 50 participants. The effect size estimate used for this calculation was derived from a review of recent, similar studies in the literature, which provided a context-specific benchmark for the anticipated impact of the intervention (Bujang, 2021; Bujang *et al.*, 2024). While a medium effect size is commonly used as a standard in many research areas, it is crucial to select an effect size that is representative of the specific population under study to better reflect the true variability and potential outcomes (Goulet-Pelletier and Cousineau, 2018; Bujang, 2021). Exercise intervention studies often report medium to large effect sizes (Posch *et al*., 2019; Haverkamp *et al*., 2020; Bujang, 2021; van Baak et al., 2021; Azab *et al*., 2022). Notably, studies involving trampoline exercises have consistently reported large effect sizes, particularly in more homogenous populations such as older women with osteopenia, healthy adult females, and children with Down's syndrome (Burt, Schipilow and Boyd, 2016; Witassek, Nitzsche and Schulz, 2018; Clement, Alexander and Draper, 2022; Di Rocco *et al.*, 2023; Seymen, 2023). These populations tend to have reduced variability in their outcomes, which likely contributes to the larger effect sizes observed in those studies.

However, the current study included a more diverse group of adults with various neurological disorders, introducing greater heterogeneity and potential variability in the results. This variability necessitated a more conservative approach to estimating the required sample size. By opting for a smaller effect size in the power analysis, the researcher ensured that the sample size calculation would account for the broader range of responses expected from a heterogeneous population, thereby increasing the robustness of the study's findings. This careful consideration helps mitigate the risk of underestimating the sample size needed to detect meaningful differences in this complex population, ensuring that the study's conclusions are valid and reliable.

4.3.5 Selection Criteria

The participants in this study were adults living in the community with neurological disorders characterised by upper motor neurone lesions, including conditions such as stroke, Parkinson's disease, multiple sclerosis, and traumatic brain injury (Marsico *et al.,* 2024; Merlo *et al*., 2021; Shirani *et al*., 2017). To be eligible for inclusion, participants were required to score 3 or less on the modified Rankin Scale, indicating that they had slight to moderate disability but could still walk independently or with minimal assistance. Additionally, participants needed to be able to walk for at least 2 minutes, either unaided or with the use of walking aids, and to have the cognitive ability to understand and follow therapy instructions. Participants were considered to have an appropriate level of understanding based on their ability to communicate effectively during the initial discussion. Participants' body weight was restricted to less than 120 kg, as this was the maximum weight capacity of the mini trampolines used in the study. This criterion was essential to ensure the safety and structural integrity of the equipment during the exercise sessions.

Exclusion criteria were established to protect participants from potential risks associated with rebound exercise. These included pregnancy, which could complicate the physical demands of the exercise, and significant comorbidities, such as cardiovascular disorders, which could pose a risk during physical activity. Additionally, individuals with severe cognitive impairment were excluded due to concerns about their ability to follow instructions and maintain safety during the sessions. Other exclusions involved those with musculoskeletal disorders that could be exacerbated by physical activity and individuals with severe visual or auditory sensory disorders, which might impede their ability to safely engage in the exercises. These criteria were communicated in the participant information sheet provided during recruitment, ensuring that potential participants were fully informed about the requirements for participating in the study. The interested volunteers were also screened during the initial discussions to ensure they were eligible before being signed up for the study.

4.3.6 Participant Recruitment

In this study, “community-dwelling” refers to participants who live independently or with minimal assistance in their own homes, outside of institutional or hospital settings (Ho *et al*., 2023). Although the participants were community-dwelling, the sessions were conducted in a supervised research environment to closely monitor participant safety and adherence to the protocol. Participants were recruited from various organisations and sectors that specialise in rehabilitating or supporting individuals with neurological disorders. These included well-known groups such as the Stroke Association, Parkinson’s Disease Association, and Multiple Sclerosis UK, as well as local support groups, neurorehabilitation centres, churches, and participant referrals. The research team approached these organisations to seek permission and gain access to recruitment, ensuring the process was ethical and aligned with the study's goals. Upon receiving approval, potential participants were provided with a participant information sheet. This document detailed the study's objectives, procedures, and the researcher’s contact information, allowing interested volunteers to reach out without feeling pressured or obligated. Informed consent was a crucial part of the recruitment process. Once a potential participant expressed interest and met the eligibility criteria, the researcher thoroughly explained the study to them. After ensuring they fully understood the study’s requirements and implications, they were asked to sign an informed consent form to confirm their voluntary participation.

About 85 people were approached, and 60 volunteered to participate in the study. Out of the sixty individuals who expressed interest, fifty-three were ultimately enrolled. Seven individuals did not proceed with the study. Four of these were deemed ineligible due to significant comorbidities, such as cancer, epilepsy, and heart conditions, or because their disability level exceeded three on the Modified Rankin Scale, indicating a severe disability with an inability to walk without assistance. The remaining three individuals withdrew before the study began, citing scheduling conflicts that prevented them from committing to the study's 12-week duration. One participant dropped out of the study before its completion due to contracting COVID-19, leaving 52 participants to conclude the study. Despite this unexpected withdrawal, the remaining participants successfully completed the 12-week intervention. The entire process, from recruitment to analysis, is presented in a flow chart (figure 4.1).

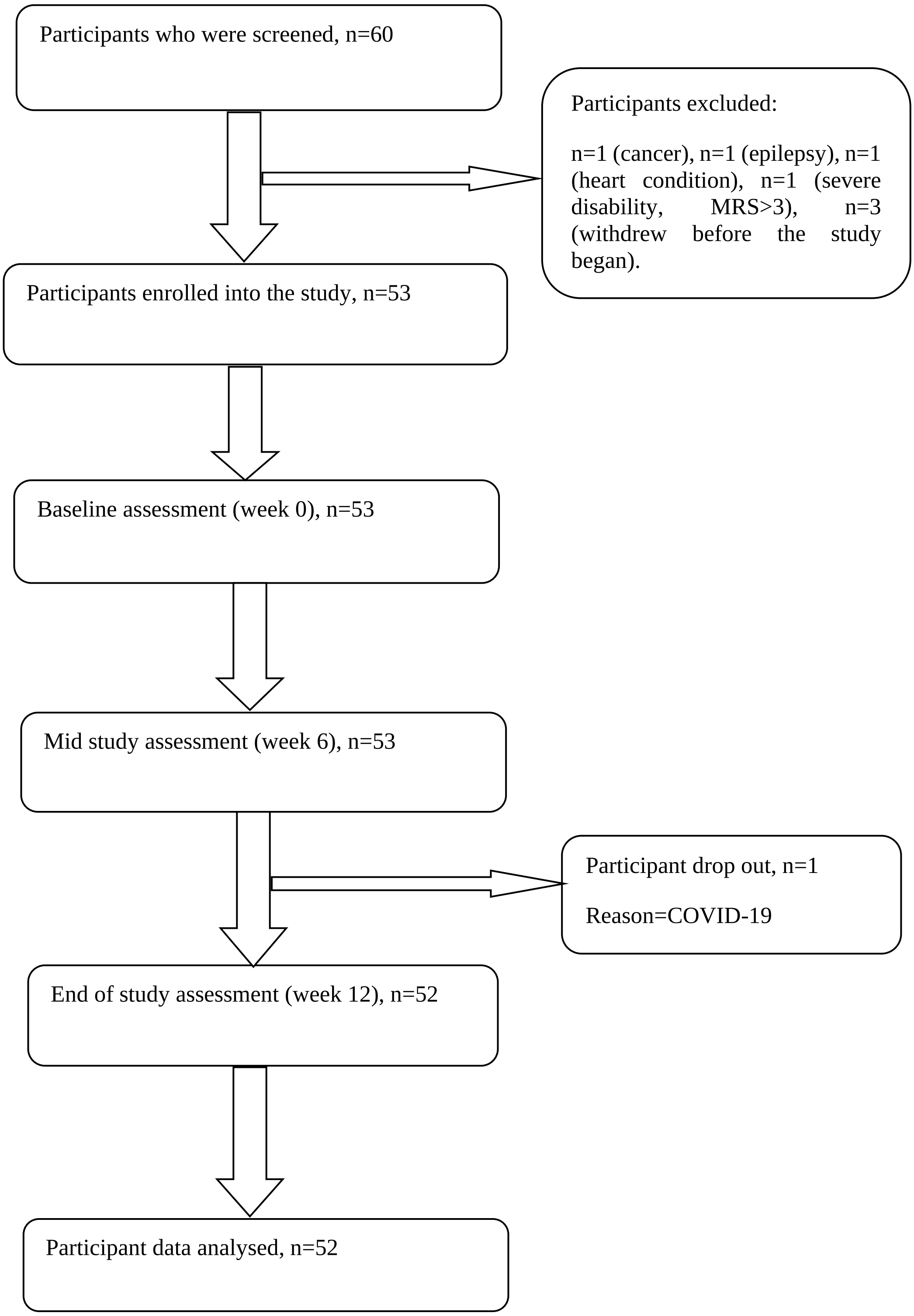


Figure 4.1: Flowchart Diagram showing the Participant Recruitment Process

4.3.7 Instrumentation

1. American Heart Association- American College of Sports Medicine (AHA-ACSM) Participation Screening Questionnaire: Prior to initiating any exercise program, it is crucial to evaluate an individual's risk factors for cardiovascular disease and their readiness to engage in physical activity. In 1998, the American Heart Association (AHA) and the American College of Sports Medicine (ACSM) developed a comprehensive screening tool specifically for this purpose (Riebe *et al.*, 2015). The AHA-ACSM Participation Screening Questionnaire consists of three sections designed to thoroughly assess cardiovascular, musculoskeletal and metabolic health risks. The first section focuses on the individual's history of cardiovascular disease, identifying any past incidents or diagnoses that might elevate their risk during exercise. The second section evaluates symptoms associated with cardiovascular issues, such as chest pain or dizziness, which could indicate underlying conditions. The third section examines other cardiovascular risk factors, including lifestyle habits, blood pressure, and cholesterol levels.

In this study, all participants underwent screening using this questionnaire before being enrolled in the rebound exercise regimen. This pre-screening process was essential for identifying and excluding participants who were at a higher risk of experiencing exercise-related adverse effects, ensuring that the exercise intervention was both safe and appropriate for the remaining participants (Rooney, Gilmartin and Heron, 2023). It also helped identify participants who needed to get clearance from their doctors before proceeding with the study. This questionnaire was selected instead of the Physical Activity Readiness Questionnaire because it offers a more comprehensive assessment. It not only focuses on cardiovascular disease diagnoses or symptoms but also identifies various cardiovascular risk factors and other health issues. This makes it a more thorough tool for evaluating an individual's readiness to participate in an exercise program.

2. International Physical Activity Questionnaire (IPAQ): This is a widely recognised self-administered instrument designed to measure health-related physical activity levels and

sedentary behaviours across diverse populations (Craig *et al*., 2003; Sember *et al*., 2020; Roberts-Lewis *et al*., 2022). Developed to provide a standardised tool for international use, the IPAQ has demonstrated acceptable validity (0.64-0.72) and reliability (0.69-0.77) in assessing physical activity and effectively classifying individuals according to the World Health Organisation's recommendations for physical activity (Tran *et al*., 2020; Kurita *et al*., 2021; Kurth and Klenosky, 2021). The questionnaire covers various domains of physical activity, including work, transportation, domestic chores, leisure-time activities, and sitting time, reflecting sedentary behaviour. Evidence suggests a consistent moderate correlation between IPAQ-reported sitting time and device-measured estimates of sedentary behaviour, particularly in populations with chronic conditions such as MS (Motl *et al*., 2019). This finding supports the utility of the IPAQ in capturing sedentary patterns, which are critical in understanding the broader context of physical activity and health outcomes. Scholes *et al*. (2016) highlighted the significance of excessive sedentary behaviour, identifying excessive sitting as 540 minutes or more per day, approximately nine hours or more of daily sitting time. Such levels of sedentary behaviour have been associated with various adverse health outcomes, emphasising the importance of accurate assessment tools like the IPAQ in both research and clinical practice.

3. World Health Organisation Quality of Life brief version (WHOQOL-BREF): The WHOQOL-BREF questionnaire is a widely used self-report instrument designed to assess an individual's overall quality of life across multiple dimensions. Comprising 26 questions, this tool has demonstrated robust reliability and validity across various populations and cultural contexts (Suárez, Tay and Abdullah, 2018). It covers four key domains:

- Physical Health (7 questions) - This domain addresses aspects such as pain and discomfort, energy levels, mobility, sleep quality, and the impact of physical limitations on daily activities.
- Psychological Health (6 questions) - It assesses elements related to body image, self-esteem, spirituality, positive and negative feelings, and cognitive functions.
- Social Relationships (3 questions) - This domain evaluates the quality of personal relationships, perceived social support, and satisfaction with sexual activity.
- Environment (8 questions) - This includes questions on physical safety, financial resources, freedom, access to quality healthcare, home environment, and opportunities for leisure activities.

In addition to these domains, two global questions are included to evaluate the individual's overall quality of life and general health (Lima-Castro *et al.*, 2021). The questionnaire uses a 5-point Likert scale, where responses range from 1 (low/bad) to 5 (high/good), allowing individuals to express the extent of their satisfaction or the frequency of certain feelings or experiences. Each item is assigned a raw score, and domain-specific mean scores are calculated. These domains' mean scores typically range between 4 and 20. To facilitate comparisons with the original WHOQOL-100, the domain scores are transformed by multiplying the mean score by 4, resulting in a scaled score ranging from 16 to 80. A higher scaled score indicates a better quality of life. The WHOQOL-BREF's comprehensive nature and ease of use make it a valuable tool for clinical assessments and research, providing meaningful insights into the multifaceted aspects of an individual's quality of life.

4. Mini-cognitive function (Mini-cog) Test: This short neuropsychological test is designed to assess various cognitive domains, including memory, visuospatial functioning, and executive thinking. Known for its accuracy and ease of administration, it is a straightforward tool that can be quickly administered and scored (Seitz *et al.*, 2021). The test has demonstrated sensitivity and specificity in diagnosing dementia across multiple clinical settings, making it a reliable instrument for early detection of cognitive decline (McCarten *et al*., 2011; Fage *et al*., 2015). The test comprises two key components: a three-word recall task and an executive clock-drawing test. The three-word recall task measures short-term memory, where participants are asked to recite and later recall three unrelated words.

Scoring for this task ranges from zero to three, with one point awarded for each word correctly recalled (Adhikari, Dev and Borson, 2021). The clock-drawing test, which evaluates executive functioning and visuospatial abilities, requires the participant to draw a clock showing a specific time. This task is scored as either normal (2 points) or abnormal (0 points), based on the accuracy and completeness of the drawing. The combined scores from these tasks provide a total possible score of 5, with higher scores indicating better cognitive function. A score of 5 reflects intact memory and executive function, while lower scores may suggest cognitive impairment. This test is particularly valuable in both clinical and research settings for its ability to provide a quick yet comprehensive snapshot of an individual's cognitive health.

5. 3-Metres Backward Walk Test (3MBWT): This clinical evaluation is widely used to assess various aspects of neuromuscular control, proprioception, protective reflexes, fall risk, and

overall balance (Abit Kocaman *et al*., 2021). It is a straightforward test that requires no special equipment, making it not only easy to administer but also cost-effective and time-efficient. One of the test's key components involves backwards walking, a critical skill necessary for performing everyday tasks such as backing up to a chair, opening a door, or quickly stepping out of the way of a sudden obstacle (Unver *et al.*, 2020). The test is particularly effective in evaluating subtle changes in synergistic motor functions that are closely linked to proprioception, especially in patients with conditions such as multiple sclerosis (Kirmaci *et al*., 2022). This makes it a valuable tool for detecting early signs of deterioration in motor coordination that might not be apparent in more traditional assessments.

Moreover, the test has been validated as a reliable measure of dynamic balance and fall risk across a range of populations, including patients with PD, stroke survivors, and those who have undergone total knee arthroplasty (Carter *et al*., 2019; Unver *et al*., 2020; Abit Kocaman *et al*., 2021). In addition to its use in these populations, the 3MBWT has demonstrated excellent test-retest reliability (0.97), particularly in assessing fall risk in patients with fibromyalgia (Leon-Llamas *et al*., 2023). This reliability highlights the test's robustness as an assessment tool in clinical practice. It provides healthcare professionals with a quick and effective means of evaluating and monitoring balance and fall risk, which are critical factors in maintaining the safety and independence of individuals with neuromuscular disorders.

6. 10-Metres Walk Test (10MWT): 10MWT is a widely recognised functional measure used to assess short-distance walking speed, typically recorded in meters per second. This test can be administered either at the participant's preferred walking speed or at their fastest possible speed, depending on the clinical context and the specific objectives of the assessment. The 10MWT is highly regarded for its simplicity and efficiency, making it a practical tool in both clinical and research settings. This test has demonstrated excellent test-retest reliability, meaning that it consistently produces stable and repeatable results across multiple administrations (Kahn and Tefertiller, 2014).

Additionally, it has strong construct validity across a range of neurological conditions, including stroke, Parkinson's disease, spinal cord injury, and traumatic brain injury (van Loo *et al.*, 2004; Scivoletto *et al.*, 2011; Lindholm *et al.*, 2018; Cheng *et al.*, 2020; Busk *et al.*, 2023). This validity indicates that the 10MWT accurately measures walking speed, a critical component of functional mobility, and correlates well with other established measures of gait and mobility. The test's applicability across diverse neurological conditions highlights its versatility as a tool for assessing mobility. Whether used to monitor progress in rehabilitation, to predict functional outcomes, or to evaluate the effectiveness of interventions, the 10MWT provides valuable insights into a patient's walking ability. Its robust reliability and validity make it an essential measure for clinicians aiming to assess and improve gait speed in individuals with neurological impairments.

7. Digital blood pressure monitor (Brand: CAZON, Model No: BSX556, Made in China): This was used to assess each participant's blood pressure and heart rate at every rebound exercise session. This device is a crucial tool in monitoring cardiovascular responses to physical activity, ensuring the safety and well-being of participants, particularly in individuals with neurological disorders who may have heightened cardiovascular risks. The monitor provides accurate and real-time measurements, allowing the research team to track any significant changes or fluctuations in blood pressure and heart rate throughout the 12-week exercise program. Regular monitoring is essential for detecting potential exercise-related complications and ensuring participants remain within safe physiological limits during the rebound exercise sessions.

8. Digital Hand-held dynamometer (Brand: Camry, measuring capacity: 90 kg, Model No: SCACAM-EH10117, Made in China): This was employed to measure the participants' grip strength throughout the study. Grip strength is a key indicator of overall muscle strength and has been correlated with functional ability and independence in individuals with neurological disorders. The digital dynamometer provides precise and consistent measurements, enabling the research team to monitor changes in muscle strength over the 12-week rebound exercise program. Assessing grip strength is particularly important in this population, as it can reflect improvements in neuromuscular function and contribute to understanding the broader physical benefits of the exercise intervention.

9. Gripping Aid (Brand: Active Hands, made in the UK): Gripping aids were provided to participants with poor grip strength to ensure their hands were securely attached to the rebounder's safety handlebar during the exercise sessions. These aids were crucial for maintaining safety and stability, particularly for individuals with neurological disorders that impair hand function. Providing gripping aids was important so participants with poor grip could confidently engage in rebound exercise without the risk of losing their grip or balance, thus allowing them to focus on the exercise movements. This accommodation ensured that the

study was inclusive of individuals with varying levels of grip strength, enabling a broader assessment of the feasibility and benefits of rebound exercise in the target population.

10. Fit Bounce PRO II Bungee Rebounder Mini Trampoline (Brand: MXL Maximus Life, Model No: 700461638780, Made in the UK): The mini-trampolines used in this study are high-quality pieces of equipment specifically designed for safe and effective rebound exercise. They featured a 40-inch round frame with a non-slip mat surface approximately 26 inches in diameter, providing ample space for various exercise movements. Standing 13 inches tall and weighing 10kg, the mini-trampoline is compact yet sturdy, accommodating a maximum user weight of 120kg (Figure 4.2).

To enhance safety, especially for individuals with neurological disorders, the mini-trampolines were equipped with stability handlebars. These handlebars offer additional support, helping participants maintain their balance during exercise sessions. The trampoline's design includes powerful bungee cords that ensure a consistent, soft, and resilient bounce, making the rebound exercise comfortable and effective. The Fit Bounce PRO II Bungee rebounder's specifications and safety features made it an ideal choice for this feasibility study, allowing participants to engage confidently in rebound exercise while minimising the risk of injury.

Figure 4.2: A Mini-trampoline Rebounder with Safety Handlebars.

4.3.8 Preparation for the Feasibility Study

The lead researcher began by conducting an extensive literature review on the use of rebound exercises, specifically focusing on its application for individuals with neurological disorders. This helped build a comprehensive understanding of its potential benefits and limitations. Following this, the researcher completed a rebound therapy training course and earned certification. The study was then formally registered on the Open Science Framework registry https://osf.io/3g9dr/?view_only=d0e7eb2078ad484b8d9052014c60a47b. To ensure appropriate resources were available for the study, an online search and review of rebound exercise tutorials were conducted to select videos best suited for the target population. Two rebounders with stability handles were purchased for the exercise sessions, along with the necessary assessment tools: a digital blood pressure monitor, hand-held dynamometer, tape measure, and active hand-gripping aids for participants with reduced grip strength. With all materials in place and ethical approval secured, trial sessions were conducted with healthy PhD students to test the feasibility of the procedures and identify any areas for adjustment before starting the main study.

4.3.9 Trial Rebound Exercise Session

After obtaining written informed consent, a rebound exercise training and outcome measurement trial was conducted with five apparently healthy volunteers simulating the real study conditions. The volunteers were assessed using questionnaires and functional tests. After the assessments, they performed rebound exercises on the rebounder for 30 minutes, closely supervised by the researcher. This trial was instrumental in developing the weekly appointment schedule for the participants because it provided insight into the average time required for a participant to complete a session. It also pointed out the need to create an online version of the questionnaires as it was observed that filling out the questionnaires took some time, as some questions required the participants to recall some activities carried out in the past seven days. To make things easier for participants who would rather complete the questionnaire on the go and before their appointments, the online version with a link and QR code was created for ease of administration. https://forms.office.com/e/hjPx15uZZF. The physical questionnaires were still printed out for participants who preferred to complete the questionnaire manually.

4.3.10 Procedure for Data Collection

Enrolled participants were invited to the High Wycombe or Aylesbury campus of Buckinghamshire New University to measure outcomes and do rebound exercise training. They were allowed to attend the rebound exercise sessions as they desired, and the frequency of attendance was noted. Several outcomes were measured at three different points during the study: before the start (baseline), mid-way (6 weeks), and at the end of the study (12 weeks).

4.3.10.1 Outcome Measurements

The primary outcomes measured included feasibility and safety measured through recruitment rates, retention rates and adverse events. Secondary outcomes were quality of life, risk of fall, walking speed, physical activity level (PAL), and cardiovascular function (heart rate and blood pressure), sedentary behaviour (SB), cognitive function and grip strength. The weight measurement was taken only at baseline to ensure that the participants weighed no more than the rebounder required weight of 120kg. Body Mass Index (BMI) was calculated from the participant's height (in metres) and weight (in kilograms) using the formula BMI= weight/height^2. This was also only collected at baseline to get a snapshot of the participants' anthropometric characteristics before the start of the study.

The **recruitment rate** was assessed by calculating the proportion of individuals who expressed interest in the study and successfully enrolled out of the total number approached. Specifically, it was the ratio of participants who met the inclusion criteria and provided informed consent to the total number of individuals initially contacted or invited to participate.

The **retention rate** was measured by tracking the number of participants who completed the full 12-week intervention compared to those who enrolled at the start. This was expressed as a percentage, with the dropout rate recorded and analysed to assess participant adherence and any barriers to completing the study.

Adherence was evaluated by tracking attendance at the rebound exercise sessions. Participants were given the flexibility to attend either once or twice weekly, and the number of sessions attended by each participant was recorded. Adherence was assessed based on whether participants met the minimum attendance requirement of once-weekly sessions. Attendance logs were kept throughout the 12-week intervention, and adherence rates were calculated as the percentage of participants who completed the required sessions out of those enrolled. To address scheduling challenges, flexibility was built into the session timings, offering evening and weekend options to accommodate participants' availability. Participants were also allowed to reschedule sessions when necessary, ensuring they could maintain regular attendance despite other commitments. Additionally, to further boost adherence, participants were allowed to attend sessions with fellow participant friends, fostering a supportive and social environment that made the sessions more enjoyable and motivating.

Safety was assessed by monitoring participants for any adverse events or complications throughout the 12-week intervention. Prior to each session, participants' blood pressure (BP) was measured using a digital BP monitor to ensure they were fit to engage in the rebound exercise session. Any reported or observed discomfort, injury, or unusual symptoms during or after exercise sessions were recorded. The lead researcher, trained in rebound exercise safety, supervised the sessions to address any immediate concerns and ensure safe participation. The mini-trampolines were fitted with stability handlebars for safety and positioned in the corner of the room to provide additional support. Handgrip aids were available to secure participants' hands to the handlebars if needed, although all participants had sufficient grip strength to use the equipment without the aids.

The participants' **cardiovascular parameters**, specifically blood pressure and heart rate, were assessed with a digital blood pressure monitor. The participants were asked to rest for at least 15 minutes after coming in for the assessment to allow sufficient time for their blood pressure to stabilise, ensuring more precise measurements. With the participants sitting in a comfortable position and their left arm supported in a heart-level position, their blood pressure and heart rate are measured with the digital monitor and recorded in millimetres of mercury (mmHg) and beats per minute (Bpm). Aside from the three assessment time points, these parameters were continually assessed before each rebound exercise session to ensure the participants were physically fit.

The participants were asked to fill out the WHOQOL BREF questionnaire to measure their **quality of life**. The questionnaire consists of four domains: physical health, psychological health, social relationships and environment domains and each domain was scored and reported separately as follows:

Physical health= 4 x [(6-Q3) + (6-Q4) + Q10 + Q15 + Q16 + Q17 + Q18] / 7

Psychological health= 4 x [Q5 + Q6 + Q7 + Q11 + Q19 + (6-Q26)] / 6

Social relationships= 4 x [Q20 + Q21 + Q22] /3

Environment= 4 x [Q8 + Q9 + Q12 + Q13 +Q14 + Q23 + Q24 + Q25] /8

To make the scores comparable to the WHOQOL-100, these domain scores were each converted to a 0-100 scale by subtracting four from the domain score and multiplying the difference by 6.25.

Physical activity levels and sedentary behaviour were assessed using the IPAQ. The participants were asked a series of questions that required them to recall the amount of time they had spent over the past seven days engaging in vigorous and moderate activities, such as walking and sitting. The participant's physical activity levels were scored in a continuous variable state as the metabolic equivalent of task (MET) minutes per week. One MET represents the energy expended at rest. Vigorous activity scores were calculated thus: 8 METs x minutes x days. Moderate activity scores were calculated thus: 4 METs x minutes x days, and walking scores were calculated as 3.3 METs x minutes x days. The total physical activity level was obtained by calculating the sum of vigorous activity scores, moderate activity scores, and walking scores. The participants were regarded as inactive if they had a total PAL of less than 600 METs minute per week, minimally active if they scored a total PAL of between 600-2999 METs minutes per week and in the Health Enhancing Physical Activity (HEPA) category if they achieved a minimum of at least 3000 METs minutes per week (Research Committee, 2005; Silva *et al.*, 2022).

Sedentary behaviour was calculated as the total amount of time the individual spent sitting in a week, including the time spent in transportation. The data was collected from the IPAQ, calculated in minutes x days (minutes x 5 weekdays + minutes x 2 weekend days + minutes x days spent sitting in transportation) and was reported in minutes per week. The sedentary behaviour was categorised as low risk if the weekly sitting time was less than 28 hours (<1680 minutes), medium risk if the weekly sitting time was between 28-56 hours (1680-3360 minutes) and high risk if the weekly sitting time was greater than 56 hours (>3360 minutes) (Hamilton *et al.*, 2008; Dunstan *et al.*, 2021).

Balance was assessed using the 3-MBWT. For this test, a 3-meter distance was marked on the floor with a start and stop writing at both ends of the line. From the 'start' marked point, the participants were asked to walk backwards as fast and safely as possible to a 3-metre 'stop' mark. They were free to look backwards if they wished and the researcher was closely walking along with them to ensure safety (figure 4.3). The time taken to reach the 3-metre marked point was recorded in seconds using a smartphone stopwatch, giving information on balance status. This test was repeated, and the average of the two tests was recorded as the balance score. This test also gave information on the participants' risk of falls.

Figure 4.3: A Participant performing the 3MBWT.

To measure **the walking speed**, the participants were instructed to walk a set and marked distance of 10 meters with or without an assistive device. They were asked to walk as fast as safely possible from the START mark to the STOP mark, and the time taken to walk the distance was noted using a smartphone stopwatch. The test was repeated twice, and the average time was recorded in seconds. To calculate the 10MWT scores, the time in seconds is divided by 10 to give the final score recorded in meters per second.

The **cognitive function** was measured using a mini-cog questionnaire. The participants were first asked to listen carefully, repeat back, and try to remember three words the researcher said. The list of words is taken from any of the six versions on the validated mini-cog questionnaire. On subsequent measurements, alternative word lists were used. So, for each measurement, the word list version used was noted so as not to reuse it in the next assessment. The word versions are as follows: version 1- banana, sunrise, chair; version 2- leader, season, table; version 3- village, kitchen, baby; version 4- river, nation, finger; version 5- captain, garden, picture and version 6- daughter, heaven, mountain. Next, the participant was asked to draw a clock on a preprinted circle, putting all the numbers in their correct position and setting the hands of the clock to ten past 11. After this was completed, the participant was asked to recall the three words initially given to them in the first step. A score of 0-3 was assigned to a participant depending on the number of words recalled. A score of either 0 for the abnormal clock or 2 for the normal clock was given for the clock draw. To be scored a 2 for clock drawing, the clock had to have all the numbers placed in the approximately correct position with no missing or duplicate numbers, with the hands pointing to 11 and 2 regardless of the length of the hand. The inability or refusal to draw a clock gained a 0 score (Tam *et al.*, 2018; Chan *et al.*, 2019).

The **grip strength** was assessed with a digital hand-held dynamometer. The participant was asked to sit up straight in a comfortable position, and with the elbow slightly flexed, they were asked to grip the dynamometer and squeeze as much as they could. The device shows the amount of force generated with each squeeze and records the maximum force generated by the participant at the end of the test. Each test is rated as weak, normal or strong based on the age and gender data entered for each participant. The scores are recorded in kilograms.

4.3.10.2 Rebound Exercise Training:

Each rebounder/mini-trampoline was fitted with a safety handle that the participants could hold on to to prevent falling. The exercise sessions were closely supervised by the physiotherapist (lead investigator), who instructed the participants on what to do on and off the mini-trampoline. A collection of YouTube videos from a rebound exercise tutor, Paul Eugene, was used in the training sessions.

Warm-up exercise: The participants were asked to perform light stretches on the ground with the lead researcher for 5 minutes before climbing onto the trampoline. This warm-up was a physiological preparatory phase to ensure the cardiovascular and musculoskeletal systems were ready for more dynamic movements. This phase was necessary to avoid the risk of muscle soreness or injury.

Rebound exercise: After completing the warm-up exercise designed to gradually increase the heart rate and prepare the muscles for exercise, participants were asked to get onto the rebounder (figure 4.4). For the rebound exercise sessions, a training video created by a certified rebound exercise tutor was displayed on a laptop and placed at a comfortable distance from the participant. The video provided visual and auditory cues, including background music, to help maintain rhythm and motivation. The tutor provided detailed verbal instructions on the correct performance of each movement, and the lead researcher closely supervised the participants to ensure proper form and technique, providing help when needed.

Participants followed the video to perform three sets of eight repetitions of various movements, with the option to rest if needed. The exercises were not performed in a specific sequence, but all movements were designed to target and activate a wide range of muscle groups, including the lower and upper limbs, as well as the core, in a coordinated pattern. As outlined in Table 4.1, the routines included controlled bouncing, side steps, arm raises, and more complex coordinated movements to stimulate various muscle systems. The act of repeatedly pushing off the trampoline surface requires activation of the quadriceps, hamstrings, and calf muscles and, at the same time, engaging the core stabiliser muscles in the hips and trunk to maintain postural balance. The upper limb muscles were also not left out as the movements involve simultaneous engagement of upper limbs, lower limbs and trunk muscles. In the initial sessions, some participants required one or two breaks during the 30-minute routine, but by the later stages, all participants could complete a full, continuous session.

Cool-down exercise: At the end of the rebound exercise, participants were guided through a structured cool-down phase designed to gradually lower their heart rate and promote muscle recovery. Participants engaged in light marching in place on the rebounder for approximately five minutes, gently shifting their weight from side to side to maintain movement without placing undue stress on their muscles or joints. This was followed by a series of dynamic and static stretching exercises, targeting key muscle groups in the arms, legs, and trunk. These stretching movements aimed to release muscle tension, improve flexibility, and prevent stiffness post-exercise, ensuring participants ended the session in a relaxed and comfortable state. The cool-down helped with physical recovery and allowed participants to mentally wind down after the more intense phases of the workout.

