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COMPARISON OF MOTOR RELEARNING OCCUPATION-BASED AND NEURODEVELOPMENTAL TREATMENT APPROACHES IN TREATING PATIENTS WITH TRAUMATIC BRAIN INJURY

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A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Science in Occupational Therapy.

Johannesburg

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Declaration

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

Signature ______________________

23th Day of **October**, 2020.

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Dedication

I dedicate this research work to my mother, Mrs Susan Nowa for her faith in me which was the only thing that kept me going. May her soul rest in eternal peace.

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This study has been completed because of the kind support from many individuals, organisations and parties. I would like to extend my sincere gratitude to all of them.

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Abstract

Background: Traumatic Brain Injury is caused by trauma related to motor vehicle accidents (MVAs), accidental falls and violence. Around the world, approximately 69 million people annually suffer a traumatic brain injury due to various causes with the majority of cases affecting low and middle income countries (LMICs). The management of traumatic brain injury requires a multidisciplinary approach which includes rehabilitation. The main aim of the study was therefore to evaluate the outcomes of the Neurodevelopmental Treatment) and motor relearning occupation-based approaches on physical performance and self-care among adults with traumatic brain injuries.

Methods: An experimental research design comparing two groups and a pre-test post-test design was used in the study. No control group was included as all participants with traumatic brain injury were receiving treatment using either of the two approaches. The researcher developed a demographic questionnaire to determine demographic characteristics of the study, the Fugl Meyer Assessment to evaluate the motor performance and a Modified Barthel Index to ascertain the functional independence of the participants before and after interventions.

Results: Forty (66.7%) participants were male with ages ranging from 18 to 68 years, half (50%) had secondary education, about 35% had tertiary education and the majority (50%) were never married. Almost all (98.3%) the participants had no previous history of injury with only one reporting a previous traumatic brain injury. Motor vehicle accidents accounted for the majority of participants' (65%) injury with an age range of 18 – 54. A Wilcoxon Signed Rank Test revealed a statistically significant increase in Fugl Meyer and Modified Barthel Index values for all aspects of the assessment following participation in the motor relearning occupation-based group and the Neurodevelopmental Treatment group in the upper and lower extremity values, ($p < 0.001$) with large effect sizes. A Mann Whitney U test revealed that motor relearning occupation-based approaches were more effective than the Neurodevelopmental Treatment approaches with most components for both groups achieving the reported minimal clinically important difference. There was a significant statistical difference in total scores for the motor relearning approach and the Neurodevelopmental Treatment group, ($p = 0.020$, with a large effect size ($r=0.42$)), upper extremity ($p = 0.014$) and wrist scores ($p = 0.027$) with large effect sizes (r=0.45) and (r=0.40) respectively indicating the difference was clinically important. Mann Whitney U test, applied to compare post-test Modified Barthel Index scores revealed a significant difference in the chair/bed transfer in motor relearning occupation-based group participants and had a significantly larger improvement in mobility components including chair/bed transfers (p = 0.002), ambulation (p = 0.037), stair climbing (p = 0.027) and toilet transfers (p = 0.023) all with large and moderate effect sizes (r=0.28-0.39).

There was an improvement on self-care components including bathing (p=0.001), dressing (p=0.001) and personal hygiene (p=0.008) with large effect sizes (r=0.34-0.53), indicating clinically important improvement compared to Neurodevelopmental Treatment group participants. There was no significant difference in ambulation, bowel and bladder control and feeding between motor relearning occupation-based and Neurodevelopmental Treatment approach group participants with small effect sizes. The Neurodevelopmental Treatment approach showed greater improvement in pain scores on a Fugl Meyer upper extremity test and lower extremity test.

Conclusion: Both the motor relearning occupation-based and the Neurodevelopmental Treatment approach are effective in improving physical performance and self-care after acute traumatic brain injury with significant changes within both groups for all components assessed. The motor relearning occupation-based approach showed greater improvement in the total, upper extremity and wrist scores as reported by the Fugl Meyer upper extremity test. It also showed superiority in the Modified Barthel index scores namely chair/bed transfers, ambulation/wheelchairs/ stair climbing, toilet transfers and bathing, dressing and personal hygiene.

Keywords: Self-care, Neurodevelopmental Treatment, Motor relearning occupation-based approach.

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Operational Definitions

Motor Relearning Treatment Approach

An approach concerned with the patient's ability to solve movement problems to accomplish everyday functional tasks in areas of occupations using movement processes, through practice or experience, that lead to permanent change in a person's capacity for skilled action (Muratori *et al.*, 2014).

Neurodevelopmental Treatment Approach

It is a client centred approach, in which the therapist uses hands-on problem solving techniques in the management of children and adults with neurological conditions that affect posture, movement and function after a damage in the central nervous system (Zanon *et al.*, 2018).

Traumatic Brain Injury

A health condition that results in a series of processes that are caused by primary and secondary injuries due to external impact to the brain causing temporary or permanent neurological deficits (Galgano *et al.*, 2017).

Neuroplasticity

It can be concisely described as the brain's ability to create adaptive changes in morphological and network neuronal structure and function of nervous system, which includes changes in neuronal connectivity, neurogenesis and neurochemical changes (Sasmita, Kuruvilla and Ling, 2018).

Occupations

These are life activities that people execute as individuals, groups or societies which include activities of daily living, education, work, leisure, social participation, rest and sleep (Brown and Hollis, 2013).

Self-care

The basic activities performed when caring for oneself on a daily basis. It involves activities of daily living such as personal care tasks including toileting, bathing, dressing, eating and grooming. (Schell *et al.*, 2013, pg 539) (Guidetti and Tham, 2002).

Abbreviations

ADLs	Activities of Daily Living
CNS	Central Nervous System
GCS	Glasgow Coma Scale
GMP	Generalised Motor Programmes
LMICs	Low and Middle Income Countries
MVAs	Motor Vehicle Accidents
NDT	Neurodevelopmental Treatment
QOL	Quality of Life
TBI	Traumatic Brain Injury

CHAPTER 1 INTRODUCTION

1.1 Introduction and background to the study

This section serves to introduce and provide background for this study about the different approaches in the rehabilitation of patients with Traumatic Brain Injury (TBI). The gaps in research were ascertained to describe the problem statement.

Traumatic brain injuries remain one of the most debilitating conditions in neurorehabilitation. It affects individuals' and communities' performance in areas of occupations which include self-care, leisure and productivity. Occupational therapists working with these clients use different approaches to assist them. By examining the effectiveness of two of the most commonly used approaches namely Neurodevelopmental Treatment (NDT) and the motor relearning occupation-based approaches, their efficacy will be ascertained which will reduce the burden of care for the patients suffering from traumatic brain injury.

"Traumatic Brain Injury is defined as an alteration in brain function, or other evidence of brain pathology caused by external forces" (Menon *et al*, 2010 p. 1637). Traumatic Brain Injury has been known to be caused by trauma related to motor vehicle accidents (MVAs), accidental falls and violence. It may cause disruptions in higher-order functions such as thinking, processing inputs from the environment and motor functions (Viano *et al.*, 2017). Around the globe, the assumption is that 69 million people suffer a TBI from various causes which are related to their socioeconomic status and other characters in different contexts annually (Dewan *et al.*, 2018). The patterns and distribution of head injury may be specific to different geographic regions/countries and may be related to adherence, preventive and safety measures (Zolotor *et al.*, 2015).

1.1.1 Impact of Traumatic brain injury.

Developing and low and middle-income countries (LMICs) report the highest prevalence of TBI affecting males at the age of 45 and below. Motor vehicle accidents account for the majority of these injuries due to poor enforcement of road and vehicle regulations (Dewan *et al.*, 2018;Bustamante *et al.*, 2016). In countries such as South Africa, Namibia, Taiwan and India, head injury resulting from MVAs is common for drivers, passengers and pedestrians (Naidoo, 2013; Dewan *et al.*, 2018). The incidence of TBI resulting from MVAs in these LMICs is reported at 56%, in comparison to the lowest rate (25%) which occurs in the United States of America (USA) (Dewan *et al.*, 2018). Although there are no prevalence figures for TBI in Namibia where this study was conducted, reported incidences of MVAs with fatalities increased by 2% in 2016 affecting the sustainable development goals which aim at reducing road deaths and injuries by 2020 (Motor Vehicle Accident Fund, 2016).

Traumatic brain injury causes a global economic and personal burden due to the extended time and cost involved in resolving the consequences of the condition, some of which may be permanent. The results from different studies done globally show that the impact of TBI is significant and of clinical concern (Hyder *et al*., 2007). While the burden of this condition is witnessed in all parts of the world, the burden in LMICs is higher. This is seen by lifetime disabilities and life-threatening risk factors as a result of the incidence of TBI and limited rehabilitation access (Hyder *et al*., 2007). It is estimated that over 80% of the people living with disabilities live in LMICs, however, only 2% receive rehabilitation services (Hyder *et al.*, 2007).

1.1.2 Current trends in management of Traumatic Brain Injury

The management of TBI and acquired brain injuries requires a multidisciplinary approach which includes rehabilitation. Rehabilitation post-TBI may be crucial if the effects of impairments, activity limitations, and participation restrictions are to be addressed (OTASA, 2017). The disruption in the execution of activities that bring meaning to life, that occurs post-TBI, is a consequence of physical and cognitive deficits. This disruption of participation in the execution of activities of daily living (ADLs) may result in increased dependence on others and decreased quality of life (QOL). This is due to deficits in higher order structures that are involved in planning and execution of smooth coordinated movements that affect the way individuals execute tasks (Chan *et al*., 2006; Powell *et al*., 2016). Occupational therapists as part of the multidisciplinary team involved in the rehabilitation of TBI, use different treatment approaches to reduce impairments and facilitate participation in activities. The outcomes of occupational therapy for clients with TBI include a return to performance in occupations that enable them to find meaning, increase participation and satisfy their potential in life in their homes and communities (Soeker and Pape, 2019).

Recent research evidence in occupational therapy shows that different approaches used in rehabilitation have different outcomes for health conditions such as stroke (OTASA, 2017; Rao, 2011). In a top-down or occupation-based approach, the outcome is measured by the execution of desired occupations by clients supporting their interests and daily life (Powell, Rich and Wise, 2016). Desired occupations can be categorised into “restorative occupations, engaging occupations, occupations that foster belonging and occupations reflecting life continuity” (Hammell, 2009). Other bottom-up approaches such as Bobath's Neurodevelopmental Treatment (NDT) support the execution of occupations but their goal is based on therapeutic handling to facilitate recovery of specific components or client factors (Bobath, 1969).

The theory of motor relearning supports the occupation-based approach which emphasizes that motor skill is acquired through three stages namely acquisition phase, retention phase and practice phase. Motor relearning is the utilization of internal processes through the practice of specific goal-directed meaningful tasks to produce changes that are long-lasting and transferable to other tasks or occupations (Jarus, 1994; Poole, 1991). The theory proposes that normal motor skills can be regained through repeated practice of goal-directed movements with the patients fully immersed in specific tasks and activities while offering feedback (Chan, Chan and Au, 2006). A good example is transfers learnt in a hospital from bed to chair that can be used to transfer a patient from the chair to the toilet seat when they are discharged. Motor relearning theory depends on movement organization, environmental factors and cognitive processes (Jarus, 1994). Motor relearning should be facilitated by goal setting and Dawson *et al.*, (2013) reported that the training for real-world outcomes required motor relearning intervention to include meaningful real-world activities in the occupation-based intervention. They found this showed a clinically significant change for the occupational goals set with patients with TBI.

Neurodevelopmental Treatment approaches follow the theory of neuroplasticity in facilitating movement in the body by using specific handling techniques. Neuroplasticity emphasizes tissue remodelling which can be done by restitution or compensation (Loubinoux *et al*., 2017). Restitution is when there is redundancy at the site of lesion and compensation is when the perilesional or distant areas are recruited. This occurs through four stages namely; cellular lysis and inflammation, diaschisis, expansion and focalization (Loubinoux *et al.*, 2017). The result will be hyper excitability or hypo excitability of neurons as well as modifications and redistributions of synaptic strength (Loubinoux *et al.*, 2017). The NDT approaches were crafted by Bertha and Karl Bobath. They emphasized that movement can be elicited by the use of key points of control while preventing abnormal reflexes (Kollen *et al*., 2009). They believed that primitive reflexes must be integrated and inhibited to assist brain areas that would have lost control of movement to regain their capabilities (Kollen *et al.*, 2009).

1.2 Problem Statement

Occupational Therapists working in neuro-rehabilitation use techniques based on neuroplasticity however, the evidence that supports their efficacy is limited and not conclusive especially in the management of TBI. In his review of research in the practice area of neurological rehabilitation published between May 2010 and October 2011, Rao (2011) concluded that most intervention studies were single-case research designs and there is a need for studies such as randomised control trials to provide better evidence. This was supported in the South African context as alluded to the position paper by OTASA (2017). Occupational therapy interventions remain deficiently documented, and there is not much known on how their interventions can assist individuals with TBI (Powell, Rich, and Wise, 2016). Therefore, it becomes difficult to ascertain the measure in which motor relearning occupation-based interventions and NDT approaches attempt to improve the care and management of TBI (Powell, Rich, and Wise, 2016). Lack of evidence-based practice in occupational therapy reduces accountability and best practices that work for the advantage of the patients receiving treatment. It also promotes subjective and biased clinical practice which hinders proper decision making and increases hospital stay. Determining the efficacy of the treatment approaches used in treating patients with TBI will enable the development and synthesis of a body of knowledge in occupational therapy, in the Namibian setting that is contextual, respectful and appropriate for the client base.

1.3 Research Question

Which approach is more effective in improving physical performance and self-care among adults with Traumatic Brain Injury between a NDT and a motor relearning occupation-based approach?

1.4 Aim of the Study

To evaluate the outcomes of the NDT and a motor relearning occupation-based approach to physical performance and self-care among adults with TBI.

1.4.1 Objectives of the study

- To determine the common causes and types of TBI among patients admitted at Katutura Intermediate Hospital.
- To determine the outcomes of motor relearning occupation-based approach on physical performance and self-care among adults post-acute TBI.
- To determine the outcomes of the NDT approach on physical performance and self-care among adults post-acute TBI.
- To compare the outcomes between motor relearning occupation-based and NDT approaches in adults post-acute TBI and association between the physical performance and self-care for both groups.

1.5 Null Hypotheses

- There will be no differences on the outcomes between motor relearning occupation-based and NDT approaches in physical performance outcomes in adults post-acute TBI.
- There will be no differences on the outcomes between motor relearning occupation-based and NDT approaches in self-care outcomes in adults post-acute TBI.

1.6 Significance of the Study

Neurological conditions cause a serious economic burden in terms of the amount of money and time required in rehabilitation. Occupational therapists working with TBI in rehabilitation centres need to know the effects of their treatment modalities, hence the need for research in this area. The research will provide evidence for treatment programmes that are cost-effective and have positive effects on occupational performance outcomes.

The study aims at increasing the body of knowledge in the profession of occupational therapy. It will assist in the training of occupational therapists with empirical evidence based on the findings from the study which supports specialised occupational therapy practices. The study also aims at approving the adoption of motor relearning occupation-based and NDT approaches in the Namibian setting when addressing patients with TBI. Evidence-based practice will be promoted to occupational therapists working in neurological rehabilitation settings.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This section reviewed the literature on the outcomes of NDT and motor relearning occupation-based approaches among adults with TBI. The literature sourced evaluated the body of knowledge to enable the comparison of treatment approaches in the rehabilitation of patients with acquired brain injuries. The information covered included the impairments, theoretical basis of treatments, principles of neuroplasticity, conceptual frameworks guiding clinical practice and treatment approaches in TBI.

The literature reviewed in this study was identified online using PubMed, Google scholar, Up to date, Cochrane database and review of books through the University of Witwatersrand library. The literature search was conducted between April 2018 and December 2018. The search words included traumatic brain injury, motor learning, neurodevelopmental treatment, neurofacilitatory approaches, occupation-based approaches and neuroplasticity. Research into theories and application of theories from the last century are included as this supports this study.