Table 4.1: Content of the Rebound Exercise Routines

Walking	Small steps to the front and the back Small steps diagonally to the northeast and northwest direction and back
Marching	In place while holding the handlebar, In place with arm lifts Marching inwards to the centre and then outwards to the edge 'Penguin high steppage march'- marching with the knees raised very high
Jogging	Jogging in place Jogging from side to side Jogging forward and backwards
Weight transfer	Weight shifts from left leg to right leg, from heels to toes Alternate side kicks Alternate hip kick and knee raise of the opposite leg Opposite elbow-to-knee raise Hip shift from side to side Trunk rotation from side to side Side lunges
Bouncing	Health bounce- gentle, slow bounce in place Bounce with alternate forward kicks Bounce with alternate arm punches (bounce boxing) Bouncing in (towards the centre) and outwards Bouncing with arm rolling Passing a softball from one hand to the other, through the font and behind while bouncing Freestyle bouncing
Jumping	Half jack with unilateral arm movements Jumping jacks, Modified jumping jacks
Cool down	Alternate side step and touch Alternate heel press and toe taps Stretching of the lower limbs, upper limbs and trunk.

Figure 4.4: Participants on the Mini-trampolines performing Rebound Exercises.

Intervention dose: The rebound exercise sessions were designed to last 30 minutes each for 12 weeks. The frequency of attendance was a minimum of once a week (Ralston *et al.*, 2018; Thomas and Burns, 2016), but participants were free to attend more frequently, and this was recorded. While studies have consistently used a frequency of three times a week for exercise interventions, these are usually in controlled settings and may not be practical in real-life community settings (Miklitsch *et al.*, 2013; Rodrigues *et al.*, 2018; Al-Nemr and Kora, 2024). This feasibility study recognises this challenge by offering a minimum of once weekly, with the flexibility to attend more often. This was to observe participants' naturalistic tendencies and real-world conditions under which long-term exercise adherence might occur. The 30-minute duration was chosen so the participants could have sufficient time to engage in meaningful physical activity without causing undue fatigue, especially considering the neurological conditions of the group. Additionally, the literature recommends a minimum of 30 minutes for moderate-intensity exercise (Allendorfer and Bamman, 2018; Kantawala *et al.*, 2023).

Progression: Participants gradually built their stamina, coordination, and strength as the weeks progressed. In the initial weeks, they were encouraged to take rest breaks if necessary, but by the later weeks, most participants could complete the entire 30-minute session without interruption. This gradual progression ensured that participants could safely and effectively increase their physical capacity over time while minimising the risk of injury or overexertion.

A handlebar was attached to the mini-trampoline primarily for safety and to offer the participants a sense of security. However, it was not mandatory for participants to hold onto the handlebar throughout the sessions. Some participants did not hold onto the handlebar throughout the sessions, and most of those who did in the initial weeks stopped doing so in later weeks.

4.4 Ethical Considerations

Ethical approval was obtained from the Buckinghamshire New University Research Ethics Committee (UEP2022Sep01) before the commencement of the study, and each participant signed an informed consent form before participating in the study. A significant ethical implication of this study would have been the participants' safety, but attaching stability bars and safety handles to the mini trampolines minimised that possibility. The rebounder was also positioned around a wall corner so that two perpendicular wall surfaces protected the back, and the front was secured by the stability bar. Furthermore, the researcher, a physiotherapist with experience working with patients with neurological disorders and their needs, was trained in using rebounders and closely supervised the rebound exercise training sessions. A gripping aid device was also made available to assist people with poor grip strength in holding on to the handlebar.

Another potential ethical implication would have been vulnerability, but the eligibility criteria were provided to minimise that. Suppose a participant's mental or physical health deteriorated during the trial, and if a participant decided not to continue for any reason outside the rebound exercise's effect or if they were ill, they were free to drop out of the study anytime. This was made clear to the participants before and during the study.

4.5 Data Analysis

The data collected was entered into an Excel spreadsheet and then transferred into SPSS. The analysis was done with the Statistical Package for Social Sciences (SPSS) version 28.

4.5.1 Descriptive Statistics

a) Frequency tables, percentages and bar/pie charts were used to summarise the data for categorical variables (Age range, sex, occupation, disease type, weekly frequency, disability level, duration of disease range, baseline PAL categories and baseline SB categories).

b) The continuous variables were summarised using mean, standard deviations, median and interquartile ranges.

4.5.2 Normality Tests

This was carried out on the continuous raw data using seven tests to determine if the data are normally distributed (mean, median, mode, skewness, kurtosis, histogram, Shapiro-Wilk test, normal Q-Q plot and Box plot).

- The following variables were normally distributed: baseline SBP, DBP, WS, SB, Mid trial SBP, DBP, WS, SB and End trial SBP, DBP, WS, SB. The above are parametric data and were tested with parametric tests.
- The rest of the variables were not normally distributed, so they were transformed with natural logarithms to correct the skewness. However, even with this transformation, these data were not corrected and were still not normally distributed after another set of Normality tests were conducted on the transformed data. Thus, non-parametric tests were carried out on them (baseline, midtrial, and end trial HR, Bal, Cog, GripS, PAL, PhH, PsH, SR, and Envt).

Keys:

SBP-Systolic Blood Pressure
DBP-Diastolic Blood Pressure
WS- Walking Speed
SB-Sedentary Behaviour
HR-Heart Rate
Bal-Balance
Cog-Cognition
GripS-Grip Strength
PAL-Physical Activity Level
PhH-Physical Health domain of quality of life
PsH-Psychological Health domain of quality of life
SR-Social Relationship domain of quality of life
Envt-Environmental domain of quality of life

Table 4.2: Outcome Variables and Statistical tests performed for Research Objectives.

S/N	Objectives	Outcomes	Descriptive statistics	Inferential statistics
A	To evaluate the impact of rebound exercise on some physiological and functional outcomes of individuals with neurological disorders.	Heartrate (non-parametric)	Median and interquartile ranges	Friedman test and post hoc Wilcoxon signed-rank test.
B	Testing for significant differences in outcomes across the 3 time points (baseline, week 6 and week 12)	Blood pressure (parametric)	Mean and standard deviation	Repeated measure ANOVA and post hoc Bonferroni tests
C	”	Quality of life (non-parametric)	Median and interquartile ranges	Friedman test and post hoc Wilcoxon signed-rank test.
D	”	Balance and Risk of fall (non-parametric)	Median and interquartile ranges	Friedman test and post hoc Wilcoxon signed-rank test.
E	”	Walking speed (parametric)	Mean and standard deviation	Repeated measure ANOVA and post hoc Bonferroni tests
F	”	Physical activity level (non-parametric)	Median and interquartile ranges	Friedman test and post hoc Wilcoxon signed-rank test.
G	”	Sedentary behaviour (parametric)	Mean and standard deviation	Repeated measure ANOVA and post hoc Bonferroni tests
H	”	Cognitive function (non-parametric)	Median and interquartile ranges	Friedman test and post hoc Wilcoxon signed-rank test.
I	”	Grip strength (non-parametric)	Median and interquartile ranges	Friedman test and post hoc Wilcoxon signed-rank test.
J	Testing for the relationship between attendance frequency and the outcomes	Blood pressure, walking speed, sedentary behaviour	____	Multiple regression analysis
K	Testing for significant differences between once and twice-weekly exercise frequency	All outcomes	____	Independent t-test and Mann-Whitney U test.

Note: Parametric data are normally distributed after normality tests were performed, and non-parametric data are not normally distributed.

4.5.3 Inferential Statistics

For the Parametric Data

- Repeated measures ANOVA was used to test for significant mean differences across the three time points within the same participants.
- Post-hoc Bonferroni test with pairwise comparison was used to pinpoint where the significant differences lay.
- Multiple regression analysis was used to examine the relationship between the weekly frequency of attendance and the outcome variables while accounting for age, disease severity and number of years since diagnosis.
- Independent t-test was used to test for significant differences between once and twice-weekly exercise frequency.

For the Non-parametric Data

- Friedman test was used to test for significant differences in the medians across the three time points within the same participants.
- Wilcoxon signed-rank test with pairwise comparison was the post hoc test used to investigate where the significant differences were.
- Mann-Whitney U test was used to test for significant differences between once and twice-weekly exercise frequency.

4.5.4 Descriptions of the Statistical Tests Used

Repeated measures ANOVA and its non-parametric equivalent, the Friedman test (for normally distributed and skewed data, respectively), were the most appropriate tests to assess outcome changes across multiple time points while accounting for within-subject correlations. For these tests to be used, the following assumptions were checked and met (Muhammad, 2023):

- The dependent variable must be on a continuous scale, i.e., the data must be measured at intervals or ratios.
- The categorical independent variable must have three or more related levels and have a balanced number of measurements. To meet this assumption, the data from the 53rd participant was removed from the analysis because of the missing 12th-week post-test data. This removal would have normally reduced the statistical power and increased the likelihood of type 2 error, but the fact that a higher sample size than the one calculated was recruited accounted for this possibility.

- The dependent variable is approximately normally distributed for each group. Where the data was skewed, and data transformation failed to correct the skewness, the Friedman test was used instead of repeated measures ANOVA.
- The data must have sphericity, i.e. equal variances across the time points. Where this assumption of sphericity was not met, the Greenhouse-Geisser statistical correction was used to avoid type 1 errors.
- There must be no spurious outliers in any of the repeated measurements.

For the post hoc tests, the adjusted p-values were reported to control for multiple comparisons.

Multiple regression analysis was the best statistical test to examine the relationship between the weekly frequency of attendance and the outcomes while controlling for confounders. The following assumptions were checked and met for this test (Williams, Grajales and Kurkiewicz, 2013):

- The relationship between the independent variables and the dependent variable must be linear.
- The dependent variables must be normally distributed. To meet this assumption, only normally distributed outcome variables were tested.
- There must be no multicollinearity (high correlation) between the independent variables. This was confirmed through a variance inflation factor of less than 10 or collinearity statistics tolerance of greater than 0.2.
- The variance of the error term is constant across all values of the independent variables (homoscedasticity).

4.6 Result

4.6.1 Homogeneity Testing

To assess baseline comparability across the different neurological disorders of the study participants (Parkinson’s disease, stroke, Multiple Sclerosis, Traumatic Brain Injury, Huntington’s disease), one-way ANOVA and Kruskal-Wallis tests were conducted for parametric and non-parametric variables, respectively.

For the parametric variables, one-way ANOVA revealed no statistically significant difference in baseline disability level (according to the Modified Rankin Scale) [$F(4,47)=2.347$, $p=0.068$], baseline SBP [$F(4,47)=0.244$, $p=0.912$], baseline DBP [$F(4,47)=1.172$, $p=0.335$]

and baseline walking speed [$F(4,47)=0.714$, $p=0.586$]. However, a statistically significant difference was observed in baseline sedentary behaviour [$F(4,47)=3.499$, $p=0.014$]. Post-hoc Bonferroni testing indicated that this difference was specifically observed between the stroke and TBI groups ($p=0.047$) with the stroke group exhibiting higher sedentary behaviour (4270.11±1190.481) compared to the TBI group (2652.83±822.930).

For non-parametric variables, the Kruskal-Wallis test showed no statistically significant difference in baseline heart rate [X^2 (4)=4.676, $p=0.322$], cognitive function [X^2 (4)=8.432, $p=0.077$], grip strength [X^2 (4)=6.325, $p=0.176$, PAL [X^2 (4)=8.790, $p=0.067$], PhH [X^2 (4)=11.141, $p=0.089$], PsH [X^2 (4)=8.374, $p=0.079$], SR [X^2 (4)=7.858, $p=0.097$], Envt [X^2 (4)=13.943, $p=0.412$]. However, a statistically significant difference was found in the baseline balance [X^2 (4)=10.789, $p=0.029$].

Overall, the baseline characteristics of the participants across the different neurological disease groups were largely comparable. While statistically significant differences were observed in baseline sedentary behaviour and balance, these differences were limited. Most key outcomes, including disability level, blood pressure, heart rate, grip strength, cognitive function, physical activity level and quality of life showed no significant difference. Therefore, the results suggest that the groups were reasonably similar at baseline, minimising the potential confounding effects of pre-existing differences on the observed outcomes of the rebound exercise intervention.

4.6.2 Participant Characteristics

The majority of the participants were female (67.3%), married (46.2%), retired (55.8%), non-smokers (90.4%) and were within the 65-74 years age range (50%) (see Table 4.3). Most of them attended the rebound exercise once a week (76.9%), had Parkinson's disease (50%), had a mild disability (59.6%) and had been diagnosed between the previous 3-4 years (34.6%). At baseline, half of the participants were minimally active (50%) and sat weekly for 28-56 hours (50%). The mean age and BMI of the participants were 61.44±9.224 years and 23.31±4.11, respectively.

4.6.3 Recruitment and Retention

Out of approximately 85 potential participants approached, 60 expressed interest in joining the study, yielding a recruitment rate of 70.59%. Of these, 53 met the eligibility criteria and were enrolled. The retention rate was notably high at 98.1%, with only one participant dropping out in week 11 due to illness (COVID-19), resulting in a low attrition rate of 1.89%.

4.6.4 Attendance Patterns

Attendance was flexible, with 40 participants (76.9%) attending once weekly and 12 participants (23.1%) attending twice weekly throughout the 12-week program. Although participants were offered scheduling flexibility, time constraints were the primary challenge, limiting most to once-weekly attendance. Despite this, adherence was high, with all participants meeting the minimum requirement of attending at least one session per week.

4.6.5 Acceptability

Participants consistently reported finding the exercise enjoyable and satisfactory, with many expressing interest in continuing the program beyond the study period if given the opportunity.

4.6.6 Safety

No injuries or adverse events were reported throughout the study, demonstrating that the intervention was safe for use in a supervised community setting.

4.6.7 Physiological and Physical Outcomes

Table 4.4 shows the results from the repeated measures ANOVA with a Greenhouse-Geisser correction revealing statistically significant changes with large effect sizes across the time points in the SBP [$F(1.650, 84.145)=29.315$, $p<0.001$, $\eta^2=0.452$], DBP [$F(1.745, 89.006)=32.080$, $p<0.001$, $\eta^2=0.485$], WS [$F(1.271, 64.834)=59.611$, $p<0.001$, $\eta^2=0.573$] and SB [$F(1.299, 66.258)=86.686$, $p<0.001$].

For the skewed data, the Friedman test was used to test for and found significant differences in the distribution across the time points for HR [$X^2(2) = 7.757$, $p=0.021$], balance [$X^2(2) = 104.000$, $p<0.001$], PAL [$X^2(2)= 78.757$, $p<0.001$], PhH domain [$X^2(2)= 88.194$, $p<0.001$], PsH domain [$X^2(2)= 94.032$, $p<0.001$], SR domain [$X^2(2)= 54.690$, $p<0.001$], Envt domain of QoL [$X^2(2)= 55.318$, $p<0.001$], cognitive function [$X^2(2)= 31.586$, $p<0.001$] and grip strength [$X^2(2)= 61.246$, $p<0.001$].

Table 4.3: Physical Characteristics of the Participants

Index	Frequency (n)	Percentage (%)
Sex:		
Male	17	32.7
Females	35	67.3
Marital status:		
Single	18	34.6
Married	24	46.2
Divorced	7	13.5
Widow/widower	3	5.8
Age range:		
35-44 years	4	7.7
45-54 years	6	11.5
55-64 years	16	30.8
65-74 years	26	50
Occupation:		
Retired	29	55.8
Active service	23	44.2
Severity of disability:		
No disability	1	1.9
Mild disability	31	59.6
Moderate disability	20	38.5
Weekly frequency:		
Once a week	40	76.9
Twice a week	12	23.1
Type of Disease:		
Stroke	14	26.9
Parkinson's disease	26	50
Huntington's disease	2	3.8
Multiple sclerosis	4	7.7
Traumatic brain injury	6	11.6
Duration of diagnosis:		
1-2 years	9	17.3
3-4 years	18	34.6
5-6 years	6	11.5
7-8 years	12	23.1
9-10 years	6	11.5
Above 10 years	1	1.9
Baseline body mass index		
Underweight	5	9.6
Normal weight	31	59.6
Overweight	14	27
Obese	2	3.8
Baseline physical activity level		
Inactive	1	1.9
Minimally active	26	50
Health enhancing active	25	48.1
Baseline sedentary behaviour		
Less than 28 hours weekly	2	3.8
28-56 hours weekly	26	50
More than 56 hours weekly	24	46.2

Table 4.4: Assessment of the Distribution of Outcomes across Time Points

Index	Baseline	6 weeks	12 weeks	Test	P value
SBP (M±SD)	123.02±7.650	120.19±6.356	116.46±5.686	F=29.315 df=1.650	<0.001*
DBP	78.13±7.817	74.63±6.993	71.58±4.912	F=32.080 df=1.745	<0.001*
HR [m(Q1-Q3)]	71(68-79.75)	72(68-76)	71(65.25-74)	X^2=7.757 df=2	0.021*
Balance	4.51(3.58-5.73)	3.23(2.53-4.65)	2.39(2.27-4.11)	X^2=104.000 df=2	0.000*
Walking speed	1.4538±0.237	1.6850±0.2916	1.7890±0.3758	F=59.611 df=1.271	<0.001*
PAL	2935(2287.75-4425)	3267(2576- 4060)	3603(3088- 4329)	X^2=78.757 df=2	0.000*
SB	3400.25±1220.29	3130.27±1182.99	2781.87±959.40	F=86.686 df=1.299	<0.001*
PhH	63(56-67.50)	69(63-75)	75(69-75)	X^2=88.194 df=2	0.000*
PsH	56(51.50-63.00)	69(63-73.50)	75(69-75)	X^2=94.032 df=2	0.000*
SR	63(56-69)	69(56-69)	69(63-75)	X^2=54.690 df=2	<0.001*
Envt	66(63-75)	69(63-75)	75(69-75)	X^2=55.318 df=2	<0.001*
Cognition	5(4-5)	5(4-5)	5(5-5)	X^2=31.586 df=2	<0.001*
Grip strength	21.10(17.73-25.20)	22.60(20.157-25.575)	22.8(20.80-28.50)	X^2=61.246 df=2	<0.001*

Key: M=mean, SD= standard deviation, m=median, Q1=first quartile, Q3= third quartile X^2=Chi-square (Friedman test), df=degree of freedom, F=ANOVA test statistics, *significance level set at $p<0.05$

A post hoc pairwise comparison with Bonferroni correction showed that these differences were significant between all the pairs for most of the outcomes (p<0.001) except for heart rate (p=0.043) and cognition (p=0.013) where significant difference was found only between the baseline and 12 weeks pair, as well as social relationship and environmental domains of quality of life where no significant difference was found between the baseline and six weeks pair (p=0.980) (table 4.5). Furthermore, an independent samples t-test and Mann-Whitney U test were used to compare the two frequency groups for the normally distributed and skewed data respectively. Results indicated no statistically significant differences between the groups attending the rebound exercise once (n=40) and twice (n=12) per week across all these various outcomes (p>0.05).

A multiple regression analysis examined the relationship between weekly frequency of attendance and three outcome variables (blood pressure, walking speed and sedentary behaviour), adjusting for age, disease severity and duration of diagnosis. However, no significant associations were found between weekly frequency of attendance and any of the health outcomes (all p-values >0.05). The models explained a small proportion of variance in each outcome variable (R^2 range: 0.037-0.118) (table 4.6).

Table 4.5: Post hoc Bonferroni test for Pairwise Comparisons

Index	Baseline vs 6 weeks	Baseline vs 12 weeks	6 weeks vs 12 weeks
SBP	<0.001*	<0.001*	<0.001*
DBP	<0.001*	<0.001*	<0.001*
HR	1.000	0.043*	0.105
Balance	0.000*	0.000*	0.000*
Walking speed	<0.001*	<0.001*	<0.001*
PAL	0.000*	0.000*	0.000*
SB	<0.001*	<0.001*	<0.001*
PhH	0.000*	0.000*	0.000*
PsH	0.000*	0.000*	0.000*
SR	0.980	0.000*	0.000*
Envt	0.980	0.000*	0.000*
Cognition	1.000	0.013*	0.093
Grip strength	0.001*	0.000*	0.000*

*adjusted significance for multiple tests

Table 4.6: Multiple Regression Analysis for Weekly Frequency vs Dependent Variables

Dependent variable	F-statistics	Degree of freedom	P value	R squared	CST	T-statistics	Unstandardised regression coefficient (B)	Standardised regression coefficient (β)
SBP	1.234	4,47	0.309	0.118	0.992	-0.183	-0.439	-0.025
DBP	0.974	4,47	0.431	0.077	0.992	-0.375	-0.851	-0.053
WS	0.451	4,47	0.771	0.037	0.992	-0.832	-0.083	-0.120
SB	0.607	4,47	0.660	0.046	0.992	0.396	54.497	0.057

CST- Collinearity Statistics Tolerance

4.7 Discussion

4.7.1 Participant Demography

A noteworthy observation from the study is that most participants were females, older adults, retired and had mild disability. The predominance of female participants aligns with existing research, indicating that women are generally more likely to participate in health-related community programs and interventions than men (Naud *et al.*, 2019; Dluhos-Sebesto *et al.*, 2021). This gender imbalance may reflect broader societal trends, such as women's generally higher health-seeking behaviour and greater willingness to participate in health interventions. Women might be more proactive about managing their health and more open to engaging in group-based physical activity interventions, potentially driven by a stronger focus on health maintenance and community support (Dluhos-Sebesto *et al.*, 2021). However, it may also highlight an unmet need to engage male participants, which future interventions should address through targeted recruitment strategies.

The study’s finding that half of the participants were older adults is consistent with the epidemiology of neurological disorders, which are more prevalent in older populations (Dumurgier and Tzourio, 2020; Huang *et al.*, 2023). As individuals age, they are more likely to experience a decline in neurological function, leading to conditions such as Parkinson's disease, stroke, and multiple sclerosis. (Reeve, Simcox and Turnbull, 2014; Li *et al.*, 2021). Furthermore, the age profile of participants suggests that rebound exercise may appeal to older adults, particularly as a low-impact exercise modality that can accommodate varying levels of mobility and fitness.

Finally, the fact that 55.8% of participants were retired may explain the high adherence rates, as retired individuals often have more flexible schedules, making it easier to attend exercise sessions (de Paula Couto *et al*., 2022; Hutchinson and Kleiber, 2023). In contrast, working-age adults may face more significant time constraints, which could affect their participation in future studies. As seen in this study, offering flexible attendance options was crucial to accommodate the needs of working individuals. Additionally, it is important to recognise that most participants had mild impairments so, additional research is necessary to assess rebound exercise's effectiveness for individuals with more severe disabilities.

4.7.2 Feasibility of Implementing Rebound Exercise in the Community

The study demonstrated the feasibility of implementing a rebound exercise program for adults with neurological disorders in a supervised community setting. High recruitment (70.59%) and retention rates (98.1%) indicate a significant interest and willingness of the participants to engage with this mode of exercise, consistent with findings from a recent study (Fricke *et al.*, 2023). These figures surpass those typically seen in exercise-based intervention studies with similar demographics (O'Grady *et al*., 2022; Hu *et al*., 2024). This highlights the appeal of rebound exercise to this cohort. Participant engagement is further demonstrated by a remarkably low attrition rate of just 1.89%, significantly lower than the 30-70% dropout rates commonly reported in longitudinal studies (Gustavson *et al*., 2012). The low attrition rate is particularly encouraging, considering that no incentives were provided to the participants. This suggests that participants' adherence was likely due to the perceived benefits and enjoyment of the exercise rather than external motivators, supporting the argument for rebound exercise as a feasible and engaging intervention.

Moreover, the flexible attendance option offered to the participants contributed to the study's success. Although literature often recommends a frequency of three times weekly for exercise interventions (Kong, Tay and Kee, 2018; Kora and Abdelazem, 2020; Okemuo, Gallagher and Dairo, 2023), this frequency might not be practical and sustainable in the community setting. This was evident as most participants attended once weekly, a few attended twice per week, and none attended three times weekly, indicating a need for a flexible participant-driven exercise regimen. This flexibility allowed individuals to fit the exercise into their schedules, addressing a common challenge of time constraints that many community-dwelling adults face (Hartley and Yeowell, 2015; Zhou *et al*., 2024). Most importantly, despite the lower exercise dose, the study observed significant improvements in key outcomes. The lack of significant difference between once and twice-weekly frequency may be due to the unequal sample sizes affecting significance. It could also mean that a minimum of once-a-week rebound exercise may be sufficient to improve outcomes in this population. The preference for once-weekly exercise sessions mirrors findings by Foley, Hillier and Barnard (2011) and Aboagye *et al*. (2017), where a similar trend was observed among community-dwelling older adults and working adults with non-specific low back pain, respectively. This consistency across studies highlights the potential of offering flexible, lower-frequency exercise programs that are more likely to be adopted and sustained over a long time.

In addition to the impressive retention and adherence rates, this study demonstrated other key feasibility indicators, such as acceptability, safety, and potential effectiveness, which are discussed in separate sections below.

4.7.3 Acceptability of Rebound Exercise

Healthcare best practices advocate for thorough acceptability assessment as a critical component of intervention evaluation (Craig and Petticrew, 2013; Eldridge *et al.*, 2016; Garizábalo-Dávila, Rodríguez-Acelas and Cañon-Montañez, 2023). Acceptability of healthcare interventions is typically inferred from participants' behaviour (Sekhon, Cartwright and Francis, 2018). This study's findings revealed a remarkably high acceptability of rebound exercise among this group, reflected in their positive attitudes, engagement, and adherence. This highlights its feasibility and potential for long-term adoption. Studies have shown that people are more likely to adhere to an intervention they consider acceptable (Sekhon, Cartwright and Francis, 2017; Klaic *et al.*, 2022).

Furthermore, the participants' enjoyment and interest in continuing the program reflect satisfactory acceptance and engagement. This is an encouraging sign of the potential sustainability of rebound exercise programs in community-based settings. Most participants disclosed their plans to purchase a mini trampoline for personal use or join a similar exercise program if offered at a local gym. This also indicates a readiness to integrate rebound exercise into their regular routines.

4.7.4 Safety of Rebound Exercise

The absence of injuries or adverse events supports the safety of rebound exercise for community-dwelling adults with neurological disorders, which aligns with reports from previous research (Simonis *et al*., 2004; Miklitsch *et al*., 2013). These findings are significant, given that half of the participants were living with Parkinson's disease, a population particularly prone to balance issues and falls (Fasano *et al*., 2017; Lima *et al*., 2022). Despite these potential risks, no safety concerns emerged throughout the study. This noteworthy finding supports the feasibility and safety of rebound exercise for individuals with neurological disorders, particularly when conducted under supervised conditions and with a handlebar attached. It is important to note that in this study, the participants exhibited relatively high baseline characteristics in terms of functional capacity. For instance, the mean baseline walking speed was 1.45 m/s, which is consistent with normative values for community-dwelling older adults who typically have good balance and mobility (Andrews *et al.*, 2023; Santos *et al.*, 2024). Therefore, the lack of adverse events may be partly due to the participants' higher baseline functional status. This observation raises the need for caution when applying these findings to populations with severe balance impairments or lower levels of functional independence.

Overall, the combination of a favourable safety profile, high adherence rates, and positive participant feedback supports the feasibility of rebound exercise as a regular component of rehabilitation programs for adults with neurological disorders in community settings. Incorporating safety measures like handlebars and expert supervision effectively mitigated potential risks, demonstrating the viability of rebound exercise as a therapeutic option for this vulnerable population. However, further research is necessary to evaluate the feasibility and safety of conducting this exercise independently or in less-supervised environments like the home, where safety measures may be more limited.

4.7.5 Challenges and Solutions

One of the primary challenges reported by participants was the limited availability of time, which led most to restrict their attendance to once-weekly sessions. Interestingly, this was the case even though many participants were retirees, a group typically assumed to have more free time. This preference for once-weekly sessions among retirees may reflect their involvement in other daily activities, responsibilities, or personal routines, such as volunteer work, family obligations, or hobbies, that occupy their time (Hartley and Yeowell, 2015;

Crossman *et al.*, 2024). Additionally, some retirees might have chosen less frequent attendance due to health or energy level considerations, preferring to pace themselves with a manageable exercise routine (Zhou *et al.*, 2024). To address the time constraints reported by participants, the study provided flexible weekly frequency attendance and scheduling options, offering evening and weekend sessions and allowing participants to reschedule sessions as needed. Flexibility in exercise programming has been shown to significantly enhance adherence rates among older adults, as it respects their autonomy and adapts to their diverse lifestyle needs (Fricke *et al.*, 2023). By accommodating participants' schedules, the study mimicked the conditions under which long-term exercise might occur in the real world, ensuring that even those with limited availability could still participate, helping to maintain high adherence levels.

Furthermore, participants expressed a clear preference for group exercise sessions over individual ones. To respond to this preference, the study introduced the 'buddy system'[6], where participants were allowed to attend sessions with a friend who is a fellow participant, to help alleviate concerns about exercising alone and increase overall motivation. This social aspect of the exercise sessions fostered a sense of community and mutual support among participants, further enhancing the program's appeal. Buddy system and group exercise have been shown to provide multiple benefits, including increased motivation, improved mood, and greater adherence to physical activity, especially among older adults (Komatsu *et al.*, 2017; Beauchamp *et al.*, 2018; Winzer *et al.*, 2019; Takeda and Takatori, 2022). This study integrated social interaction into the exercise sessions, addressing the challenge of adherence and enriching the overall experience for participants, making the program more enjoyable and sustainable.

Flexibility in this study was not a methodological flaw but a feature incorporated to observe participants' behaviours, preferences and challenges in a community setting. Community-based interventions must account for the realities of participants' lives, including time constraints, social factors and individual preferences (Hartley and Yeowell, 2015; Crossman *et al.*, 2024). Incorporating flexibility enabled the study to observe how participants naturally engage with exercise and identify the most feasible approach. The flexible scheduling

[6] Buddy system is a cooperative arrangement where two individuals work together to support and monitor each other. It is increasingly used in different fields like the workplace, military, police force, student life, research etc to provide peer support, social interaction and motivation. There is evidence of the social support of the buddy system as a strong driver of health behaviours/modifications (Takeda, 2022; Winzer *et al.*, 2019).

arrangement promoted high participation and engagement outcomes, supporting the argument that rebound exercise is feasible and sustainable when delivered in a flexible and socially supportive manner. Indeed, flexibility, motivation and social support are all key factors in the success of community-based interventions (Farrance, Tsofliou and Clark, 2016; Killaspy *et al*., 2022; Hong *et al*., 2023; Snowden *et al*., 2023; Vangeepuram *et al*., 2023). Future programs should consider incorporating flexible scheduling, group sessions, and affordable access to equipment to enhance participation and sustainability.

4.7.6 Balance and Walking Speed

Another noteworthy observation in this study was the potential positive impact of rebound exercise on the balance of community-dwelling adults with neurological disorders. A progressive decrease in the time to complete the 3MBWT was observed between baseline and 12 weeks, with an average gain of 2.12 seconds. This finding is particularly compelling as backwards walking is a more challenging dynamic balance test with increased reliance on neuromuscular control and protective reflexes (DeMark *et al.*, 2019; Abit Kocaman *et al.*, 2021). An increased ability to walk backwards faster indicates a better balance and reduced risk of falls, which are critical concerns in neurorehabilitation (Rose *et al.*, 2018; DeMark *et al.*, 2019). The unstable surface of the trampoline requiring complex neuromuscular stimulation and coordination may be directly responsible for these observed effects. Although this finding differs from a recent review involving hospitalised participants (Okemuo, Gallagher and Dairo, 2023), it agrees with several studies that have reported increased balance with aerobic exercise in older adults (Ehrari *et al.*, 2020; Papalia *et al.*, 2020), women with osteoporosis (Dizdar *et al.*, 2018), individuals with visual impairment (Zhikai, Zizhao and Junsheng, 2023), individuals with Parkinson's disease (Zhen *et al.*, 2022) and adults with intellectual disabilities (Oviedo *et al.*, 2014).

Consistent with the literature, our findings further indicate a significant improvement in walking speed among participants following rebound exercise, as measured by the 10MWT. This improvement suggests that the intervention may effectively enhance participants' functional mobility. The rhythmic and dynamic nature of rebound exercise likely contributed to this enhancement by strengthening the lower limb muscles and improving overall physical conditioning. Faster walking speeds are associated with greater independence and a lower risk of falls, particularly in older adults or those with mobility impairments (Fielding *et al.*, 2017; de Oliveira *et al.*, 2021).

4.7.7 Physical Activity Level and Sedentary Behaviour

This study also examined participants' physical activity levels and sedentary behaviours, revealing that most had minimal activity levels at baseline, with METs values ranging from 600-2999 METs minutes per week. Participants also spent a considerable amount of time being sedentary, ranging from 28 to 56 hours per week. These findings reflect the common trend among individuals with neurological disorders, who often face barriers such as mobility limitations, fatigue, and pain, leading to reduced physical activity and prolonged periods of inactivity (Martin Ginis *et al.*, 2021; Ningrum and Kung, 2023). However, after 12 weeks of participating in the rebound exercise program, significant improvements were observed in both physical activity levels and sedentary behaviours. The dynamic, rhythmic nature of rebound exercise, which incorporates low-impact bouncing and engaging movements, likely played a crucial role in encouraging participants to be more active. This positive shift in physical activity is particularly noteworthy as it aligns with the growing body of research suggesting that exercise programs perceived as enjoyable, achievable, and accessible are more likely to result in sustained behavioural change. Lachman *et al*. (2018) and Gasana *et al*. (2023) highlight the importance of enjoyment and self-efficacy in promoting long-term adherence to physical activity regimens, especially in older adults or those with chronic conditions.