2.2 Impairments in Traumatic Brain Injury

Traumatic brain injury is a traumatically elicited injury to the structure of the brain that causes neurophysiologic changes such as changes in consciousness, memory and decreased movement functions when an external force is applied to the head (VA/DoD, 2009). According to Mckee & Daneshvar (2015), the clinical signs of a TBI include reduced level consciousness, loss of memory straight-off pre and post the insult. It also includes alteration in mental status neurological deficits and intracranial lesions. This leads to a decrease in an individual's ability to perform daily tasks at home and at work. The injury can be associated with long term physical, emotional, behavioural and cognitive deficits

2.2.1 Classification of traumatic brain damage

The severity of TBI can be quantified using the Glasgow Coma Scale (GCS) which grades the dysfunction as mild, moderate and severe. Glasgow Coma Scale scores between 13 and 15 show mild insults, while scores between 9 and 13 show moderate insults, they are often unresponsive to weak stimuli and severe TBI patients (GCS 3 -8) are comatose. Other classifications of TBI mentioned are either focal or diffuse injuries with mass lesions classified as diffuse injuries which have higher mortality than focal injuries that affect specific anatomical regions of the brain (Mckee and Daneshvar, 2015).

Classification of TBI can also be based on whether the injury resulted from direct or indirect physical injury. External mechanical forces produce primary direct injuries that manifest deformities of the brain tissue and disturb the traditional physiology of the brain. Mckee and Daneshvar notes "These forces can include acceleration/deceleration forces, rotational forces, blast forces, blunt forces, impact forces, and penetration forces" (Mckee and Daneshvar, 2015, pg 46). The traumatic forces are also known to damage the nerve cells, together with blood vessels that supply these areas in a focal, multifocal, or diffuse pattern (Vieira *et al.*, 2016). After the traumatic event, a number of cellular changes are observed which lead to inflammatory processes and changes in metabolism within the cells. On the other hand, secondary indirect neurologic impairment is produced by a series of secondary events that occur after the primary injury which include ischemic, hypoxic damage, cerebral oedema, increased intracranial pressure, hydrocephalus, and infection. If noted earlier in their development, these indirect secondary impairments can be altered (Mckee and Daneshvar, 2015).

2.2.2 Consequences of traumatic brain damage

Traumatic Brain Injury causes a global burden because of the extended time and costs in resolving the consequences of the condition. The disruption of the execution of activities that bring meaning to the lives of those with TBI is also a consequence due to physical and cognitive deficits. The participation in and execution of daily tasks is also littered with increasing dependence and decreasing QOL (Powell *et al*., 2016) because of a spread of impairments in mood, cognition, and movement, relying upon the severity and site of the injury.

The changes associated with TBI are not only related to motor manifestations. A number of psychosocial impairments are witnessed which include cognitive, memory, perceptual, language or intelligence deficits. Patients show signs of confusion, agitation, disorientation and delirium. Their information processing, attention and vigilance are affected in most cases. Some patients tend to be withdrawn, dull, and apathetic and lack motivation. A number of patients show attention and memory deficits. Visual and visuospatial dysfunction such as impaired figure-ground perception and constructional abilities are often witnessed in TBI patients (Sudarsanan *et al.*, 2007). A number of motor manifestations have been witnessed after an insult to the brain, these include a decline in planning movements, reduced memories of movement schemes, inability to correct movements, motor programming, motor integration and a decrease in gross motor and fine motor skills (Walker and Pickett, 2007) which affect the way they execute daily tasks (Chan *et al*., 2006). Difficulties in mobility that are caused by problems in balance, power, coordination, and cognition are common in traumatic brain injuries (Katz *et al.*, 2004). The other devastating impairment that is not always recognised is the loss of upper extremity function including the hand due to paralysis/paresis and clinicians should incorporate this into their rehabilitation protocols (Galea *et al.*, 2016). Occupational therapists are one of the team members involved in the rehabilitation of TBI and they use different intervention approaches designed to reduce impairments. Occupational therapy goals for successful rehabilitation of people with TBI should facilitate performance in occupations that enable them to address meaning, increase participation and satisfy their potential in life in their homes and communities.

Animals have been studied at length to determine how they are influenced by rehabilitation outcomes post TBI and this has led to a deep understanding of motor recovery in animal models. However, injury-induced neural-plasticity is elaborately concerning in motor rehabilitation following TBI. There is need for additional analysis in people with TBI to grasp the management of movement and theories of motor relearning. This will enable concise application of rehabilitation following brain injury (Kozlowski, Leasure and Schallert, 2013).

2.3 Motor control and motor learning

Motor neurorehabilitation is based on assumptions about the cause and nature of deficits in movement and the theories underlying practices in various disciplines including occupational therapy. Several theories of motor control are considered in providing rehabilitation of motor deficits after TBI as are the theories of motor learning and factors affecting motor relearning. These are applied using various clinical principles and techniques taking the concept of neuroplasticity into account (CanodelaCuerdaa *et al.*, 2015).

2.3.1 Theories of motor control

Motor control is the process of governing and regulating normal movement patterns by analysing and grading purposeful movement, it also involves use of reflexes (Roller *et al.*, 2013). Different client factors are used to initiate and maintain smooth coordinated movement generated at a higher level in the central nervous system (CNS). A number of motor control theories elaborate that voluntary movement involves use of adaptation, reflexes and is automatic in nature. This is needed in order to perform appropriate, smooth, goal-directed movement. The working theories of motor control are the reflex theory, hierarchical theory, motor programming theory, systems theory and the ecological theory (Shumway-Cook and Woollacott, 2012).

2.3.1.1 The reflex theory of motor control

Sir Charles Sherrington in the 1800s constructed a theory of motor control known as the reflex theory. He argued that reflexes are required to build on normal regulated patterns required to achieve a certain movement (Shumway-Cook and Woollacott, 2012). In his theory, he assumed that individuals require reflexes for them to perform movements and these reflexes are combined into actions that compose human behaviour. In terms of clinical implications, this requires that sensory input be used to control motor output by stimulating “good” reflexes such as righting reflexes and inhibiting undesirable (primitive) reflexes (Roller *et al.*, 2013).

The theory indicates that movement relies heavily on feedback which produces a stimulus and a response cascade sequentially to achieve a chain of responses (CanodelaCuerdaa *et al.*, 2015). The most undesirable outcome of the reflex theory of motor control is the lack of inclusion of centrally generated goals, or "open-loop" control, anticipatory, or "feedforward," movements (Horak, 1991).

2.3.1.2 The hierarchical theory of motor control

Scientists realised that reflexes cannot be the only factor determining motor control although they are viewed as essential processes in the initiation of movement. In hierarchical theory, the understanding of levels in a hierarchy which control movement is viewed depending on the task at hand. The hierarchical theory consolidated based on the work of many researchers in the early 1900s. This theory suggests that the CNS is organised hierarchically from the higher association areas which control the cortical areas then sends input to the spinal cord levels for motor function (CanodelaCuerdaa *et al.*, 2015; Shumway-Cook and Woollacott, 2012). The influence brought by the levels on each other shows that higher levels dominate and control the lower levels so that cortical centres control movement in a top-down approach throughout the central and peripheral nervous system (CanodelaCuerdaa *et al.*, 2015). The closed-loop nature of the reflex theory necessitates sensory feedback to be used to control movement.

The neuromaturational theory of development proposed by Gesell and McGraw in the 1940s, stresses that the normal movement is determined hierarchically. Increased myelination in the CNS results in control of lower levels by higher levels. Reflexes are suppressed by the CNS maturation which directly affects movement as a whole (CanodelaCuerdaa *et al.*, 2015). The undesirable limitation of this model is the lack of explanation for the distinction between voluntary and reflex control. Synergistic activity and postural adjustments that occur with every voluntary movement allow for automatic adjustments. Individuals can influence reflex responses to sensory stimuli voluntarily (Horak, 1991).

Thus, while voluntary movement is controlled by the individual, the inability to suppress reflexive movements may occur with damage to the CNS. The implications of the use of this theory clinically when treating patients with CNS damage is that the therapist should use a developmental sequence of movements, identify and prevent primitive reflexes while normalizing tone and facilitate "normal" movement patterns (Roller *et al.*, 2013).

2.3.1.3 The motor programming theory of motor control

The theories above cannot adequately show proof of the influence of feedback in the alteration of ongoing movement in terms of motor programme storage. The motor programming theory of motor control does not describe motor control as a reactive system, it illustrates the mechanism of action involved in the movement rather than the nature of reactions when moving. It was suggested that generalized motor programmes (GMP) or an abstract representation of movements with features relative to timing and force of the action required exists. This means therefore that

GMPs control actions that have common characteristics and rules for generating these movements can be stored by the individual. Researchers suggest that reflex actions in the spinal neural networks are also able to produce locomotor rhythms without control of higher centres (CanodelaCuerdaa *et al.*, 2015). In his study of motor control Schmidt (1976), suggested that a motor programme has a set of rules governing how a movement can be achieved which can be applied to different environments. An adaptive, higher-level movement pattern based on the selection of GMP parameters is developed when learning novel situations depending on prior experience. A number of movements can be achieved by this phenomenon using the same motor programme and new movement patterns can also be produced by specifying new parameters (Latash *et al.*, 2011).

When the constructs of this theory are incorporated into clinical practice for patients with neurological damage it must be assumed that abnormal movements are not only reflexive but result from dysfunctions observed in central pattern generators and motor programmes that are derived from higher centres which need to be relearnt. Therefore, retraining the movements for functional common tasks must be addressed and muscle activity cannot be re-educated in isolation (Roller *et al.*, 2013).

2.3.1.4 The ecological theory of motor control

In 1967 the ecological theory was developed by James Gibson when he explored the relationship between the motor systems, the environment and how they influence goal-directed behaviour (Shumway-Cook and Woollacott, 2012). This addressed how information was used to determine actions that are then translated into movements (CanodelaCuerdaa *et al.*, 2015). Thus his theory elaborated the interaction of the individual, the task, and the environment with the aim of eliciting a motor behaviour. The environment determines how an individual executes an activity which in turn results in the performance of environmentally appropriate activities or hindrance thereof. Exploration of this environment will enable the individual to use problem solving skills with the aim of accomplishing the performance of a task. The application of this theory in clinical practice allows the patient to explore multiple ways of achieving a functional task by achieving the best movement in a given set of limitations due to CNS damage (Roller *et al.*, 2013).

2.3.1.5 The systems model of motor control

The systems theory of motor control explains that the neural control over movement requires a clear understanding of body systems that are related to motion and their characteristics (CanodelaCuerdaa *et al.*, 2015). In 1967 Bernstein presented a systems model of motor control which hypothesised that when one elicits a movement, it cannot clearly be attributed to the hierarchy formed by the higher centres or lower centres but are a result of interactions between a number of body systems (CanodelaCuerdaa *et al.*, 2015). The human body is known as a mechanical system that is subject to both internal stressors such as changes in physiological states and external stressors such as gravity. A number of movements could result from interactions between external forces and a number of commands from the system can elicit different varieties of these movements (CanodelaCuerdaa *et al.*, 2015). The theory tries to elaborate how initial conditions of a system can affect the characteristics of movement (Shumway-Cook and Woollacott, 2012) and it incorporates neurophysiology, biomechanics, and motor learning principles. The model emphasises the reciprocity between the person and the environment which results in unique movement patterns. The systems model forms the basis of other approaches to motor control including the neural network approach (Arbib, 1979) and the task-oriented approach (Greene, 1972).

This theory is suited to the rehabilitation of patients with neurological conditions such as TBI as it considers the relationship intertwined between the participant, the occupation and the environment (Roller *et al.*, 2013). Scott Kelso & Tuller, (2013) indicated that the execution of normal smooth movement is developed naturally through the practice of observable, functional occupation from a myriad of conditions and experiences. This can support techniques used in rehabilitation where environmental contexts can be modified (CanodelaCuerda *et al.*, 2015, Roller *et al.*, 2013).

None of the above theories has proven to be better in explaining the regulation of motor control and movement. The major emphasis in neurorehabilitation is taking the gains from therapy and transferring them to the patients' contexts. This has to be done looking at other constructs such as variability, active participation, the likelihood of creating mistakes, feedback, and incentives for motivation, that are important for decreasing practical deficits in neurological patients. The above variables can better be explained by principles of motor learning which focus mainly on how individuals process information to elicit a movement.

2.3.2 Theories of motor learning

Motor learning is "an array of internal processes associated with practice and experience and which, in the context of the acquisition of a specific skill, will produce relatively permanent changes in how the motor activity is elicited" (CanodelaCuerda *et al*., 2015 pg 36). It entails the reacquisition of previous movements that are lost due to injury or illness and affect the sensory, motor, and cognitive pathways.

Motor learning has different theories explaining its existence, the widely used theories include the Adams closed-loop theory, Schmidt's schema theory, and the ecological theory. These theories are used in neurorehabilitation by therapists to maintain, restore and remediate lost functions in their patients. Factors known to affect motor relearning include age, gender, culture, and genetics. The way an individual can display motor behaviour is directly linked to theories of learning (CanodelaCuerda *et al.*, 2015).

Adams closed-loop theory

The Adams closed-loop theory was developed by Adams *et al* in 1971. Adams theory suggested that motor behaviour is seen after a series of reactions that cascade on each other while utilising proprioceptive feedback to gain sensation for the production of the next efferent signal in the motor behaviour. The theory describes two states of memory that are responsible for the execution of a task namely the memory trace, and perceptual trace. The memory trace is a motor programme responsible for the initiation and execution of a movement behaviour while the perceptual trace is a representation of feedback consequences of past experiences. This means that memory trace and perceptual trace work together in the ongoing production of skilled movement. The theory is thought to explain movements that were slow, graded and self-paced as well as explaining positioning responses (Adams, Marshall, and Bray, 1971). The memory trace chooses the direction of movement whereas the perceptual trace provides feedback from the movement to determine the endpoint.

In therapy, repetition of movements has been seen to improve the capability of the individual to utilise the reference in the closed-loop (Schmidt and Wrisberg, 1973).

This is done until the patient performs them accurately and with ease. Practice increases the chances of learning however, these errors that an individual can produce during learning have been seen to strengthen the incorrect perceptual trace. The major priority in the Adams theory was to ensure the individual learns and preserves correct movements since all movements that an individual performs are stored in a perceptual trace. Increasing the quantity of practice trials will increase the build-up of sensory activity traces in memory. Augmented feedback was viewed as a method by which the individual ought to perform the "correct" movement more often than an incorrect movement, thereby storing and serving a higher number of correct perceptual traces.

Schmidt's schema theory

Schmidt's schema theory was developed by Schmidt in 1975. He argued that a lot of definitions of motor programmes left very little flexibility in what the motor programme depicted and the way it unfolded in time. Schmidt's theory assumed that there are two variables in this theory namely the generalised motor programme, and the schema (Sherwood and Lee, 2003).

A schema may be a set of rules that govern movements and may be applied to different contexts. Recall schema is liable for the choice of specific responses and governs rules producing the movement. Recognition schema evaluates responses and reports errors to the individual performing the movement. In schema theory, movements resulted in the abstraction of different aspects of information. Just like the way closed-loop theory works, data is used that is extracted and accumulates with constant and repetitive movements, and the schema's strength shows a direct relationship with the amount of repetition an individual has over time of performing the same activity. If there is no movement, there ought to be neither intrinsic feedback nor increased feedback concerning action from which to extract data to strengthen a schema (Schmidt, 1975).

In therapy, feedback is employed once completion of a task until movement learnt is fluid. This enhances the movement pattern by evaluating the movement and changing the memory representation. Within the schema theory, the stress is on practice variability during which movement patterns in novel situations are a results of numerous conditions from which the individual adds parameters to their generalised motor programme (Bate, 1997).

Ecological theory

The ecological theory was developed by Newel in 1991. It was based on systems and ecological motor control theories. It states that learning involves the exploration of perceptual and motor spheres. Individuals identify important perceptual properties that work as cues. Given the task, they explore the most efficient or feasible movements. Then they transfer the optimum perceptual cues and effective movements to a specific task. In this theory, individuals learn to develop important perceptual cues responsible for motor responses. There are no rules followed which allow for individuals to perform trial and errors (Newell, 1991).

Motor learning based on these theories is used to effect changes in motor performance post TBI based on the neuroplasticity of the brain (Raine, Meadows and Lynch-Ellerington, 2009). These theories follow the principles of neuroplasticity which take into consideration that the human brain has a potential to change and recover after an insult to the brain.

2.4 Neuroplasticity

Neuroplasticity refers to the capability of the brain to change itself functionally and structurally and the transfer of activity associated with a given function to a different location "due to changes in neuronal connectivity and neurogenesis'' (Kleim and Jones, 2008; Sasmita, Kuruvilla and Ling, 2018). Thus the human brain has the potential to recover lost functions after an insult to the brain by changing its neural structure. The process involves "the proliferation of dendrites and axons during cytogenesis, histogenesis, the formation of synapses and cellular differentiation, and apoptotic phenomena''. Some literature has shown that situation related changes in the brain occur due to environmental inputs and the activities completed daily (Chen, Epstein and Stern, 2010).

Even after a brain injury sustained from stroke or TBI, neuroplasticity can be observed because the CNS has connections and pathways that regenerate to develop new pathways through remapping (Chen, Epstein and Stern, 2010) and permanent changes in motor performance after continuous practice (Raine, Meadows and

Lynch-Ellerington, 2009). Regaining function after an injury can occur in different ways, in some cases the remaining connections are strengthened and silent pathways are unmasked. While in other cases, axonal sprouting can cover the damaged cells. Literature also suggests that there may be a possibility of reducing the damage in the CNS by transplanting cells in the damaged areas (Taub, Uswatte and Elbert, 2007).

Two types of recovery are associated with neural-plasticity namely; spontaneous reorganization and training-induced recovery. Spontaneous recovery occurs at a time close to the injury with some recovery of neural transmission close to the injury site being possible whereas training-induced recovery is dependent on the individual's experiences, adaptations, and rehabilitation. Successful functional recovery is associated with neuroplastic changes in regions around the damaged brain area. It is also accompanied by reorganization of interaction within the existing network and recruitment of new areas or the use of alternative networks in the cortex.

These changes are caused by changes in synaptic levels, cytoarchitecture, and neurogenesis (Chen, Epstein and Stern, 2010).

It is suggested that the basic principles of neuroplasticity that govern learning should be applied in cases of TBI to drive recovery.

2.4.1 Principles of Neuroplasticity

There are ten principles of neuroplasticity that can be applied for spontaneous and training-induced recovery. The first principle emphasizes the importance of using neural circuits that are affected and it stresses that disuse will cause further deterioration of the circuits. Most literature points out that performance in activities using affected extremities stimulate neuroplasticity after brain damage. The second principle dwells on improving neuroplasticity through continuous use and training. Experiments done in animals have shown that certain regions of the brain improve through training. The third principle deals with specificity, thus skill acquisition is not only dependent on learning but specific kinds of experience (Kleim and Jones, 2008). This means rehabilitation that employs training can change specific circuits and influence how one attains behaviours in non-trained modalities (Chen, Epstein and Stern, 2010).

The fourth and fifth principles deal with repetition and intensity, engaging neural circuits without repeating movements and behaviours will not influence plasticity (Kerr, Cheng and Jones, 2012). Repetition of behaviours that have been acquired is required to produce lasting results that are resistant to extinction even after training (Kandell *et al.*, 2013). The sixth principle is time. Timing is crucial in neuroplasticity, during the first few days after insult excessive training can cause more damage to the injured brain, at the same time recovery is time-dependent (Kerr, Cheng and Jones, 2012). Some researchers discovered that forced use of a limb the first seven days following an insult might increase the lesion and worsen functional outcomes (Chen, Epstein and Stern, 2010). Thus the forms of neuroplasticity we observe are dependent on timing after injury which is important given the changes that take place in the damaged brain from time of insult.

The seventh principle relates to the function based on the prominence or importance of the activity to the individual (Kandell *et al.*, 2013). Analysis done using stimuli from auditory tones for purposes of classical conditioning provided proof for such a system and demonstrated that plasticity within the auditory area relies upon which is most salient (Kleim and Jones, 2008). The eighth principle dwells on age. Neuroplasticity occurs from birth to death but it occurs at different levels with the aged brain responding differently to insults in the brain (Kerr, Cheng and Jones, 2012). Researchers have noted that older organisms have decreased synaptic activities and cortical organization as compared to their younger versions (Kleim and Jones, 2008). That implies that neuroplasticity changes with age with older people experiencing neuronal atrophy (Kerr, Cheng and Jones, 2012). This shows that a damage to an aging brain can take time for neuroplastic changes to be observed (Kleim and Jones, 2008). However, the aging brain is additionally clearly aware of experience and neuroplastic changes, albeit the brain changes might not be as profound.

The ninth and tenth principles are transference and interference. Transference refers to the “ability of plasticity within one set of neural circuits to promote concurrent or subsequent plasticity” (Kleim and Jones, 2008, pg S232). Plasticity following training in one part of a cortex which controls digit movement can be transferred to hand movement represented on the same areas of the cortex, this phenomenon has been seen in animals and humans (Ludlow *et al*, 2008). Neuroplasticity typically encompasses a favourable connotation once represented within the context of recovery of performance in one area. However, the same change in plasticity can cause poor behavioural changes in another area. The interference principle states that changes in neural function may cause deterioration in other skills and behaviours (Ludlow *et al.*, 2008). The principles mentioned strongly suggest that rehabilitation after an insult to the brain should be used after seven days to improve functional outcomes and facilitate neuroplasticity.

However, several problems that have potential to be important for improving rehabilitation remain poorly understood and more needs to be done by neurorehabilitation therapists. A stronger understanding is required of how training-induced experiences interact with the CNS in a damaged brain, with self-taught compensatory behavioural changes, and with age, together with how a combination of rehabilitative training and conventional approaches can be used to elicit changes in TBI patients (Kleim and Jones, 2008). The effect and rehabilitation of motor impairments have been extensively studied especially in moderately to severely injured patients. Recent research evidence shows that different approaches used in rehabilitation have different outcomes in terms of the impairments caused by health conditions such as stroke. (OTASA, 2017; Rao, 2011). In a top-down or motor relearning occupation-based approach, the outcome is measured by the execution of desired occupations by clients supporting their interests and daily life (Powell, Rich and Wise, 2016). Other bottom-up approaches such as Bobath's NDT (Bobath, 1969) support the execution of occupations but their goal is based on therapeutic handling to facilitate recovery of specific components or client factors.

2.5 Treatment approaches used in neurorehabilitation

Most protocols for neurorehabilitation for motor recovery and learning are based on neuroplasticity including inducing “dendrite sprouting, new synapse formation, alterations in existing synapses, and neurochemical production” (Mulder and Hochstenbach, 2001; Mathiowetz and Haugen, 1994). Different approaches and techniques are used in the rehabilitation of patients with TBI. These include task-oriented approaches, neurofacilitatory techniques, virtual reality, electrical stimulation among others. The most commonly used are task-oriented approaches and neurofacilitatory techniques which are based on the different models of motor control (Figure 2.1). However, little is known on determination of the effectiveness of these techniques in a patient with moderate and mild TBI.

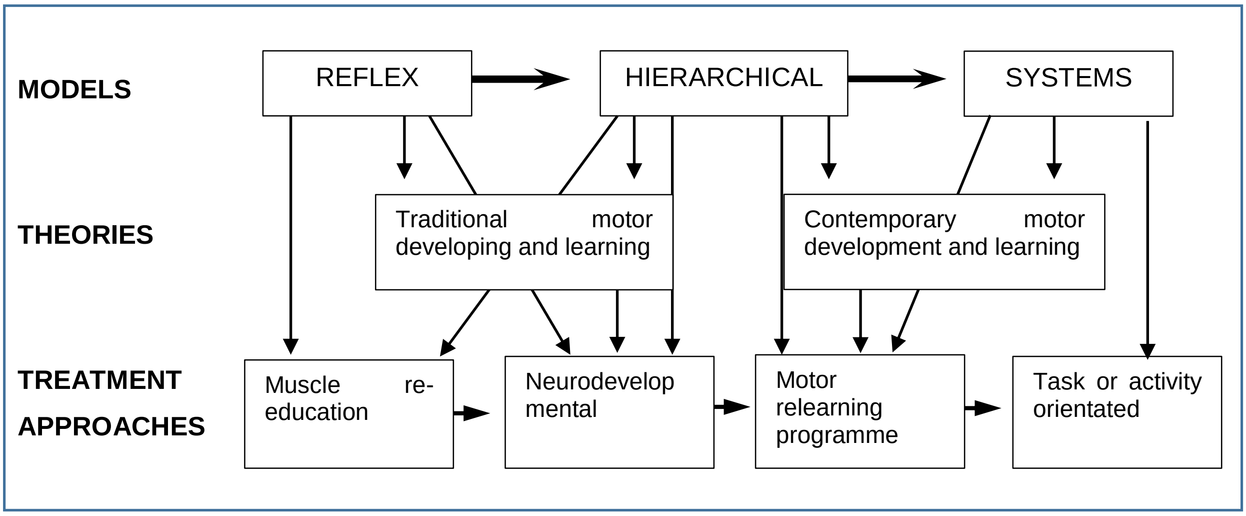

Figure 2. 1: Models and theories of motor control and their relationship to treatment approach to central nervous system (CNS) dysfunction. (Adopted from Mathiowetz, V. and Haugen, J.B., 1994).

2.5.1 Neurodevelopmental Treatment approach

The Neurodevelopmental Treatment (NDT) approach is also known as the Bobath Concept or Bobath NDT approach, it was described by Karl and Bertha Bobath in the 1940s. Initially, the Bobaths noted that the development of reflex inhibiting postures and later reflex inhibiting patterns were used to influence tone. In 1990, Mrs. Bobath discovered that the main deficits from neurological conditions were not only caused by abnormal coordination and tone but also by problems with movement and function. This led to a focus in this treatment approach on movement and function (Raine, Meadows and Lynch-Ellerington, 2009).

The Bobath NDT approach has evolved to become a problem solving NDT approach to assessment and treatment of neurological deficits which has been extended from the treatment of children with neurological deficits to adults (Kollen *et al.*, 2009a). It supports the ability of a person to maintain plasticity and to learn through challenges that cause refinement of movement and the potential to recover. It is based on the systems theory of motor control and the nervous system working hierarchically and in parallel with other levels and subsystems. Recovery in the CNS and motor learning is attributed to plasticity within the system (Raine, Meadows and Lynch-Ellerington, 2009).

The approach assumes that damage in the brain causes abnormal movement which affects different muscle groups as well as postural tone, equilibrium reactions and protective reflexes (Velickovic, Perat and Tretmana, 2005). Quality of movement is addressed in the NDT approach and not the deficits of muscle functionality alone. Treatment considers the whole individual and is not at a level of client factors such as sensory-motor, perceptual, cognitive, emotional and social components.

The basic principles of NDT include inhibitory control of abnormal movements at the same time facilitating automatic postural reactions using the therapist's hands and different techniques in goal-directed activities. The therapist enables the movement from “key points of control” (head, shoulders, trunk, pelvis) to achieve the desired movement (Raine, Meadows and Lynch-Ellerington, 2009).

The effects of NDT on TBI patients have not yet been fully explored. Research shows the efficacy on stroke patients which might be similar for patients with TBI since both conditions are acquired neurological disorders. A study conducted by Hafsteinsdottir, (2014) with 324 participants who had suffered a cerebrovascular accident in a number of Dutch hospitals concluded that the NDT was ineffective in the motor rehabilitation of stroke patients in the hospital setting.

A systematic literature search conducted by Kollen *et al* (2009) of studies within which the results of the NDT approach were investigated showed that overall, this approach is not superior to alternative approaches. Díaz-Arribas et al (2019) indicate moderate proof for greater results of alternative approaches in motor control and dexterity in the upper extremity. Due to methodological heterogeneity within the selected studies, statistical pooling was not considered. However, two independent researchers rated all retrieved literature according to the Physiotherapy Evidence Database (PEDro) scale from which the best evidence synthesis was derived to determine the strength of the evidence for the effectiveness of NDT for adults. The researchers noticed methodological issues that included inappropriate randomisation and blinding procedures as well as dropouts which caused bias resulting in false-positive or negative results (Kollen *et al.*, 2009a).

2.5.2 Motor relearning approach

The motor relearning approach which utilise the same principles as the task-oriented approach and occupation-based approach was a product of Carr and Shepherd’s work. The task-oriented and the occupation-based approaches have elements and building blocks based on motor relearning and literature suggests that the presentation of motor learning elements in a coherent framework includes very diverse approaches (Kafri and Atun-Einy, 2019). Task-oriented approaches were developed by Carr and Shepherd in 1987 with the major focus on active participation and focus on functional tasks rather than simple, repetitive training of natural movement patterns (French *et al.*, 2008). The approach follows a dynamic systems and occupation based models which suggest that movement patterns emerge from the interaction between the person's abilities, environment and the goal (Mastos *et al.*, 2007). The approach is used in the management of patients with neurological dysfunctions such as TBI. The approach assumes that the brain is dynamic and capable of organising itself after injury or insult. It is task-oriented because it encourages the use of activities that are contextually based and encourages active participation to achieve functional recovery and motor relearning can be achieved better if the meaningful, repetitive, and intensive practice of activities is used (Mulder and Hochstenbach, 2001).

In this approach, rehabilitation is started as soon as the patient stabilizes. Early involvement of affected extremities helps stimulate the patients learning skills in motor performance. Motor training ought to target goals that are relevant to the functional desires of the patient to facilitate performance in the ADLs. The motor relearning approach is task-oriented and stimulates cognitive and perceptual functions required to support the motor function which is elicited as the patient is compelled to involve the affected extremities. The therapist uses verbal and visual cues that enable the patient to learn movements. Treatment is context-specific during a stimulating, practical setting primarily based around daily tasks (Carr and Shepherd, 2012).

Most studies on the efficacy of the motor relearning programme show significant effects of the programme on functional outcomes and rehabilitation. A study conducted by Chan *et al*. (2006) in Hong Kong used a matched-pair randomized control trial with 52 outpatients who suffered a cerebrovascular accident. In six weeks, the patients received eighteen 2-hour sessions of either the motor relearning programme or a conventional therapy programme and the motor relearning programme was found to be more effective in enabling functional recovery of these patients who had a stroke. However, they also stated that both conventional and function-based activities should be implemented in neurorehabilitation. The limitations they noted included problems with best pair matches, dropouts, and participants receiving other forms of treatment including physiotherapy and speech therapy. A study conducted by Immadi *et al*., (2015) with 60 outpatients also revealed the efficacy of the motor relearning programme. This study showed a greater functional ability found in patients assessed on their functional status after their involvement in the task-oriented performance than the other conventional physiotherapy treatments looking at the scores of both treatments. Two types of task-orientated or activity-based intervention using motor relearning approach have been described.

2.5.2.1 Repetitive task practice

In the repetitive task practice the occupations given to patients by therapists are structured to allow for repetition to increase engagement in the activities. (Nilsen *et al.*, 2015). Task-specific training improves neuroplasticity, this is achieved through repetitive practice of skilled motor performance (Bayona *et al.*, 2005; Richards *et al.*, 2008). There is compelling proof for task-specific training which is noticed by functional movement recovery, related to adaptive neural-plasticity (Richards *et al.*, 2008) and that task-oriented training may be superior to classical treatments, although high variable control groups have had a major effect on the Cochrane meta-analyses for this approach (French *et al.*, 2016). Recovery in functional upper extremity movements after task-specific training produces motor relearning capabilities that have enduring effects and causes new organisations in the cortex (Thant *et al.*, 2019).