Additionally, the reduction in sedentary behaviour is a critical outcome, as prolonged sedentary time is linked to numerous adverse health outcomes, including an increased risk of cardiovascular disease, type 2 diabetes, and certain cancers (Schwartz *et al.*, 2019). The rebound exercise program's ability to break up prolonged periods of sitting or inactivity likely contributed to these improvements, offering participants a structured yet enjoyable means of increasing movement throughout their week. The study’s findings highlight the potential of rebound exercise to not only enhance physical activity levels but also reduce sedentary behaviour in adults with neurological disorders, thus mitigating some of the associated health risks. This outcome is particularly significant in the context of neurorehabilitation, where promoting even small increments of physical activity can result in meaningful health benefits (Haseler, Crooke and Haseler, 2019; Martin Ginis *et al*., 2021). Furthermore, the findings suggest that this form of exercise could be a valuable addition to broader health promotion efforts aimed at reducing the global burden of physical inactivity.

4.7.8 Quality of Life

Our study findings reveal a significant improvement in overall quality of life after 12 weeks of rebound exercise, which is a notable outcome. Interestingly, this improvement was not uniform across all QoL domains. Significant improvements were observed within the first 6 weeks in the physical and psychological domains, while improvements in the social relationship and environmental domains became significant only in the latter half of the intervention period (between 6 weeks and 12 weeks). The early improvements in physical and psychological domains can be attributed to the immediate effects of physical exercise on physical health and mental well-being. Exercise rapidly influences physical health through improved fitness (Daneshvar *et al.*, 2019; Clement, Alexander and Draper, 2022) and psychological well-being through mechanisms such as endorphin release, which can enhance mood and mental state (Sadeghi, Ahmadi and Rasekhi, 2022). This aligns with existing literature suggesting the quick onset of physical and psychological benefits following regular physical activity (Mandolesi *et al.*, 2018; Nystoriak and Bhatnagar, 2018; Mahindru, Patil and Agrawal, 2023).

On the other hand, the later improvements in social relationships and environmental domains may be due to the gradual development of social interactions, a sense of community within the exercise program, and gradual adaptations to the participants' broader living environments. These aspects often take longer to manifest as they rely on developing relationships, changes in lifestyle habits, and participants' perceptions of their place in the community and environment (Wong *et al.*, 2018). As individuals feel better physically and psychologically, they become more socially active and engage more with their environment, enhancing their social well-being. These findings suggest that while physical exercise interventions can rapidly improve certain aspects of quality of life, other aspects may require more time to exhibit significant changes. This has important implications for exercise program design and expectation management, particularly in clinical and community settings. These findings corroborate previous studies that reported improved quality of life with aerobic exercise participation (Amini *et al.*, 2018; Rao, Noronha and Adiga, 2020; Shams *et al.*, 2021).

4.7.9 Cardiovascular Function

In this study, rebound exercise appeared to impact blood pressure positively. Systolic and diastolic blood pressures showed significant improvements, with reductions of approximately

3 mmHg and 4 mmHg, respectively, as early as six weeks into the trial. These improvements continued through the 12th week, resulting in a total drop of approximately 7 mmHg for both systolic and diastolic blood pressures. This corroborates several previous studies that have reported reduced systolic and diastolic blood pressures following aerobic exercises in various populations (Punia *et al.*, 2016; Wen and Wang, 2017; Kim and Kang, 2019; Saco-Ledo *et al.*, 2020). The mechanism by which rebound exercise reduces blood pressure is multifaceted, involving physiological and biomechanical aspects. Regular exercise strengthens the heart, increasing its efficiency and lowering the force exerted on the arteries, thus lowering blood pressure (Dimeo *et al.*, 2012; Hegde and Solomon, 2015). It also reduces blood pressure by lessening the sympathetic nervous system activity and improving the elasticity of the blood vessels, enhancing their ability to dilate and effectively manage blood flow and pressure (Green and Smith, 2018; Pescatello *et al.*, 2019). The participants' heart rates were also reduced after 12 weeks of rebound exercise, which aligns with previous studies (Nystoriak and Bhatnagar, 2018; Reimers, Knapp and Reimers, 2018). Like blood pressure regulation, regular exercise reduces heart rate through reduced sympathetic nervous system activity, enhanced vagal tone, increased stroke volume and cardiac remodelling (Reimers, Knapp and Reimers, 2018).

4.7.10 Cognitive Function

The study's results suggest that participating in rebound exercise for 12 weeks significantly improved cognitive function among adults with neurological disorders. This aligns with previous studies that have demonstrated that aerobic exercise improves cognitive function in healthy adults (Caponnetto *et al.*, 2021; Yates *et al.*, 2023), stroke survivors (Pallesen *et al.*, 2019) and people with traumatic brain injury (Chin *et al.*, 2015). However, the post hoc analysis revealed that statistical significance was only observed between baseline and 12 weeks, with no significant differences detected between baseline and 6 weeks or between 6 weeks and 12 weeks. This temporal pattern of improvement suggests that the cognitive benefits of rebound exercise may take time to manifest and may not be immediately apparent within the first 6 weeks of participation.

There are possible explanations for this observed pattern. First, it is likely that the cognitive improvements resulting from rebound exercise require a specific duration of consistent engagement before becoming evident. Cognitive gains may accrue gradually over time as individuals adapt to the exercise regimen and experience neuroplastic changes in response to repeated stimulation. Studies that have demonstrated early improvement in cognitive function following aerobic exercise have used a higher exercise dose of 3 times weekly for 30-45 minutes per session (Krogh *et al.*, 2014; Olson *et al.*, 2017; Brush *et al.*, 2020; Imboden *et al.*, 2020). Another possibility is that individual variability in response to rebound exercise may have influenced the observed results. Considering the participants' diverse neurological disease backgrounds, some may have experienced rapid cognitive improvements early in the intervention, while others may have shown delayed responses or no significant changes within the 12-week timeframe. This heterogeneity in response patterns could obscure the detection of significant differences at specific time points.

Rebound exercise, like other aerobic exercises, is believed to improve cognitive function through various mechanisms. These include enhancing cerebral blood flow, stimulating the production of brain-derived neurotrophic factor (which is associated with neuroplasticity), releasing endorphins that help reduce stress and enhance mood, and protecting the brain from inflammatory changes (Gomez-Pinilla and Hillman, 2013; Mandolesi *et al.*, 2018).

4.7.11 Grip Strength

Consistent with the literature (Al-Sharif *et al.*, 2014; Al-Shreef, Al-Jiffri and Abd El-Kader, 2015; Kim *et al.*, 2020; Seong *et al.*, 2020), this study observed a statistically significant improvement in the participants' grip strength following 12 weeks of rebound exercise. The finding of significant improvement in grip strength between all the pairs (baseline vs 6 weeks, 6 weeks vs 12 weeks, and baseline vs 12 weeks) indicates that the benefits of rebound exercise on muscular strength were evident early in the intervention and persisted throughout the duration of the study. This pattern of improvement suggests that rebound exercise effectively enhances grip strength and maintains these gains over time. This finding is clinically relevant because grip strength is an important functional outcome associated with activities of daily living and overall physical functioning and is increasingly used as a quality-of-life and health status indicator (Bohannon, 2015, 2019, 2024; Musalek and Kirchengast, 2017).

It is important to acknowledge that the observed improvements in grip strength may be from a combination of holding on to the handlebar and the dynamic nature of rebounding. However, the static muscle contraction from holding the handlebar is less likely to contribute to the same level of functional strength gain as the repetitive, gravity resistance-based movements involved in rebounding (Santarém *et al.*, 2023). Static contraction primarily engages the forearm and hand muscles, whereas the dynamic movement inherent in rebound exercise activates various muscle groups throughout the body, promoting systemic muscle strengthening (Abe and Loenneke, 2015). Moreover, the extent of the grip strength improvements from holding the handlebar depends on how frequently and forcefully the participants gripped it during the sessions. Even for those who initially held the handlebar, the fact that most stopped using it in later weeks suggests that their muscle strength, balance and confidence had improved. This progression indicates that the improved grip strength is more likely related to overall muscle strengthening from rebound exercise than the passive act of holding on to the handlebar (Franchi *et al.*, 2019; Rathi *et al.*, 2024).

4.7.12 Strengths and Limitations

This study is one of the first to explore the feasibility of rebound exercise among adults with neurological disorders in a community setting, enabling the simultaneous assessment of multiple health outcomes. Conducted in a real-world environment, participants engaged in rebound exercise alongside their usual rehabilitation or physical activities, allowing for an authentic evaluation of rebound exercise's practical integration into daily life. Offering rebound exercise at a minimum frequency of once a week accommodated participants' schedules and provided insight into realistic adherence levels, while the inclusion of concurrent rehabilitation activities highlighted the potential of rebound exercise as a complementary intervention. The flexibility in session frequency, scheduling, and social support further aligned with the needs of community-dwelling adults with neurological disorders, making rebound exercise a feasible and engaging option in a community setting. This study also serves as a foundation for future controlled trials by providing valuable insights into participant recruitment, adherence, engagement, and safety considerations. Lastly, the inclusion of mid-study measurements strengthened the study by revealing the timeline of changes, offering a comprehensive view of rebound exercise's effects over time.

While this study provides valuable insights into the feasibility of rebound exercise for individuals with neurological disorders living in the community, it is essential to acknowledge a limitation in the diversity of the neurological disorders represented in the study population. Including participants with various neurological conditions, despite all having upper motor neuron lesions, introduces a degree of heterogeneity. This variation could affect the generalisability of the findings, as different neurological disorders may respond differently to the exercise intervention. Another limitation of this study is the lack of a control group, making it challenging to draw definitive conclusions about the specific effects of rebound exercise compared to other forms of intervention. Without a comparison group, it is harder to account for confounding variables that might influence the outcome. A randomised controlled trial design would provide stronger evidence of the intervention's effectiveness. Additionally, although many participants were retired, they cited time constraints for preferring once-weekly sessions. This suggests that other factors, such as personal schedules, perceived travel burden, or competing responsibilities (e.g., caregiving or medical appointments), may have influenced participation, but these were not thoroughly explored.

Another limitation of the study is using a self-reported instrument like IPAQ with a 7-day recall, which can be a source of recall, social desirability biases, and measurement error. These can result in overestimating or underestimating physical activity levels and sedentary behaviour and inaccurately classifying participants into different activity levels or sedentary behaviour categories. The questionnaire provided clear instructions and definitions to minimise measurement errors. Finally, the 12-week duration of the study may not fully capture the long-term feasibility and safety of rebound exercise for this population. Longer follow-up periods are needed to assess the sustainability of the intervention, adherence rates, and the potential for lasting improvements in physical and physiological outcomes.

4.7.13 Implications for Research and Practice

This prospective observational study explored the feasibility and potential effectiveness of rebound exercise for adults with neurological disorders living in the community and found that rebound exercise is feasible when delivered with a flexible approach. It also observed significant improvements in physiological and physical outcomes over the 12 weeks. This finding is impactful as it highlights the potential for rebound exercise as a public health promotion tool for combating physical inactivity and promoting health in adults with neurological disorders. Although the primary focus of the study was on feasibility, the results indicate that even low-frequency rebound exercise (just once or twice a week) combined with the participants' usual care or activities, may positively influence physiological and physical functions. The study did not exclude or control for the participants’ involvement in other rehabilitation therapies or regular activities, which reflects real-world conditions. This further supports the potential of rebound exercise as a complementary intervention to improve physical and physiological outcomes in adults with neurological disorders. The results from this study also lay the foundation for further research, potentially involving more comprehensive trials or longer-term follow-up. Future studies should also focus on specific types of neurological disorders to provide a more detailed understanding of the effectiveness of rebound exercise for each condition. Additionally, it is recommended that future studies assess the intensity levels at which participants engage in rebound exercise and its minimum effective frequency dose to gain a more comprehensive understanding of the necessary exercise dosage.

4.8 Conclusion

This feasibility study shows that a supervised community-based rebound exercise program is practical, safe, and acceptable for adults with neurological disorders. High recruitment and retention rates and flexible attendance highlight the feasibility of this intervention in a real-world setting. Although a secondary objective, this study also observed positive trends in the studied population's blood pressure, balance, mobility, quality of life and physical activity behaviour, suggesting that rebound exercise could potentially be a valuable tool for public health promotion efforts. These findings further support the potential of rebound exercise as a complementary intervention to enhance physical and physiological outcomes in community-dwelling adults with neurological disorders. While these findings are not confirmatory due to the study's observational design, they provide valuable insights into the feasibility of incorporating rebound exercise into the routine of community-dwelling adults with neurological disorders. Given the promising findings, further research is warranted to confirm these results in more extensive, diverse populations and explore the intervention's potential for integration into standard community rehabilitation services.

CHAPTER FIVE

A QUALITATIVE EXPLORATION OF REBOUND EXERCISE TRAINING: PERSPECTIVES AND EXPERIENCES OF INDIVIDUALS WITH NEUROLOGICAL DISORDERS

5.0 Chapter Overview

This chapter examines participants' views, experiences, perceived effectiveness, and acceptance of rebound exercises. Exploring these perspectives was essential to understanding the feasibility study's outcomes and identifying potential barriers and facilitators to engagement. The chapter presents the qualitative findings, highlighting participants' experiences, perceptions, and the factors influencing their participation in the rebound exercise. It also discusses the study's limitations and outlines future research and practice implications.

5.1 Background of the Study

It is well-established that physical activity offers substantial health benefits. The importance of maintaining regular physical activity has been regularly and widely publicised (Bull *et al.*, 2020; Collado-Mateo *et al.*, 2021). Over the last 20 years, public and private organisations have invested substantial financial resources into physical activity research, including physical activity surveillance, health consequences of inactivity, interventions, campaigns and advertisements to promote active lifestyles and the development of policies and guidelines (Thomas *et al.*, 2018; Ding *et al.*, 2020). As a result of such policies, the World Health Organisation (WHO) has recommended a minimum of 75-150 minutes of vigorous exercise or 150-300 minutes of moderate exercise every week for every adult to maintain good health and avoid the risk of chronic diseases (Bull *et al.*, 2020; WHO, 2020). These recommended physical activity guidelines also apply to people with existing chronic diseases, like individuals with neurological disorders, to regain lost function, improve functional independence and prevent further deterioration, deformities and death (Bull *et al.*, 2020; CDC, 2024).

Despite this knowledge, many people still do not meet these recommended physical activity guidelines, and even more are physically inactive and sedentary (Westcott, 2016; Guthold *et* *al.*, 2018). Evidence shows that fewer than half of people with chronic diseases meet these guidelines. For instance, only 46% of people living with diabetes mellitus (Janevic, McLaughlin and Connell, 2012), 35% of breast cancer survivors (Hair *et al.*, 2014), 9% of adults with intellectual disabilities (Dairo *et al.*, 2016) and 32% of people with heart disease (Valero-Elizondo *et al.*, 2016) meet the recommended physical activity guidelines. Even for adults with chronic diseases who attempt to meet these guidelines, adherence to exercise programs has proven difficult. For example, as many as 30-50% of stroke survivors discontinue their exercise routines within the first year post-stroke (Levy *et al.*, 2019). People with neurological disorders have low adherence rates to exercise. This is not surprising considering they face impairments such as pain, fatigue, muscle weakness and loss of balance compared to their healthy counterparts (Bullard *et al.*, 2019; Catala *et al.*, 2021).

Rebound exercise emerges as a promising intervention, offering a time and cost-effective, low-impact, enjoyable, and safe alternative that addresses many of the abovementioned barriers (Bhattacharya *et al.*, 1980; Burandt, 2016; Maharaj and Nuhu, 2016; Şahin, Demir and Aydın, 2016). Given the multifaceted challenges associated with exercise adherence, it is imperative to evaluate the views, experiences, and acceptance of rebound exercise in community-dwelling adults with neurological disorders. Understanding these factors can help tailor interventions to improve participation, enhance physical and mental health outcomes, and ultimately foster a more inclusive and supportive exercise environment.

The acceptability of exercise intervention is a critical factor to assess in any feasibility study, as it directly influences exercise adherence, a key determinant of success. Acceptability involves evaluating the degree to which an intervention will be embraced by the intended recipients and the extent to which the new intervention or its components align with the needs of both the target population and the organisational context (Ayala and Elder, 2011; Sekhon, Cartwright and Francis, 2017). Moreover, poor acceptance of an intervention may result in randomised controlled trials designed to evaluate the benefits of exercise on various health outcomes, failing to yield significant results. Therefore, evaluating the intervention's acceptance among this population before embarking on such robust studies could provide valuable insights for developing more effective and sustainable rehabilitation strategies.

Given the importance of promoting long-lasting exercise adherence in addressing health inequalities related to neurological diseases, understanding the perceptions and acceptance of exercise interventions among individuals with neurological disorders is crucial. In addition to the typical challenges associated with disabilities, factors like accessibility issues, lack of motivation, physical discomfort, unrealistic expectations, and time constraints significantly contribute to low exercise adherence and high dropout rates (Sullivan and Lachman, 2017; Kinnafick *et al.*, 2018).

Over the past few decades, various psychological models have been used to understand better the factors that lead people to engage in physical activity (PA) (Wang and Wang, 2015). Some of these models include social cognitive theory, self-determination theory, and the theory of planned behaviour (TPB). Among these, TPB stands out as an effective, concise, and adaptable model for studying the factors influencing PA behaviour in individuals with disabilities (Kirk and Haegele, 2018; Sur, Jung and Shapiro, 2022). While not guided by the theoretical framework for implementing the intervention, this study drew on the TPB to explain and inform the interpretation of findings. According to TPB, people's behaviour is influenced by their intentions which are determined by their attitudes, subjective norms, and perceived behavioural control (Ajzen, 2020). TPB posits that attitudes towards a behaviour are shaped by beliefs about the outcomes of that behaviour (Ajzen, 2020). If participants believe that engaging in rebound exercise will lead to positive outcomes, they are more likely to have a favourable attitude towards it. In comparison, the subjective norm is the perceived social pressure to perform or not to perform a behaviour. If participants' social circle, such as family, friends, and healthcare providers, support and encourage rebound exercise, they are more likely to perceive it positively and feel motivated to engage in it. On the other hand, perceived behavioural control relates to the perceived ease or difficulty of performing the behaviour, which is influenced by past experiences and anticipated obstacles (Hagger, Chatzisarantis and Biddle, 2002; Norman, Webb and Millings, 2019). Factors such as equipment accessibility, physical ability, and time availability play crucial roles in rebound exercise. If participants feel confident in their ability to perform rebound exercise and believe they have control over the factors that facilitate or hinder it, they are more likely to engage in the activity.

Building on previous research, this study leverages findings from the systematic review (Chapter 3) and feasibility study (Chapter 4) to inform its approach. The systematic review identified significant improvements in mobility but highlighted the scarcity of studies addressing the psychosocial impacts and applicability in community settings. The feasibility study, on the other hand, demonstrated the feasibility, safety, and potential effects of rebound exercise among community-dwelling adults with neurological disorders. It further demonstrated its potential to address barriers to exercise adherence and revealed gaps in understanding participants' subjective experiences. These foundational studies highlight the need for a deeper exploration of the views, experiences, and perceived effectiveness of rebound exercises in real-world, community-based contexts. Such insights are crucial for tailoring interventions that improve participation, address physical and psychosocial needs, and foster long-term adherence. This study aims to gain deeper insights into their attitudes, perceptions, experiences and acceptance of rebound exercise, drawing on TPB to contextualise findings and inform future intervention design. This study, therefore, sought to address the following research questions:

1. What are the participants' views of rebound exercise?
2. What are the participants' experiences of rebound exercise?
3. Do the participants perceive rebound exercise to be effective?
4. Is the rebound exercise accepted by the participants?

5.2 Research Objectives

1. To explore the participants' views, experiences and perceived effectiveness of rebound exercise.
2. To explore the participants' acceptance of rebound exercise.

5.3 Ethical Considerations

The study adhered to good clinical practice principles, and all procedures were conducted in compliance with the Helsinki and Oviedo declarations (World Medical Association, 2013). The Buckinghamshire New University Research Ethics Committee reviewed and approved this study. Participants who consented to the study were informed of their right to withdraw at any point. They were also informed that their data would be anonymised and stored securely. The interviewer, who also supervised the rebound exercise section, engaged in reflexivity throughout the study to reduce researcher bias. This is discussed in more detail in section 5.7.

This study was reported per the Consolidated Criteria for Reporting Qualitative Studies (COREQ) guidelines. COREQ is a 32-item checklist developed in 2007 to enhance the reporting of qualitative research, especially studies involving interviews and focus groups (Tong, Sainsbury and Craig, 2007). The checklist aims to encourage thorough and transparent reporting among researchers and, in turn, enhance the rigour, comprehensiveness, and credibility of qualitative studies. It comprises three main domains: research team and reflexivity, study design and analysis, and reporting (Booth *et al.*, 2014).

5.4 Philosophical Standpoint of the Study

The philosophical assumptions in a study are a range of perspectives that start with ontological views that support the research and extend to the methods used for gathering and analysing data. Addressing these assumptions is crucial to developing a theoretical framework for how the researcher interprets the data and how the reader should understand the results (Braun and Clarke, 2012; Braun, Clarke and Weate, 2016; Byrne, 2022). Acknowledging these philosophical assumptions ensures transparency about the underlying beliefs that influence the study approach. This transparency helps to ensure that the interpretations are consistent with the methodological choices and theoretical perspectives. It also allows readers to critically evaluate the validity and reliability of the findings within the context of these assumptions.

5.4.1 Ontology (Realism versus Relativism)

Ontology refers to the nature of reality (Hudson and Ozanne, 1988). Two major ontological worldviews exist for research studies: realism and relativism. By adhering to realism, the researcher relies on the idea of independence of reality from the human mind and adopts a unidirectional understanding that only one truth which doesn’t change exists (Pettit, 1991; Schwandt, 1997). The realist researcher seeks to discover, understand or explain the cause of an observed phenomenon through scientific measurements, and as such, the findings are generalisable (Schwandt, 1997).

Conversely, relativist researchers tend to adopt a multidirectional understanding of reality, arguing that reality is subjective, context-dependent, and has multiple valid interpretations (Lincoln, Lynham and Guba, 1994; Guba and Lincoln, 2005). The concept of relativism acknowledges that there can be multiple subjective realities instead of just one objective truth that needs to be discovered (Österman, 2021). In keeping with the qualitative philosophy of Reflective Thematic Analysis employed for this study, the ontological consideration adopted was relativism. As such, meaning and experience were understood to be socially generated and perpetuated through interactions between subjective and inter-subjective constructs. This is particularly relevant in this research involving adults with neurological disorders, representing a diverse population with different experiences and cultural backgrounds. By adopting a relativist stance, researchers can acknowledge and understand the variety of viewpoints and experiences, recognising that neurological conditions, personal histories, and cultural contexts may shape individual experiences (Österman, 2021). Rehabilitation, such as rebound exercise interventions, is inherently subjective, and its effectiveness can be highly individualised and context-dependent. The effectiveness of these interventions can vary widely due to several factors, including the specific neurological disorder, the severity of symptoms, the individual's physical and mental health status, the environment and their personal goals and motivations. A relativist approach enables researchers to explore the varied interpretations of rebound exercise as a rehabilitation tool. Additionally, this ontological stance recognises the participants as active agents in the research process by allowing them to construct their realities and make sense of their experiences.

5.4.2 Epistemology (Interpretivism versus Constructivism)

Epistemology refers to the study of the knowledge of the nature of things or reality (Audi, 2010). Unlike the opposite end of the spectrum, where the positivists argue that knowledge is objective and the researcher plays no part in data interpretation (Ponterotto, 2005; Park, Konge and Artino, 2020), the interpretivist and constructivist researchers assume that truth and knowledge are subjective and appreciate the integral role of the researcher in the process (Ryan, 2018). While constructivism and interpretivism share some similarities of being subjective and context-dependent with multiple valid interpretations, they also have distinct emphases. Interpretivism primarily focuses on understanding the meanings and interpretations of individuals, while constructivism emphasises the active construction of knowledge by individuals and how their unique cognitive processes contribute to their experiences (Schwandt, 1994; Neuman, 2000; Kivunja and Kuyini, 2017).

The epistemological approach underpinning this study is interpretivism, and this choice is based on the acknowledgement that participants' perceptions, beliefs and interpretations play a pivotal role in shaping their engagement in physical activity, including rebound exercise. Neurological disorders are highly individualised conditions, and the experiences of individuals living with them are deeply rooted in their unique life contexts, medical histories and personal narratives (Jain, 2021). The multifaceted nature of human behaviour, particularly in the context of exercise adherence and rehabilitation, demands an epistemological stance that can capture the intricacies of participants' motivations, intentions and decision-making processes (Hay-Smith *et al.*, 2016).

5.4.3 Methodological Approach (Deductive versus Inductive Approach)

A researcher can choose between a deductive or inductive approach for coding data. If researchers use a deductive approach, they tend to follow a pre-specified conceptual framework or codebook. This approach is "analyst-driven" and based on the researcher's theoretical interpretation, often providing a less detailed dataset analysis (Braun and Clarke, 2020; Byrne, 2022). On the other hand, if researchers use an inductive or "data-driven" approach, they tend to produce codes that reflect the content of the data without any preconceived theory or conceptual framework. Data are not coded to fit an existing coding frame in this case. Instead, they are "open-coded" to most accurately communicate the meaning as conveyed by the participants (Braun and Clarke, 2012). Coding and analysis frequently integrate elements of both inductive and deductive methodologies (Braun and Clarke, 2012, 2019, 2020, 2021). An exclusively deductive analysis is difficult, as it requires understanding the relationship between different pieces of information in the dataset to identify commonalities that align with a pre-specified theory or conceptual framework (Byrne, 2022). Similarly, an exclusively inductive analysis is not attainable, as the researcher needs some criteria to identify relevant information that can address the research question. Braun and Clarke (2012) suggest that the predominance of either approach can indicate a preference for theory-based or data-based meaning. This study primarily used an inductive approach where the data was open-coded, and the meanings provided by the respondents/data were given priority. However, some deductive analysis was also used to ensure that the open coding helped produce themes relevant to the research questions and that the meanings emphasised by the respondents/data were appropriate to the research questions.

5.5 Methods

This qualitative study used semi-structured interviews (table 5.1) to understand participants' perceptions and lived experiences of the rebound exercise phenomenon. The semi-structured interview questions were formulated drawing on the existing studies in the literature for guidance (Smith, 1995; Kaur *et al.*, 2021; Jassil *et al.*, 2022). The participants were enrolled through purposive sampling. The eligibility criteria included (i) adults with neurological disorders living in the community who engaged in the 12-week rebound exercise trial. (ii) participants must have completed 12 weeks of rebound exercise.

Table 5.1: The Interview Schedule

a) Experience of rebound exercise
1. Can you give me a brief history of your journey from diagnosis till you started rebound exercise? 2. Can you share your experience on the rebound exercise you participated in? 3. Could you describe in your own words how you feel when you are rebounding? Prompts: physically? Emotionally? 4. How did it make you feel afterwards?
b) Views on rebound exercise
1. How does your condition affect your daily life? Prompts: physically? Mentally? 2. Could you recall your thoughts on using rebounders for exercise before you started this trial? Probing: What about now that you have completed the trial? 3. What difference, if any, has rebounding made to your health? 4. Has taking part in rebound exercise made you more active? 5. Has it motivated you to be more active daily? 6. What about compared to other exercises or any other physical activities you have been doing previously? (pre-diagnosis? Post-diagnosis?)
c) Acceptability of rebound exercise
1. How would you describe your adherence to the rebound exercise sessions? 2. What motivated you to keep coming for your sessions? 3. How did you feel about the frequency and duration of the rebound exercise sessions? 4. How would you rate the rebound exercise therapy's satisfaction? Follow up: Rebound exercise effectiveness?
d) Future expectations
1. Would you recommend rebound exercise to others with neurological disorders as a form of rehabilitation exercise? 2. What do you think could have been improved in the rebound exercise sessions to make them more effective or enjoyable for you? 3. Will you be able to continue with the rebound exercise after the trial? 4. What do you foresee as barriers to continuing with the rebound exercise? Prompts: (social, financial, psychological, environmental) 5. Do you consider a rebounder something you would like to use at home or go to rehab centres to do?

5.5.1 The Rebound Exercise Study

This study is a follow up on the trial looking at feasibility of rebound exercise in a supervised community setting. The trial took place between January and September 2023 at Buckinghamshire New University. Participants were recruited from organisations known to support or rehabilitate individuals with neurological disorders, such as the Stroke Association, Parkinson's Disease Association, Multiple Sclerosis UK, support groups, churches, and referrals from participants. Eligible participants were invited to attend weekly rebound exercise training at the university's Aylesbury or High Wycombe campus. Participants were free to choose to attend as much as they wanted every week, with their preferred weekly frequency noted. Data collection occurred at three time points: baseline, 6 weeks, and 12 weeks. The study used two mini-trampolines (Brand: Fit Bounce Pro, Model No:

700461638780, Made in the UK). Each rebounder/mini-trampoline had a safety handle that participants could hold on to prevent falling, and the lead researcher (a licensed physiotherapist) closely supervised the exercise sessions. This physiotherapist instructed participants on what to do on and off the mini-trampoline.

The rebound exercise sessions were standardised (followed a consistent format) using instructional YouTube videos from a rebound exercise tutor, Paul Eugene, accompanied by music. Participants were instructed to follow all movements observed in the tutorial video as directed by the tutor. The lead researcher exercised along with the participants and closely supervised the sessions. Participants were advised to take breaks if they needed to rest during the rebound exercise program. Each rebound exercise session lasted 30 minutes including warm-up and cool-down exercises. Warm-up exercises and light stretches were done for 10 minutes before the main rebound exercises, after which some cool-down exercises and stretches were done. The set of movements performed by the participants on the rebounder is described in Chapter 4.

5.6 Preparation for the Qualitative Study

Significant efforts were made to develop a solid methodological foundation for this qualitative study, ensuring the researcher was well-equipped to conduct meaningful and rigorous qualitative interviews. This preparation was critical to enhancing the reliability and validity of the data collected and ensuring that the research process was robust and ethically sound. Firstly, the researcher undertook extensive literature searches on qualitative research methodologies, mainly focusing on the nuances of conducting semi-structured interviews, which were the primary data collection methods for this study. Key texts such as “Qualitative Researching” by Mason (2017), “Interviewing as Qualitative Research” by Seidman (2006) and “InterViews” by Kvale and Brinkmann (2009) provided a foundational understanding of the theoretical underpinnings of qualitative interviewing. These readings highlighted the importance of reflexivity, rapport-building, and the iterative nature of qualitative data collection and analysis, which are crucial for capturing the depth and richness of participants' experiences. They also elucidated the dangers of excessive reading on the subject matter before interviewing participants so that the interviewer is not burdened with too many preconceptions from the literature but is receptive to what the participants say.

Next, the researcher participated in formal training sessions on qualitative interviewing techniques to complement this theoretical grounding. These sessions, conducted both within the school and through external courses organised by the University of East Anglia, provided practical insights into crafting effective interview questions, conducting in-depth interviews, and managing the complexities of qualitative data analysis. Such training emphasised the importance of open-ended questioning and active listening skills, enabling the researcher to foster a conversational environment where participants felt comfortable sharing their perspectives. The training also addressed common pitfalls in qualitative interviewing, such as leading questions and confirmation bias, and strategies to mitigate them, aligning with methodological best practices (Clarke and Braun, 2013).

Recognising the value of experiential learning, the researcher supplemented formal training with additional resources, including expert-led YouTube tutorials on qualitative research methods. These tutorials provided practical advice on various aspects of the qualitative interview process, such as establishing rapport, managing silence, and probing for deeper insights without leading the participant. This multi-modal learning approach ensured that the researcher was theoretically informed and practically prepared to handle the dynamic and unpredictable nature of qualitative interviews. Furthermore, the researcher sought practical experience by shadowing a colleague in the concluding stages of their qualitative data collection. This shadowing experience was invaluable, providing a real-world context to the theoretical knowledge gained and highlighting the importance of adaptability and responsiveness in the field. Observing the colleague's approach to managing interview dynamics, such as handling emotionally charged moments or steering the conversation back on track, reinforced the importance of being flexible and attentive, qualities essential for effective qualitative research (Seidman, 2006).

Finally, the researcher conducted pilot interviews to ensure readiness for the data collection phase. These pilot sessions served as a crucial step in refining the interview guide, testing the clarity and appropriateness of the questions, and evaluating the overall flow of the interview process. Methodologically, piloting is a recommended practice in qualitative research as it allows the researcher to identify and rectify potential issues before the main study (Seidman, 2006; Morse, 2015; Majid *et al.*, 2017). Through these pilot interviews, the researcher could critically assess their interviewing skills, identify areas for improvement, and make necessary adjustments to the interview protocol. The pilot interviews also facilitated the development of reflexive awareness, an essential qualitative research component. This practice of reflexivity is vital in qualitative research, as it helps researchers remain cognisant of how their positionality and preconceptions may influence the research process and interpretation of data

(Finlay, 2002). Engaging in reflexive practice enabled the researcher to approach the actual interviews with a heightened sense of self-awareness and a commitment to minimising bias, thereby enhancing the credibility and trustworthiness of the study findings.

5.6.1 Pilot Interview

Initially, the researcher conducted pilot interviews with colleagues. However, it quickly became apparent that meaningful progress could not be made, as the interview questions were specifically designed for individuals with neurological disorders who had participated in rebound exercises. In response, the pilot interviews were adapted and conducted with two participants mid-way through their trial. A practice interview session with the research supervisor also provided valuable, constructive feedback. Notably, the pilot interviews were not included in the study data. Their primary purpose was to evaluate the clarity and relevance of the interview questions, ensuring they accurately addressed the critical areas of investigation. Furthermore, the pilot interviews provided an estimate of the interview duration, facilitating efficient scheduling for the main study. This process also played a crucial role in refining the researcher's interview skills and boosting confidence ahead of the full-scale data collection.

5.6.2 Lessons Learnt from the Pilot Interviews

Conducting pilot interviews was essential in refining both the methodological approach and the practical execution of the qualitative research process. The pilot interviews provided invaluable insights into the practical aspects of conducting qualitative research and emphasised the importance of a reflexive approach. Several key lessons emerged from these pilot interviews, each contributing to the overall rigour and validity of the study.

A significant lesson from conducting the pilot interviews was the importance of consistent practice in improving interview technique and data quality. Early interviews served as a learning platform, where the initial discomfort and lack of familiarity with the interview process gradually gave way to more fluent and confident exchanges with participants. Methodological literature supports this notion, suggesting that repeated practice helps researchers develop more nuanced questioning techniques and better rapport with participants (Kvale and Brinkmann, 2009). This iterative improvement process aligns with the concept of "researcher reflexivity," where the researcher continuously reflects on and refines their methods to enhance the quality of data collected (Finlay, 2002). Another lesson from the pilot interviews was the importance of using multiple recording devices to ensure data integrity. In several instances, the primary recording device failed to capture specific segments clearly, making the backup recordings invaluable. This aligns with best practices in qualitative research, which advocate for combining multiple methods rather than just one to prevent data loss (Seidman, 2006; Tessier, 2012; Rutakumwa *et al.*, 2020). By employing multiple recording devices, the researcher ensures that technical failures do not compromise the richness and completeness of the data, thereby safeguarding the study's validity and reliability.

A further lesson learned was the importance of scheduling interviews with adequate intervals between them and limiting the number conducted within a short timeframe. This strategy allowed for immediate review of the recordings, enabling the researcher to identify and address any issues, such as instances where researcher prompts overshadowed participant responses. This approach is supported by methodological literature, emphasising the need for careful pacing in qualitative interviews to prevent interviewer fatigue and maintain high-quality interactions (Seidman, 2006). Additionally, the immediate review and interview reflection is consistent with a reflexive approach, helping researchers adapt their techniques in real-time (Leblanc, 2010).

Furthermore, the pilot phase highlighted the value of active listening and minimising verbal prompts during interviews. Initially, the researcher’s frequent interjections occasionally overshadowed the participants' voices, impacting the clarity of the audio recordings. Methodological insights suggest that employing non-verbal cues, such as nodding or maintaining eye contact, can be more effective in encouraging participants to elaborate on their responses without interrupting the flow of conversation (Seidman, 2006; Creswell and Poth, 2018; Tarnoki and Puentes, 2019). This adjustment not only improved the recordings' quality but also helped capture more in-depth and uninterrupted narratives from participants, thereby enriching the data. Moreover, the prompt transcription of interviews was another critical lesson learned. Transcribing interviews immediately after they were conducted allowed the researcher to maintain a high level of accuracy in capturing the nuances of the conversation. According to Braun and Clarke (2006), immediate transcription helps preserve the context and subtleties of the interview, as the details are still fresh in the researcher’s memory. This practice enhances data accuracy and facilitates a deeper understanding of the themes and patterns emerging from the data, thereby contributing to a more robust analysis.

Finally, the pilot interviews revealed the necessity of refining the wording and structure of interview questions to improve participant comprehension. Some questions that seemed clear in theory were found to be ambiguous or confusing in practice, necessitating revisions. This aligns with the iterative nature of qualitative research design, where questions are continually refined to better align with the research objectives and to facilitate richer data collection (Patton, 2015). Refining questions also reflects a commitment to methodological rigour, ensuring that questions are not leading and are easily understood by participants, thereby improving the reliability and validity of the responses.

5.7 Data Collection

Fifteen participants who completed a 12-week rebound exercise program at Buckinghamshire New University's Aylesbury and High Wycombe campuses were recruited for this qualitative study. Prior to commencing data collection, participants were thoroughly briefed on the study’s objectives, and informed consent was obtained both in writing and verbally to ensure full understanding and agreement. Ethical considerations were at the forefront of this process, with participants being explicitly informed of their right to withdraw at any time without consequence and their ability to skip any questions they found uncomfortable. These measures were designed to foster a respectful and supportive interview environment, encouraging openness and trust between the researcher and participants (Seidman, 2006; Mero-Jaffe, 2011).

The interviews were conducted one-on-one in a comfortable, airy room to create a relaxed atmosphere conducive to discussion. Careful consideration was given to the interview setting to minimise potential discomfort, distractions, or environmental biases. The lead researcher, a licensed female physiotherapist with a master’s degree and a PhD candidate, had an established rapport with participants, having supervised their rebound exercise sessions. This prior relationship was beneficial for rapport-building but also required a conscious effort to minimise researcher bias. The researcher remained mindful of the potential for familiarity to influence responses, deliberately maintaining neutrality and allowing participants to express their views freely without expecting specific answers.

Each interview lasted approximately 60 minutes. Before beginning, the researcher reiterated the purpose of the interview and obtained explicit consent to record the conversation using a digital audio recorder (Brand-Evistar, Model no: B0998D83F6) with a smartphone (Google Pixel Pro 6) as a backup. This redundancy in data capture was crucial, particularly in light of lessons learned from pilot interviews, where technical malfunctions or poor audio quality were anticipated (Mero-Jaffe, 2011). Participants were assured of privacy and confidentiality; non-identifiable initials were assigned to their data, and their real names were never used during the interview. This assurance helped mitigate reluctance to speak candidly and enhanced the reliability of the data collected.

Interviews were conducted until data saturation was reached, where no new themes or insights emerged after the 13th interview. While 15 participants were ultimately interviewed, the decision to stop at this point was based on the principles of saturation, ensuring that the sample size was appropriate for capturing the full range of participant experiences without redundancy (Fusch and Ness, 2015). Following the interviews, the researcher manually transcribed the recordings verbatim. This manual transcription process, although time-consuming, allowed the researcher to engage closely with the data, becoming familiar with the nuances of each participant's responses and aligning with best practices (Tuckett, 2005; Bailey, 2008; Naeem *et al.*, 2023). To ensure credibility and accuracy, the transcripts were sent to a subset of participants for member-checking, a process designed to validate the researcher's interpretation and confirm that the participants' perspectives were accurately reflected (Mero-Jaffe, 2011). Feedback from participants confirmed the transcripts' accuracy, ensuring the integrity of the data for subsequent analysis. The final transcripts were anonymised by removing identifiable information and assigning each participant a unique ID. These transcripts were then prepared for qualitative analysis, ensuring that ethical standards were upheld throughout the process and that the data collection process was robust and participant-centred.

The term 'participant' was deliberately chosen in this study to refer to the individuals interviewed, as it reflects their active involvement and positions them as equal partners in the research process (Seidman, 2006). This terminology aligns with the collaborative nature of this qualitative research, where the aim is not only to gather information but also to value the perspectives and contributions of those taking part. The use of 'participant' avoids the more passive connotations of other terms that were considered but ultimately deemed unsuitable for the study's goals. For example, 'interviewee' or 'respondent' suggests a more passive role, implying that the individual's primary function is to answer pre-determined questions in a transactional manner, which does not reflect the dynamic and interactive nature of qualitative interviewing (Lincoln and Guba, 1985). These terms reinforce an "answer-to-question" format that reduces the richness of the participant's contribution to the study. Similarly, the term ‘subject’, although it shifts from objectifying the person to recognising them as an active being, implies a hierarchical relationship where the researcher retains power over the ‘subject,’ which can create an imbalance in the interview dynamics (Patai, 1988; Watkins, 2005).

‘Informant’ is another term that was considered inappropriate for this study. Typically used in anthropology and linguistics, it refers to someone providing specialised information about a language or culture. This term suggests that the participant’s role is to inform the researcher about a specific domain of knowledge, which did not align with the broader, more holistic approach this study sought to understand personal experiences (Otto, 1997). Lastly, the term ‘co-researcher’ could have been considered, as it emphasises collaboration and partnership (Smith, 1994; Heron and Reason, 2008). However, this term suggests that the participants were involved in all aspects of the research process, including design and analysis, which was not the case in this study. While participants actively contributed through interviews, they were not engaged in the broader decision-making processes of the research, which limits the applicability of ‘co-researcher.’

5.8 Data Analysis

Reflexive Thematic Analysis (RTA) was employed for this qualitative study because it best suits my research goals and method. While Interpretive phenomenology is a viable alternative, it focuses on understanding people’s lived experiences, consciousness and meaning-making processes (Smith and Osborn, 2015; Alase, 2017). Moreover, it uses focus groups or open-ended interviews, mostly phenomenological and sometimes semi-structured, to uncover the essence of participants’ lived experiences and the meanings they attach to those experiences (Alase, 2017; Frechette *et al.*, 2020). Furthermore, it adopts techniques like bracketing and epoche, the act of setting aside one’s preconceptions and judgements about the studied phenomenon or the natural world to focus solely on the participant’s experience to minimise researcher bias (Alase, 2017). In contrast, RTA offers a flexible approach to data analysis well-suited to a wide range of research questions, allowing for a broader examination of patterns and themes within the data (Braun and Clarke, 2020). This flexibility makes RTA appropriate for exploring diverse aspects of participants' views, experiences, perceived effectiveness, and acceptance of rebound exercises. RTA encourages reflexivity, where researchers actively consider their influence on the research process and outcomes. Since this study's researcher also supervised the rebound exercise sessions, reflexivity is crucial to acknowledge and address potential biases.

5.8.1 Reflexivity

As the researcher conducting this thematic analysis, I acknowledge the importance of reflecting on my perspectives, biases, and experiences throughout the research process. My background as a licensed physiotherapist, hailing from Nigeria, a middle-income country with limited access to advanced medical treatments, undoubtedly shapes my approach to this study. Having provided care for individuals with neurological disorders, including stroke, spinal cord injuries, Parkinson’s disease, and traumatic brain injury, both professionally and personally, I approach this research with a profound understanding and empathy for the subject matter. Furthermore, my personal experiences, particularly my involvement in the rehabilitation journey of close relatives who endured strokes, have deeply influenced my motivations and perspectives. These experiences have instilled in me a passion for seeking ways to enhance the well-being and quality of life of individuals suffering from neurological disorders, driving my exploration of novel interventions such as rebound exercise.

Throughout this thematic analysis, I remain vigilant in critically examining my assumptions, biases, and preconceptions to ensure they do not unduly influence the interpretation of the data by keeping a reflexive journal to document my biases. Additionally, I recognise the potential impact of my insider status, having a professional background in physiotherapy, on the research process and findings. Therefore, I approach this study with humility, openness, and a commitment to transparency, striving to maintain reflexivity and rigour in all aspects of the research process. It is essential to note that while my background and experiences undoubtedly inform my perspective, I endeavour to maintain objectivity and impartiality in the analysis and interpretation of the data. By acknowledging and addressing my own positionality and biases through reflexivity, I aim to enhance the validity and trustworthiness of the findings generated from this thematic analysis.

5.8.2 Assumptions, Biases and Preconceptions

Entering the study, I held several assumptions based on my research experience and the existing literature on exercise intervention studies. One of my primary assumptions was that there would be a considerable dropout rate from the rebound exercise program. Previous studies, such as Gustavson *et al*. (2012), informed this expectation, highlighting high attrition rates in exercise interventions, often due to factors like lack of motivation, physical discomfort, or absence of financial incentives. Given the 12-week duration of the intervention and the absence of monetary rewards, I anticipated sustaining participant engagement would be challenging.

However, the retention rate was significantly higher than expected, with only one participant withdrawing from the study due to an illness unrelated to the intervention. This outcome challenged my initial assumption and prompted a reflective analysis of the factors contributing to this unexpected level of adherence. Through post-intervention interviews and reflections on participants' feedback, it became clear that their continued engagement was driven by a combination of enjoyment, perceived health benefits, and a sense of personal commitment to both the exercise regimen and the researcher. Participants frequently expressed that they found the rebound exercise enjoyable and beneficial, which motivated them to continue attending sessions. Additionally, several participants mentioned that their commitment to the study and not wanting to disappoint me played a crucial role in their adherence. This realisation highlighted the importance of building strong rapport and fostering a supportive environment for participants (Seidman, 2006).

As a researcher, I recognised that my relationship with the participants was a significant factor in their decision to stay engaged. To facilitate this, I consciously nurtured positive relationships by maintaining regular and open communication. I sent weekly reminders to keep the participants informed and motivated and offered a flexible appointment schedule to accommodate their changing needs and preferences. This approach demonstrated responsiveness to participants' needs and created a sense of partnership and trust, which likely contributed to their willingness to remain in the study.

Reflecting on this experience, I learned that my preconceptions about participant retention were influenced by a narrow focus on structural incentives, such as financial rewards, without fully considering the impact of relational dynamics and intrinsic motivators. The high retention rate observed in this study highlighted the importance of understanding participants' motivations and experiences beyond the surface level. It also reinforced the value of maintaining a reflexive stance throughout the research process, continually questioning my assumptions and being open to adapting my approach based on participants' actual experiences and feedback.

Another assumption I carried into the study was that rebound exercise would universally positively affect all participants with neurological disorders. This belief was shaped by existing literature, which frequently stresses the benefits of physical activity, including rebound exercise, for individuals with neurological impairments, suggesting improvements in balance, strength, and overall mobility (Miklitsch *et al.*, 2013; Okemuo, Gallagher and Dairo, 2023). However, I recognised the potential for this positive bias to influence my interactions with participants and the interpretation of their experiences. To mitigate this, I remained vigilant and deliberately approached each participant's experience as unique and open to diverse responses to the exercise intervention. While most participants reported perceived benefits from rebound exercise, such as improved mobility and balance, a few did not notice significant health or daily functioning improvements. These participants attributed the lack of noticeable benefits to the low frequency of the sessions, which they attended only once a week. Interestingly, despite their subjective reports of no perceived benefits, objective tests and assessments showed measurable improvements from baseline to post-intervention for these participants. This discrepancy between subjective experience and objective outcomes highlighted the complex nature of exercise interventions and the importance of considering both self-reported data and objective measurements when evaluating effectiveness.

This variance in participant experiences reminded me of the importance of maintaining a balanced perspective and not allowing my initial positive bias to overshadow the nuances of each individual's experience. It also stressed the need for a flexible, participant-centred approach in exercise intervention studies, recognising that frequency, individual health status, and personal expectations can significantly influence perceived outcomes. This reflection reinforced the value of listening carefully to all participants' feedback and understanding that exercise interventions may not have uniform effects across a diverse population, even when objective measures indicate otherwise.

Additionally, I assumed that most participants in the study would be individuals with stroke, given that stroke is among the most prevalent neurological disorders in the UK (King *et al.*, 2020; Stroke Association, 2020). This assumption was based on epidemiological data suggesting a high incidence of stroke relative to other neurological conditions (Feigin *et al.*, 2020; Elfil *et al.*, 2023). However, I was mindful of this preconception from the start of the study. To ensure that it did not bias the research, I deliberately sought a diverse representation of participants with various neurological disorders during the recruitment phase. To achieve this, I actively contacted organisations that support individuals with different neurological conditions, not just stroke. This purposeful recruitment approach was intended to prevent an overrepresentation of stroke patients and ensure a more balanced participant cohort. Interestingly, contrary to my initial expectation, the study ended up including more participants with Parkinson's disease than with stroke. This unexpected outcome highlighted the importance of challenging assumptions and being open to findings that deviate from initial expectations. By embracing this approach, I ensured that the study's findings were not disproportionately focused on any single condition but were truly representative of the entire cohort's experiences.

Finally, I held the preconception that participants would favour the convenience and cost savings of exercising with a rebounder at home rather than attending classes at a community centre. This assumption was rooted in the perceived benefits of home-based exercise programs, such as ease of access and flexibility. However, I was mindful of this bias and made it a priority to gather detailed information on participants' actual preferences for exercise locations, whether at home or in a community setting. Contrary to my initial expectation, while some participants expressed openness to purchasing and using rebounders at home, the majority preferred attending sessions at rehabilitation centres where they could exercise alongside others facing similar challenges. I maintained a reflexive journal throughout the study to ensure that my interpretation of these preferences remained true to the participants' responses. This practice helped me monitor any biases arising from my preconceived notions, allowing me to stay objective. By carefully analysing the data, I could understand the full spectrum of preferences and the various factors influencing these choices. This reflexive approach ensured that my initial assumptions did not overshadow my analysis but were instead deeply rooted in the diverse perspectives shared by the participants.

To ensure that the study's findings were influenced by the participants' experiences and perspectives rather than my preconceptions, I consistently documented my assumptions and biases, engaged in regular self-reflection, and sought feedback from peers and mentors. This approach helped me critically evaluate my role as a researcher.

5.8.3 Reflexive Thematic Analysis

After the transcriptions, the data were exported into NVivo software for analysis following the reflexive thematic analysis 6-step process proposed by Braun and Clarke (2020). These steps can aid in the analysis process and assist the researcher in identifying and addressing the critical aspects of thematic analysis. Although the six analysis phases are listed logically and sequentially, it's important to note that the analysis is not a linear process that moves forward through these phases. Instead, it is a recursive and iterative process demanding that the researcher navigate back and forth through the phases as needed (Braun and Clarke, 2020).

5.8.3.1 Phase one: Data familiarisation

During the initial phase of thematic analysis, I immersed myself in the data by listening to each interview recording without taking any notes, allowing active listening to grasp the primary areas addressed in each interview. This approach facilitated understanding the nuances captured in the recordings, including non-verbal cues and mannerisms. Subsequently, I manually transcribed each recording verbatim to accurately represent the participants' responses and immerse myself in the data. Following transcription, I extensively reviewed each transcript, making casual observations of emerging patterns and identifying potentially significant passages. Noteworthy information and recurring themes were highlighted as potential codes, and I documented my reflections on both the data and the analytical process (figure 5.1). Preliminary notes generated during this phase served as valuable insights that would later contribute to developing the thematic framework.

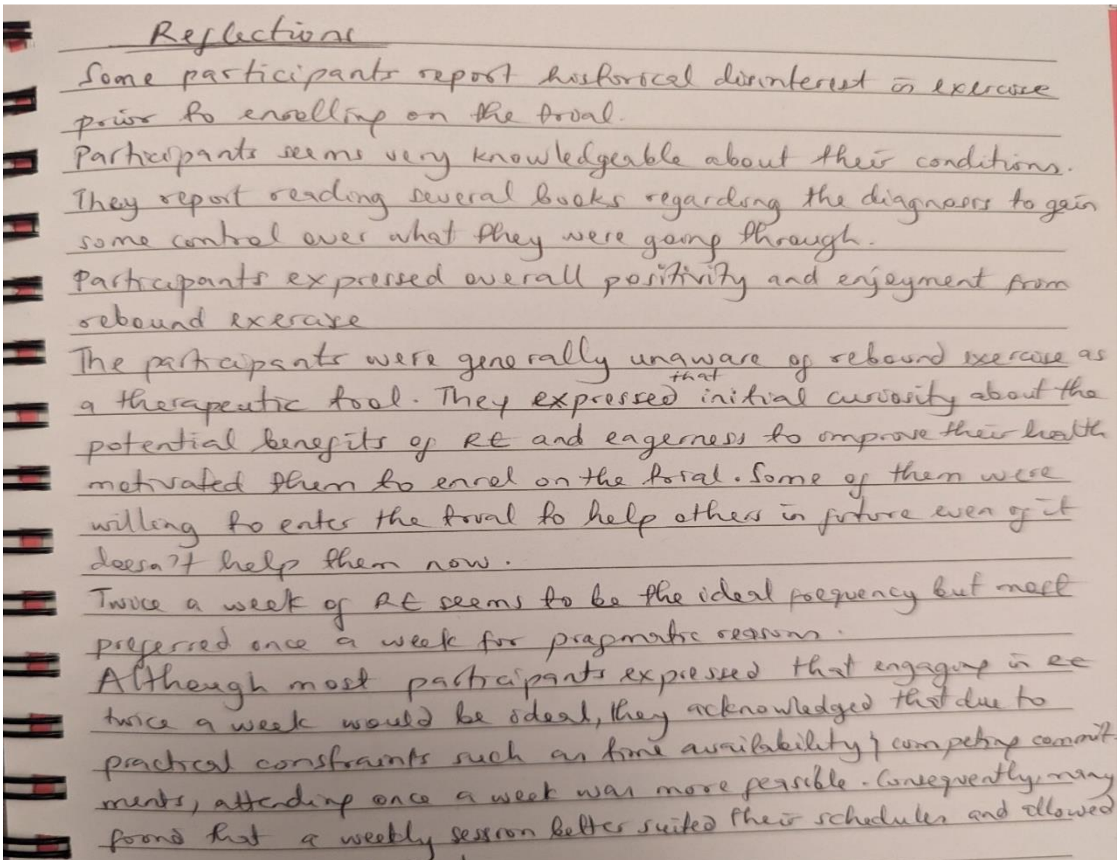
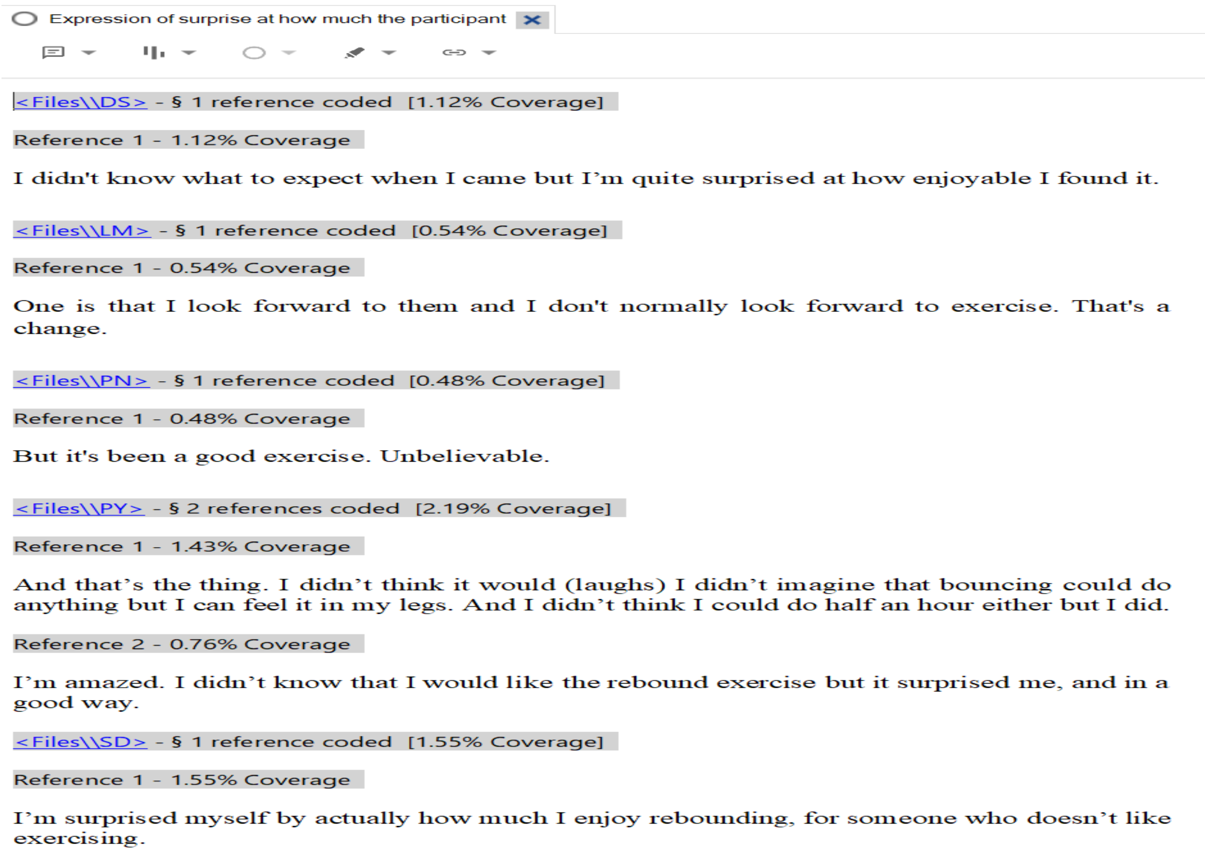

Reflections
Some participants report historical disinterest in exercise prior to enrolling on the trial.
Participants seems very knowledgeable about their conditions. They report reading several books regarding the diagnosis to gain some control over what they were going through.
Participants expressed overall positivity and enjoyment from rebound exercise
The participants were generally unaware of rebound exercise as a therapeutic tool. They expressed that initial curiosity about the potential benefits of RE and eagerness to improve their health motivated them to enrol on the trial. Some of them were willing to enter the trial to help others in future even if it doesn't help them now.
Twice a week of RE seems to be the ideal frequency but most preferred once a week for pragmatic reasons.
Although most participants expressed that engaging in RE twice a week would be ideal, they acknowledged that due to practical constraints such as time availability & competing commitments, attending once a week was more feasible. Consequently, many found that a weekly session better suited their schedules and allowed for consistent participation.

Figure 5.1: Example of the Reflection Notes on the Dataset written during Data Familiarisation.

5.8.3.2 Phase two: Generating initial codes

In this phase, I utilised NVivo software to generate initial codes from the qualitative data collected during the interviews. Initial coding involved systematically identifying and labelling data segments representing meaningful concepts, themes, or patterns related to participants' views, experiences, and acceptance of the rebound exercise. A brief extract of the initial coding process of how a code was created from interview transcripts is presented in Figure 5.2 below. I identified several extracts from the transcripts that captured participants' expressions of surprise at the enjoyment they derived from the rebound exercise. One such extract from DS stated, "I didn't know what to expect when I came, but I'm quite surprised at how enjoyable I found it." Another participant, LM, expressed, "One is that I look forward to them, and I don't normally look forward to exercise. That's a change." Based on these extracts, I generated the initial code 'Expression of surprise at how much the participant enjoys rebound exercise' to encapsulate the common theme of participants expressing astonishment or disbelief at the level of enjoyment they experienced during rebound exercise sessions. This initial code served as a foundational element in the subsequent stages of data analysis, facilitating the identification of broader patterns and themes within the dataset.


Expression of surprise at how much the participant

<Files\\DS> - § 1 reference coded [1.12% Coverage]

Reference 1 - 1.12% Coverage

I didn't know what to expect when I came but I'm quite surprised at how enjoyable I found it.

<Files\\LM> - § 1 reference coded [0.54% Coverage]

Reference 1 - 0.54% Coverage

One is that I look forward to them and I don't normally look forward to exercise. That's a change.

<Files\\PN> - § 1 reference coded [0.48% Coverage]

Reference 1 - 0.48% Coverage

But it's been a good exercise. Unbelievable.

<Files\\PY> - § 2 references coded [2.19% Coverage]

Reference 1 - 1.43% Coverage

And that's the thing. I didn't think it would (laughs) I didn't imagine that bouncing could do anything but I can feel it in my legs. And I didn't think I could do half an hour either but I did.

Reference 2 - 0.76% Coverage

I'm amazed. I didn't know that I would like the rebound exercise but it surprised me, and in a good way.

<Files\\SD> - § 1 reference coded [1.55% Coverage]

Reference 1 - 1.55% Coverage

I'm surprised myself by actually how much I enjoy rebounding, for someone who doesn't like exercising.

Figure 5.2: Example of Code generation from Interview Transcripts.

Beyond initial coding, I thoroughly reviewed the codes to ensure they accurately captured the essence of the data. I refined the codes to align with the data extracts if necessary. To maintain transparency and track changes, I documented my coding process in an Excel spreadsheet (Figure 5.3), highlighting code revisions across each iteration. This iterative process allowed me to critically evaluate and refine my analysis, ensuring the codes accurately represented the data and facilitating easy reference to revisit specific codes as needed.

1	Participants	Data item	Iteration 1	Iteration 2
2	PY	But on the trampoline, I feel reassured because I don't get such injuries and won't fall over. It's safe and fun.	Perceived safety & uniqueness of RE	Positive perception & safety of RE
3	BC	But as it was local, I said to myself that it wouldn't hurt to try it.	Openness to trying RE as it wouldn't hurt	Perception of RE as a safe exercise
4	VO	Absolutely without a shadow of a doubt, I will recommend it.	Willingness to recommend RE to others	Recommendation and advocacy for RE
5	LM	It helps you do things you don't think you can do, which is good. It makes you let go of your inhibitions	Surpassing perceived limitations	Surpassing perceived limitations

Figure 5.3: Excerpt of Excel Spreadsheet tracking Code Changes

5.8.3.3 Phase Three: Generating Themes

I exported the generated codes from NVivo to Microsoft Word in this phase. I generated themes by organising the codes into clusters based on their shared relationships and meaning using a table format (see Figure 5.4). I did this for each research question to ensure that these questions were adequately answered from the dataset. Additionally, I created a separate category labelled 'Other emerging themes' to encompass codes that did not readily fit into any of the prospective themes. After a thorough review and iterative process of grouping and regrouping, I identified 15 initial themes that emerged from the coded data. The 15 initial themes encompassed various topics, such as participants' perceptions of rebound exercise effectiveness, barriers and facilitators to participation, emotional and physical experiences during rebound exercise sessions, and perceived benefits and drawbacks of the intervention.

1. What are the participants' views of the rebound exercise? Rebound views

Cluster 1: Perception of Rebound Exercise as a Positive Tool	Cluster 2: Evolution of Perception and Understanding of Rebound Exercise	Cluster 3: Perceived Safety and Uniqueness of Rebound Exercise
Acknowledgement of a positive difference in life due to rebound exercise. The belief that rebound exercise is energetic Observation about the physiological effects of rebound exercise Sense of concentration during rebound exercise	Curiosity about rebound exercise Initial apprehension about rebound exercise being too strenuous Initial doubts about the potential benefits Initial expectation that rebound exercise would be good for weight loss (unrealistic expectations) Initial fear of falling off the trampoline Initial uncertainty about what rebound exercise was about Transition from scepticism to a positive view The belief that rebound exercise may be more suitable for individuals with strength and good balance	Perception as a safe exercise Feeling that rebound exercise is different from other forms of exercise Openness to trying it as it wouldn't hurt

Figure 5.4: A Sample of Initial Theme Generation from Codes

Under the first research question, "What are the participants' views of rebound exercise?" three initial themes emerged to describe the participants' varied perceptions of rebound exercise. Participants generally had a positive opinion about rebound exercise as an exercise tool, citing the energy and sense of concentration during the activity, hence the theme "the perception of rebound exercise as a positive tool". They also perceived rebound exercise as safe and different from traditional exercises, hence the theme "the perceived safety and uniqueness of rebound exercise". The participants expressed their initial uncertainty, apprehension and curiosity towards rebound exercise at the start of the trial and how this scepticism changed during the trial, hence the theme "the evolution of perception and understanding of rebound exercise". The second research question, "What are the participants' experiences of rebound exercise?" also generated three themes. i) Positive emotional and physical engagement: This theme reflects the overall positive physical and emotional responses and experiences associated with rebound experiences, such as joy, empowerment, comfort, relaxation, increased alertness and energy, etc. It also highlights the positive relationship participants have with the rebound exercise tutor and their surprising enjoyment of the activity despite prior disinterest in exercise for some participants. ii) Recognising physical challenge: this theme emphasises some participants' acknowledgement of the efforts required and the demanding nature of the rebound activity. iii) Physical discomfort: This theme reflects the experiences of some participants, who felt decreased energy levels and heightened body temperature (feeling very hot) during and after rebound exercise.

On the third research question, “Do participants perceive rebound exercise to be effective?” three themes emerged. Participants generally acknowledged the positive features, effectiveness, and physical and emotional benefits of rebound exercise, including pain relief, improved sleep quality, confidence, balance, mobility, etc, hence the theme ‘Benefits of rebound exercise’. Some participants communicated their uncertainties about further benefits they couldn’t observe, hence the theme ‘Uncertainty about additional benefits’. In addition, participants conveyed their experiences of overcoming their own perceived physical or mental limitations during rebound exercise, hence the theme ‘Surpassing perceived limitations’. The last research question, “Is rebound exercise accepted by the participants?” generated three themes. i) Adherence and commitment to rebound exercise: This theme emphasises participants’ dedication to attending and participating in rebound exercise sessions and their commitment to continuing this exercise. ii) Satisfaction and contentment with rebound exercise: This theme represents participants’ overall feelings of satisfaction and contentment related to their experience with rebound exercise. iii) Recommendation and advocacy for rebound exercise: This theme reflects participants’ willingness and enthusiasm to recommend rebound exercise to others.

Aside from the research questions, other informative and relevant themes were also found in the data and were all grouped under “Other emerging important themes”. The 'Other emerging themes' category also provided a space to capture any unanticipated or unexpected insights that emerged during the coding process, ensuring that no relevant information was overlooked or disregarded. i) Barriers and challenges in sustaining rebound exercise: This theme highlights the various obstacles and difficulties participants face when trying to continue with rebound exercise. ii) Intrinsic motivation and altruism in participation: This theme reflects participants’ motivation for engaging in rebound exercise, including personal motivations for their own well-being and the potential to help others through research participation. iii) Participant feedback and recommendations: this theme represents participants’ active engagement in providing feedback and offering constructive input to enhance the overall rebound exercise program.

Moving forward, these initial themes served as a foundation for the subsequent stages of data analysis, guiding the development of a refined thematic framework that would form the basis for interpreting and discussing the findings of the qualitative research study.

5.8.3.4 Phase Four: Reviewing Potential Themes

During this phase, I critically reviewed the identified themes using the following critical questions that Braun and Clarke (2012) proposed to address when reviewing potential themes. These questions include:

- Is this a theme or a code?
- Is this theme sufficiently informative in addressing the dataset and research question?
- What are the parameters defining this theme, including its inclusions and exclusions?
- Does the theme have adequate supporting data demonstrating its significance?
- Is the theme cohesive, or does it encompass overly diverse or disparate data?