2.5.2.2 Occupation-based intervention

The occupation-based treatment is activity-based and uses more than repetitive task practice. This approach used in occupational therapy uses client-directed occupations that match goals identified by the clients (Dawson *et al.*, 2013). The principles of this approach support the principles of neuroplasticity (Kleim and Jones, 2008). A study by Skubik-Peplaski *et al.*, (2012) shows compelling evidence that treatments based on occupations can cause increased use of extremities affected by paralysis/paresis and engagement in occupational performance. Setting goals for meaningful engagement in occupations also enhances participation in therapy and better outcomes for motor performance and quality of life (Doig *et al.*, 2014). Resemblance is noticed between the occupation-based and the task-based approaches because they both use the aspects of goal directed tasks that are individualised. However, the occupation-based approaches use tasks that require bimanual movement within a complete activity and do not focus as much on repetitions (Skubik-Peplaski *et al.*, 2017).

2.5.3 Comparison of motor relearning approach and neurodevelopmental treatment approach

Research to compare the effects of motor relearning and NDT have reported outcomes for early rehabilitation for patients with stroke but not TBI. These studies are controversial and a Cochrane review which covered four studies on the motor relearning approach indicated that the motor relearning interventions did not show a higher significant clinical effectiveness from other conventional neurorehabilitation approaches. But these studies did not include the principles of repetition or a function-based component (Pollock *et al*., 2014). Research by Langhammer and Stanghelle, (2000) indicated that patients who received motor relearning therapy had early hospital discharge, with greater improvement in motor function and ADLs than those treated with NDT. Chan *et al* (2006) agree that patients treated three months' post-stroke with the motor relearning strategies have more favourable outcomes in self-care and execution of ADLs, they showed a better transfer of skills learned to other occupations. However, the intervention did not have an effect on balance, speed or outdoor mobility (Chan *et al*., 2006). The researcher in this current study wishes to unpack the efficacy of the two treatment approaches in physical performance and self-care among TBI patients.

A study that compared the NDT approach and also the motor relearning programme by Krutulyte *et al*., (2003) used 240 participants who suffered a cerebrovascular accident. Their assessment and treatment was conducted at the rehabilitation centre at Kaunas Hospital. The participants were divided into a pair of teams. The NDT approach was applied to the primary with 147 patients and the motor relearning task-oriented approach was applied to the second cluster with ninety-three patients. The study showed that therapy with task-oriented methods described by motor relearning programme was preferred to therapy with facilitation/inhibition methods, like the NDT programme, within the rehabilitation of cerebrovascular accident patients. However, there is not enough evidence supporting one approach against the others. This review showed many flaws in the conduct of the studies and concluded that more high-quality randomised control trials should be published. Evidence-based principles should be followed when conducting the randomised control trials and not focus on what the therapists prefer as guiding principles from which they derive their efficacy protocols (Kollen *et al.*, 2009).

A study by Annethattil, Paul and Sebastian, (2017) looked at the effectiveness of the individual and combined effects of the Bobath technique and motor relearning program to improve upper limb functional recovery and motor control in stroke patients. They conducted an experimental study with three groups of participants randomly allocated. They concluded that individual effect of motor relearning program is more effective than Bobath technique but the combined effect of these two techniques are more effective than the individual effect in the functional recovery of the upper limbs in stroke patients. Another study by Firoozeh *et al.*, (2019) compared in a randomized control trial with participants with stroke allocated to either an intervention task-oriented training and Bobath program or task-oriented training alone groups. They concluded that although combination and task-oriented programs showed comparable improvements in functional measures of upper limb, no one has priority over another in improving upper limb function. Their results were inconclusive. A study by Tunney, (2018) also agrees to these findings and state that employment of an eclectic approach based on patient needs and responses to rehabilitation of adult hemiplegia is a reasonable conclusion. It is therefore not clear as to whether the motor relearning occupation-based approach is more superior than the Bobath NDT. The researcher would like to find out the best approach to use with clients after TBI.

2.6 Summary

Traumatic brain injury is a neurological condition that causes paralysis or paresis after an insult to the brain. The injury causes dependence in function and an inability to use the affected limbs. The severity of the injury ranges from mild, moderate to severe. Motor neurorehabilitation focuses on motor control, motor learning and neuroplasticity principles as well as theories which govern clinical practice in occupational therapy. The theories include reflex theory, hierarchical theory, motor programming, ecological theory as well as the systems theory.

Based on these theories occupational therapists use treatment approaches such as motor relearning and NDT approaches. Activity-based therapy includes both a repetitive task practice which involves the use of specific tasks using repetition to promote skilled movements and an occupation-based approach that involves completion of activities bilaterally. The NDT approach focuses on abnormal coordination and tone to improve movement. Studies have shown that these approaches are effective in treating neurological conditions however, the superiority of one approach against the other has not yet been ascertained. The researcher would like to unpack the use of these approaches on patients with TBI to determine their efficacy on physical performance and self-care.

CHAPTER 3: METHODOLOGY

3.1 Introduction

This section describe the research methodology used in the study and explains the target population from which the sample was extracted as well as the sampling method. Furthermore, instruments used in the study were discussed, how validity and reliability were ensured, data collection procedures, and the ethical considerations that were taken.

3.2 Research design

An experimental research design comparing two groups and a pre-test post-test design was used in the study (Kumar, 2011). This is a pretest-posttest design with two treatment groups were participants were assigned randomly to the groups, to consider the difference in treatment approaches with patients with TBI (Walker, 2005). No control group was included as all participants with TBI were receiving treatment using either a motor relearning occupation-based or NDT approach. Pretest-posttest study designs are mostly used with experimental and quasi-experimental research designs because they are useful in assessing change in variables over time which can be used to compare two or more groups. The amount of difference between interventions can be used to determine the effectiveness of treatment approaches such as the motor relearning and the NDT. With this randomised experimental design, all conditions are assumed to be the same for both the motor relearning occupation-based and the NDT group, and there is no control group as both are exposed to different treatment approaches (Dimitrov and Rumrill, 2003).

Maturation and history can be viewed as the most common problems affecting internal validity in the pre-test post-test design, whereas the external validity is threatened by the interaction between pretesting and treatment. Maturation is when certain biological and psychological factors are altered during the period of experiment affecting the post-test results. History can be seen as affecting the post-test scores if any event occurs during the experiment that is not caused by the treatment itself. The link between the treatment and pretesting exist which may cause the participants to be sensitised thereby affecting their post-test scores which are called interaction (Dimitrov and Rumrill, 2003).

This research design was preferred for the study because it compared two groups before and after the intervention while preventing bias through randomisation. It allowed the researchers to compare the final post-test scores to determine if the two treatment approaches were effective. This also allowed the changes between pre-test and post-test scores to be made to find out whether or not the approaches improved. This approach also allowed a comparison of two pre-test scores to see whether randomisation worked.

3.3 Site of Research

The participants that were recruited for the study are those that were receiving treatment at Katutura Intermediate Hospital in Namibia. Katutura Intermediate Hospital is together with Windhoek Central Hospital a tertiary institution found in the capital city of Windhoek, Namibia. It serves as a referral hospital for the population from all the regions in Namibia as well as the Khomas region which is the capital region. It has an 880-bed capacity, which caters for orthopaedics, surgery, internal medicine, neurology, paediatrics, head injuries, tuberculosis, obstetrics, and gynaecology.

At Katutura Intermediate Hospital, the occupational therapy department caters to most of the wards at the institution. It has 5 therapists' positions on its establishment and they are divided accordingly to the wards they serve and the outpatients. The participants who were drawn for the research were selected from neurology wards which included the TBI wards as well as other neurology related internal medicine wards. The patients from these wards usually spend 12 weeks on average in the specialised wards to allow for their stabilisation, early intervention, and full rehabilitation before discharge. In the rehabilitation phase, they are seen on average of two times a day for occupational therapy, physiotherapy, speech, and language therapy as per need. Two therapists responsible for these wards were automatically chosen for the two approaches, since one therapists had postgraduate training in the NDT approach and gave their consent to take part in the research study.

3.4 Population and Selection of Participants

The population for the study consisted of patients with TBI treated at Katutura Intermediate Hospital. Participants were chosen from the inpatient TBI unit and other related units. Upon discharge, they also attended outpatient occupational therapy at the same hospital.

Participants who met the inclusion criteria and were willing to take part in the research were selected using total population sampling in the wards of the hospital over six months' period. They were allocated randomly to either motor relearning occupation-based group or the NDT group using a random numbers table.

Inclusion Criteria

- Adults aged eighteen years and above.
- Mild to moderate TBI (GCS Score 9 -15)
- Evidence of decreased level of consciousness (LOC) on admission and a present Glasgow Coma Scale (GCS) of 15/15.
- Patients on the Rancho Los Amigos Scale (Level of Cognitive Functioning Scale) Level VIII and below who have caregivers to give consent.
- Adults with previously fully remitted TBI with reoccurrence at the time of the study.
- Motor or sensory dysfunction in at least one limb.

Exclusion Criteria

- Medical conditions other than TBI.
- History of psychiatric conditions.
- History of substance use disorders.

3.4.1 Sample size

Unit statistics calculations were used to determine the sample size. A total of 375 patients who sustained fractures to the skull and facial bones were admitted at Katutura Intermediate hospital during November 2017 and April 2018. The mean monthly admissions at the hospital were 63. Based on a difference of 11 points with an SD of 15 on the Barthel Index between the groups set at a significance of 0.05 and over six months, the confidence interval of 15 and a power of 80%, a sample of

30 participants per group were used in the study (Langhammer and Stanghelle, 2000).

3.5 Instrumentation and Outcome Measures

3.5.1 Demographic questionnaire

The researcher developed a demographic questionnaire (Appendix A) to determine the demographic characteristics of the study participants. Demographics assist in the description of participants and to better understand their context for better analysis of the data. The demographic details included sex, age, level of education, marital status, occupation, cause of injury and the participants' GCS.

3.5.2 Fugl Meyer Assessment of Physical Performance (FMA)

The FMA (Appendix B) is an instrument used to evaluate motor performance after a neurological lesion. It is used to notify changes that take place after patients have been involved in different therapies to ascertain their level of recovery. It evaluates six categories of the patient; the amount of movement, pain, sensitivity, motor function of the upper limb and lower limb, balance, coordination, and speed (Fugl Meyer, Jaasko and Leyman, 1975). The scale adds up to 100 points for normal movement; 66 for upper limb and 34 for lower limb (Padovani *et al.*, 2013; Sullivan *et al.*, 2011).

A score of 0 shows that there is no movement observed, 1 shows that the movement is minimal and 2 shows that a full range of movement has been achieved (Gladstone, Danells and Black, 2002). The time needed to administer the test is between 5-30 minutes. A change in the score of 4.25 to 7.25 is seen as a clinically important difference (CID) (Page, Fulk, and Boyne, 2012). A Global Rating Scale of Change (GROC) for the FMA indicates a change of > 50% is excellent, a change of 30% - 50% is marked, 30% -10% is moderate and < 10% is slight (Page, Fulk, and Boyne, 2012).

Recorded Intra-rater reliability had high values in the motor domain with total motor, 0.99; upper extremity, 0.95; and lower extremity, 0.99. The sensory assessments total scores were 0.96; light touch, 1.0; and proprioception, 0.95. The inter-rater reliability also had significantly high values for the total motor score (ICC, 0.98; 95% CI, 0.93–0.99) and the total sensory score (ICC, 0.93; 95% CI, 0.83–0.98) (Sullivan *et al.*, 2011).

3.5.3 Modified Barthel Index (MBI)

The modified Barthel Index (Appendix C) is a measurement of functional independence in patients who have suffered a lesion in their brains. It provides objective and quantifiable measures of a patient's functioning (Shah, 1998). It shows how an individual is performing self-care and mobility tasks and their clinical status. It has a 5 step scoring system with items scored from 0-15, 0-10 and 0-5 with a total of 100. (Küçükdeveci *et al.*, 2000).

The MBI five-point scoring system shows the level of ability in self-care and their clinical status. Items are scored from 0-15, 0-10 and 0-5, a score of 99 shows “slight dependence”, a score below 90 shows “moderate dependence”, a score below 60 describes “severe dependence” and a score below 20 indicates “total dependence” (Shah, 1998).

The MBI takes 5-10 minutes if the person self-reports or 20-60 minutes for direct observation (Shah, Vanclay and Cooper, 1989). Reliability and validity in stroke rehabilitation were done by Shah *et al* (1989) and the internal consistency of the MBI was tested by Cronbach's alpha. On admission, it recorded 0.927 whereas, on discharge it recorded 0.930 for the stroke group. The validity was significantly related to ASIA Impairment Scale on both admission (Kruskal Wallis test, $p = 0.005$) and discharge ($p = 0.003$).

3.5.4 Glasgow Coma Scale

The “Glasgow Coma Scale” (GCS) (Appendix D) was constructed in 1973 (Teasdale and Jennett, 1974) as a way to assess the neurologic status and now routinely used to check clinical status. It is used to analyse the level of consciousness in patients after an injury to the head and follow through their neurological functioning (Bastos *et al.*, 1993). The given score gauges the severity of an acute brain injury and its prognosis. The scores derived from the GCS range from 3 which is the lowest to 15 which is the highest score based on three parameters namely eye response, verbal response and motor response. Each category when summed up gives a total score ranging from 3 to 15. Its interrater reliability was established to range between 0.32 to 0.48 among health professionals however, its validity has been criticised since it cannot accurately record responses from intubated and aphasic patients (Mcnett, Amato and Philippbar, 2016).

3.6 Research Procedure

Once ethical clearance and permission to do the study had been obtained, patients in the wards at the Katutura Intermediate Hospital with mild to moderate TBI (GCS score 9 -15) on admission were selected and invited to participate in the study since they met the inclusion criteria for the study. Informed consent from the participants was sought. Family members and guardians of vulnerable participants with Rancho Los Amigos Scale Level VII and below signed the consent forms on the participants' behalf. An occupational therapist research assistant was responsible for the random assignments of participants into the two treatment groups based on participant random numbers table.

3.6.1 Data collection

An occupational therapist who served as part of the research assistants performed a pre-test assessment using the FMA of physical performance and the Modified Barthel Index on all the patients recruited into the study. To prevent bias, this research assistant was blinded and was unaware of which therapy they were receiving (Kumar, 2011). The pre-test assessment was carried out in the occupational therapy department at Katutura Intermediate hospital where the hospital porters carried all the identified patients to the department in the period they were involved in the research while they were inpatients. The treatments were carried out at Katutura intermediate hospital occupational therapy department where participants were seen by two different therapists who were blinded to prevent bias, the researcher was involved with Group 1 – motor relearning occupation-based approach (Appendix E) and the other fully qualified therapist was responsible for Group 2 – NDT approach (Appendix E). Documentation by therapists was done using SOAP notes in patient files that were kept in the hospital for purposes of recording treatment outcomes and confidentiality.

Following the routine practice in the occupational therapy department daily interventions for an hour, five days a week were implemented for four weeks with each participant in the morning until 20 sessions were recorded. According to literature the first month or two post-acute stage is crucial for brain plasticity hence incorporating patients in therapy for the first four weeks (Royal College of Physicians, 2003).

Participants who were discharged continued treatment as outpatients in their respective groups until 20 sessions were completed where they were given transport fares to continue visiting the occupational therapy department. A post-test assessment was conducted by the occupational therapist research assistant using the Fugl-Meyer Assessment of physical performance and the Modified Barthel Index. This therapist was still blinded as to which therapy participants had received and conducted the assessments in the same occupational therapy department at Katutura Intermediate Hospital.

Data was transferred from hard copies to an excel spreadsheet for analysis by the researcher.

3.7 Ethical Considerations

Ethics is a system of principles based on a moral campus, they provide a basis for a decision on what is right and what is wrong (Marianna and Paraskevi, 2011). Researchers group ethical considerations into different categories. The categories used in this study were according to Marianna and Paraskevi (2011) who state that research ethics are divided into four sections namely “respect for persons, concern for welfare, concern for justice and respect for the community”.