The initial themes were evaluated through iterative analysis and discussion based on their relevance, coherence, and alignment with the research objectives. Each theme encapsulated a distinct aspect of the participants' views, experiences, acceptance and perceived effectiveness of the rebound exercise, providing a comprehensive framework for understanding the qualitative data collected during the interviews. After careful consideration, the following six themes emerged as the most salient and representative of the participants' views, experiences, and acceptance of the rebound exercise: Positive perception and safety of rebound exercise, Evolution of rebound exercise perception and understanding, Positive experience of rebound exercise, Acceptance, satisfaction and advocacy of rebound exercise, Value and benefits of rebound exercise, and finally Participant feedback, challenges, and recommendations (figure 5.5).

Name	Files	References
(RQ1) Rebound views	15	56
Theme 1-Positive perception and safety of rebound exercise	12	29
Theme 2-Evolution of Rebound exercise perception and underst	13	26
(RQ2) Rebound experience	15	85
Theme 3-Positive Experience of rebound exercise	15	85
(RQ3) Rebound acceptance	15	65
Theme 4-Acceptance, satisfaction and advocacy for rebound ex	15	65
(RQ4) Perceived rebound effectiveness	15	77
Theme 5-Value and benefits of Rebound exercise	15	77
Other emerging themes	15	74
Theme 6-Participant feedback, challenges and recommendation	15	74

Figure 5.5: Excerpt of the Final Themes

The themes of ‘perception of rebound exercise as a positive tool’ and ‘perceived safety and uniqueness of rebound exercise’ were merged into a cohesive theme ‘Positive perception and safety of rebound exercise’ because of the conceptual overlap. Both themes revolve around participants’ positive views of rebound exercise, with the former focusing on its benefits and the latter highlighting its distinctiveness. The theme ‘Evolution of rebound exercise perception and understanding’ was maintained because it represents a distinct and separate idea of the transformative nature of participants’ views and how they changed over time. Concerning the participants’ experiences, the three initial themes were merged into a single theme, ‘Positive Experience of rebound exercise’, as the three themes share the common thread of participants’ positive experiences with rebound exercise. It highlights the complex nature of participants' experiences as emotional engagement (enjoyment, fun) is closely tied to their physical experience (physical challenge, discomfort of sweating). Although the participants largely reported positive experiences with the rebounder, some revealed that they found it quite pleasantly challenging as they had not expected it to raise their heartbeats or make them sweat. This is better represented in a subtheme, “Unanticipated challenge of rebound exercise”, to emphasise the unexpected nature of the challenges the participants experienced.

The fourth theme, “Acceptance, satisfaction and advocacy for rebound exercise”, was developed by merging the three initial themes under the research question around acceptance of the intervention. These initial themes all shared a common thread of the participants’ positive experience with the rebound exercise and followed a logical progression, so it made sense to combine them into one. The participants adhered to and committed to the rebound exercise (acceptance), experienced satisfaction and contentment (satisfaction), and ultimately recommended and advocated for it (advocacy). The research question on the perceived effectiveness of the intervention has the main theme, “Value and benefits of rebound exercise”. Encompassing both the perceived benefits and unexpected advantages, this main theme provides a clearer understanding of the overall perceived benefits of rebound exercise. Very few participants revealed that there may have been some additional benefits that they are unaware of, so the initial theme, “Uncertainty about additional benefits”, was removed since there are very few data sets to support it as a theme/ subtheme. The final theme, “Participant feedback, challenges and recommendations of rebound exercise”, was developed by merging two initial related themes to enhance clarity and minimise repetition and redundancy. The initial theme, “Intrinsic motivation and altruism in participation”, was retained as a sub-theme because it represents a distinct concept of participants' motivation. However, this subtheme is more closely related to the positive experiences and engagement with the rebound exercise theme, making it a natural fit and contributing to understanding what drives positive engagement. The finalised thematic map is presented in Figure 5.6 below.

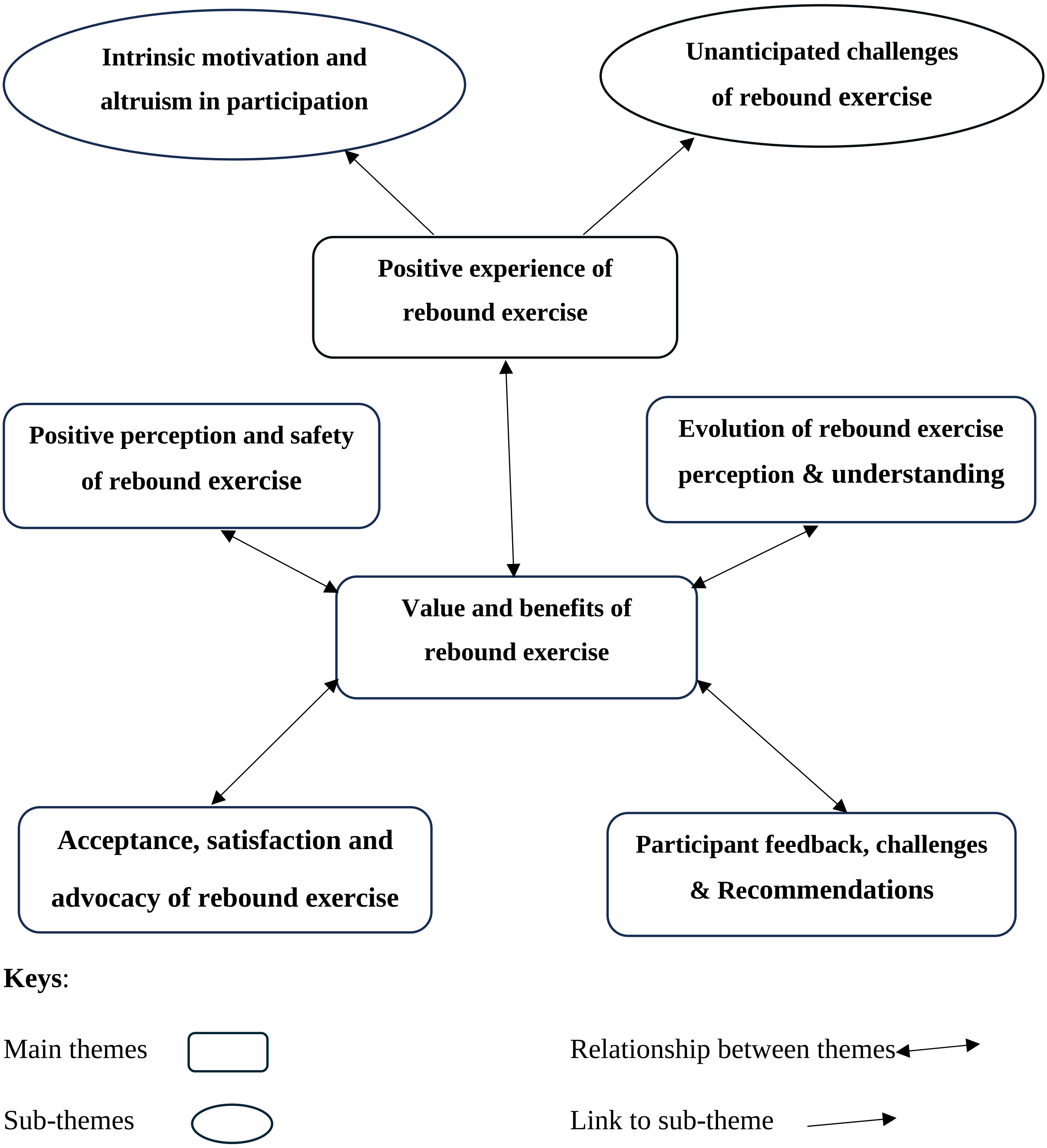


Figure 5.6: Thematic Map demonstrating the Final Themes.

5.9 Results

5.9.1 Phases Five and Six: Defining and Naming Themes and Report Writing.

The six main themes emerging from the data were deliberately presented in a specific order to reflect the narrative arc of participants' experiences with rebound exercises. We began with 'Evolution of rebound exercise perception and understanding' (Theme 1) to establish the foundation of participants' initial thoughts and misconceptions about rebound exercise. This theme sets the stage for the subsequent themes, which explore the participants' growing understanding and engagement with the exercise. Next, we presented 'Positive perception and safety of rebound exercise' (Theme 2) to highlight the participants' developing trust and confidence in the exercise. This theme naturally leads into the 'Positive experience of rebound exercise' (Theme 3), highlighting participants' reported feelings of happiness, enjoyment, empowerment, alertness and invigoration during rebound exercise sessions. It also showcases the participants' intrinsic motivation and altruism in participating in the rebound exercise and their unanticipated pleasant challenges.

The 'Value and benefits of rebound exercise' (Theme 4) follows logically as participants begin to appreciate the benefits and value of the exercise. This theme is closely tied to 'Acceptance, satisfaction, and advocacy for rebound exercise' (Theme 5), demonstrating the participants' growing acceptance and enthusiasm for rebound exercise. This fifth theme builds upon the previous one, as participants' appreciation for the benefits and value of rebound exercise leads to increased acceptance, satisfaction and advocacy. Finally, we presented 'Participant feedback, challenges, and recommendations' (Theme 6) to comprehensively understand the participants' experiences and suggestions for improving the rebound exercise. This theme connects to all the previous themes, as participants' feedback and suggestions are informed by their evolving understanding, positive engagement and appreciation for the exercise. The theme offers practical insights for future rebound exercise program development and implementation.

The fourth theme, "Value and benefits of rebound exercise," is the central theme connecting all the other themes because it represents the core outcome of the participants' experiences with rebound exercise. The value and benefits they derive from the exercise are the ultimate goals and motivations for their engagement. In the first theme, the participants' initial understanding and perception of the rebound exercise lay the foundation for their eventual appreciation of its value and benefits. Developing a positive perception and sense of safety associated with the second theme enables participants to engage with rebound exercise and experience its value and benefits. In the third theme, participants' positive experiences during rebound exercise sessions contribute to their appreciation of its value and benefits. Likewise, the value and benefits derived from rebound exercise drive the participants' acceptance, satisfaction and advocacy (theme 5). Finally, the participants' experiences and appreciation of the rebound exercise's value and benefits inform their feedback, challenges and recommendations (theme 6).

Theme 1: Evolution of Rebound Exercise Perception and Understanding

This theme reflects the changes in participants' views and knowledge about rebound exercises, emphasising the transition from scepticism to more positive views. Most participants admitted that they had no idea what rebound exercise was when they first learned about the trial. As a result, they initially felt curious, doubtful, apprehensive, and uncertain about the exercise. However, their perspectives and understanding changed and developed throughout the trial.

SD: *I just thought it was a fun exercise equipment for kids. So when I heard about the trial, I was curious to see how it would help me*.

RB: *I had never been on the trampoline or anything like that before so when I saw the opportunity, I thought that was interesting. I was curious to see how it would help me.*

PN: *And at the time I didn't take it very seriously. I didn't think that it would really give me the kind of workout it did. But it's been a good exercise. Unbelievable. Now, I respect it. I've changed my mind.*

PY*: I didn't think it would be helpful. I knew I could do it but I didn't think it would make me feel like I had exercised. I also initially thought it would be boring like a nightmare. I also didn't think I would be able to do half an hour of trampolining. Now I'm discussing with my friend so that one of us can buy it for the two of us or if we can find somewhere rebound exercise sessions are held, so that we can carry on doing it. Previously, we used to go hiking in the summer, but now there's the rebound exercise, which I would prefer to do. I'm amazed. I didn't know that I would like the rebound exercise, but it surprised me in a good way.*

Theme 2: Positive Perception and Safety of Rebound Exercise

This theme reflects participants' views of rebound exercise as a safe form of physical activity, distinct from other types of exercise. It emphasises the unique appeal and perceived safety of rebound exercise as a fitness option. The participants expressed that rebound exercise was different and unique from most other forms of exercise.

LM: *Using the rebounder is a really good thing to add to things I think I already do because it's fun, and it seems to give a bigger workout than you get doing other things because of the fact that you're bouncing up and down.*

PN*: Those other exercises are quite demanding. Like when you're running, you really feel when you climbing a hill that you climbing a hill, so physically, it's more demanding. And this is a more neutral exercise in the sense that it accommodates people with different kinds of disabilities. Like with this on the treadmill, I wouldn't really be able to keep up. This is a decent alternative*

RB*: It's been a long time since I did exercise and this is quite different from what I'm used to.*

The participants reported that rebound exercise was safe and gave them a sense of security because of the attached handlebars and its low impact on the joints. They were quite open to trying the exercise because they believed it wouldn't hurt them.

PS: *And somehow, it feels safe. I do hold on to the bar most of the time. Over the weeks, I find that I didn't have to hold on like I did in the first place.*

PY: *…. Oh, I love it. Very comfortable, and I'm not worried getting off that I'm gonna be aching. If I do yoga and I used to run and my knees would hurt afterwards and feel pain in my hips. But on the trampoline, I feel reassured because I don't get such injuries and won't fall over. It's quite safe and fun.*

BC: *……But as it was local, I said to myself that it wouldn't hurt to try it.*

DS*: So rebounding is just really accessible. You know with running, you've got to go out in the weather and all and you've got to pound pavement, but with rebounding, you don't have that. You can rebound in a creative way, in your own home and you're not hurting your joints or anything. But also, you know, it's a low-impact exercise……..*

PS*: I think it's really helpful. I think it would be helpful to most people with disability actually because it cushions you and you've got a safety bar on it. This form of exercise, even if you're not jumping up and down too much really gets the blood circulating through the body and hopefully everywhere and it makes your brain think that you're using the side which is weak. It's like a complete thing, the rebound, do you see what I mean? It has both sides of your body doing it.*

Theme 3: Positive Experience of Rebound Exercise

This theme highlights the holistic positivity surrounding participants' engagement with rebound exercise. The participants communicated that they experienced fun, happiness, and enjoyment when exercising on the trampoline.

SB: *I've loved it. I've really enjoyed it. Um, I've really enjoyed the whole routine of it coming in on a Tuesday and a Thursday. Um, I've enjoyed working with you, Adaora. You made it fun, and it's also particularly nice that you've been doing it with me. It's been good and fun. Um, because exercise is the only weapon we have, it's important that it's enjoyable, and this is an enjoyable exercise.*

SD: *I found it really enjoyable. I've never done rebound exercise before. So I didn't know what to expect when I came but I had so much fun doing it*.

MB: *I feel happy and energised. The good thing about rebound exercise is the fact that it is enjoyable, so you always look forward to rebounding*.

DS: *I've never done anything that exciting before. I feel very happy*.

Aside from experiencing joy during rebound exercise, participants revealed that they particularly enjoyed the rebound exercise tutor's cheerful personality, attributing part of the joy they experienced to him. They appreciated that the rebound tutor encouraged them throughout the session and also counted down the movements, making it easy for them to know when to move on to the next exercise.

PS: *…. I enjoy watching the instructor on the video. He cheers you up doesn't he? Makes you laugh a bit which is very important*.

PY: *Oh, I like the tutor man with his cheerful personality. He makes me laugh…(laughs). You guys are encouraging because Huntington's can be depressing. And it was quite good when* *he had that other older lady with him in the video. It was quite encouraging to see someone like me doing it. Yeah, I think I quite like that. I mean, she was doing it quite badly (laughs), you know, the modified version*.

SB: *Yeah, I can always find Paul. I enjoy Paul's because he's a happy man. He makes it fun, and he's good because he does the countdown …four, three, two, one, so you know when to switch. He's very good*.

Some participants expressed happiness about the fact that the rebound exercise routine involved music and dance.

MB: *I feel happy and energised. I love the dance moves so I enjoyed it*.

PS: *I feel quite pleased with myself that I can do it. I feel quite energised. I do like dance moves so I really enjoyed it*.

LM: *It makes you happy, the dancing's good and trying to do some of those things, without the aid of a trampoline, it's pretty difficult, because people with Parkinson's, often lose their sense of rhythm. A lot of them will tell you they want to dance but they just can't do it anymore*.

SD: *I was fully engaged with it. I love the moves and the music playing in the background*.

The participants revealed how surprised they were that they enjoyed rebound exercise. A few of them divulged that despite their historical disinterest in exercise, they found rebound exercise enjoyable.

DS: *Oh, I like coming here, I do enjoy it. Um, I feel good. I've never liked exercise. Exercise never appealed to me in the past, but I'm surprised by how much I enjoy rebounding. So much so that now the trial is over, I will get myself a rebounder*.

SD: *Um I feel happy……. I never liked to exercise in the past before my diagnosis… But I'm surprised myself by actually how much I enjoy rebounding, for someone who doesn't like exercising*.

LM: *One is that I look forward to rebound exercise, and I don't normally look forward to exercise. That's a change. Yeah, I shall miss them*.

The participants described their feelings during the exercise as a sense of empowerment, increased alertness, increased energy, and a sense of control and freedom. One participant used the metaphor “It seems to give you wings” to convey the liberation and freedom from the constraints of their condition they experience on the rebounder.

LM: *I feel less like a person with Parkinson’s because it seems to give you wings. Being on the trampoline, it just gives you that extra bit of something*.

SD: *It also energised me because tiredness is my main problem but after my rebound sessions, I don’t feel so tired anymore*.

SB: *….it's made me feel in control. Um, I think before I started this trial, all I had really was PD power and Tai Chi whereas this is like something else I’ve got to help me hold back the disease, you know. So um, Yeah, it's made me feel more positive. I've got this. I can do this*.

Sub-theme 1: Unanticipated Challenges of Rebound Exercise

This sub-theme highlights the participants’ sense of surprise that rebound exercise could raise their heartbeats, make them sweat and feel challenged contrary to their initial expectations. They found the exercise invigorating and were pleasantly surprised by the unexpected challenge.

PN: *I didn’t think that it could work you out. That you could feel exhausted the way I did. I thought it was easy because normally trampoline reminds me of children's play. So, yeah, it wasn’t anything that I thought Uh, will get me to this level of workout*. *I feel a little sweaty which I like when I do exercise. I get thirsty and I have to rehydrate myself.*

SB: *I'm concentrating because of the coordination. I'm quite surprised at how much coordination is needed. And of course, that's something that you know we're losing. So, it's good for neuroplasticity. As I'm concentrating, I'm not noticing that I'm actually doing a lot of exercise. And I enjoy the movement, it's very gentle movement, all of it is very gentle. Well, some… most of it is very gentle and then every little while you get a burst of energetic activity*.

RB: *There's some similarity that you've got to concentrate using your brain as well as your body. You’ve got to keep changing moves. You know, you got to concentrate on different moves and changing things*.

ML: *I found out it more difficult to try and coordinate the timing of the movement and the bouncing on the Trampoline. So that was quite interesting*.

PS: *And yes, I feel after I've done it, you know, the next day that I've used my muscles, which is what I want to achieve because I don't always use my muscles normally every day*.

SD: *I had so much fun doing it. And it was not strenuous. Although it made me go out of breath sometimes, especially in the initial weeks, it wasn't difficult and I feel like I exercised afterwards*.

Sub-theme 2: Intrinsic Motivation and Altruism in Participation

This sub-theme reflects the participants' internal motivation for engaging in rebound exercise, including personal motivations for their own well-being and the potential to help others through research participation. Some participants expressed their willingness to participate, whether it would benefit them personally or not. They were very enthusiastic about supporting clinical trials to do everything they could to help find a cure for their conditions.

JK: *I felt it was probably good for me, you know, it was something that I felt I could probably consider doing in the future. It gave me an insight into rebounding and plus, I enjoy taking part in any sort of research, I mean, even if it's not going to actually benefit me greatly, you know, it might help people in the future. So I think it's important to take part and you know, do these things.*.

BC: *Even if it doesn't make a difference to me, if it can help somebody else in the future, I'm happy with that*.

PS: *I wanted to participate to improve my balance and strength*.

ML: …*To see how much improvement I can get. Also, because I think any exercise is better than none, and at this point in time, because we're moving house, I've not been doing any other regular exercise. So, this is helpful*.

Theme 4: Value and Benefits of Rebound Exercise

This theme highlights participants' recognition of the physical and emotional benefits of rebound exercise, including pain relief, improved sleep, balance, and coordination, better mobility and confidence, and increased alertness and energy. The participants acknowledged that engaging in the trial invoked a sense of personal growth, invigoration and accomplishment associated with rebound exercise.

PY: *I was amazed I could do half an hour, both of us were. It makes you more confident, don't you think? Doing things you never thought you could do. I got something out of it. It is very effective. I can feel it's done something. Whether it has made a difference, I think it has, hasn't it? I'm not sure about my memory, but it's definitely helped with the pain from my hip arthritis. It has stopped my hip pains because I don't have them anymore. I was really pleasantly surprised. I feel it has strengthened my legs because they feel stronger now, and I walk better and faster than before. Rebound exercise has built my confidence in walking again because I used to be scared about going out for fear of pain from walking, and I would always get a taxi so I wouldn't walk too much. But now, I can confidently work without pain.*

PY: *Normally, when I do exercise, I get exhausted afterwards. But the rebound exercise doesn't exhaust me, and I don't feel the pains I would normally feel after other forms of exercise. Yesterday, I went shopping at Aldi all evening, and when I got home, I was absolutely exhausted. But on the days when I rebound, I get this burst of energy afterwards. So I would say that rebound exercise energises me*.

SB*: … it's energised me, it's made me feel in control. Um, I think before I started this trial, all I had really was PD power and Tai Chi whereas this is like something else I've got to help me hold back the disease, you know. So um, Yeah, it's made me feel more positive. I've got this. I can do this.*

PS: *It's definitely made a difference to my balance. I do things on there that I couldn't do at the start, and I feel more confident. I think it's helped with my walking. Whether it's enough, I don't know as it's only once a week, but I'm now confident walking around in Wycombe. It's difficult to know whether it's that, isn't it? I think it makes you feel better, thereby giving you more confidence*.

SD: *It has made my balance and walking better*. *It also energized me because tiredness is my main problem but after my rebound sessions, I don't feel so tired anymore. It also helps relieve my pain*.

VO: *It makes me sleep better. And I wasn't expecting that. So that's something that was a pleasant surprise because I didn't feel tired when I was doing the rebound, but it made me sleep. Ever since the accident, I noticed that I found it difficult to sleep and sometimes had to* *take sleep medication, but on the days I rebound, I quickly fall asleep when I get home. So I must be doing something good*.

They also revealed that rebound exercise can empower individuals to push beyond their preconceived boundaries and achieve more than they initially thought possible, thus surpassing their perceived limitations. One participant shared that initially, he couldn't perform basic functional movements such as marching on the spot and coordinating the movement of his arms and legs simultaneously. However, after several sessions of rebound exercise, he could now do these activities. Another person reported that they could not dance in recent years following their diagnosis. However, they found they could dance again at a concert after participating in the trial.

LM: *…I think I mentioned before I went to a concert, a Beetles concert the other night, and I was able to get up and look stupid on the dance floor, which I wouldn't have been able to do before. So, I think it has… I know exercising in Parkinson's doesn't last, as in, you can't save it up; you have to do it regularly. But certainly, having done this 12-week rebound course has released something in me that wasn't there before. It helps you do things you don't think you can do, which is good. It makes you let go of your inhibitions*.

KT: *Well, to start with, I was really quite nervous about it. Um, I initially found it really quite difficult. I was holding on to the bar. As I grew more confident, I found I could move. I found, I could actually do the jump, the bouncing, and I enjoyed doing that. And I got better and better with it as my confidence increased. And I think it actually helps your coordination because it's very difficult to move your legs and your arms at the same time if you have Parkinson's. And that is something I did find I was doing towards the end. Marching, you know, you march with your legs and arms moving up. I couldn't do that before I started but now I can move my arms together with my legs. So, I did find that my coordination was gradually improving*.

Despite most participants reporting perceived benefits of rebound exercise, two reported not noticing any notable changes, attributing the lack of improvement to coming just once weekly.

BC: *I can't really see significant changes. I know my walking improved a bit but aside from that, there's no real change or feeling. Maybe there are some other improvements that are not apparent to me*.

DG: *The effect that I had thought it would have….weight loss, it didn't because I needed to do more, I know. I think if I also had gone on a strict diet plan, I would have lost weight. Yes, I think it's effective*.

Theme 5: Acceptance, Satisfaction, and Advocacy for Rebound Exercise.

This theme represents participants' overall feelings of satisfaction, contentment, and acceptance of rebound exercise. They rated their satisfaction from rebound exercises between 7 and 10. Some even revealed their intentions to continue with rebound exercise by getting one for themselves, while others were keen to register for rebound classes if they found such centres operating locally.

DS: *Oh, I would give it a top score—a 10. I'm very satisfied with it. I will take it forward and get one at home so I can have it in the house. I hope to continue doing it for at least 15 minutes several times a week. I think I will be disciplined enough to carry on doing it at home regularly because I enjoy it*.

KT: *I've enjoyed doing it and am satisfied with it, and I would rate it a seven or eight. In fact, I'd be quite happy to repeat, you know, if you wanted to repeat the trial, I'd do it again. Easily. So, I did enjoy it.*

MB: *10/10, that's how satisfied I am with it. If I find a rebound class in the community, I will sign up for it. I would like to have one at home to continue enjoying the benefits I've gained so far.*

LM: *Oh, I'm satisfied with it. I would give it a 10 out of 10. I think the possibility of being able to do this kind of thing in the gyms that people with Parkinson's can join for free would be excellent. I would really love that*.

VO: *I enjoy the social aspect of meeting up with other people. So, I'd like to be able to go somewhere to do it, but I'd also like to have it in my house so I can do it when I feel like doing it or if the weather is bad and I can't go out, I can just be at home and do it*.

PY: *I definitely want to continue with it. My friend and I already talked about this, looking for how to carry on doing it? Can we continue coming for the rebound exercise classes? Or do you know of any centre running rebound exercise classes?........... My friend and I were also thinking of buying a rebounder between us and put in our houses to do at home. But we would also like the option of booking it at a centre where we have to attend the sessions weekly. I* *feel that while I'm thinking of buying it for home use, I would prefer to go out to the centre to do the exercise. I may have it at home and just be looking at it, whereas if I paid something to do it, then I would more likely carry on with the exercise*.

The participants were eager to recommend the rebound exercise to others who would benefit from it. They shared their thoughts on how individuals with neurological disorders and various disabilities can utilise and benefit from rebound exercise.

ML: *Uh, yeah, I would recommend it to others. It depends on what neurological orders they have, but I can see that it has a wide application because people can hang on to the handle if they're unbalanced*.

VO: *Absolutely without a shadow of a doubt, I will recommend it*.

SB: *I have always recommended it to people since I started enjoying the benefits of the exercise. Some of them even signed up for the trial*.

Theme 6: Participant Feedback, Challenges and Recommendations

This theme encompasses other relevant information from the dataset outside of the research objectives, including the feedback and recommendations communicated by the participants. While most participants preferred rebound exercise once a week, they also acknowledged that twice a week would be better. They ascribed their preference for once a week to time constraints. However, regarding the exercise duration per session, the participants expressed that 30 minutes was perfect.

SD: *To be honest, I didn't think I could last 30 minutes on the rebounder, but I did, and that surprised me. I think the 30 minutes just feels right. I wouldn't want it any longer. ….. I think rebound exercise once or twice weekly is perfect*.

VO: *I think once a week for 30 minutes is okay. I mean I would like to come more but I won't be able to fit it into my daily routine because I still work*.

PN: *Like I said, 30 minutes was feeling like it would never end, but I kept on doing it and got used to it. Yeah, to get a good workout, 30 minutes is okay. I think twice a week will be perfect for good results*.

LM: *I think probably the ideal would be twice a week if you had time. If you had the equipment at home, that would be ideal, but I think incorporating it twice into a regular* *routine will be good. But once is good, I think once every seven days, but I think twice would be better. Yeah, spaced out, though, because two days in succession will be a bit much. 30 minutes per session is perfect*.

The participants described the challenges they encountered during the exercise, such as the small circumference of the trampoline surface restricting too much movement and the attached safety handlebar restricting some of their movements. They also suggested ways for improvement to tackle the challenges.

JK: *The bar. It was a hindrance. But I know it has to be there because some people use it. But I found that hindered my arm movements at times. Also, the size of the trampoline was a little bit small. I think, had it been a little bit bigger, it would give you a bit more scope to move around.*

LM: *…..Um, and the safety rail kind of …. I look at it two ways because it's good to have it there clearly because you don't fall off, but it can get in the way a little bit with some of the exercises*.

MB: *I think getting a rebounder with a larger surface gives you more space to play around*.

RB: *I would recommend a bigger rebounder with more surface to exercise on*.

Insufficient space and a lack of rebound exercise classes were the barriers to continuing rebound exercise after the trial recounted by the participants. Some expressed that while they would love to buy rebounders for home use, they wouldn't have the space to store them. One participant appreciated that although the rebounders are foldable for easy storage, they wouldn't be physically able to fold and unfold them constantly each time. Most participants prefer to go to local rebound exercise centres if such are available and are willing to pay to register.

JK: *I don't feel like I have the space, really, Um, to put a trampoline up and I'm guessing it would be awkward to pack away all the time and store them. So, probably not, but if it's out, there was something local, I would consider it*.

KT: *I don't really have the space. I wouldn't really have the place to put a rebounder. I could put it in the garage, but realistically, I wouldn't do it. Doing something on your own is so much harder and challenging. I'd be more than happy to continue it if you want to set up a class; I'd be happy to come along and make a payment for it*.

LM: *I'm not sure I've got the space actually to have one at home. We're downsizing. Or maybe doing it in the garage, which wouldn't be much fun in the winter, perhaps. So yeah, I think the availability of being able to do this kind of thing in the gyms that people with Parkinson's can join for free would be excellent*.

ML: *I'm going to join a sports centre and I'm going to see what they have in terms of exercise classes. And then I'll see from there, but my intention is once we move, because we're moving to the seaside, I want to be walking and cycling. I would have loved to buy it for home use, but not at the moment because I don't have the space. But once I'm settled into the new place and I find space for it, then I will. If rebound exercise classes are available at the sports centre, I will register to attend*.

Participants further suggested establishing rebound exercise centres in the community and making them group sessions rather than one-on-one. They expressed their wish to integrate socially with others who share the same condition and to be able to support one another. One participant appreciated being allowed to come with a friend.

PN: *I would prefer to go to any centre offering rebound exercise because I desire to be in groups, compare what I'm doing with what the others are doing, and have a goal to see where I'm going*.

PS: *If there was a class here, I'd definitely come for it, in case you want to start one (laughs). I don't know if they have them in the physiotherapy departments in the hospitals, but I honestly think they should establish them*.

RB: *I recommend having it in small groups with others….like a group class would be nice. And you can help and support each other*.

SB: *Group sessions would be fun. Especially if you're there because then you'll exercise with other people with neurological conditions. When I do my PD power class at what's now called Chiltern Neuro Centre. I didn't know anybody else who had Parkinson's before then, so that's been quite good, as you can see other people who have the same condition as you*.

DS: *I think you could do it as a group. I think a group rebound session would be quite good. If they had a group rebound session, I think a lot of people would benefit and I think people who are further along the road than I will also gain from it*.

PY: *I really appreciate being allowed to come with my friend. We keep an eye on each other during the sessions, and it's been such great support. It's motivating to have someone there with you, cheering you on, and it makes the whole experience even better.*

5.10 Discussion

This study explored the current perceptions, experience and acceptance of rebound exercise among community-dwelling adults with neurological disorders who participated in a 12-week rebound exercise study. This study breaks new ground by exploring participants' opinions and experiences of rebound exercise through in-depth interviews, an approach that has not been previously employed in the field. While survey questionnaires have provided valuable insights into participants' views and attitudes (Fricke *et al.*, 2023), this study's qualitative approach offers a more immersive and detailed exploration of participants' experiences, providing a fresh perspective on rebound exercise and its potential impact on physical activity behaviour.

5.10.1 Theme 1: Evolution of Rebound Exercise Perception and Understanding

One interesting finding of this study was the remarkable evolution in participants' perception and understanding of rebound exercise over time. Initially, participants held misconceptions and scepticism about the rebound exercise, which transformed into a more positive and empowering experience as they continuously engaged with the exercise. This corroborates the existing literature, suggesting that individuals' perceptions and attitudes towards exercise play a crucial role in adopting and maintaining physical activity (Ajzen, 1991). Participants' initial negative attitudes and misconceptions about rebound exercise were influenced by their limited knowledge and lack of prior experiences. This aligns with the 'Theory of Planned Behaviour', which posits that attitudes and subjective norms shape behavioural intentions (Ajzen, 2020). As participants gained experience and understanding of rebound exercise, their attitudes shifted positively, mirroring the findings of a study on exercise behaviour change (Brand and Cheval, 2019). The evolution of perception and understanding was influenced by participants' observations, affective judgements, and personal experiences, consistent with the literature (Rhodes, Gray and Husband, 2019). The transformation from scepticism to empowerment resonates with literature on self-efficacy and perceived behavioural control (Motalebi *et al.*, 2014). Participants' growing confidence in their ability to perform rebound exercise and its benefits reflects higher perceived behavioural control, a critical factor that predicts exercise intention and eventual engagement (Wang and Wang, 2015). These are necessary for exercise behaviour adoption and long-term maintenance (Sur, Jung and Shapiro, 2022).

5.10.2 Theme 2: Positive Perception and Safety of Rebound Exercise

The findings of this study reveal that participants developed a positive perception of rebound exercise, emphasising its safety, uniqueness, and enjoyable nature. The participants' positive attitudes towards rebound exercise were influenced by their experiences and observations, consistent with the TPB. Their perception of rebound exercise as safe stemmed from the increased sense of security due to the attached safety handlebars and its low impact on the joints and body systems, making it an attractive option for those concerned about an injury or chronic pain (Burandt, 2016; Maharaj and Nuhu, 2016; Şahin, Demir and Aydın, 2016). Enjoyment and absence of unpleasant experiences such as pain and physical discomfort are essential for increasing exercise adherence (Collado-Mateo *et al.*, 2021). So, this study suggests rebound exercise could improve long-term adherence to exercise. Moreover, participants perceived rebound exercise as unique and distinct from traditional exercise modes, offering a novel and engaging way to stay physically active. This perception of uniqueness and safety likely contributed to their intention to continue and maintain rebound exercise behaviour. These findings are consistent with previous studies showing that people with disabilities are more likely to intend to participate in physical activity when they have positive attitudes, feel strong encouragement from important people in their lives (such as family, friends, and doctors), and feel that they have control over their physical activity engagement (Sur, Jung and Shapiro, 2022).

5.10.3 Theme 3: Positive Experience of Rebound Exercise

Aside from expressing a positive view of rebound exercise, this study's participants also recounted having a positive experience, characterised by enjoyment, fun, and a sense of empowerment. Their perceived enjoyment and satisfaction influenced participants' positive experience with rebound exercise. The fun and enjoyable nature of rebound exercise possibly contributed to participants' intention to continue, as enjoyment is a critical factor in exercise behaviour adoption and maintenance. The participants' willingness to participate, whether or not it would benefit them personally, demonstrates their altruistic and personal motives. This aligns with studies that have reported personal benefits and benefits for others as the most frequently mentioned motives for participating in exercise research (Gavin *et al.*, 2014; Zervou *et al.*, 2017; Sheridan *et al.*, 2020; Stadelmaier, Meerpohl and Toews, 2022). The primary factor that drives people to continue exercising is the enjoyment they derive from it, regardless of their initial motives (Rodrigues *et al.*, 2020; Teixeira *et al.*, 2022). Research suggests that individuals who exercise for fun are more likely to adhere to a specific exercise program than those motivated by internal or external rewards (Deci and Ryan, 2008). This finding is relevant as it has highlighted rebound exercise as an enjoyable exercise option for promoting long-lasting exercise adherence in this population. Moreover, participants experienced a pleasantly surprising unanticipated challenge during the rebound exercise, enhancing their positive experience. Despite initial perceptions of rebound exercise as a low-intensity activity, participants were challenged by dynamic movements and aerobic demands. This unexpected challenge led to a sense of accomplishment and pride, reinforcing their positive attitude towards rebound exercise.

The social norms factor, a critical component of the TPB, also significantly impacted participants' positive experience with rebound exercise. Participants expressed that part of the joy they experienced during rebounding was due to the rebound exercise tutor's cheerful personality, support, and encouragement throughout the sessions. This suggests that the social environment and the instructor's behaviour influenced participants' subjective norms, shaping their attitudes and intentions towards rebound exercise. According to the TPB, subjective norms are influenced by the perceived social pressure from significant others, such as instructors or peers (Ham, Jeger and Ivković, 2015). In this case, the rebound exercise instructor's cheerful and supportive demeanour likely created a positive social environment, encouraging participants to enjoy the exercise and feel motivated to continue. Furthermore, the instructor’s behaviour and support may have also influenced participants’ perceived behavioural control, another crucial component of TPB, as the participants may have felt more confident and in control of their ability to perform rebound exercises due to the instructor's guidance and encouragement, further reinforcing their intention to continue. Participants' positive experience was due to the exercise itself and the social support and encouragement they received from the instructor, highlighting the importance of social norms in shaping exercise behaviour. This finding supports previous studies' evidence that social interaction with a cheerful and supportive instructor is key to enjoying and sustaining exercise behaviour (Kerkelä *et al.*, 2015; Fricke *et al.*, 2023).

5.10.4 Theme 4: Value and Benefits of Rebound Exercise

A key theme identified in this study was the "Value and Benefits of Rebound Exercise." This theme encapsulates participants' perceptions of rebound exercise as both physically and psychologically beneficial, highlighting its overall contribution to their health and quality of life. Participants consistently reported significant physical improvements attributed to rebound exercise. These included enhanced mobility, better balance, pain relief, improved sleep quality, and increased cardiovascular health. Participants noted that they could move more freely and easily after rebound exercises. This finding aligns with existing literature suggesting that rebound exercise can enhance mobility, joint flexibility, and muscle strength (Daneshvar *et al.*, 2019; Okemuo, Gallagher and Dairo, 2023). Many participants observed improvements in their balance, which is particularly crucial for individuals with neurological disorders who are at a higher risk of falls. Rebounding involves maintaining stability on an unstable surface, likely contributing to these balance improvements (Beerse and Wu, 2020; Mademli *et al.*, 2021). Additionally, several participants mentioned feeling more energetic and experiencing improved heart rate and blood pressure, indicating better cardiovascular health. This is significant given that cardiovascular issues are common in people with neurological disorders and can further complicate their health (Bernardi, Aromolaran and Aromolaran, 2021; Ziaka and Exadaktylos, 2023). Participants also reported pain relief and improved sleep quality, aligning with previous studies that have demonstrated that aerobic exercises can relieve pain and enhance sleep quality (Banno *et al.*, 2018; García-Correa *et al.*, 2021; Alnawwar *et al.*, 2023).

Beyond physical improvements, several psychological benefits of rebound exercise were also highlighted. Many participants described feeling happier and more uplifted during and after their rebound exercise sessions. This mood enhancement is critical for individuals with neurological disorders who may experience depression or anxiety. This corroborates findings from other studies demonstrating the emotional benefits associated with exercise in various populations (Aweto *et al.*, 2016; Crank *et al.*, 2017; Daneshvar *et al.*, 2019; Mahindru, Patil and Agrawal, 2023). Like other exercises, the rhythmic movement of rebounding triggers the release of ‘feel good’ hormones, such as serotonin and endorphins, leading to mood-boosting, stress-relieving, and overall happiness (American Psychological Association, 2020). Interestingly, participants also reported surpassing their perceived limitations during rebound exercise, experiencing a sense of accomplishment and pride in their ability to perform functions they previously thought were beyond their capabilities since their diagnosis.

Overcoming these perceived limitations further strengthened participants' positive attitudes and intentions to continue rebound exercise, as they felt empowered and confident in their ability to overcome challenges. This sense of achievement can be empowering and boost self-esteem. People are more likely to continue interventions when they enjoy them and see clear benefits from them (Lachman *et al.*, 2018). Overall, the findings underscore the multifaceted value of rebound exercise, which supports physical health and enhances psychological well-being, making it a highly beneficial activity for individuals with neurological disorders.

5.10.5 Theme 5: Acceptance, Satisfaction and Advocacy for Rebound Exercise

Another important theme from the study was the participants' sense of satisfaction, acceptance, and advocacy for rebound exercise. This theme highlights the participants' commitment to the activity, reflecting their positive attitudes and experiences. Participants found rebound exercise to be enjoyable, beneficial, and well-suited to their needs. Their perceived behavioural control influenced their acceptance, as they felt confident in performing rebound exercises effectively. Some participants even expressed their intention to purchase a mini-trampoline, enabling them to continue the activity at home. This intention emphasises their commitment and dedication to integrating rebound exercise into their daily routines. Moreover, participants expressed high satisfaction with rebound exercise, citing numerous physical and psychological benefits. This sense of satisfaction acted as a reinforcing factor, solidifying their positive attitudes towards rebound exercise and motivating them to continue their engagement with the activity. The findings align with numerous studies demonstrating a strong correlation between positive attitudes, high intention, and adopting a particular behaviour (Kraus, 1995; Martinez and Lewis, 2016; Sur, Jung and Shapiro, 2022). In this study, participants' positive attitudes and intentions towards rebound exercise suggest a high likelihood of them adopting and maintaining this behaviour over time.

Participants also exhibited great enthusiasm in recommending rebound exercises to others with similar conditions. This advocacy stresses their belief in the efficacy and value of rebound exercise as a beneficial activity for individuals facing similar challenges. Their willingness to recommend the exercise to others showcases their personal satisfaction and highlights the potential benefits of rebound exercise for a wider audience. This finding is consistent with the body of evidence indicating that individuals are more likely to recommend a service or intervention to others if they are satisfied with it (Rita, Oliveira and Farisa, 2019; Khoo, 2022). The participants' advocacy for rebound exercise is particularly noteworthy as it suggests that they see the exercise as beneficial for themselves and a valuable intervention for others with neurological disorders. This advocacy can play a crucial role in increasing the adoption of rebound exercise within this population, potentially leading to broader health benefits and improved quality of life for more individuals.

Overall, the high levels of acceptance, satisfaction, and advocacy demonstrated by participants in this study reflect the perceived value and effectiveness of rebound exercises. These positive perceptions are critical for any intervention's long-term success and sustainability, as they foster continued engagement and dissemination within the community.

5.10.6 Theme 6: Participant Feedback, Challenges and Recommendations.

Although not the focus of this study, it is essential to note the valuable feedback, identified challenges and recommended suggestions offered by the participants. Firstly, it was found that while most participants preferred engaging in rebound exercise once a week due to time constraints, they acknowledged that increasing the frequency to twice a week may be more beneficial. This highlights their desire for more opportunities to participate in this form of exercise. Participants expressed that a minimum of 30 minutes was ideal for the exercise duration per session. This finding aligns with previous literature documenting that working adults and older adults prefer to exercise once a week (Paw *et al*., 2001; Foley, Hillier and Barnard, 2011; Aboagye *et al*., 2017). This insight provides valuable information for designing rebound exercise programs, ensuring they align with the participants' preferences.

Furthermore, participants described specific challenges they encountered during the exercise. A major concern was the limited circumference of the trampoline surface, which restricted their movement and potentially hindered the exercise's effectiveness. They noted that enjoying the full experience of bouncing on the trampoline required more space to move around freely. Additionally, the attached safety handlebar, which initially provided security for participants with less balance and confidence, eventually became an obstacle. As participants gained balance and confidence, the handlebar limited their range of motion. This shift from being a supportive feature to a hindrance aligns with evidence in the literature on the dynamic nature of stressors and the necessity for regular appraisal, as what was initially viewed as supportive could later be perceived as obstructive (Horan *et al.*, 2020). These challenges shed light on the areas that need improvement in terms of equipment design and functionality. Participants suggested practical solutions to overcome these obstacles. For instance, they recommended using mini-trampolines with a larger surface area to allow more freedom of movement. They also proposed modifying the safety handlebar to enable greater flexibility during exercise. Fortunately, the safety handlebar of the mini-trampoline is designed to be removable or detachable, allowing confident participants to remove it for greater flexibility during their workouts. However, the handlebar was kept in place throughout the rebound exercise study as a security measure for this vulnerable cohort with neurological disorders. In addition to physical challenges, participants identified barriers to continuing rebound exercise post-study. Insufficient space at home and the lack of rebound exercise classes locally were significant obstacles. Some participants expressed a desire to purchase rebounders for home use but lacked the necessary storage space. One participant mentioned the physical difficulty of constantly folding and unfolding the rebounders, further complicating home use.

Interestingly, participants expressed a preference for attending local rebound exercise centres, indicating their willingness to pay for registration. They suggested establishing these centres within the community to facilitate group sessions. This preference aligns with previous studies that have found participants tend to favour group exercise sessions over individual ones for adopting and maintaining exercise behaviour (Kerkelä *et al.*, 2015; Aboagye *et al.*, 2017; Stødle *et al.*, 2019; Stevens *et al.*, 2021). The desire for a social aspect of rebound exercise highlights the participants' wish to connect with others who share similar conditions and provide mutual support. Participants' preference for group rebound exercise classes indicates the perceived social influence or approval from their peers with neurological disorders. They believe exercising with others who share their health condition would offer motivation and social interaction. This preference aligns with the concept of subjective norm, reflecting their belief that engaging in group rebound exercise is socially endorsed and encouraged within their peer group (Ham, Jeger and Ivković, 2015). Such social dynamics and potential influencers can significantly impact exercise adherence among individuals with neurological disorders. The participants' suggestions underscore the importance of considering social and community aspects when designing exercise programs. Establishing local rebound exercise centres could provide a structured and supportive environment and foster a sense of community and shared experience among participants. This approach could enhance motivation, adherence, and overall satisfaction with the exercise program, leading to better health outcomes and quality of life for individuals with neurological disorders.

5.10.7 Strengths and Limitations of the Study

To the best of the author's knowledge, this is the first study to explore participants' opinions and experiences of rebound exercise through in-depth interviews. This study's strengths lie in its ability to delve deeply into participants' personal experiences and perceptions. By employing semi-structured interviews, the research captured rich, detailed accounts of how individuals with neurological disorders perceive and experience rebound exercise. The study also benefitted from the diversity of its participants, who had different neurological conditions, enhancing the relevance and applicability of the findings across various contexts. Additionally, this research examines community-dwelling adults' unique barriers and provides insights into adapting and optimising rebound exercise for home and community use. It also identifies practical recommendations from participants for informing future program development.

Despite these strengths, this study has some limitations. The findings are based on self-reported data, which can be subject to social desirability bias, especially considering that the interviewer was also the lead researcher who supervised the rebound exercise sessions. This researcher-participant relationship may have influenced the responses, potentially affecting the accuracy of the reported behaviours and experiences. However, the researcher tried to minimise the influence of this bias by explicitly encouraging participants to provide honest responses that would be kept confidential and free from judgment. Additionally, the subjective nature of qualitative research means that the researcher's biases and interpretations may influence the findings. To mitigate this, the researcher engaged in reflexivity throughout the research process, enhancing transparency and striving to minimise bias. Another limitation is the limited generalisability of the findings. The study's results may apply only to individuals with neurological disorders who are similar to the participants in this study. The study participants' specific demographic and clinical characteristics may not represent the broader population of individuals with neurological disorders. Consequently, caution should be exercised when applying these findings to other groups or settings.

5.10.8 Clinical Implications

The study's findings have important clinical implications. They highlight the potential for rebound exercise to be a well-accepted and enjoyable form of physical activity for individuals with neurological disorders. Clinicians can consider incorporating rebound exercise into rehabilitation programs, emphasising its psychological and social benefits alongside physical improvements. The participants' preference for group sessions suggests that incorporating social interaction into exercise programs could enhance motivation and adherence. Additionally, the feedback regarding equipment design, such as the need for larger trampoline surfaces and adjustable safety handlebars, provides valuable information for improving the safety and effectiveness of rebound exercise equipment.

5.10.9 Recommendations for Future Studies

Longitudinal qualitative studies would be valuable in understanding how perceptions and experiences with rebound exercise evolve over time and in identifying long-term adherence patterns. Investigating the specific needs and preferences of subgroups within the neurological disorder population, such as those with varying levels of mobility or different types of neurological conditions, can provide more tailored recommendations. Additionally, examining the role of social support and group dynamics in sustaining exercise behaviours could offer deeper insights into designing effective and engaging rehabilitation programs.

5.11 Conclusion

This qualitative study provides valuable insights into the acceptance, perception, and experience of rebound exercise among individuals with neurological disorders. The participants' positive attitudes, enjoyment, and perceived benefits of rebound exercise stress its potential as an effective and engaging physical activity for this population. The study highlights the importance of perceived behavioural control and the social dynamics that influence exercise adherence. Participants' feedback on equipment design and their preference for group sessions offer practical recommendations for enhancing rebound exercise programs. These findings suggest that rebound exercise can be a feasible and beneficial addition to rehabilitation programs for individuals with neurological disorders, promoting both physical and psychological well-being. However, further research is needed to explore rebound exercise's long-term adherence and effectiveness and address the identified challenges and barriers.

CHAPTER SIX

CONCLUSION

6.0 Overview

This chapter integrates the findings from the three studies conducted within this PhD research: the systematic review, the quantitative feasibility study, and the qualitative study. Through data triangulation, it synthesises these findings, highlighting their convergence, complementarity, and divergence. The objective is to draw well-supported conclusions about the feasibility and potential impact of rebound exercise on adults with neurological disorders. This chapter also outlines the implications for clinical practice and suggests directions for future research.

6.1 Data Triangulation

6.1.1 Summary of Findings

The systematic review provided a comprehensive, evidence-based assessment of rebound exercise's physical impact on individuals with neurological disorders, primarily within inpatient settings. It highlighted significant improvements in mobility, a key functional outcome for this population. However, a critical gap was identified in the scope of existing studies, as they focused mainly on physical outcomes like balance, mobility, and strength, while the psychosocial dimensions of rebound exercise remain underexplored. This raises important questions about the holistic impact of rebound exercise on psychosocial well-being, social engagement and adherence to long-term physical activity. Additionally, the limited attention to community-based settings restricts the generalisability of findings to real-world contexts, where environmental and social factors play a vital role in program feasibility and participant motivation.

This limitation in the literature informed the subsequent feasibility study conducted in the community setting, investigating both the physical and psychosocial impacts of rebound exercise. Using a prospective observational design, the study demonstrated that rebound exercise is feasible and safe in a community setting. High recruitment (70.59%) and retention (98.1%) rates and the absence of adverse events indicate good participant engagement and exercise tolerance. A notable finding was that 76.9% of participants chose to attend sessions once weekly due to time constraints despite the flexibility offered. The low attrition rate (1.89%), achieved without using incentives, suggests that this population is well-accepted and tolerated rebound exercise. This is particularly encouraging in the context of community-based neurorehabilitation, where adherence can be a major challenge. The feasibility study also revealed that flexible scheduling and buddy system sessions enhanced social engagement and improved adherence, indicating that these strategies are promising for successfully implementing rebound exercises in a community-based setting. Importantly, the study further observed significant improvements in several outcomes following 12 weeks of rebound exercise. These included cardiovascular health, balance, walking speed, physical activity levels, cognitive function, grip strength, and overall quality of life.

It is noteworthy to mention that the heterogeneous nature of the sample made of adults with different neurological disorders could potentially affect the generalisability of the findings. Participants with neurological disorders and elderly individuals often have highly individualised physical functions, which could impact the interpretation of the results. Also, the study did not explicitly exclude participants receiving concurrent rehabilitation. Hence, the significant improvements in outcomes suggest that rebound exercise contributed to these improvements, likely augmenting the participants' usual care. While this observational study provides preliminary evidence suggesting that rebound exercise is feasible and safe for community-dwelling adults with neurological disorders, it is essential to acknowledge its inherent limitations. Observational studies are beneficial for exploring feasibility, participants' perspectives and real-world applicability but are limited in their ability to establish causality due to potential confounders and the absence of randomisation or control groups. This means that although relationships can be observed, definitive conclusions about the effectiveness of rebound exercise cannot be drawn with confidence.

In addition to the quantitative results, a semi-structured qualitative interview was conducted to explore participants' perspectives on the rebound exercise. Participants reported that they found the exercise enjoyable, safe, and effective, noting improvements in balance, coordination, muscle strength, mobility, confidence, and overall well-being. These subjective insights closely mirrored the quantitative findings, particularly in terms of enhanced physical activity levels, further supporting the potential of rebound exercise as a valuable public health tool to increase physical activity among adults with neurological conditions. Together, these findings provide a strong foundation for future research and clinical practice, highlighting rebound exercise as a viable, engaging, and beneficial intervention for this population in a community setting. The consistency between the quantitative results and the qualitative feedback adds validity and a form of confirmation to the observed benefits. They also reinforce the need for further research, particularly randomised controlled trials, to explore the broader impacts, minimum effective dose and optimal implementation strategies of rebound exercise in community-based neurorehabilitation.

6.1.2 Convergence of Findings

The triangulation of data from the quantitative and qualitative studies provided a valuable understanding of the participant experience and the potential impact of a 12-week rebound exercise intervention. While the quantitative data indicated improvements in balance, mobility, physical activity levels and quality of life, the qualitative findings offered rich insight into participants' lived experiences, particularly regarding feasibility and perceived benefits. Participants reported increased confidence and independence in performing everyday tasks, which, they attributed to the rebound exercise program. This, in turn, appeared to encourage greater participation in physical activity, aligning with the observed quantitative improvements in physical activity levels. The improvements in balance and mobility likely reduced the fear of falls, a common barrier to physical activity among individuals with neurological disorders.

It is important to note that due to the observational design of this study, definitive causal relationships cannot be established. However, the convergence of findings from both data sources suggests that rebound exercise is a feasible and potentially beneficial intervention for community-dwelling adults with neurological disorders, warranting further investigation in controlled experimental studies.

6.1.3 Complementarity

Although the findings were largely convergent, the qualitative study offered complementary insights into the participants' psychological and emotional responses to rebound exercise, which were not fully captured in the quantitative study. For instance, participants emphasised the enjoyable nature of the exercise and its role in enhancing their motivation to engage in physical activity. This feedback aligns with the notably high adherence rates observed in the quantitative data, where all participants met the minimum attendance requirements despite time constraints. Additionally, the high recruitment and retention rates, as well as the low attrition, demonstrate the feasibility of implementing rebound exercises within a community setting. These rates, along with the qualitative feedback regarding flexibility and group participation, highlight the acceptability of the intervention. Participants not only valued the flexible scheduling options, which allowed them to manage their time constraints but also reported a preference for group sessions to foster social interaction and further motivate adherence. Although the rebound exercise sessions were initially individualised, some participants expressed a preference for a more social experience. In response, the study introduced a "buddy system," where participants were allowed to bring a friend, who was also a participant, to attend the session with them, offering support and encouragement. This system allowed participants to watch each other's sessions, fostering social support and creating a sense of shared experience. The qualitative interviews revealed that participants found the buddy system to be a valuable source of motivation and social connection. Many participants even recommended that future rebound exercise programs incorporate group sessions to further enhance the social benefits of the intervention.

While the buddy system worked well to foster social engagement and adherence in this study, the participants' preference for formal group sessions suggests that future implementations could explore structured group formats to enhance motivation, social support, and overall program satisfaction. Moreover, the qualitative study provided valuable feedback from participants regarding potential barriers to engaging in rebound exercise, such as time constraints, while the feasibility data demonstrated that offering flexible, accessible scheduling solutions significantly improved attendance and engagement. These insights enrich the understanding of how rebound exercise could be more effectively implemented in community settings, addressing both the benefits and challenges from participants' perspectives. This highlights how the qualitative study not only supported the quantitative findings but also enriched the understanding of how rebound exercise could be more effectively implemented, addressing both benefits and challenges from the participants' perspectives.

6.1.4 Divergence

The systematic review indicated that while rebound exercise significantly improved mobility in hospitalised patients, it did not show notable improvements in balance. This outcome may be attributed to the limited opportunities for patients in hospital settings to adequately challenge their balance and the potential ceiling effects of the Berg Balance Scale used in those studies. The restricted, controlled environments of hospitals may not provide the dynamic conditions needed to improve balance skills. In contrast, the quantitative research conducted in a community setting observed significant improvements in balance, as assessed by the 3-meter backward test. This test likely captured a wider range of balance abilities and was sensitive to the gradual improvements that participants experienced over the 12-week intervention. The divergence between these findings can be explained by the differences in both the setting and the balance assessment tools used. The community setting may have offered more natural and varied opportunities for participants to engage in movements that challenged and enhanced their balance. This variation in daily activities, combined with the more sensitive 3-meter backward test, likely contributed to the observed improvements. Unlike the hospital setting, where patients might have been confined to simpler or more regulated movements, the community-based environment could have promoted more active participation, further stimulating balance recovery.

The qualitative study added another layer to this understanding. Participants highlighted improved balance and coordination during the interviews, describing how rebound exercise helped them feel more stable and confident in their daily movements. They also mentioned the enjoyable nature of the exercise, which likely contributed to their sustained engagement and adherence. These subjective experiences complement the objective findings, adding depth to the quantitative improvements observed in balance. This divergence between settings, tools, and participant experiences highlights the importance of considering both the environment and the assessment methods when evaluating interventions like rebound exercises. The triangulation of these findings suggests that rebound exercise may be especially effective when implemented in more dynamic and flexible community environments, where participants can fully engage in balance-challenging activities. It also reinforces the value of integrating multiple perspectives to better understand the exercise's impact on balance, mobility, and overall quality of life in individuals with neurological disorders. Such triangulated findings show the potential of rebound exercise as a valuable component in neurorehabilitation, reinforcing its practicality and acceptance in community settings.

6.2 Summary of Thesis

Neurological disorders represent a significant global health burden, contributing to high rates of mortality and disability across populations. Given the complex needs of individuals with neurological disorders, among the myriad of challenges they face, the importance of regular physical activity cannot be overstated. Physical activity is crucial in enhancing overall health and well-being and is a key component of rehabilitation strategies for individuals with neurological conditions. However, despite the known benefits of physical activity, many individuals with neurological disorders struggle to meet recommended levels of exercise, placing them at increased risk of functional decline, secondary complications, and diminished quality of life. Recognising the pressing need to address this issue, this PhD research explored the potential of rebound exercise as an intervention for individuals with neurological disorders. Rebound exercise, characterised by its unique features such as enjoyment, low-impact nature, time efficiency, safety, and affordability, emerged as a promising avenue for promoting physical activity in this population.

The research journey commenced its first study with a systematic review and meta-analysis aimed at synthesising existing evidence on the efficacy of rebound exercise in individuals with neurological disorders. The systematic review employed established guidelines and protocols (PRISMA) to ensure methodological rigour and transparency throughout the review process. Comprehensive search strategies were developed and implemented across several electronic databases to identify relevant studies published in peer-reviewed journals. The inclusion criteria were carefully defined to encompass studies examining the effects of rebound exercise on various health outcomes, including mobility, balance, quality of life, and other relevant parameters, in adults with neurological disorders.

Following the retrieval of relevant studies, a systematic screening process was undertaken to assess the eligibility of identified articles based on predefined criteria. Studies meeting the inclusion criteria underwent rigorous data extraction, where key information on study design, participant characteristics, intervention details, and outcome measures was systematically recorded and synthesised. The methodological quality of the included studies was critically appraised using an established assessment tool (CASP RCT) to evaluate the risk of bias, methodological limitations, and overall study quality. This process enabled the identification of strengths and weaknesses within the existing literature, informing the interpretation and synthesis of study findings. Subsequently, a meta-analysis was conducted on Review Manager to synthesise the pooled effect sizes of the three quantitatively included studies and assess the overall impact of rebound exercise on relevant health outcomes in individuals with neurological disorders. Despite the scarce available studies, the review provided valuable insights into the benefits of rebound exercise, particularly in improving mobility among adults with neurological conditions. However, a notable limitation in the existing evidence was the predominant focus on hospital-based rebound exercise interventions, raising questions about the applicability and feasibility of community-based rebound exercise programs (Okemuo, Gallagher and Dairo, 2023).

Building upon the systematic review's findings, this research then delved into exploratory research to assess the practicality of implementing rebound exercises in a community setting. This second study aimed to investigate the feasibility of rebound exercise and its effects on the physiological and physical functions of individuals with neurological disorders in the community through an observational study design. Employing a prospective observational study design for this preliminary inquiry was grounded in obtaining information on feasibility, safety, potential benefits, barriers or facilitators, participant recruitment feasibility, and exercise protocols. This information is essential before investing in a larger, more resource-intensive, randomised controlled trial. The eligibility criteria included adults with neurological disorders living in the Bucks community who could walk for at least 2 minutes, understand therapy instructions, and had no significant comorbidities.

Using a prospective cohort design, the study involved 53 participants engaging in rebound exercise sessions over 12 weeks. Participants attended sessions as often as they desired, each lasting 30 minutes, to observe their naturalistic tendencies. Data was collected at baseline, 6 weeks, and 12 weeks. Data analysis was performed using SPSS version 28 with appropriate statistical tests. The results of this study provide evidence supporting the feasibility and safety of community-based rebound exercise programs, demonstrated by high recruitment rate, retention rate, adherence and absence of injuries/adverse events. Significant improvements were observed in various health outcomes, including balance, mobility, blood pressure, heart rate, physical activity level, quality of life, and cognition. These findings highlight the potential benefits and practicality of implementing rebound exercise as a therapeutic intervention in community settings for individuals with neurological disorders.

Furthermore, the research extended its inquiry in the third study to explore the acceptability and experiences of participants engaging in rebound exercises through qualitative methods. Recognising the importance of incorporating participant voices into the research process, this qualitative inquiry sought to provide a deeper understanding of the acceptability, perceptions, and perceived benefits of rebound exercise from the perspective of those directly impacted by the intervention. Semi-structured interviews were conducted to capture participants' nuanced perspectives and insights regarding their perceptions, experiences, and attitudes towards rebound exercise. The interview recordings were manually transcribed verbatim, and coding was done and organised using NVivo and Microsoft Excel. A rigorous reflexive thematic analysis guided the interpretation and synthesis of interview data, facilitating the identification of emergent themes and patterns across participant narratives. Through iterative coding, categorisation, and theme development, the qualitative analysis aimed to capture the essence of participant experiences and identify key factors that shaped their perceptions of the rebound exercise's acceptability and effectiveness. From this qualitative exploration, six overarching themes emerged, each encapsulating distinct facets of participant perspectives and experiences:

i. *Positive Perception and Safety of Rebound Exercise***:** Participants expressed favourable views of rebound exercise as an enjoyable and safe modality for physical activity, highlighting its appeal and perceived efficacy in enhancing health and well-being.

ii. *Evolution of Rebound Exercise Perception and Understanding:* The study revealed shifts in participants' perceptions and understanding of rebound exercise over time, from initial scepticism to increased acceptance and appreciation of its benefits.

iii. *Positive Experience of Rebound Exercise:* Participants reported active engagement and enjoyment during rebound exercise sessions, noting feelings of satisfaction and accomplishment associated with participation.

iv. *Value and Benefits of Rebound Exercise:* Participants identified numerous benefits of rebound exercise, including improved sleep quality, balance, mobility, confidence, pain relief and overall quality of life, highlighting its multifaceted impact on health and well-being.

v. *Acceptance, Satisfaction, and Advocacy of Rebound Exercise:* Many participants expressed high acceptance, satisfaction, and advocacy for rebound exercise, emphasising their willingness and enthusiasm to recommend it to others.

vi. *Participant Feedback, Challenges, and Recommendations:* Participants provided valuable feedback on their experiences with the rebound exercise, highlighting both positive aspects and challenges encountered during participation. They also recommended optimising program delivery and enhancing the overall participant experience. One top recommendation was establishing a community-based rebound exercise class with group sessions.

The qualitative findings revealed a remarkably high acceptance, enthusiasm, and advocacy for rebound exercise among participants, further highlighting its potential as a preferred physical activity modality for individuals with neurological disorders. Overall, this PhD research highlights the importance of considering both quantitative and qualitative dimensions in assessing rebound exercise interventions' efficacy, feasibility, and acceptability. The findings contribute to the growing body of evidence supporting rebound exercise's effectiveness and provide valuable insights into its practical implementation and integration into community-based rehabilitation programs for individuals with neurological disorders.

6.3 Implications for Research and Practice

This research offers valuable insights into the feasibility of implementing rebound exercises for individuals with neurological disorders in a community setting. While the findings are promising, they are not definitive, given the study's observational nature. However, the research provides the foundation for future randomised controlled trials that could further explore the clinical efficacy of rebound exercise, addressing the practical challenges identified and validating the potential benefits observed in this feasibility study. The study suggests rebound exercise could be a viable intervention to enhance physical and physiological function in individuals with neurological disorders.

While it is too early to recommend its broad inclusion in public health strategies or community-based rehabilitation programs, the evidence points to its potential as an engaging and enjoyable form of exercise that could improve balance, mobility, cardiovascular health, and overall quality of life. These findings are particularly significant for public health initiatives promoting physical activity in this population, where adherence to rehabilitation programs is often challenging. Rebound exercise, with its flexibility and social support components, could help address this issue. Additionally, the high recruitment and retention rates and the participants' qualitative feedback suggest that rebound exercise is acceptable and well-received in this population. These findings are essential for developing tailored rehabilitation programs focusing on physical improvements and the social and motivational factors influencing long-term adherence.

However, more rigorous research (like RCTs, qualitative studies, etc) is needed to establish rebound exercise's long-term effects, safety and sustainability in community settings. Larger RCTs are essential to validate these findings and to examine rebound exercise's impact across different neurological conditions and demographics. This research lays the groundwork for future studies that can more definitively assess rebound exercise's role in neurorehabilitation. Ultimately, the PhD research contributes significantly to the field by offering evidence-based insights that can inform clinical practices, healthcare policies, and the future development of community-based exercise programs for individuals with neurological disorders.

6.4 Recommendations for Future Studies

Building upon the promising feasibility findings of this observational study, future research should prioritise several key areas to further understand and optimise rebound exercise for community-dwelling adults with neurological disorders.

1. Feasibility and Optimisation: Given the positive trends observed in cardiovascular parameters, balance, walking speed, physical activity, cognitive function, grip strength, and quality of life, future studies should focus on refining the intervention parameters. Specifically, conducting RCTs to determine the minimum effective dose of rebound exercise is recommended. This would involve systematically varying the frequency, intensity, and duration of exercise sessions to identify the optimal dosage that yields significant benefits while minimising participant burden.

The qualitative findings highlighted practical barriers to participation, including storage space, equipment concerns, time constraints, and accessibility of community classes. Future studies should explore strategies to overcome these barriers. This could include investigating the feasibility and safety of home-based rebound exercise programs, developing tailored interventions that address specific concerns, and exploring the role of telehealth and remote support in facilitating adherence.

2. Understanding Participant Experience and Social Factors: Participants emphasised the positive impact of the social aspects of rebound exercise. Future studies should investigate how social support from peers, family, or healthcare providers affects participation and outcomes. This could inform the development of group-based or community-supported exercise interventions that leverage social dynamics to enhance adherence. Future qualitative research should also explore the long-term experiences of participants engaging in rebound exercise, focusing on factors that contribute to sustained participation and perceived benefits.