3.7.1 Respect for persons

Respect for persons considers three aspects namely informed consent, autonomy, and vulnerability. Informed consent relates that a person knowingly, voluntarily and willingly grants permission to be part of a research study (Marianna and Paraskevi, 2011). Researchers provide clear information on what the participants will be asked to do, the potential risks and benefits, how the information will be used and their rights as participants. In this study, information sheets where given to all participants and were asked to sign informed consent to take part in the study (Appendix G). In this study, the participants' autonomy which is respect for individuals in research was ascertained by explaining that participation in the study was voluntary (Owonikoko, 2013). Denial to participate and discontinuation at any given time involved no penalty or loss of benefits to which the participant was otherwise entitled. Informed consent from vulnerable groups regardless of capacity was sought through caregivers (Appendix G).

3.7.2 Concern for Welfare

Concern for the welfare of participants includes beneficence and confidentiality. Beneficence is a principle of benefit and doing no harm (Marianna and Paraskevi, 2011). Harm may be social, behavioural, psychological, physical or economic. In this study, all forms of harm were prevented by using double-blinding techniques in choosing participants and the use of routine therapy techniques that have been known in occupational therapy at Katutura Hospital. Potential benefits and risks of the study were explained to the participants and travelling costs incurred after discharge were reimbursed. Confidentiality is a principle of welfare, protecting the participants' information and ensuring that the information is kept safe (Marianna and Paraskevi, 2011). In this study information that was taken from participants was kept under lock and key, only the researcher and the supervisor had access to the information given.

3.7.3 Concern for Justice

Under concern for justice, ethical principles to think of include equitable treatment, appropriate inclusion, and power. Equitable treatment relates to equal treatment and equal benefits for all research participants. This principle was upheld by ensuring that all participants who fit the inclusion were given equal treatment and equal benefits. Appropriate inclusion ensures that individuals or groups are not excluded from the study due to conditions not linked to the study. This was upheld by ensuring that participants were not chosen according to race, ethnicity or gender. Power is a principle of ethics that ensures that researchers will work to mitigate imbalances in power between them and the participants. This was ascertained by ensuring that the researcher upholds the rights of the participants involved in the study.

3.7.4 Respect for Community

Principles that lie under respect for the community include understanding the community, respect for the community and community inclusion. Understanding the community relates to knowing the community one is engaging in geographically and culturally. This principle was upheld by using the TBI unit at Katutura which caters to all Namibians who would have suffered a TBI. The researchers have been mixed with and learning the Namibian culture for more than two years and this assisted in upholding and respecting the community norms. A total population sampling was used for this study and this ensured that all individuals in the community affected at the time were included in the study.

3.7.5 Other ethical considerations

Ethical clearance to conduct the study was obtained from the Human Research Ethics Committee (HREC) at the University of Witwatersrand (ethical clearance number: M180970). Permission to conduct the study at Katutura Intermediate Hospital was obtained from the Ministry of Health and Social Services through the Office of the Medical Superintendents at the hospital (Appendix F). The therapist assisting with the therapy in one group was provided with an information sheet and was asked to sign informed consent to take part in the study (Appendix H).

3.8 Data Analysis

Data gathered was entered into Microsoft Excel and transferred to SPSS for analysis. Frequencies and measures of central tendency were analysed using descriptive statistics.

Table 3.1: Descriptive and inferential statistics

Objective	Type of Data	Within-group Analysis	Between-group Analysis
Demographics	Nominal Ordinal	Frequencies	
To determine the outcomes of motor relearning occupation-based treatment approaches on physical performance and self-care among adults post-acute TBI.	Ordinal	Wilcoxon Test	
To determine the outcomes of neurodevelopmental treatment approaches on physical performance and self-care among adults post-acute TBI.	Ordinal	Wilcoxon Test	
To compare the outcomes between motor relearning occupation-based and neurodevelopmental treatment Approaches on functional outcomes in adults post-acute TBI.	Ordinal		Man-Whitney Tests
Association between physical performance and self-care in the motor relearning occupation-based and neurodevelopmental treatment groups			Spearman's correlation coefficient

Inferential statistics used were non-parametric and included the Wilcoxon and Mann Whitney U test since data were ordinal and the small sample resulted in data that were not normally distributed. These statistics were used to determine within-group differences pre and post-test as well as between-group differences pre and post-test.

CHAPTER 4: RESULTS

4.1 Introduction

This section describes a presentation of results and findings from 60 participants that were randomly selected in two groups using random number tables. Group 1 used the motor relearning occupation-based approach whereas group 2 used the NDT approach when they were diagnosed and hospitalized due to traumatic brain injury at Katutura Intermediate Hospital in their occupational therapy management. Sixty participants were recruited into the study and assigned to the two treatment groups. There was a 100% response rate since all participants that consented to be in the program and met the inclusion criteria finished the 20 sessions, 1 hour/day program in five working days until the completion of the sessions.

4.2 Sample Description

4.2.1 Demographic Characteristics

Table 4.1 below describes the demographic profile of the participants in frequencies and percentages. Forty (66.7%) participants in the study were male. The participants' ages ranged from 18 to 68 years, the majority of the age range was 25 - 34 (48.3%). The average age of the study participants was 36.5 with standard deviation of 10.99. These factors did not differ significantly between the NDT and motor relearning occupation-based groups indicating the groups were comparable for gender and age.

Of the respondents, half (50%) had secondary education, about 35% had tertiary education and only nine (15%) participants had primary education. There was no significant difference ($p=0.69$) in the education levels for the two groups although more participants in the motor relearning occupation-based group had primary school education only. The marital status of the participants revealed that the majority (50%) were never married, 21 (35%) were currently married, eight (13.3) were cohabitating and only one (1.7%) was divorced. This factor differed significantly between the NDT and motor relearning occupation-based groups ($p=0.010$) with more motor relearning occupation-based group participants cohabiting. Marital status significant differences when analysed using the Kruskal-Wallis ANOVA only applied to change in physical performance in the upper extremity. The greatest change in marital status was found for unmarried participants (median change of 16) for this variable compared to participants with other marital status (median change of 14).

Table 4.2: Demographic Characteristics (n= 60)

Demographic Characteristics		**Total group**	**Neuro-developmental group**	**Motor relearning occupation-based group**	**p value**
		n(%)			
Sex	Male	40(66.7)	19(63.3)	21(70.0)	0.421
	Female	20(33.3)	11(36.4)	9(30.0)	
Age (Years)	18 - 24	4(6.7)	2(6.6)	2(6.6)	0.438
Mean Age (S.D) 36.5 (10.998)	25 – 34	29(48.3)	16(53.33)	13(43.33)	
	35 – 44	15(25.0)	6(19.9)	9(30.1)	
	45 – 54	8(13.3)	2(6.6)	6(19.9)	
	55 – 64	3(5.0)	3(9.9)		
	65+	1(1.7)	1(3.3)		
Level of Education	Primary	9(15.0)	2(6.6)	7(23.7)	0.069
	Secondary	30(50.0)	19(63.4)	11(36.6)	
	Tertiary	21(35.0)	9(30.0)	12(40.0)	
Marital Status	Cohabiting	8(13.3)		8(26.7)	0.010**
	Currently Married	21(35.0)	10(23.4)	11(36.6)	
	Divorced	1(1.7)	1(3.3)		
	Never Married	30(50.0)	19(63.3)	11(36.6)	
Current Occupation	Non-paid work (e.g. volunteer)	1(1.7)		1(3.3)	0.433
	Paid Employment	34(56.7)	19(63.4)	15(50.0)	
	Self Employed	9(15.0)	3 (10)	6(19.9)	
	Student	4(6.7)	1(3.3)	3(10)	
	Unemployed	12(20.0)	7(23.4)	5(15.0)	

Thirty-four (56.7%) of the participants reported had paid employment, while twelve (20.0%) reported they were unemployed and nine (15%) reported they were self-employed. The remainder reported that they were students (6.7%) and volunteers (1.7%) respectively. There was no significant difference (p=0.69) in the education levels for the two groups although more participants in the NDT group had paid employment.

4.2.2 Common causes of head injuries

Figure 4.1 below illustrates the causes of TBI in the sample. Motor vehicle accidents accounted for the majority of participants (65%) injury, followed by violence which contributed to TBI in 30% of the participants and falls which was the cause of TBI in 5% of the participants. The majority of people who sustained vehicle-related collisions were in the age range of 18 – 54.

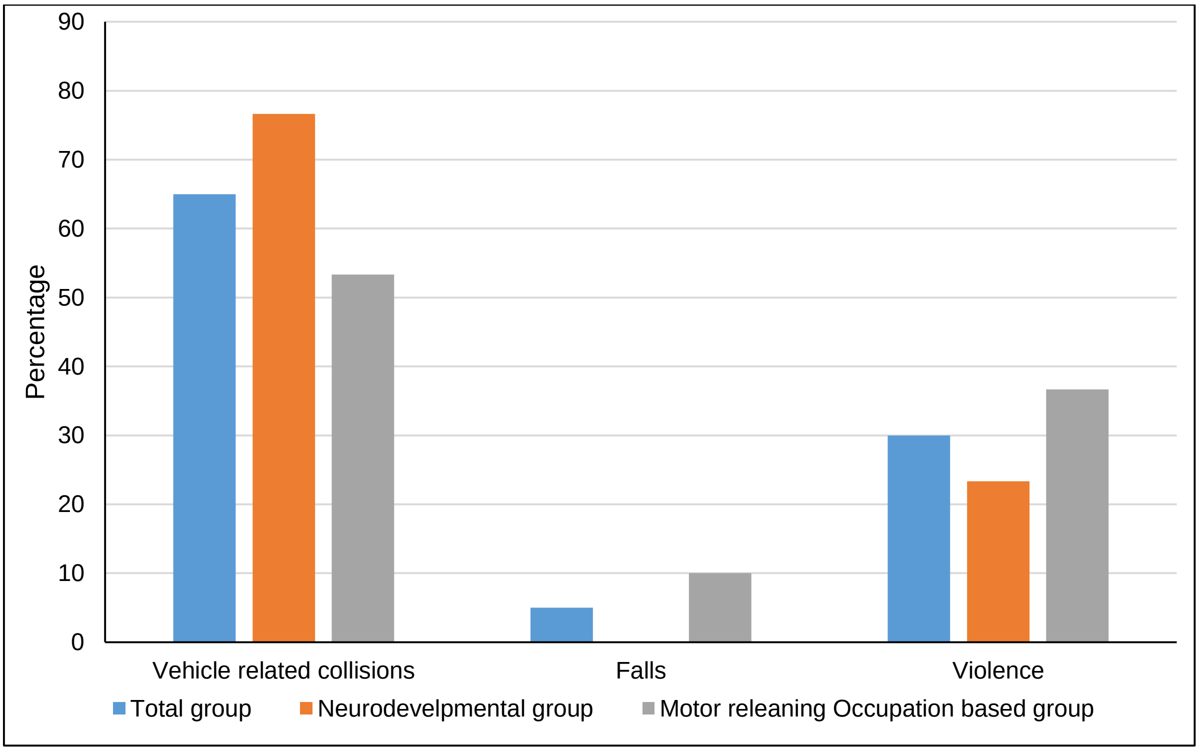

Figure 4. 1: Causes of Injury

The cause of injury differed significantly between the NDT and motor relearning occupation-based groups (p=0.001) with the motor relearning occupation-based group having more injuries caused by violence.

4.2.3 Types of Head Injuries

Figure 4.2 illustrates the types of head injuries among the participants. Twenty-five (41.7%) participants had mild head injuries, followed by moderate head injuries which constituted 35% of the sample. Low values were noted in moderate-severe head injuries (15%), subdural hematoma (1.7%), epidural hematoma (1.7%) and subarachnoid haemorrhage (5%).

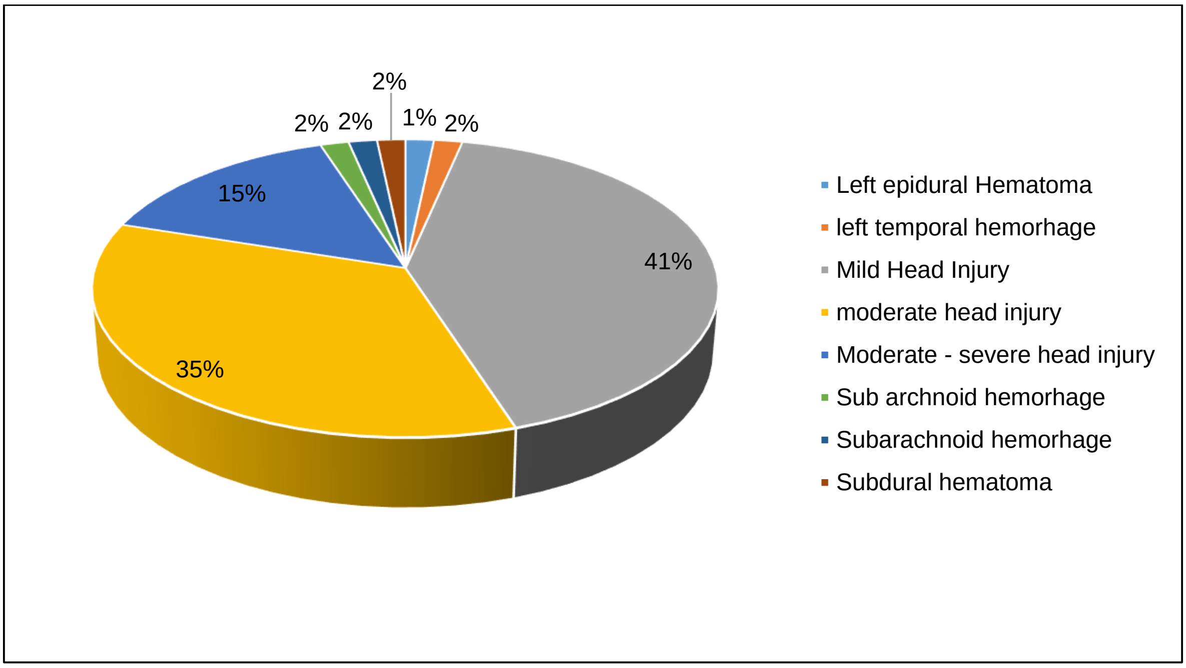

Figure 4. 2: Types of Brain Injury

4.2.4 Glasgow Coma Scale

Figure 4.3 illustrates the Glasgow coma scale (GCS) scores for all the participants in the study, the minimum GCS scale score was 9 and the maximum was 15.

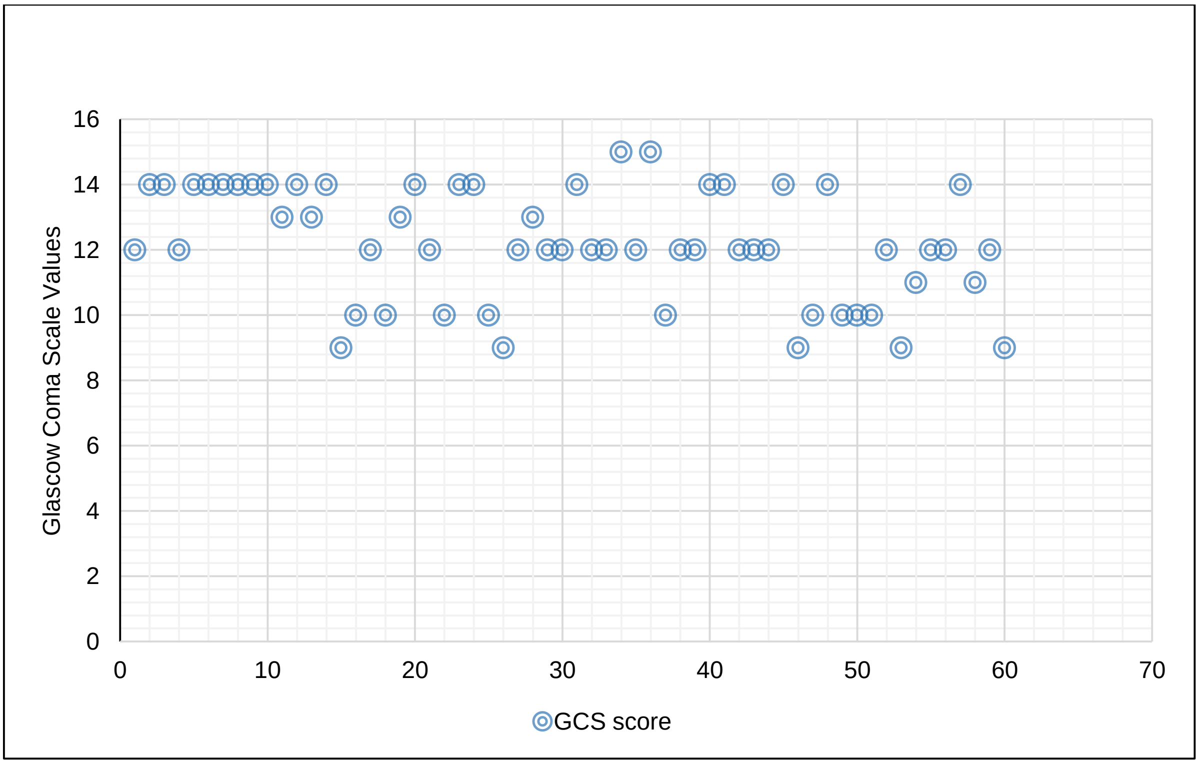

Figure 4. 3: Types of Brain Injury

The Figure 4.4 below shows a comparison of the average GCS scores in two treatment groups. The average GCS scale score in Group 1 was 12.53 (S.D – 1.68) whereas the average score for Group 2 was 11.9 (S.D – 1.77). About 38 participants had GCS scores between 12 and 14. Glasgow Coma Scale scores from 12 to 15 showed more likelihood of mild and moderate traumatic brain injuries. GCS scores of 9 to 11 were associated with moderate-severe traumatic injuries but these scores fell within the inclusion criteria for the study. Figure 4.4 Illustrates that the mean in the two groups was not significantly different (p=0.127).