3. Future Controlled Trials: While this observational study provided valuable feasibility data, future research should include RCTs to establish the efficacy of rebound exercise and explore

the underlying mechanisms of observed improvements. RCTs are essential for controlling confounding variables and enabling clearer attribution of outcomes to the intervention. Furthermore, given the heterogeneity of neurological disorders, future RCTs should investigate the long-term effects of rebound exercise and its impact on different subgroups within the population. This could involve examining outcomes in individuals with varying degrees of severity, age groups, or specific neurological conditions to tailor interventions to diverse needs.

6.5 Conclusion

This PhD research embarked on a comprehensive exploration of rebound exercise for community-dwelling adults with neurological disorders encompassing a systematic review, an observational feasibility study, and qualitative research. The integration of findings from these three interconnected studies provides valuable insights into the feasibility and potential benefits of this intervention. The observational feasibility study demonstrated that rebound exercise is a feasible intervention for this population, with participants reporting positive experiences. These qualitative insights, which highlighted perceived improvements in daily functioning and well-being, were supported by trends observed in quantitative measures across multiple physical and physiological domains.

While the observational design of the feasibility study limits definitive causal inferences, the consistency between the quantitative and qualitative findings suggests that rebound exercise warrants further investigation. Specifically, RCTs are necessary to rigorously evaluate its efficacy and establish causal relationships. These trials should focus on confirming the observed trends and exploring the underlying mechanisms of potential benefits. In addition, further research should explore the optimal parameters of rebound exercise, addressing practical barriers to implementation and focusing on long-term adherence.

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Appendices

Appendix 1: URL to Search Strategy

1. Search link on SportDiscus

https://web.p.ebscohost.com/ehost/resultsadvanced?vid=4&sid=fc38fe87-771b-4ea9-a336-3f423aff6fe5%40redis&bquery=TX+(+rebound+therapy+or+trampoline+or+trampolining+)+AND+TX+(+neurological+disorders+or+neurological+disease+or+disability+)&bdata=JmRiPXMzaCZ0eXBlPTEmc2VhcmNoTW9kZT1TdGFuZGFyZCZzaXRlPWVob3N0LWxpdmUmc2NvcGU9c2l0ZQ%3d%3d

2. Search link for ProQuest

https://www.proquest.com/search/2056032?accountid=7179

3. Search link for Google Scholar

https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=rebound+therapy+or+mini-trampoline+exercise+and+neurological+disorder&btnG=

4. Search link for PubMed

https://pubmed.ncbi.nlm.nih.gov/?term=%28%28rebound+exercise*%5BMeSH+Terms%5D%29+OR+%28mini-trampoline+exercise*%5BMeSH+Terms%5D%29%29+AND+%28neurological+disorder%29&size=200

5. Search link for PsycInfo

https://web.s.ebscohost.com/ehost/resultsadvanced?vid=4&sid=e6a9ffcf-6e15-4dd8-be4a-36db1b9ded4e%40redis&bquery=TX+(+rebound+therapy+or+trampoline+or+trampolining+)+AND+TX+(+neurological+disorders+or+neurological+disease+or+disability+)&bdata=JmRiPXBzeWgmdHlwZT0xJnNlYXJjaE1vZGU9U3RhbmRhcmQmc2l0ZT1laG9zdC1saXZlJnNjb3BlPXNpdGU%3d

6. Search link for Cochrane library

https://www.cochranelibrary.com/advanced-search

7. Medline via Ovid*

https://openathens.ovid.com/secure-ssl/home.oa?idpselect=https://idp.bucks.ac.uk/entity&entityID=https://idp.bucks.ac.uk/entity&?T=JS&NEWS=N&PAGE=main&SHAREDSEARCHID=2crR5eALsi86blBfYm8oCqTuYgtEq5ZgRNPsCxYLF2Tt2angti3WL6MX0OqgWSw1

Appendix 2: Ethical Approval Letter

BUCKINGHAMSHIRE
NEW UNIVERSITY
EST. 1891

Research & Enterprise Development Unit

email: ResearchUnit@bucks.ac.uk

23 January 2023

Ms Adaora Okemuo
School of Health and Social care
Buckinghamshire New University
Queen Alexandra Road
High Wycombe
HP11 2JZ

Dear Adaora

Ethical approval: Ref UEP2022Sep01

I am writing to confirm that ethical approval was granted by the University Research Ethics Panel of Buckinghamshire New University on 26 September for your project:

Effect of rebound exercise in people with neurological disorders.

This approval is valid for data collection between 26 September 2022 and 25 September 2024.

Please ensure that you quote the above reference number as evidence of ethical approval and in all materials used to recruit participants.

The Research and Enterprise Development Unit must be notified of any amendments to the proposed research or any extension to the period of data collection.

I hope that your research project goes well.

Yours sincerely,

Dr M. Nakisa

Secretary to the University Research Ethics Panel
Research and Enterprise Development Unit

Appendix 3: Participant Information Sheet

Effect of rebound exercise on people with neurological disorders

We invite you to support research by participating in this study to determine whether people with neurological disorders would benefit from rebound exercise. Whether or not you wish to take part is entirely up to you. Before you decide, you must understand why the research is being done and what it will involve.

What is the purpose of the study?

Rebound exercise is a safe and effective exercise successfully used in other populations. Considering its benefits on humans, its minimal stress on the heart, bones and joints and its fun-giving experience, it can be an adjunct in rehabilitating neurological disorders. The pleasure obtained with rebound exercise helps prolong exercise as the individual does not realise how hard they are exercising. This makes regular engagement easier than traditional exercises that may feel like a task. We want to conduct this study to investigate the use of rebound exercise in people with neurological disorders in the community and determine the appropriate dosage required to effect changes in physiological and functional outcomes.

Why have I been invited to take part?

You have been invited to participate if you have any neurological disorders such as stroke, multiple sclerosis, Parkinson’s disease, or traumatic brain injury. To be eligible, you need to be able to stand and walk for at least 2 minutes (with or without a walking aid), communicate in English and understand therapy instructions. You must be 18 years old and above. Your weight must be less than 120 kg. Your doctor must clear you to do aerobic exercises. You cannot participate if you: are pregnant, have other significant co-existing medical conditions (heart disorders, cancer, musculoskeletal disorders, respiratory problems), or have visual or auditory sensory disorders. You cannot participate if your knee goes backwards into hyperextension while standing, if you are epileptic or suffer from vertigo.

Do I have to take part?

Participation is entirely voluntary; therefore, it is your decision whether you want to participate. You will be asked to sign a consent form if you decide to participate. If you decide that you would like to withdraw, you can do so at any time. If you wish to withdraw, you do not have to provide a reason which will not adversely affect you.

What will happen to me if I take part?

Each volunteer participant will be screened for eligibility and will sign the consent form if eligible. The researcher will answer any questions and ensure you understand what the study involves before you are asked to sign it.

The measurements:- You will visit the research site at Bucks New University's High Wycombe or Aylesbury campus for assessment. During this assessment, you will be asked to complete some questionnaires and functional tests. These measurements will be taken at three different points throughout the study: before the start of the intervention (baseline), mid-intervention (6 weeks) and post-intervention (12 weeks). This enables us to observe how the duration of intervention influences these outcomes. Height, weight, BMI, heart rate, and blood pressure measurements will be taken. Outcomes such as your risk of falling, walking speed, cognitive function, grip strength, physical activity level and quality of life will be assessed using questionnaires and functional tests. The functional tests include the 3-metre backward test (3MBWT), 10-metre walk test (10MWT) and Mini-cog, while the questionnaires include the World Health Organisation Quality of Life brief version and the International Physical Activity Questionnaire.

To measure the risk of falls, from a marked point, you will be asked to walk backwards as fast and safely as you can to a 3-metre marked point. You are free to look back if you wish. The time taken to reach the 3-metre marked point will be recorded, giving information on fall risk. To measure walking speed, you will be instructed to walk a set distance of 10 meters with or without an assistive device and the time taken to walk the distance is noted. Your grip strength will be measured with a handheld dynamometer. To measure your cognitive function, you will be given a task to test your memory and executive functioning. You will be told three random words and asked to repeat and remember them for later. You will then be asked to draw a clock and fix the time to depict a particular time. After this, you will be asked to repeat those three words you were given. The resulting score will provide information on your cognitive function.

The intervention: You will participate in rebound exercise training once or twice weekly for about 30 minutes per session for 12 weeks. The frequency of your sessions (once or twice a week) depends on your preference, but it will be noted. The sessions will take place on the Aylesbury or High Wycombe University campus. The rebounder/ mini-trampoline will be fitted with a safety handle that you can hold on to prevent falling. Active hand-gripping aids will secure your hands to the safety handle if you have poor grip strength. The exercise sessions are closely supervised by the physiotherapist (chief investigator), who will instruct you on what to do on the mini-trampoline. You will continue with your regular physiotherapy sessions.

The interview: Towards the end of the 12 weeks, some of you who consent will be interviewed individually to ascertain your experience, views, and acceptability of the rebound exercise. The interview sessions will take about 30-60 minutes. It will be recorded on a digital audio recorder and transcribed verbatim at the end of the interview. Your interview will be anonymised, and the information on the transcript cannot be linked to you in any way. However, the anonymised data on the transcript will be used for research and publication.

What are the possible benefits of taking part?

Receiving rebound exercise training may improve your health. We hope the results of this trial will help improve treatments and provide more exercise alternatives for the rehabilitation of people with neurological disorders in the future. It will also help us determine the appropriate frequency of rebound exercise required for beneficial effects to be observed.

What are the possible risks associated with taking part?

There is minimal risk involved in this study. Safety is considered by attaching a stability bar/safety handle to the rebounder. The rebounder will be disinfected and wiped before and after each use. The researcher will constantly monitor and supervise the walking assessments and rebound exercises. A research team member will ask you about your medical history to ensure it’s safe for you to participate in the program, and your blood pressure will be assessed before each rebound training session.

Will my taking part in this study be kept confidential?

Your participation in the study will be kept confidential; nobody else outside the research team will be informed. A code number will be used instead of your name so that no identifiable information can be traced back to you.

What will happen to the results of the research study?

The study results will be published in a scientific journal and presented at a conference so we can share them with other researchers and healthcare professionals. We will also send a summary of the results to all the participants.

Who is organising and funding the research?

The study is a PhD study sponsored by Buckinghamshire New University, UK.

How will we use information about you?

We will need to use information from you for this research project. This information will include your name and contact details. The research team will only use this information to send you a summary of the research findings at the end of the study. People outside the research team cannot see your name or contact details. Instead, your data will have a code number, and the reports will not reveal your identity. We will keep all information about you safe and secure.

Contact details

If you need more information on the study or decide to volunteer to participate, please email the research team at adaora.okemuo@bucks.ac.uk or phone them on 07xxxxxxxxxx.

Complaints

If you have concerns about your rights as a participant or a complaint about how the research is conducted, you can contact the research supervisor, Dr Yetunde Dairo yetunde.dairo@bucks.ac.uk

Thank you for taking the time to read this and considering participating in this study.

Appendix 4: Recruitment flier

Buckinghamshire New University
School of Health and Social Care Professions

Volunteers Needed for Research Study on Rebound Exercise

Are you diagnosed with a neurological disorder? You may be eligible for a 12 weeks study on rebound exercise that could improve your physical and mental health.

Who can participate?
- People with neurological disorders (stroke, multiple sclerosis, Parkinson's disease, acquired brain injury) who are 18 years and above
- If you can stand and walk for at least 2 minutes with or without a walking aid
- If you can understand therapy instructions.

Why should you participate?
- You may experience improvement in your physical and mental health
- You may discover a new enjoyable way to remain physically active
- You will contribute to valuable information that may help people with neurological disorders, advance science and help us with our research.

What is the purpose?
This study will investigate the effect of rebound exercise in people with neurological disorders.

Where will it take place?
Buckinghamshire New University's High Wycombe or Aylesbury campus.

Who will benefit?
- Community of individuals with neurological disorders
- Research Community

Interested?

For more information, please get in touch with the research team on

Appendix 5: Informed Consent form

Please tick the appropriate boxes.

1. Taking part in the study, I have read and understood the study information dated Click or tap here to enter text.

I have been able to ask questions about the study, and my questions have been answered to my satisfaction. ☐

I consent voluntarily to participate in this study and understand that I can refuse to answer questions and withdraw from the study at any time without giving a reason. I can withdraw my data until 31/10/2023, before the data is analysed. ☐

I understand that taking part in participating in the study involves filling out short questionnaires and participating in rebound exercise training and functional measurements.

I understand that I may be asked to participate in a 30-60 minute interview, which will be recorded with a digital audio recorder and transcribed verbatim. ☐ ☐

2. Use of the information in the study

I understand that the information I provide will be used for scientific publications and conference presentations ☐

I understand that personal information collected about me that can identify me, such as my name (initials) or where I live, will not be shared beyond the study team ☐

I consent to the processing of my personal information for the purposes of this research study. I understand that such information will be treated as strictly confidential and handled in accordance with current UK Data Protection legislation ☐

I agree that my information can be quoted in research outputs ☐

3. Future use and reuse of the information by others

I give permission for the de-identified/anonymised questionnaire answers, interview transcripts and measured data that I provide to be used for future research and learning. The stored data will be anonymised by using initials and no identifying information ☐

4. Signatures

Click or tap here to enter text. __________ Click or tap to enter a date.

Name of participant [IN CAPITALS]   Signature   Date

For participants unable to sign their name, mark the box instead of signing ☐

Email Click or tap here to enter text. Mobile Click or tap here to enter text.

I have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

ADAORA OKEMUO		19/04/2023
Name of researcher [IN CAPITALS]	Signature	Date

5. Study contact details for further information

Adaora Okemuo, mobile- 07xxxxxxxxxx, email- adaora.okemuo@bucks.ac.uk One copy is to be kept by the participant, and one is to be kept by the researcher

Appendix 6: Questionnaires for physical activity and quality of life

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

Name………………………………………. Sex (F/M)   Age………years

We are interested in learning about the physical activities people do in their everyday lives. Think about all your vigorous and moderate activities in the **last seven days**. **Vigorous** physical activities require hard physical effort and make you breathe much harder than normal. **Moderate** activities require moderate physical effort and make you breathe somewhat harder than normal.

PART 1: JOB-RELATED PHYSICAL ACTIVITY

The first section is about your work. This includes paid jobs, farming, volunteer work, coursework, and any other unpaid work you did outside your home. Do not include unpaid work you might do around your home, like housework, yard work, general maintenance, and family care. These are asked in Part 3.

1. Do you currently have a job or do any unpaid work outside your home?

☐ Yes

☐ → No   ***Skip to PART 2: TRANSPORTATION***

The next questions are about all the physical activity you did in the **last 7 days** as part of your paid or unpaid work. This does not include travelling to and from work.

2. During the **last 7 days**, how many days did you do **vigorous** physical activities like heavy lifting, digging, construction, or climbing stairs **as part of your work**? Think about only those physical activities that you did for at least 10 minutes at a time.

☐_____ **days per week**

→ No vigorous job-related physical activity   ***Skip to question 4***

3. How much time did you usually spend on one of those days doing **vigorous** physical activities as part of your work?

_____ **hours per day**

_____ **minutes per day**

4. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads **as part of your work**? Please do not include walking.

_____ **days per week**

→ ☐ No moderate job-related physical activity ***Skip to question 6***

5. How much time did you usually spend on one of those days doing **moderate** physical activities as part of your work?

_____ **hours per day**

_____ **minutes per day**

6. During the **last 7 days**, how many days did you **walk** for at least 10 minutes **as part of your work**? Please do not count any walking you did to travel to or from work.

_____ **days per week**

☐ → No job-related walking ***Skip to PART 2: TRANSPORTATION***

7. How much time did you usually spend on one of those days **walking** as part of your work?

_____ **hours per day**

_____ **minutes per day**

PART 2: TRANSPORTATION PHYSICAL ACTIVITY

These questions are about how you travelled from place to place, including to places like work, stores, movies, and so on.

8. During the **last 7 days**, on how many days did you **travel in a motor vehicle** like a train, bus, car, or tram?

☐_____ **days per week**

→ No travelling in a motor vehicle ***Skip to question 10***

9. How much time did you usually spend on one of those days **travelling** in a train, bus, car, tram, or another kind of motor vehicle?

_____ **hours per day**

_____ **minutes per day**

Now think only about the **bicycling** and **walking** you might have done to travel to and from work, to do errands, or to go from place to place.

10. During the **last 7 days**, on how many days did you **bicycle** for at least 10 minutes at a time to go **from place to place**?

☐_____ **days per week**

→ No bicycling from place to place ***Skip to question 12***

11. How much time did you usually spend on one of those days to **bicycle** from place to place?

_____ **hours per day**

_____ **minutes per day**

12. During the **last 7 days**, how many days did you **walk** for at least 10 minutes at a time to go **from place to place**?_____ **days per week**

□ → No walking from place to place ***Skip to PART 3: HOUSEWORK, HOUSE MAINTENANCE, AND CARING FOR FAMILY***

13. How much time did you usually spend **walking** from place to place on one of those days?

_____ **hours per day**

_____ **minutes per day**

PART 3: HOUSEWORK, HOUSE MAINTENANCE, AND CARING FOR FAMILY

This section concerns some physical activities you might have done in the **last 7 days** in and around your home, like housework, gardening, yard work, general maintenance work, and family care.

14. Think about only those physical activities you did for at least 10 minutes. During the **last 7 days**, how many days did you do **vigorous** physical activities like heavy lifting, chopping wood, shovelling snow, or digging **in the garden or yard**?

□ _____ **days per week**

No vigorous activity in the garden or yard ***Skip to question 16***

15. How much time did you usually spend on one of those days doing **vigorous** physical activities in the garden or yard?

_____ **hours per day**

_____ **minutes per day**

16. Again, think about only those physical activities you did for at least 10 minutes. During the **last 7 days**, on how many days did you do **moderate** activities like carrying light loads, sweeping, washing windows, and raking **in the garden or yard**?

_____ **days per week**

→ No moderate activity in the garden or yard ***Skip to question 18***

17. How much time did you usually spend on one of those days doing **moderate** physical activities in the garden or yard?

_____ **hours per day**

_____ **minutes per day**

18. Once again, think about only those physical activities you did for at least 10 minutes. During the **last 7 days**, how often did you do **moderate** activities like carrying light loads, washing windows, scrubbing floors and sweeping **inside your home**?

_____ **days per week**

No moderate activity inside the home ***Skip to PART 4: RECREATION, SPORT AND LEISURE-TIME PHYSICAL ACTIVITY***

19. How much time did you usually spend on one of those days doing **moderate** physical activities inside your home?

_____ **hours per day**

_____ **minutes per day**

PART 4: RECREATION, SPORT, AND LEISURE-TIME PHYSICAL ACTIVITY

This section is about all your physical activities in the **last 7 days** solely for recreation, sport, exercise or leisure. Please do not include any activities you have already mentioned.

20. Not counting any walking you have already mentioned, during the **last 7 days**, how many days did you walk for at least 10 minutes **in your leisure time**?

_____ **days per week**

No walking in leisure time ***Skip to question 22***

21. How much time did you usually spend **walking** in your leisure time on one of those days?

_____ **hours per day**

_____ **minutes per day**

22. Think about only those physical activities you did for at least 10 minutes. During the **last 7 days**, how many days did you do **vigorous** physical activities like aerobics, running, fast bicycling, or fast swimming **in your leisure time**?

_____ **days per week**

No vigorous activity in leisure time ***Skip to question 24***

23. How much time did you usually spend on one of those days doing **vigorous** physical activities in your leisure time?

_____ **hours per day**

_____ **minutes per day**

24. Again, think about only those physical activities you did for at least 10 minutes. During the **last 7 days**, on how many days did you do **moderate** physical activities like bicycling at a regular pace, swimming at a regular pace, and doubles tennis **in your leisure time**?

_____ **days per week**

No moderate activity in leisure time ***Skip to PART 5: TIME SPENT SITTING***

25. How much time did you usually spend on one of those days doing **moderate** physical activities in your leisure time?

_____ **hours per day**

_____ **minutes per day**

PART 5: TIME SPENT SITTING

The last questions are about the time you spend sitting at work, home, coursework, and leisure time. This may include time spent sitting at a desk, visiting friends, reading or sitting or lying down to watch television. Please do not include any time spent sitting in a motor vehicle you have already told me about.

26. During the **last 7 days**, how much time did you usually spend **sitting** on a **weekday**?

_____ **hours per day**

_____ **minutes per day**

27. During the **last 7 days**, how much time did you usually spend **sitting** on a **weekend day**?

_____ **hours per day**

_____ **minutes per day**

Quality of life assessment (WHOQOL-BREF)

Please read the question, assess your feelings for the last two weeks, and circle the number on the scale for each question that gives the best answer for you.

		Very poor	Poor	Neither poor nor good	Good	Very good
1	How would you rate your quality of life?	1	2	3	4	5

		Very dissatisfied	Fairly Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very satisfied
2	How satisfied are you with your health?	1	2	3	4	5

The following questions ask about how much you have experienced certain things in the **last two weeks**.

		Not at all	A Small amount	A Moderate amount	A great deal	An Extreme amount
3	To what extent do you feel that physical pain prevents you from doing what you need to do?	1	2	3	4	5
4	How much do you need any medical treatment to function in your daily life?	1	2	3	4	5
5	How much do you enjoy life?	1	2	3	4	5
6	To what extent do you feel your life is meaningful?	1	2	3	4	5

		Not at all	Slightly	Moderately	Very	Extremely
7	How well are you able to concentrate?	1	2	3	4	5
8	How safe do you feel in your daily life?	1	2	3	4	5
9	How healthy is your physical environment?	1	2	3	4	5
		Not at all	Slightly	Somewhat	To a great extent	Completely
10	Do you have enough energy for everyday life?	1	2	3	4	5
11	Are you able to accept your	1	2	3	4	5

	bodily appearance?					
12	Have you enough money to meet your needs?	1	2	3	4	5
13	How available to you is the information you need in your daily life?	1	2	3	4	5
14	To what extent do you have the opportunity for leisure activities?	1	2	3	4	5

		Not at all	Slightly	Moderately	Very	Extremely
15	How well are you able to get around physically?	1	2	3	4	5

The following questions ask you to say how good or satisfied you have felt about various aspects of your life over the **last two weeks**.

		Very Dissatisfied	Fairly Dissatisfied	Neither Satisfied nor Dissatisfied	Satisfied	Very satisfied
16	How satisfied are you with your sleep?	1	2	3	4	5
17	How satisfied are you with your ability to perform your daily living activities?	1	2	3	4	5
18	How satisfied are you with your capacity for work	1	2	3	4	5
19	How satisfied are you with yourself?	1	2	3	4	5

20	How satisfied are you with your personal relationships?	1	2	3	4	5
21	How satisfied are you with your sex life?	1	2	3	4	5
22	How satisfied are you with the support you get from your friends?	1	2	3	4	5
23	How satisfied are you with the conditions of your living place?	1	2	3	4	5
24	How satisfied are you with your access to health services?	1	2	3	4	5
25	How satisfied are you with your transport?	1	2	3	4	5

The following question refers to **how often** you have felt or experienced certain things in the last two weeks.

		Never	Infrequently	Sometimes	Frequently	Always
26	How often do you have negative feelings such as blue mood, despair, anxiety or depression?	1	2	3	4	5

This is the end of the questionnaire. Thank you for participating.

Appendix 7: Minicog Questionnaire

Mini-Cog™

Instructions for Administration & Scoring

ID: ______________ Date: ________________________

Step 1: Three Word Registration

Look directly at person and say, "Please listen carefully. I am going to say three words that I want you to repeat back to me now and try to remember. The words are [select a list of words from the versions below]. Please say them for me now." If the person is unable to repeat the words after three attempts, move on to Step 2 (clock drawing).

The following and other word lists have been used in one or more clinical studies.[1-3] For repeated administrations, use of an alternative word list is recommended.

Version 1	Version 2	Version 3	Version 4	Version 5	Version 6
Banana	Leader	Village	River	Captain	Daughter
Sunrise	Season	Kitchen	Nation	Garden	Heaven
Chair	Table	Baby	Finger	Picture	Mountain

Step 2: Clock Drawing

Say: "Next, I want you to draw a clock for me. First, put in all of the numbers where they go." When that is completed, say: "Now, set the hands to 10 past 11."

Use preprinted circle (see next page) for this exercise. Repeat instructions as needed as this is not a memory test. Move to Step 3 if the clock is not complete within three minutes.

Step 3: Three Word Recall

Ask the person to recall the three words you stated in Step 1. Say: "What were the three words I asked you to remember?" Record the word list version number and the person's answers below.

Word List Version: _____ Person's Answers: ___________________ ___________________ ___________________

Scoring

Word Recall: ______ (0-3 points)	1 point for each word spontaneously recalled without cueing.
Clock Draw: ______ (0 or 2 points)	Normal clock = 2 points. A normal clock has all numbers placed in the correct sequence and approximately correct position (e.g., 12, 3, 6 and 9 are in anchor positions) with no missing or duplicate numbers. Hands are pointing to the 11 and 2 (11:10). Hand length is not scored. Inability or refusal to draw a clock (abnormal) = 0 points.
Total Score: ______ (0-5 points)	Total score = Word Recall score + Clock Draw score. A cut point of <3 on the Mini-Cog™ has been validated for dementia screening, but many individuals with clinically meaningful cognitive impairment will score higher. When greater sensitivity is desired, a cut point of <4 is recommended as it may indicate a need for further evaluation of cognitive status.

Clock Drawing

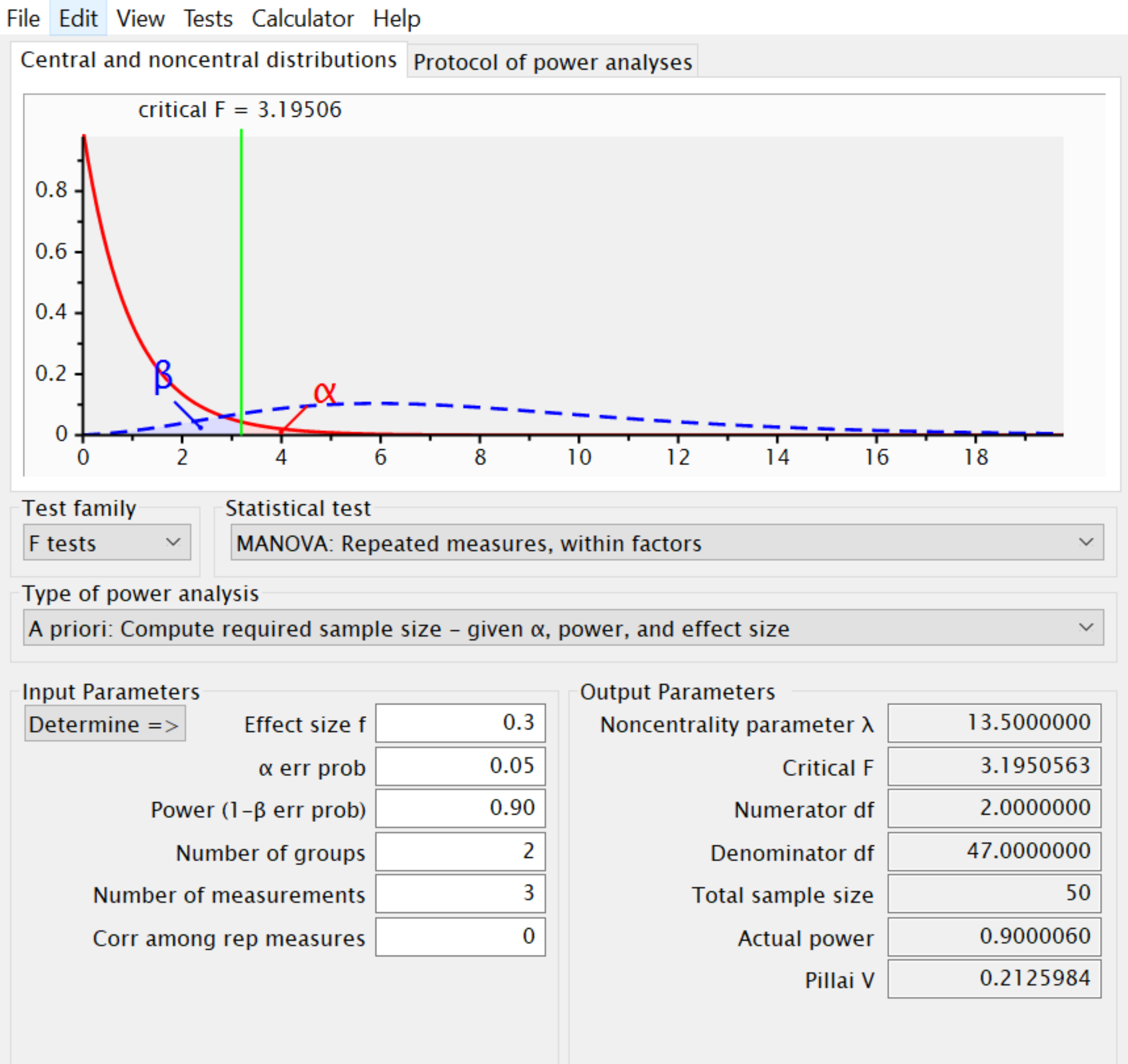
ID: ______________ Date: ________________________

Appendix 8: Raw data excerpt

	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Age	Sex	Race	Marital st	Occupatio	Height in	Weight in	BMI	Disease type	Year of diagn	Duration	Educational level	Weekly frequ	Disability
2	36	Male	Asian	Married	Engineer	171	96	32.8	Traumatic Brain Injur	2021	2	Postgraduate deg	1	2
3	50	Male	Black	Married	Construct	178	90	28.41	Traumatic Brain Injur	2020	3	Undergraduate de	1	2
4	52	Male	Asian	Single	Sales repr	172	80	27.04	Stroke	2022	1	Undergraduate de	1	3
5	58	Female	Black	Married	Lawyer	158	68	27.24	Stroke	2019	4	High school	1	3
6	69	Female	British	Widow/w	Retired	170	80	28	Huntington's disease	2014	9	Undergraduate de	1	3
7	72	Female	British	Single	Retired	168	52	19	Stroke	1968	55	High school	1	2
8	61	Female	Black	Single	Book keep	165	99	36.4	Stroke	2018	5	High school	1	2
9	38	Male	British	Married	Exercise tl	172	86	29.1	Traumatic Brain Injur	2016	7	Undergraduate de	1	2
10	74	Male	British	Married	Retired	166	70	25.4	Stroke	2015	8	Undergraduate de	1	2
11	70	Male	British	Single	Retired	170	58	20.1	Parkinson's disease	2020	3	Undergraduate de	1	3
12	58	Female	British	Divorced	Private ca	175	55	18	Parkinson's disease	2018	5	High school	1	2
13	68	Female	British	Married	Retired	168	57	20.2	Parkinson's disease	2019	4	Undergraduate de	1	3
14	60	Female	Asian	Widow/w	Carer	175	62	20.2	Stroke	2023	0	High school	1	3
15	63	Male	Asian	Married	Retired	185	72	21.04	Parkinson's disease	2016	7	Postgraduate deg	1	1
16	67	Female	Black	Single	Retired	168	52	19	Parkinson's disease	2015	8	Undergraduate de	1	2
17	68	Female	British	Married	Retired	164	62	23.1	Parkinson's disease	2020	3	Undergraduate de	1	2
18	66	Female	British	Married	Retired	165	49	18	Parkinson's disease	2014	9	Undergraduate de	1	2
19	66	Male	British	Married	Retired	175	74	24	Parkinson's disease	2016	7	Postgraduate deg	1	2
20	63	Female	British	Single	Nurse	155	64	27	Parkinson's disease	2015	8	Postgraduate deg	1	2
21	66	Female	British	Single	Journalist	168	52	19	Parkinson's disease	2015	8	Postgraduate deg	1	2
22	38	Male	Black	Married	Support w	178	70	22.09	Traumatic Brain Injur	2021	2	Undergraduate de	1	2
23	58	Female	British	Married	Retired	165	60	22.04	Multiple Sclerosis	2014	9	Undergraduate de	1	2
24	61	Female	Black	Married	Marketer	170	78	28	Stroke	2020	3	High school	1	3
25	60	Male	Black	Married	Teacher	158	68	27.24	Stroke	2019	4	High school	1	3
26	70	Female	Asian	Divorced	Retired	170	60	20.8	Parkinson's disease	2017	6	Undergraduate de	1	3
27	68	Male	British	Divorced	Retired	168	57	20.2	Parkinson's disease	2020	3	Undergraduate de	1	2
28	67	Female	Black	Single	Retired	165	49	18	Parkinson's disease	2019	4	Undergraduate de	1	2
29	42	Male	British	Single	Engineer	175	74	24	Multiple Sclerosis	2021	2	High school	1	2
30	62	Female	British	Married	Librarian	155	64	27	Multiple Sclerosis	2014	9	High school	1	3
31	68	Female	British	Married	Retired	165	49	18	Parkinson's disease	2015	8	Undergraduate de	1	2
32	66	Female	Black	Single	Retired	175	74	24	Parkinson's disease	2015	8	High school	1	2
33	66	Female	Black	Divorced	Retired	165	60	22.04	Parkinson's disease	2022	1	Undergraduate de	1	2
34	63	Female	Asian	Married	Teacher	168	52	19	Parkinson's disease	2021	2	Undergraduate de	1	3
35	50	Female	Black	Single	Retired	160	66	25.78	Stroke	2014	9	Undergraduate de	1	2
36	61	Female	Asian	Single	Retired	165	49	18	Stroke	2020	3	High school	1	2
37	60	Female	Asian	Married	Retired	168	52	19	Parkinson's disease	2019	4	Undergraduate de	1	3
38	70	Female	British	Married	Engineer	153	58	24.8	Parkinson's disease	2017	6	High school	1	3
39	68	Female	British	Single	Retired	165	53	19.5	Parkinson's disease	2020	3	Postgraduate deg	1	3

	C	D	E	F	G	H	I	J	K	L	M	N	O	P
39	68	Female	British	Single	Retired	165	53	19.5	Parkinson's disease	2020	3	Postgraduate deg	1	3
40	67	Male	British	Divorced	Retired	175	74	24	Parkinson's disease	2019	4	Undergraduate de	1	2
41	71	Male	British	Married	Retired	167	80	28.69	Stroke	2018	5	High school	1	3
42	47	Female	Asian	Single	IT support	166	57	20.7	Multiple Sclerosis	2015	8	Postgraduate deg	2	2
43	66	Male	British	Widow/w	Sales man	175	74	24	Huntington's disease	2019	4	High school	2	3
44	52	Female	British	Divorced	Teacher	165	65	23.88	Traumatic Brain Injur	2015	8	High school	2	2
45	70	Female	Asian	Married	Retired	165	59	21.67	Stroke	2021	2	High school	2	3
46	50	Female	Asian	Single	Private ca	175	74	24	Traumatic Brain Injur	2014	9	Undergraduate de	2	2
47	59	Male	Asian	Single	Nurse	155	64	27	Parkinson's disease	2020	3	Undergraduate de	2	2
48	62	Male	British	Married	Teacher	168	52	19	Stroke	2019	4	Undergraduate de	2	3
49	66	Female	Black	Married	Retired	165	55	20.2	Parkinson's disease	2022	1	Postgraduate deg	2	3
50	68	Female	British	Single	Retired	170	70	24.22	Parkinson's disease	2020	3	Undergraduate de	2	2
51	55	Female	British	Divorced	Retired	158	68	27.24	Stroke	2019	4	High school	2	2
52	69	Female	British	Married	Retired	170	70	24.22	Parkinson's disease	2018	5	High school	2	2
53	70	Female	British	Single	Retired	168	58	20.6	Parkinson's disease	2015	8	Undergraduate de	2	3

Appendix 9: Sample size calculation using G-power



Appendix 10: Rebound exercise training certificate

Physioplus

This is to certify that

Adaora Justina Okemuo

Completed the Physioplus online course:

Rebound Therapy

Course instructor:

Paul Vernon Kaye

2.8

Physioplus points awarded

Rachael Lowe, CEO Physioplus **Date: 27 Jul 2022**

1 Physioplus point is equivalent to 1 hour of learning - accreditors may award different CCUs, CEUs or CPD points

Certificate validity code (http://bit.ly/ppcertcheck): afc0c9fc26855890e338b9b104ef57b3-u129097-t20364-p2.8-d1658937054

Health and Care Professions Council: License No. PH128856

South African Society of Physiotherapy: PPB007/PT000/2022/070 (4 General CEUs Level 1)

10 Queen Street Place, London, EC4R 1BE, United Kingdom : accreditation@physio-pedia.com

Appendix 11: Data Collection Sheet

Name (initials): S/N:

Sex: Age: Occupation: Marital status:

Height: Weight: BMI: Year of diagnosis:

Smoking status: Disease type: BP: HR:

Educational level: High school, Undergraduate degree, Postgraduate degree

Disability level on Modified Rankin Scale:

Baseline measurement Date:

3MBWT:

10MWT:

QOL:

PAL:

Mini-cog:

Grip strength:

Mid-trial assessment Date:

3MBWT:

10MWT:

QOL:

PAL:

Mini-cog:

Grip strength:

End of trial assessment Date:

3MBWT:

10MWT:

QOL:

PAL:

Mini-cog:

Grip strength:

Appendix 12: Risk Assessment/ Pre-participation Screening Questionnaire

Assess your health status by marking all true statements

History catheterisation

-a heart attack	-heart surgery	-cardiac catheterisation coronary
-angioplasty (PTCA)	-heart failure	- congenital heart disease
-rhythm disturbance	-heart valve disease	-heart transplantation

-Pacemaker/implantable cardiac defibrillator

Symptoms:

Do you experience chest discomfort with exertion?

Do you experience unreasonable breathlessness?

Do you experience dizziness, fainting, or blackouts?

Do you take heart medications?

Other health issues

Diabetes Mellitus	Asthma or other lung diseases
Concerns about the safety of exercise	Take prescription medication(s).

Burning or cramping sensation in your lower legs when walking short distances

Musculoskeletal problems that limit your physical activity.

Cardiovascular risk factors

You are a man older than 45 years.

You are a woman older than 55, have had a hysterectomy, or are postmenopausal.

You smoke or quit smoking within the previous six months.

Your blood pressure is >140/190 mm Hg.

You take blood pressure medication.

Your blood cholesterol level is >200 mg/dl.

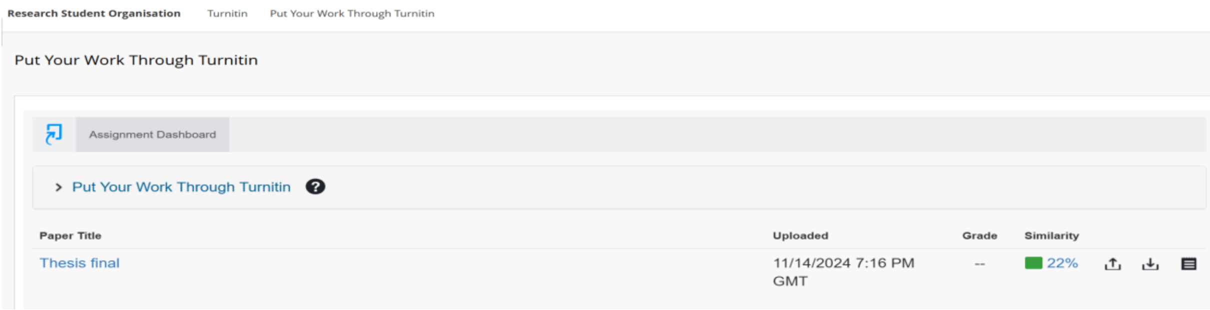
You do not know your cholesterol level.

You have a close blood relative who had a heart attack or heart surgery before age 55 (father or brother) or age 65 (mother or sister).

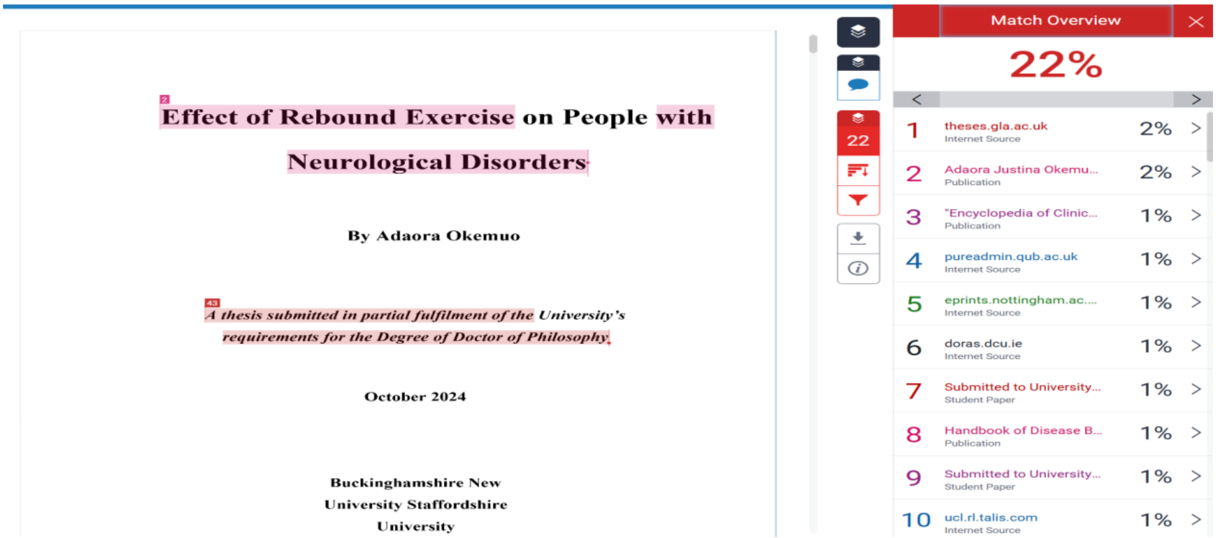
You are physically inactive (i.e., you get <30 minutes of physical activity on at least three days per week).

You are >20 pounds overweight.

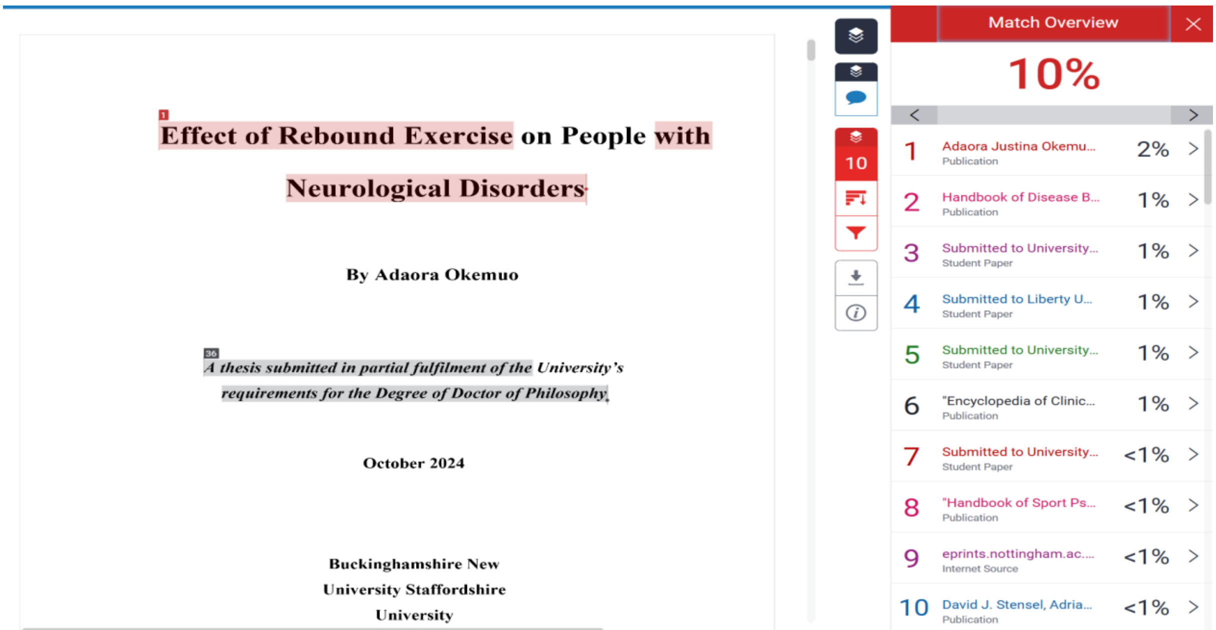
Appendix 13: Similarity check report



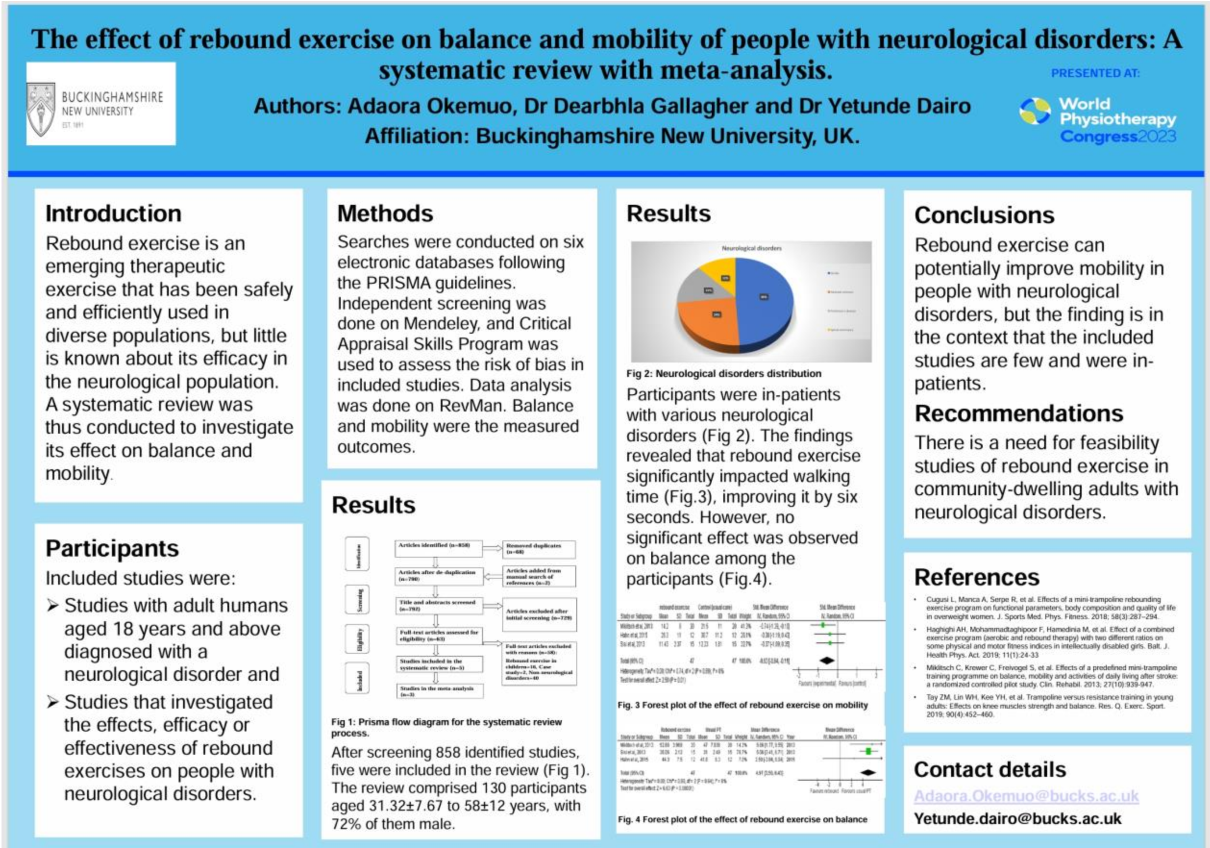
With the bibliography (reference list) included



With the bibliography (reference list) excluded



Appendix 14: Poster presentation of study one at World Physiotherapy Congress, 2023.



Appendix 15: Postcard presentation at the BNU Conference in July 2024.

Appendix 16: Study one publication at PlosOne journal and link to the full text.

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RESEARCH ARTICLE

Effects of rebound exercises on balance and mobility of people with neurological disorders: A systematic review

Adaora Justina Okemuo, Dearbhla Gallagher, Yetunde Marion Dairo

Published: October 5, 2023 • https://doi.org/10.1371/journal.pone.0292312

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Abstract

Background

Therapeutic rebound exercise is gaining popularity among the general population, but its effectiveness in individuals with neurological impairments remains uncertain. To shed light on this, a systematic review was conducted between November 2021 and March 2023 to study the impact of rebound exercise on balance and mobility in this group.

Methods

Six databases were searched. Studies were included if written in English, peer-reviewed, had original research data and assessed the effect of rebound exercise in adults with neurological disorders. The outcomes measured were balance and mobility. Two reviewers independently appraised study quality using the Critical Appraisal Skills Program for Randomized Controlled Trials. Finally, a meta-summary of the included studies was completed, and a meta-analysis was performed using RevMan software version 5.3 to determine the effectiveness of the intervention.

Results

Five studies were included comprising 130 participants aged 31.32±7.67 to 58±12 years, 72% male and 28% female. Participants were in-patients with stroke (49%), multiple sclerosis (24%), Parkinson's disease (15%) and spinal cord injury (12%). The included papers had moderate to high methodological quality. The timed up-and-go test revealed that the rebound group

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Exercise
Metaanalysis
Systematic reviews
Database searching
Exercise therapy
Strength training
Walking

https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0292312

Appendix 17: Study two publication in Nursing and Health Sciences with a link to the full text.

Nursing & Health Sciences

RESEARCH ARTICLE | Open Access

Feasibility of Using Rebound Exercise in Community-Dwelling Adults With Neurological Disorders

Adaora Justina Okemuo, Yetunde Marion Dairo, Dearbhla Gallagher

First published: 29 November 2024 | https://doi.org/10.1111/nhs.70004

Funding: This study was part of a fully-funded PhD research by Buckinghamshire New University, High Wycombe.

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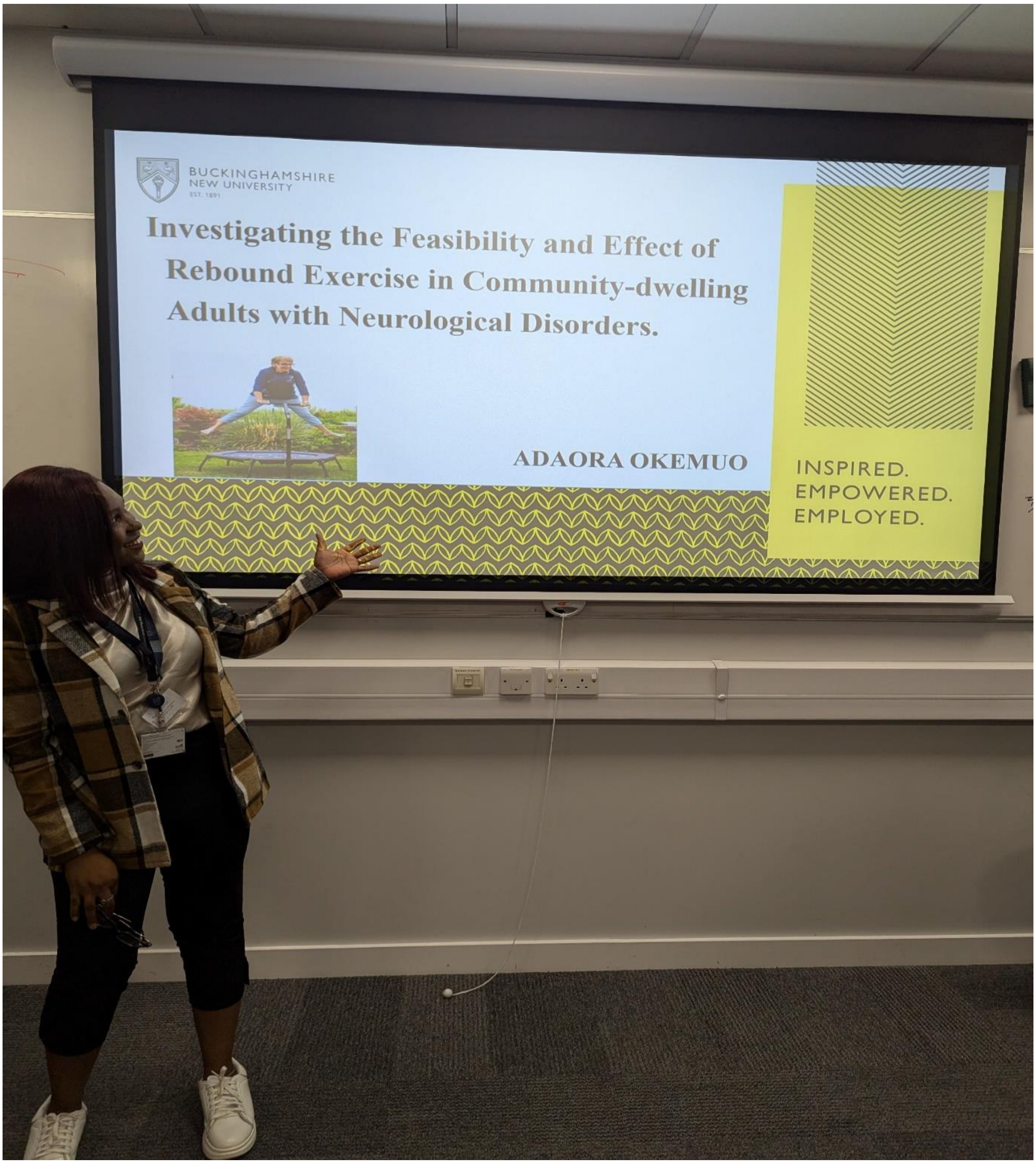
ABSTRACT

Rebound exercise (RE) increases mobility in hospitalized adults with neurological disorders (AwND), but its feasibility in community settings remains largely unexplored. This study evaluates the practicality of implementing RE in the community, particularly for AwND. The feasibility study involved 53 community-dwelling AwND engaging in RE sessions for 30 min, once- or twice-weekly, over 12 weeks. Feasibility was assessed through recruitment rates, adherence, attrition, and participant feedback. The study measured blood pressure (BP), walking speed (WS), and physical activity level (PAL) at baseline, 6 weeks, and 12 weeks. Repeated measures ANOVA and the Friedman tests were used to test for significant differences across the time points. The study demonstrated high recruitment (70.59%) and retention (98.1%) rates, with most participants (76.9%) preferring once-weekly sessions due to time constraints. There were no reported injuries or adverse events. Most participants were older adults (50%), females (67.3%), and retired (55.8%). Significantly lower resting BP ($p < 0.001$), higher WS ($p < 0.001$), and PAL ($p = 0.000$) were observed after 12 weeks of RE. In conclusion, RE is a feasible, safe, and acceptable intervention for supervised community-dwelling AwND and could be a valuable tool for promoting PAL in this population.

https://onlinelibrary.wiley.com/doi/full/10.1111/nhs.70004

Appendix 18: Platform and poster presentations at BNU Conference, July 2024.



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Empowerment Through Research: Bridging Academia and Society

Investigating a Minimum Effective Dose and Effect of Rebound Exercise in Community -Dwelling Adults with Neurological Disorders: A Pre -Post Interventional Study.

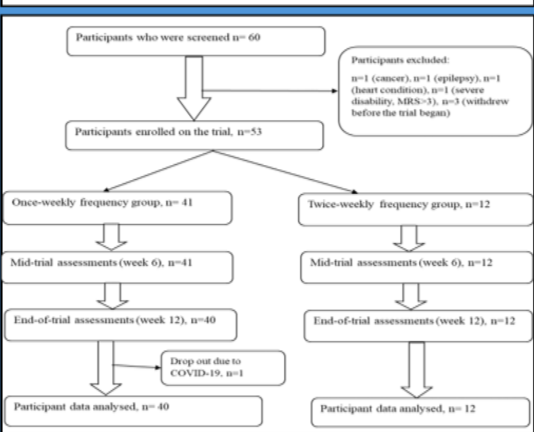
Adaora Okemuo

Background and purpose

Studies show that performing rebound exercises (RE) thrice weekly can improve mobility for patients with neurological disorders (ND) in a hospital setting. However, it is unclear whether the same result can be achieved in the community with less frequent intervention. Therefore, this study aimed to identify a low effective frequency dose of RE and its impact on the physiological and physical functions of adults with ND living in the community.

Method

The study involved 52 individuals (17 men and 35 women) with ND who could walk independently for at least two minutes. The participants engaged in a 30-minute RE once or twice weekly, based on their preference. The study measured their blood pressure (BP), heart rate (HR), balance, walking speed (WS), physical activity level (PAL), and quality of life (QoL) at the baseline, six weeks, and 12 weeks. Statistical tests like Repeated measures ANOVA, Friedman, Independent t-test, and Mann-Whitney U tests were used to test for significant differences within and between groups for the normally distributed and skewed data. The analysis was conducted using SPSS software, version 28.

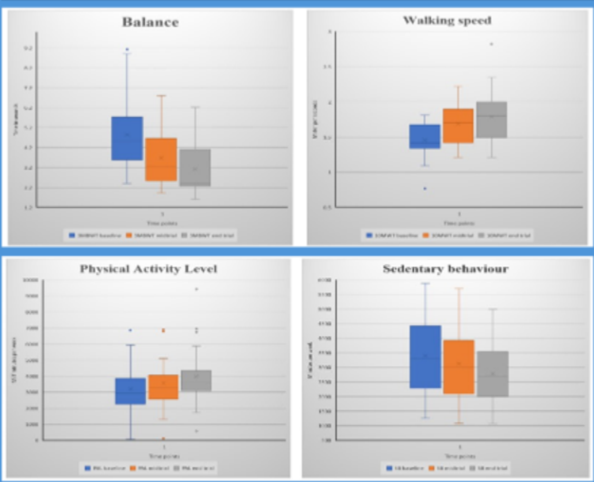


Acknowledgement

I want to express my gratitude to the participants who participated in this study and to Parkinson's Disease UK for their support in the recruitment process.

Result

The majority of the participants were female (67.3%), married (46.2%), retired (55.8%), non-smokers (90.4%) and were within the 65-74 years age range (50%). Most of them attended the rebound exercise once a week (76.9%), had Parkinson's disease (50%) and had been diagnosed within the previous 3-4 years (34.6%). The study found significant differences in the participants' BP ($p<0.05$), HR ($p=0.021$), balance ($p=0.000$), WS ($p<0.05$), PAL ($p=0.000$) and QoL ($p<0.05$) across all time points. However, no significant difference was found between participants who attended once-weekly (n=40) and those who attended twice-weekly (n=12) groups for all outcomes ($p>0.05$).



Conclusion

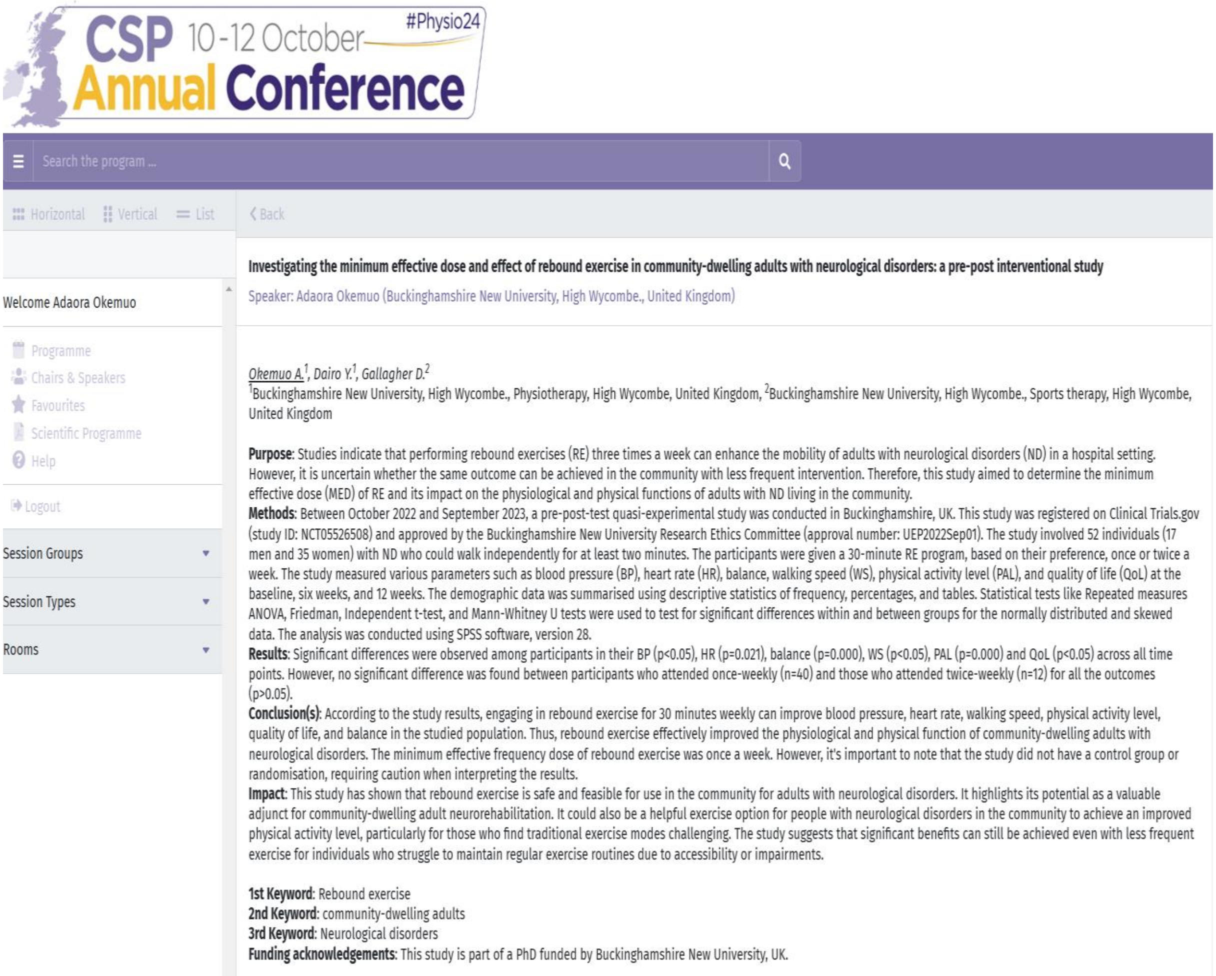
Rebound exercise has shown promising results in improving the physiological and physical function of community-dwelling adults with neurological disorders. The study found that a once-a-week frequency improves these outcomes in this population. Identifying a minimum effective frequency dose holds significant implications for enhancing the accessibility and feasibility of rebound exercise interventions in community-based rehabilitation programs.

References

Okemuo, A.J., Gallagher, D. and Dairo, Y.M. (2023) "Effects of rebound exercises on balance and mobility of people with neurological disorders: A systematic review," *PLOS ONE*. Edited by R.K.Elnaggar, 18(10), p. e0292312.

Posch, M. *et al.* (2019b) "Effectiveness of a mini-trampoline training program on balance and functional mobility, gait performance, strength, fear of falling and bone mineral density in older women with osteopenia," *Clinical Interventions in Aging*, 14, pp. 2281–2293. Available at: https://doi.org/10.2147/CIA.S230008

Appendix 19: Platform presentation at the CSP Conference, Manchester Oct. 2024.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Investigating the minimum effective dose and effect of rebound exercise in community-dwelling adults with neurological disorders: a pre-post interventional study

Speaker: Adaora Okemuo (Buckinghamshire New University, High Wycombe., United Kingdom)

Okemuo A.[1], *Dairo Y.*[1], *Gallagher D.*[2]
[1]Buckinghamshire New University, High Wycombe., Physiotherapy, High Wycombe, United Kingdom, [2]Buckinghamshire New University, High Wycombe., Sports therapy, High Wycombe, United Kingdom

Purpose: Studies indicate that performing rebound exercises (RE) three times a week can enhance the mobility of adults with neurological disorders (ND) in a hospital setting. However, it is uncertain whether the same outcome can be achieved in the community with less frequent intervention. Therefore, this study aimed to determine the minimum effective dose (MED) of RE and its impact on the physiological and physical functions of adults with ND living in the community.
Methods: Between October 2022 and September 2023, a pre-post-test quasi-experimental study was conducted in Buckinghamshire, UK. This study was registered on Clinical Trials.gov (study ID: NCT05526508) and approved by the Buckinghamshire New University Research Ethics Committee (approval number: UEP2022Sep01). The study involved 52 individuals (17 men and 35 women) with ND who could walk independently for at least two minutes. The participants were given a 30-minute RE program, based on their preference, once or twice a week. The study measured various parameters such as blood pressure (BP), heart rate (HR), balance, walking speed (WS), physical activity level (PAL), and quality of life (QoL) at the baseline, six weeks, and 12 weeks. The demographic data was summarised using descriptive statistics of frequency, percentages, and tables. Statistical tests like Repeated measures ANOVA, Friedman, Independent t-test, and Mann-Whitney U tests were used to test for significant differences within and between groups for the normally distributed and skewed data. The analysis was conducted using SPSS software, version 28.
Results: Significant differences were observed among participants in their BP ($p<0.05$), HR ($p=0.021$), balance ($p=0.000$), WS ($p<0.05$), PAL ($p=0.000$) and QoL ($p<0.05$) across all time points. However, no significant difference was found between participants who attended once-weekly ($n=40$) and those who attended twice-weekly ($n=12$) for all the outcomes ($p>0.05$).
Conclusion(s): According to the study results, engaging in rebound exercise for 30 minutes weekly can improve blood pressure, heart rate, walking speed, physical activity level, quality of life, and balance in the studied population. Thus, rebound exercise effectively improved the physiological and physical function of community-dwelling adults with neurological disorders. The minimum effective frequency dose of rebound exercise was once a week. However, it's important to note that the study did not have a control group or randomisation, requiring caution when interpreting the results.
Impact: This study has shown that rebound exercise is safe and feasible for use in the community for adults with neurological disorders. It highlights its potential as a valuable adjunct for community-dwelling adult neurorehabilitation. It could also be a helpful exercise option for people with neurological disorders in the community to achieve an improved physical activity level, particularly for those who find traditional exercise modes challenging. The study suggests that significant benefits can still be achieved even with less frequent exercise for individuals who struggle to maintain regular exercise routines due to accessibility or impairments.

1st Keyword: Rebound exercise
2nd Keyword: community-dwelling adults
3rd Keyword: Neurological disorders
Funding acknowledgements: This study is part of a PhD funded by Buckinghamshire New University, UK.

Appendix 20: Rebound exercise training video links

https://youtu.be/XetVh2nH0RA?si=Brl-nDSoqW_RDqsF

https://youtu.be/fAdh8inD7QU?si=tClrqceJ9rqDBjJh

https://youtu.be/N8I2_PkE6u0?si=e8G-aZZJL1aRh59S