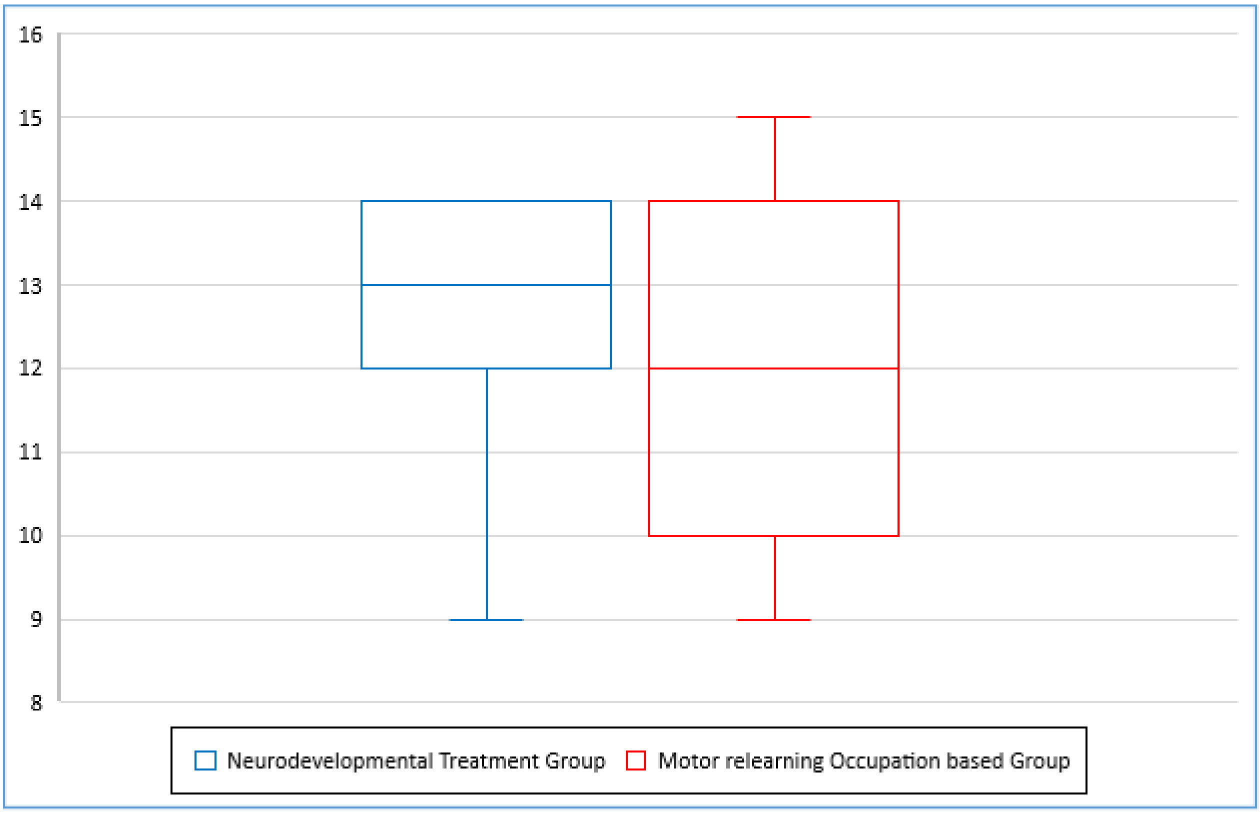

Figure 4. 4: Differences in Glasgow Coma Scale scores between two groups

4.3 Fugl-Meyer Treatment approaches to physical performance

Seven areas from the Fugl Meyer upper extremity assessment which assessed upper extremity, hand, wrist, sensation, coordination, joint pain and passive joint movements and five areas from the Fugl Meyer assessment of the lower limb which included coordination, lower extremity, passive joint motion, sensation, and joint pain were presented. A visual inspection of the histograms, normal Q-Q plots and box plots and a Shapiro Wilk's test (*p*<0.05) showed that most Fugl Meyer scores for both motor relearning occupation-based and NDT groups were approximately normally distributed with slight negative skewness, most skewness and kurtosis *z* values were ranging from -1.96 to +1.96. This justified the use of non-parametric tests. Mann-Whitney U tests were used to determine the differences in the median between the two groups respectively. The Wilcoxon signed-rank test was used to compare repeated measures within the groups.

4.3.1 Within-group changes Group 1 - Motor relearning occupation-based approach on upper extremity physical performance

4.3.1.1 Upper extremity

Table 4.2 below shows the statistical analysis of physical performance outcomes using the Fugl Meyer Upper extremity values. A Wilcoxon Signed Rank Test revealed a statistically significant increase in Fugl Meyer values for all aspects of the assessment following participation in the motor relearning group, (*p*< 0.001). A large effect size (*r* = 0.62) was found for the upper extremity, the wrist and the hand indicating a clinical difference in the movement.

Table 4.2: Group 1 - Motor relearning occupation-based approach on upper extremity physical performance

Fugl Meyer Variables	**Pre-test (n=30)**	**Post-test (n=30)**	***z*-value**	**p value**	**Effect size (Cohen's r)**
	Median (Lower and upper quartile)	Median (Lower and upper quartile)			
Upper extremity	12.50 (10-18)	30.50 (20-36)	-4.80	≤0.001**	0.62***
Wrist	1.50 (0-5)	10.00 (7 - 10)	-4.83	≤0.001**	0.62***
Hand	1.00 (0 - 6)	10.00 (7 -12)	-4.79	≤0.001**	0.62***
Coordination	6.00 (2 - 6)	6.00 (6 - 6)	-3.23	≤0.001**	0.42**
Total	24 (10 – 33)	52.00 (46 – 62)	-4.62	≤0.001**	0.60***
Sensation	6.00 (6 - 12)	12.00 (10 - 12)	-4.19	≤0.001**	0.54***
Passive Joint Motion	16.00 (10 - 24)	20.00 (20 - 24)	-3.64	≤0.001**	0.47**
Joint Pain	8.00 (6 - 10)	18.00 (14 - 20)	-4.74	≤0.001**	0.61***

*. Significant at p <0.05**. Significant at p <.0.01***.*

*Large Effect Size = 0.5***.*
*Medium Effect Size = 0.3***
*Small Effect Size = 0.1**

The Fugl Meyer coordination values also showed a statistically significant increase, ($p \leq 0.001$), with a large effect size ($r = 0.42$) even though the median value did not change since12 participants did show improvement. The overall total improvement was 43.9%.

The sensation values on the Fugl Meyer also increased significantly, ($p < 0.001$), with a large effect size ($r = 0.54$). Similar significant results were noted with passive joint motion values, (p < 0.001) with a large effect size ($r = 0.47$) and pain values with a large effect size ($r = 0.61$).

4.3.1.2 Lower extremity.

Table 4.3 below shows the statistical analysis of physical performance outcomes using the Fugl Meyer lower extremity values.

Table 4.3: Group 1 - Motor relearning occupation-based approach on lower extremity physical performance

Fugl Meyer Variables	**Pre-test (Md) (n=30)**	**Post-test (Md) (n=30)**	***z*-value**	**p value**	**Effect size (Cohen's r)**
	Median (Lower and upper quartile)	Median (Lower and upper quartile)			
Lower extremity	12 (8.00 – 16.00)	24.00 (20.00 – 26.00)	-4.64	≤0.001**	0.60***
Coordination	4.00 (3.00 – 6.00)	6.00 (6.00 – 6.00)	-3.70	≤0.001**	0.48**
Total	18 (12.50 – 22.00)	30 (26.00 – 32.00)	-4.79	≤0.001**	0.62***
Sensation	6.00 (6.00 – 12.00)	12.00 (12.00 – 12.00)	-3.98	≤0.001**	0.51***
Passive Joint Motion	15.00 (10.00 – 20.00)	20.00 (20.00 – 20.00)	-3.71	≤0.001**	0.48**
Joint Pain	10.00 (7.00 – 10.50)	20.00 (18.00 – 20.00)	-4.75	≤0.001**	0.61***

*. Significant at p <0.05**. Significant at p <.0.01***.*

*Large Effect Size = 0.5***.*
*Medium Effect Size = 0.3***
*Small Effect Size = 0.1**

A Wilcoxon Signed Rank Test revealed a statistically significant increase in Fugl Meyer lower extremity values following participation in motor relearning occupation-based group, *(*p < 0.001), with a large effect size (*r* = 0.60). This included a statistically significant increase in Fugl Meyer lower extremity coordination values (*p* < 0.001), with a large effect size (*r* = 0.48) and a 35.2% increase in the total score

Likewise, lower extremity sensation values revealed a statistically significant increase, *(p* < 0.001), with a large effect size (*r* = 0.51) and the Fugl Meyer lower extremity passive join motion and joint pain values, with a large effect size (*r* = 0.48) and (*r* = 0.61) respectively.

4.3.2 Within-group changes Group 2 - Neurodevelopmental Treatment approach

4.3.2.1 Upper extremity

Table 4.4 below shows the statistical analysis of physical performance outcomes using the Fugl Meyer upper extremity values.

A Wilcoxon Signed Rank Test revealed a statistically significant increase in Fugl Meyer upper extremity values following participation in NDT group, *(p*< 0.001), with a large effect size (*r* = 0.62) with similar significance for the wrist and hand values with large effect size (*r* = 0.58) and (*r* = 0.60) respectively.

A statistically significant increase in Fugl Meyer coordination with a change in the median was found for this group with a 37.8% improvement in the total score. An improvement in sensation (*p* < 0.001) was also found, with large effect sizes (*r* = 0.46) and (*r* = 0.54) respectively. Likewise, Fugl Meyer passive joint motion values and pain values (*p* < 0.001) had statistical significant increases, with large effect sizes (*r* = 0.46) and (*r* = 0.60) respectively.

Table 4.4: Group 2 -Neurodevelopmental treatment approach on upper extremity physical performance

Fugl Meyer Variables	**Pre-test (n=30)**	**Post-test (n=30)**	***z*-value**	**p value**	**Effect size (Cohen's r)**
	Median (Lower and upper quartile)	Median (Lower and upper quartile)			
Upper extremity	13.50 (9.75 – 19.00)	28.00 (20.00 – 36.00)	-3.58	≤0.001**	0.46**
Wrist	3.00 (0.00 – 5.00)	7.00 (5.00 – 10.00)	-4.49	≤0.001**	0.58***
Hand	2.00 (0.00 – 7.00)	10.00 (6.00 – 14.00)	-4.64	≤0.001**	0.60**
Coordination	4.00 (3.00 – 6.00)	6.00 (6.00 – 6.00)	-3.58	≤0.001**	0.46**
Total	22.5 (12.75 – 33.5)	49 (38.75 – 63.75)	-4.79	≤0.001**	0.62***
Sensation	6.00 (6.00 – 12.00)	12.00 (10.00 -12.00)	-4.06	≤0.001**	0.54***
Passive Joint Motion	20.00 (12.00 – 24.00)	24.00 (20.00 – 24.00)	-3.53	≤0.001**	0.46**
Joint Pain	8.00 (0.00 – 12.00)	20.00 (17.25 – 24.00)	-4.65	≤0.001**	0.60***

*Significant at p <0.05**. Significant at p <.0.01***.*

*Large Effect Size = 0.5***.*
*Medium Effect Size = 0.3***
*Small Effect Size = 0.1**

4.3.2.2 Lower extremity.

Table 4.5 below shows the outcomes of the Fugl Meyer lower extremity physical performance after a Wilcoxon Signed rank test was done. Following participation in the NDT approach, a statistically significant increase in Fugl Meyer lower extremity and coordination values, $p < 0.001$ was observed with a total improvement of 38.3%, with large effect sizes (r = 0.61) and (r = 0.48) respectively. It also revealed a statistically significant increase in Fugl Meyer's lower extremity sensation values, $p < 0.001$, with a large effect size (r = 0.43).

Table 4.5: Group 2- Neurodevelopmental treatment on lower extremity physical performance

Fugl Meyer Variables	**Pre-test (Md) (n=30)**	**Post-test (Md) (n=30)**	***z*-value**	**p value**	**Effect size (Cohen's r)**
	Median (Lower and upper quartile)	Median (Lower and upper quartile)			
Lower extremity	12.5 (6.00 – 16.00)	24.50 (18.00 - 26.00)	-4.71	≤0.001**	0.61***
Coordination	4.00 (2.25 – 6.00)	6.00 (6.00 – 6.00)	-3.74	≤0.001**	0.48**
Total	17.5 (6.75 – 22.00)	30.5 (24.00 – 34.00)	-4.71	≤0.001**	0.61***
Sensation	10.00 (6.00 – 12.00)	12.00 (10.00 -12.00)	-3.34	≤0.001**	0.43**
Passive Joint Motion	20.00 (10.00 – 20.00)	20.00 (20.00 – 20.00)	-3.31	≤0.001**	0.43**
Joint Pain	10.00 (6.75 – 14.50)	20.00 (15.50 – 20.00)	-4.33	≤0.001**	0.56***

*. Significant at p <0.05**. Significant at p <.0.01***.*

*Large Effect Size = 0.5***.*
*Medium Effect Size = 0.3***
*Small Effect Size = 0.1**

Consequently, the test revealed a statistically significant increase in Fugl Meyer lower extremity passive join motion values $p < 0.001$, with a large effect size ($r = 0.48$) and a statistically significant increase in Fugl Meyer lower extremity joint pain values $p < 0.001$, with a large effect size ($r = 0.56$).

4.4 Between-group comparison of treatment approaches

4.4.1 Upper extremity

Table 4.6 below shows a Mann Whitney U test conducted to determine whether the motor relearning occupation-based approaches were more effective than NDT approaches.

All components for both groups except coordination and passive joint motion for Group 2- NDT approach participants, achieved the reported minimal clinically important difference (MCID) for the Fugl Meyer upper extremity scores. The change in scores was above the MCID reported for stroke patients which are 12.4 (total), 5.6

(upper arm), and 4.9 (wrist/hand). All scores should achieve a change of 4.25 points for MCID.

There was a significant statistical difference in total scores for motor relearning occupation-based approach and NDT group, (p = 0.020, with a large effect size (r=0.42)), upper extremity (p = 0.014) and wrist scores (p = 0.027) with large effect sizes (r=0.45) and (r=0.40) respectively indicating the difference was clinically important. The significantly greater change for these components in Group 1- motor relearning occupation-based approach participants compared to those for Group 2- NDT approach participants indicated clinical effectiveness of the motor relearning occupation-based approach.

Table 4.6: Between group comparison of treatment approaches on upper extremity physical performance

Physical Components	**Change in Motor learning occupation-based scores**	**Change in Neurodevelopmental Treatment scores**		
	Median (Lower and upper quartile)	Median (Lower and upper quartile)	p value	Effect size (Cohen's r)
Upper Extremity	16.00 (14.00-18.00)	13.00 (8.00-16.00)	0.014*	0.45**
Wrist	5.00 (4.00 – 10.00)	5.00 (2.00 – 5.00)	0.027*	0.40**
Hand	7.00 (5.00 – 9.00)	7.00 (4.00 – 8.00)	0.290	0.19*
Coordination	0.00 (0.00 – 3.00)	1.00 (0.00 – 3.00)	0.970	-0.01
Total	29.00 (25.00 – 34.00)	25.00 (20.00 – 30.00)	0.020*	0.42**
Sensation	4.00 (0.00 – 6.00)	4.00 (0.00 – 6.00)	0.864	-0.03
Passive joint motion	5.00 (0.00 – 10.00)	2.00 (0.00 – 8.00)	0.468	0.13*
Joint pain	10.00 (6.00 – 10.00)	12.00 (8.00 – 14.00)	0.010**	-0.47**

*Significant at p <0.05**. Significant at p <.0.01***.* *Large Effect Size = 0.5***.*
*Medium Effect Size = 0.3***
*Small Effect Size = 0.1**

The significant difference for joint pain showed that Group 2- NDT approach participants had greater improvement (p=0.010) with a large effect size (r=0.47) for this component than Group 1- motor relearning occupation-based approach participants.

There was no significant difference in the change in scores for Group 1 motor relearning approach participants and the Group 2-NDT approach participants for hand, coordination, sensation and passive joint motion scores. Improvement for both coordination and sensation scores were greater for Group 2- NDT approach participants. Effect sizes were small and medium with the Group 2- NDT approach participants having very small improvements for coordination (r=-0.01) and sensation (r=-0.03) respectively. Group 1 motor relearning approach participants had more improvement in hand and passive joint motion scores with effect sizes of (r=0.19) and (r=0.13) respectively.

4.4.2 Lower extremity

Mann Whitney U tests were conducted for comparison of treatment approaches on lower extremity physical performance.

Table 4.7: Comparison on treatment approaches on lower limb physical performance

Physical Components	**Change in Motor learning occupation-based scores**	**Change in Neurodevelopmental Treatment scores**	**p value**	**Effect size (Cohen's r)**
	Median (Lower and upper quartile)	Median (Lower and upper quartile)		
Lower Extremity	12.00 (8.00 – 18.00)	10.00 (8.00 – 16.00)	0.482	0.13*
Coordination	2.00 (0.00 – 3.00)	1.00 (0.00 -3.00)	0.848	0.02
Total	12.50 (8.75 – 19.25)	13.00 (8.00 – 19.25)	0.711	0.05
Sensation	4.00 (0.00 – 6.00)	0 (0.00 – 4.50)	0.131	0.20*
Passive joint motion	4.00 (0.00 – 10.00)	0.00 (0.00 – 10.00)	0.862	0.02
Joint pain	10.00 (6.00 – 10.00)	9.50 (3.50 – 10.00)	0.197	0.17*

*. Significant at p <0.05**. Significant at p <.0.01***.*

*Large Effect Size = 0.5***.*
*Medium Effect Size = 0.3***
*Small Effect Size = 0.1**

The total for both groups achieved the reported minimal clinically important difference (MCID) for the Fugl Meyer lower extremity scores. The change in scores was above the MCID reported for stroke patients which is 6 for the total score. The results for the lower extremity scores comparing Group 1- motor relearning occupation-based approach participants and Group 2- NDT approach participants achieved no significant differences between the groups.

Small effect sizes were found for all components when the groups were compared with Group 1- motor relearning occupation-based approach participants achieving more improvement for all components.

4.5 Modified Barthel Index - treatment approaches in self-care

4.5.1 Within-group changes Group 1 Motor relearning occupation-based approach in self-care

To understand the effectiveness of the motor learning occupation-based approach on self-care a Wilcoxon Signed Rank Test was performed on each of the following post-test scores revealing results as stated below. The test revealed statistically significant increases in Barthel Index chair/bed transfers, ambulation and ambulation/wheelchair ($p < 0.001$), with a large effect size ($r = 0.62$). The test also revealed a statistically significant increase in Barthel Index stair climbing values, ($p < 0.001$), with a large effect size ($r = 0.59$).

Statistically significant increases in Barthel Index toilet transfer values, ($p < 0.001$), with a large effect size ($r = 0.62$) was observed. Bowel control, bladder control had a similar significant increase in scores with a large effect size ($r = 0.46$) for both.

Statistically significant increases in the Barthel Index for bathing, dressing, personal hygiene and feeding values ($p < 0.001$), with a large effect size ($r = 0.62$) for all components were found. The total improvement for the Barthel Index was 78.0%.

Table 4.8: Effectiveness of motor learning occupation-based approaches on self-care

Barthel Index	**Pre-test (Md) (n=30)**	**Post-test (Md) (n=30)**	***z*-value**	**p value**	**Effect size (Cohen's r)**
	Median (Lower and upper quartile)	Median (Lower and upper quartile)			
Chair/bed Transfers	0.00 (0.00 – 3.00)	12.00 (8.00 – 12.00)	-4.82	≤0.001**	0.62***
Ambulation	1.50 (0.00 – 3.00)	8.00 (8.00 – 12.00)	-4.82	≤0.001**	0.62***
Ambulation/ Wheelchair	1.00 (0.00 – 1.00)	4.00 (3.00 – 5.00)	-4.87	≤0.001**	0.62***
Stair Climbing	0.00 (0.00 – 0.00)	5.00 (2.00 – 8.00)	-4.59	≤0.001**	0.59***
Toilet Transfers	1.00 (0.00 – 2.00)	8.00 (5.00 – 10.00)	-4.83	≤0.001**	0.62***
Bowel control	5.00 (3.75 – 10.00)	10.00 (5.00 – 10.00)	-3.56	≤0.001**	0.46**
Bladder control	5.00 (3.75 – 10.00)	10.00 (5.00 – 10.00)	-3.56	≤0.001**	0.46**
Bathing	0.00 (0.00 – 1.50)	4.00 (3.00 – 5.00)	-4.81	≤0.001**	0.62***
Dressing	0.00 (0.00 – 2.00)	8.00 (5.00 – 8.00)	-4.83	≤0.001**	0.62***
Personal hygiene	0.00 (0.00 – 1.00)	4.00 (3.00 -5.00)	-4.83	≤0.001**	0.62***
Feeding	2.00 (0.00 – 2.00)	8.00 (5.00 – 10.00)	-4.83	≤0.001**	0.62***
Total	2.00 (10.50 – 34.00)	80.00 (59.50 – 86.50)	-4.78	≤0.001**	0.62***

*. Significant at p <0.05**. Significant at p <.0.01***.*

*Large Effect Size = 0.5***.*
*Medium Effect Size = 0.3***
*Small Effect Size = 0.1**

4.5.2 Within group changes Group 2 neurodevelopmental treatment approach on self-care

To comprehend the effectiveness of NDT approach on self-care the Wilcoxon Signed Rank Test was performed on the each of the following revealing results as stated below. The test revealed statistically significant increases in Barthel Index chair/bed transfers, ambulation p < 0.001, with a large effect size (r = 0.62). The test also revealed a statistically significant increase in ambulation/wheelchair (p < 0.001), with a large effect size (r = 0.63).

Statistically significant increase in Barthel Index stair climbing values $p < 0.001$, with a large effect size ($r = 0.54$) was found. The total improvement for the Barthel Index was 56%.

Table 4.9: Effectiveness of neurodevelopmental treatment on self-care

Barthel Index	**Pre-test (Md) (n=30)**	**Post-test (Md) (n=30)**	***z*-value**	**p value**	**Effect size (Cohen's r)**
	Median (Lower and upper quartile)	**Median (Lower and upper quartile)**			
Chair/bed Transfers	0.00 (0.00 – 3.00)	8.00 (3.00 -12.00)	-4.83	≤0.001**	0.62***
Ambulation	0.00 (0.00 – 0.00)	5.50 (3.00 – 12.00)	-4.78	≤0.001**	0.62***
Ambulation/ Wheelchair	0.00 (0.00 – 0.00)	3.50 (3.00 – 4.00)	-4.86	≤0.001**	0.63***
Stair Climbing	0.00 (0.00 – 0.00)	2.00 (0.00 – 2.75)	-4.16	≤0.001**	0.54***
Toilet Transfers	0.00 (0.00 – 0.00)	5.00 (2.00 – 8.00)	-4.83	≤0.001**	0.62***
Bowel control	0.00 (0.00 – 5.00)	10.00 (5.00 – 10.00)	-4.33	≤0.001**	0.56***
Bladder control	0.00 (0.00 – 5.00)	10.00 (5.00 – 10.00)	-4.26	≤0.001**	0.55***
Bathing	0.00 (0.00 – 0.00)	3.00 (3.00 – 3.00)	-4.94	≤0.001**	0.64***
Dressing	0.00 (0.00 – 0.00)	5.00 (2.00 – 5.00)	-4.87	≤0.001**	0.63***
Personal hygiene	0.00 (0.00 – 0.00)	3.00 (3.00 – 4.00)	-4.82	≤0.001**	0.62***
Feeding	0.00 (0.00 – 2.00)	5.00 (2.00 – 10.00)	-4.81	≤0.001**	0.62***
Total	2.00 (0.00 -12.75)	58.00 (38.50 – 72.25)	-4.78	≤0.001**	0.62***

*. Significant at p <0.05**. Significant at p <.0.01***.*

*Large Effect Size = 0.5***.*
*Medium Effect Size = 0.3***
*Small Effect Size = 0.1**

Statistically significant increase in Barthel Index toilet transfers values $p < 0.001$, with a large effect size ($r = 0.62$) was also found. The test also showed a statistically significant increase in bowel control values $p < 0.001$, with a large effect size ($r = 0.56$). Bladder control values and bathing also revealed a statistically significant increase $p < 0.001$, with a large effect sizes ($r = 0.55$) and ($r = 0.64$) respectively.

Statistically significant increase in Barthel Index dressing values, $p < 0.001$, with a large effect size ($r = 0.63$) was found. Statistically significant increases in the Barthel Index for personal hygiene and feeding values ($p < 0.001$), with a large effect size ($r = 0.62$) for both components were found.

4.6 Between group comparison of treatment approaches on self-care

Table 4.10 shows the results of Mann Whitney U test, applied to compare the post-test Barthel Index scores. The test revealed a significant difference in the chair/bed transfer in Group 1 motor relearning approach participants has a significantly larger improvement in mobility components including chair/bed transfers ($p = 0.002$), ambulation ($p = 0.037$), stair climbing ($p = 0.027$) and toilet transfers ($p = 0.023$) all with large and moderate effect sizes ($r=0.28-0.39$), indicating clinically important improvement compared to Group 2 NDT approach participants.

Group 1- motor relearning approach participants also had significantly more improvement for self-care components including bathing ($p=0.001$), dressing ($p=0.001$) and personal hygiene ($p=0.008$) with large effect sizes ($r=0.34-0.53$), indicating clinically important improvement compared to Group 2 - NDT approach participants indicating clinical difference for the two groups.

There was no significant difference in ambulation, bowel and bladder control and feeding between Group 1 motor relearning approach participants and Group 2 NDT approach participants. All of these components had small effect sizes between ($r=0,10$ and $r=0.28$) with Group 1 motor relearning approach participants having a greater increase in change scores than Group 2 NDT approach participants except for ambulation/wheelchair.

Table 4.10: Comparison of treatment approaches on self-care

Barthel index	Change in Motor learning occupation-based scores(n = 30)	Change in Neurodevelopmental Treatment scores (n = 30)		
	Median (lower and upper quartile)	**Median (lower and upper quartile)**	**p value**	**Effect size – Cohen's r value**
Chair/bed transfers	12.00 (8.00 – 12.00)	8.00 (3.00 – 12.00)	0.002**	0.39**
Ambulation	8.00 (8.00 – 12.00)	5.50 (3.00 – 12.00)	0.072	0.23*
Ambulation/ wheelchair	4.00 (3.00 – 5.00)	3.50 (3.00 – 4.00)	0.035*	0.28*
Stair climbing	5.00 (2.00 – 8.00)	2.00 (0.00 -2.75)	0.027*	0.31**
Toilet transfers	8.00 (5.00 – 10.00)	5.00 (2.00 – 8.00)	0.023*	0.31**
Bowel control	10.00 (5.00 – 10.00)	10.00 (5.00 – 10.00)	0.413	0.10*
Bladder control	10.00 (5.00 – 10.00)	10.00 (5.00 – 10.00)	0.364	0.12*
Bathing	4.00 (3.00 – 5.00)	3.00 (3.00 – 3.00)	0.001**	0.53***
Dressing	8.00 (5.00 – 8.00)	5.00 (2.00 – 5.00)	0.001**	0.43**
Personal Hygiene	4.00 (3.00 – 5.00)	3.00 (3.00 – 4.00)	0.008**	0.34**
Feeding	8.00 (5.00 – 10.00)	5.00 (2.00 – 10.00)	0.096	0.22*
Total	80.00 (59.50 – 86.50)	58.00 (38.50 – 72.25)	0.004	0.37**

*Significant at p <0.05**. Significant at p <.0.01***.*

*Large Effect Size = 0.5***.*
*Medium Effect Size = 0.3***
*Small Effect Size = 0.1**

4.7 Correlation of the change in physical performance and self-care

4.7.1 Motor relearning occupation-based group

The change in the Fugl Meyer scores showed a low correlation between the upper and lower extremity Group 1 motor relearning approach participants. This indicates the percentage increase in physical performance in the upper and lower extremity were not related in this group with a higher increase in upper extremity function.

The group also had a low correlation for change in the total scores for physical performance in the upper and lower extremity with the change in self-care indicating no relationship between physical performance and self-care as the percentage increase in total Barthel Index scores was much higher than for the total Fugl Meyer scores.

Table 4.11: Correlation of change in scores for physical performance self-care for the Neurodevelopmental Treatment and Motor relearning occupation-based groups

	Change in Neurodevelopmental Treatment scores		Change in Motor relearning occupation-based scores	
	Change total lower extremity	**Total change Barthel Index**	**Change total lower extremity**	**Total change Barthel Index**
Change total upper extremity	0.62*	0.35*	0.24	-0.13
Change total lower limb		0.39*		-0.23

Significance p≤ 0.05

4.7.2 Neurodevelopmental Treatment group

The change in the Fugl Meyer scores showed a moderate correlation between the upper and lower extremity in Group 2 NDT approach participants. This indicates a similar percentage increase in physical performance in the upper and lower extremity in this group. The group also had a low significant correlation for change in the total scores for physical performance in the upper and lower extremity with the change in self-care indicating a weak relationship between physical performance and self-care in this group as the percentage increase in total Barthel Index scores was higher than for the total Fugl Meyer scores.

4.8 Summary

This chapter presented the results from quantitative data collected in a pre-test post-test quasi-experimental study. The researcher wanted to explore the outcomes of two approaches commonly used in occupational therapy for rehabilitation of patients with TBI namely the motor relearning occupation-based and the NDT approach.

The study shows that both the motor relearning occupation-based and the NDT approach are effective in improving physical performance and self-care after acute TBI with significant changes within both groups for all components assessed.

Nevertheless, the motor relearning occupation-based approach showed greater improvement in the total, upper extremity and wrist scores as reported by the Fugl Meyer upper extremity test. The NDT approach showed greater improvement in pain scores on a Fugl Meyer upper extremity test and lower extremity test. Thus the hypothesis that there will be no differences in the outcomes between motor relearning occupation based and NDT approaches in physical performance outcomes in adults post-acute TBI was partially rejected for the upper extremity and accepted for the lower extremity.

It also showed superiority in Barthel index scores namely ambulation/wheelchairs/ stair climbing, chair/bed transfers, toilet transfers, dressing, bathing, and personal hygiene. Whereas the neurodevelopmental approach showed greater improvement in pain scores on a Fugl Meyer upper extremity test and lower extremity test. Thus the hypothesis that there will be no differences in the outcomes between motor relearning occupation based and NDT approaches in for self-care outcomes in adults post-acute TBI was rejected.

CHAPTER 5: DISCUSSION

5.1 Introduction

In this chapter the common causes of TBI among patients admitted at Katutura Intermediate Hospital are considered. The outcomes of motor relearning occupation-based approach on physical performance and self-care among adults post-acute TBI as well as the outcomes of NDT approach on physical performance and self-care among adults post-acute TBI are discussed. The outcomes between these two approaches are compared for both physical performance and self-care for both groups. The limitations and strengths of the study were also presented.

5.2 Demographic characteristics

The demographic details revealed that most of the participants were of the ages between 25 and 34 years with the majority being males, most of them had secondary education and had paid employment. These variables showed no significant difference between the motor relearning occupation-based group and the NDT group. This was similar to a study by Theadom *et al.*, (2017) done in New Zealand which recorded a mean age of 39.63 and the majority of the participants being males (57.3%) whereas a study by Dawson *et al.*, (2013b) done in Canada showed a mean age of 42 between groups with more males than females being affected by TBI. This shows that TBI is more prevalent among young adults and males are more susceptible to TBI as compared to their female counterparts. It was noted by Harris *et al.*, (2019) that concussions and mild TBI are mostly prevalent in youths and young adults between 25 to 34 years, the researchers further reiterated that occupational therapists working with this population can assist in identifying domains that are mostly affected which influence patient care. The effects seen with mild TBI are however as debilitating and they cause financial, social and QOL ills, a large number of patients describe serious symptoms after mild TBI (Bramlett and Dietrich, 2015).

The characteristics that had a significant difference between groups included the marital status with Group 1 motor relearning occupation-based approach having more cohabiting participants than Group 2 –NDT approach. However, the effect of this on the two groups' outcomes indicated that the unmarried participants had greater improvement in upper extremity physical performance although there appears to be little research on the relationship of these variables. For occupational performance outcomes however no significant differences were found in the current study although literature has reported that pre-injury occupation, high level of education, female sex and being married make a significant contributing factor to occupational performance outcomes (Walker *et al.*, 2006). No significant differences were noted between the two groups; this shows that the demographic characteristics were not predictors of better or worse occupational outcomes.

5.3 Head injuries in patients admitted at Katutura Intermediate Hospital

The first objective of the study strived to determine the common causes and types of TBI among patients admitted at Katutura Intermediate Hospital.

5.3.1 Common causes of head injuries

The findings from the current study suggest that most of TBI cases were caused by vehicle-related collisions and affect mostly adults aged between 25 to 34, the same findings were noted in a study by Dewan *et al.*, (2018) who reported that road traffic accidents are responsible for the silent epidemic of TBI, among the productive age groups in LMICs, a classification into which Namibia falls. This is supported by the high rates of motor related accidents in Namibia as stated by Motor Vehicle Accident Fund, (2016) which is a cause for concern. A study conducted in India, another LMIC by Agrawal *et al.*, (2012) also confirmed that MVAs remain the leading cause of TBI affecting mainly young adult males. This supports the fact that traffic related injuries internationally still remain a cause for concern as a cause of TBI especially in LMIC. A study by Scholten *et al.*, (2014) in Netherlands indicates that in developed countries the majority of patients who sustained a TBI caused by a traffic related injury (33.5%) were in the age group between 15 to 54 years. Research by Peeters *et al.*, (2015) that summarised findings from 28 epidemiological studies on TBI from a number of European countries determined that falls as well as road traffic accidents were the two most frequent causes of TBI, with falls being reported more frequently than road traffic accidents.

There also was evidence of other causes of traumatic brain injuries namely violence and falls. Although there were significant differences in causes of injury between groups, this did not affect the treatment outcomes and therapy given to the two groups since all injuries were caused by external forces. This was confirmed in a study by Theadom *et al.*, (2017) who showed intervention results were not associated with mechanisms of injury such as falls that were predominant in their study, as well as assault and exposure to other mechanical forces.

5.3.2 Types of head injuries

The findings from this study suggest that that the majority of the participants had mild TBI. Literature indicates that mild TBI were seen to occur in greater frequencies than moderate or severe TBI with estimates of a 10 fold occurrence of mild head injuries compared to moderate or severe TBI in a study by Dewan *et al.*, (2019). Agrawal *et al.*, (2012) stated that around 10% of survivors had moderate or more severe TBI-related disabilities. In a study by Theadom *et al.*, (2018) they concur but indicate that even mild TBI can cause symptoms that result in performance and long term community participation deficits that are manifest years after the injuries.

Research by Dawson *et al.*, (2013b) showed a ratio of hospitalised mild: moderate-severe to be 1:6 stating that there are more moderate-severe cases treated as those with mild cases of TBI do not seek treatment or are not always hospitalised. The severity of TBI is difficult to ascertain however because different regions use different measurements, therefore measures on consciousness are used to describe the severity of TBI (Cassidy *et al.*, 2004).

5.3.3 Glasgow Coma Scale

The GCS is used to describe impairments that affect consciousness in cases of trauma and assesses responsiveness to motor, eye opening and communication. It is used as an important prognostic factor after trauma and in the current study participants in the two groups had GCS scores with a mean of 12 to 13. This illustrated that most of the participants in the study had mild to moderate head injuries. Although a few of the participants had GCS scores ranging from 9 – 11, they met the inclusion criteria in this study since these scores are regarded as indicating a moderate TBI. Total scores between 3 and 8 are regarded as severe, those between 9 – 11 as moderate and scores between 12-15 indicate mild TBI (Middleton, 2012). A study by Zhu *et al.*, (2007) revealed that a GCS score of 12 and above will be considered as mild and intense rehabilitation can improve functional outcomes in particular of patients who present with this level of GCS.

5.4 Effectiveness of motor relearning occupation-based approach on physical performance and self-care

The second objective of the study was to determine the outcomes of motor relearning occupation based approach on physical performance and self-care among adults post-acute TBI. The results of the study indicate that there was a significant improvement in physical performance and self-care after using motor relearning occupation-based approach. Overall, there was a significant improvement noted on a Fugl Meyer scale which included upper extremity, wrist, hand, coordination, pain, passive range of motion and sensation as well as the lower limb coordination, pain, sensation, and passive range of motion.

The percentage improvement in the physical performance of the upper extremity in Group 1 – motor relearning occupation-based approach participants was greater at 43.9% compared to the lower extremity at 35.2% in the current study. The notable improvements in upper extremity as compared to lower extremity found in the current study could be attributed to the fact that occupational therapists tend to focus more on the upper extremity than the lower extremity. Rowland *et al.*, (2008) found that occupational therapists mostly work on improving upper extremity motor control and hand function after acquired brain injuries. However, Powell, Rich and Wise, (2018) in their appraisal seem not to be convinced of the full efficacy of motor relearning occupation-based approach or occupation/activity-based intervention when treating physical performance, they stated that there is only moderate evidence that it works in the treatment of TBI. The same could be drawn from this study since there was more improvement in self-care than there was in physical performance.

The participants in the motor relearning occupation-based group were found to have a 78% improvement on the Barthel Index indicating the effectiveness of this approach in self-care in adults with TBI. This was confirmed by statistically significant results and the observed effect sizes which were high, describing the high clinical importance of the approach.

The process of motor relearning involves understanding sequences that allow for specific functional tasks, this process causes more connectivity within brain cells and communication within cells which allows for more representation of skill concepts in the brain (Turolla *et al.*, 2018). It appears that patients using motor relearning concepts in an occupation based programme regain function and independence by being involved in occupations they find meaningful to them since these occupations improve cortical representation of their skill sets.

Occupation-based treatments done in a hospital setup that mimic the home environment improved neuroplasticity, increased functional use of the affected upper and lower extremities, and improved occupational performance (Skubik-Peplaski *et al.*, 2017). The motor relearning occupation based programme used in the current study involved occupation specific training in a hospital milieu according to task demands. There was training of performance skills and patterns required for the particular tasks chosen by participants. The therapists did not follow developmental sequences and progression was made by increasing the complexity in execution of the tasks. Therapist and patients both participated in analysis and correction of the movements for completion of tasks and emphasis was on repetition of tasks (Bhalerao, Kulkami and Kapoor, 2011).

Interventions which utilise task specific concepts are increasingly being used because of their ability to stimulate motor relearning as well as their effects on the reorganisation around the brain lesion (Shepherd, 2001). Research suggests this approach which includes bilateral upper extremity movement may result in neuroplastic change related to both upper extremities and not only the affected upper extremity, with cortical-motor reorganisation occurring bilaterally (Skubik-Peplaski *et al.*, 2012). This study demonstrated that activities that are meaningful to an individual are not structured in any way, motor relearning occupation-based programme allows the therapist to facilitate and not to lead in movements that a patient wants to achieve. This supports the assumption followed in motor relearning occupation-based approach that performance of a task that is meaningful to the patient, relatively difficult and has an end product can elicit neuroplasticity and enable functional recovery in patients (Shepherd, 2001). Since the approach is not a hands on approach there is also evidence supporting the role of the patient in the recovery process since according to Horn *et al.*, (2015) the level of effort the patients put in the execution of activities predicts their recovery. In the current study observations were made that participants using the motor relearning occupation-based group made more efforts in fulfilling their occupations as an end goal.

This was also noted by Giuffrida *et al.*, (2009) who stated that a significant improvement in performance is seen more in random practice than in structured practice and a transfer of skill is noted in the random practice. In this study, the participants who were involved in motor relearning occupation-based group had their therapies structured on occupations that were meaningful to them. Their engagement in these occupations showed significant outcomes, they were motivated to perform and participate than in engagement in rote exercises and tasks. The findings give proof that individuals with TBI will improve their everyday life by applying gains found using motor relearning occupation-based approaches.

The motor relearning occupation-based approach was thus found to be effective in enhancing physical performance and task performance after acquired brain injury, in the current study. Similar findings were noted in a number of other studies. Chan *et al.*, (2006) found that the patients' recovery was noted by significant improvement in physical ability in balance as well as for all aspects of self-care assessed by the Functional Independence Measure. Kollen *et al.*, (2009) also concluded that activities when used in inpatient therapy can elicit functional recovery when the activities are relatively challenging to the individual performing the task. The studies by Kollen *et al.*, (2009) and Chan *et al.*, (2006) found Barthel Index as in the current study showed responsiveness for improvements in transfers, bathing, personal hygiene, dressing and feeding.

5.5 Effectiveness of Neurodevelopmental Treatment approach on physical performance and self-care

The third objective of the study was to determine the outcomes of NDT approach on physical performance and self-care among adults post-acute TBI. Although a study by Kollen *et al.*, (2009) also illustrated the fact that evidence supporting NDT's superiority is lacking in managing sensorimotor deficits in the upper extremity and the lower extremity as well as in execution of ADLs there was a significant improvement in physical performance and self-care for participants in the NDT treatment group in the current study.

There are some neurological changes that are expected to occur due to a brain lesion that affect motor pathways and connections, these include loss of power, differences in tone and poor communication with the cortical areas that affect movement

(Shepherd, 2001). These symptoms can be addressed by using NDT which focuses mainly on the motor units and the physical performance domain assessed by the Fugl Meyer showed significant improvements in upper and lower extremity total scores, sensation, coordination, movements and pain scores in the current study. The percentage improvement in the physical performance of the upper extremity in Group 2 – NDT approach participants was slightly lower at 37.8% compared to the lower extremity at 38.2% in the current study. The improvement seen in the upper and lower extremity in Group 2 NDT approach participants was similar as therapy applies equally to both extremities since the approach supports clinical reasoning which allows the therapist to focus on individual deficits. In the current study, the therapist in the NDT group focused on training of normal movement patterns, normal postures and isolated weight shift during movement. Emphasis was laid on testing, training of response to handling, protective reactions, postural control, and equilibrium reactions without task specific movement patterns. Guidelines used focused on developmental sequences, movements were elicited in prone, supine, sitting, standing and walking. The therapist analysed and corrected the movements then the participants had to follow the guidelines given by the therapist. The main guidelines included influencing of spasticity, avoidance of abnormal patterns of movement and facilitation of normal movement patterns (Bhalerao, Kulkami and Kapoor, 2011).

No published studies on the effectiveness of NDT for adult TBI patients were sourced but Huseyinsinoglu, Ozdincler and Krespi, (2012), concluded that participants treated with an NDT approach showed significant improvement in physical performance including sensorimotor function, quality and speed of movement in paretic upper extremity after stroke. They did not indicate the effect of treatment in the lower extremity. A study by Bhalerao, Kulkami and Kapoor, (2011) however revealed that post-therapy participants treated with an NDT approach showed significant improvement in both upper and lower extremities on all scales of motor function and functional mobility after stroke. However upper and lower extremities could not be compared since only a total Fugl Meyer assessment score was reported.

The improvement seen in self-care for Group 2 – NDT approach participants supports the hierarchical approach in NDT that follows steps that need to be taken to achieve functional recovery by eliciting normal movements and preventing compensation.

The NDT approach is a bottom up approach which relies on treating underlying symptoms with the assumption that this will lead to an improvement in occupational performance.

The findings of the current study were very different from Hafsteinsdóttir *et al.*, (2005) which found NDT ineffective as a treatment modality for self-care in stroke patients. The researchers stated that there was no improvement noted as measured by the Barthel Index which showed poor outcome. They attributed this to the approach's deficiency in emphasizing active participation, just right challenge and enabling independence. Their study was however carried out on patients with stroke by nurses and physiotherapists. It can be assumed in the current study that more emphasis was placed on self-management for participants in Group 2, since the therapist involved in the NDT programme was an occupational therapist. She may well have placed more emphasis on participation in self-care since there was a change of over 50% in the self-care assessed on the Barthel Index which was higher than the change seen in the physical performance for the upper and lower extremity.

5.6 Comparison of treatment approaches on physical performance and self-care

The fourth objective was to compare the outcomes between motor relearning occupation based and NDT approaches on functional outcomes in adults post-acute TBI and determine association between the physical performance and self-care for both groups. The results showed that both the motor relearning occupation-based and NDT approach are useful approaches in treating individuals with TBI in addressing recovery of physical performance and independence in self-care.

5.6.1 Comparison of treatment approaches

In the current study, between-group comparison showed that most components for both groups achieved the reported minimal clinically important difference (MCID) for the FMA upper extremity scores. Although the MCID included in the current study were recorded for stroke patients it was assumed this could be applied to patients with TBI since they are all acquired brain injuries. The MCID of the FMA scores should be greater than a change of 12.4 for the upper extremity, 5.6 in the upper arm, and 4.9 in wrist/hand scores. (Hiragami, Inoue and Harada, 2019).

Thus, the current study shows improvements in physical performance were above the MCID for both groups with more improvements noted in Group 1 – motor relearning occupation-based approach participants except for coordination, sensation and joint pain.

Although a study by Lannin and McCluskey, (2008) stated that there was no comprehensive evidence of effects of different treatment approaches used in TBI, , these approaches have provided evidence of efficacy. While this is true for the current study overall, the change for the upper extremity was higher in Group 1 - motor relearning occupation-based approach participants was significantly higher with a total percentage increase of 43.9% compared to 37.8% in Group 2 - NDT approach participants. These results are in line with a study by Langhammer and Stanghelle, (2000) who concluded that treatment that used the motor relearning approach was preferred in improving upper extremity physical performance to the one using the NDT approach in the acute rehabilitation of stroke patients. A later study by the same authors in 2011 which showed significant improvements in physical performance after using occupation-based approaches in stroke patients compared to an NDT on both the motor assessment scale and the Sodring Motor Evaluation Scale, also confirmed these findings (Langhammer and Stanghelle, 2011). Skubik-Peplaski *et al.*, (2017) also showed a significant improvement in total FMA scores in occupation-based intervention programme. They also noted that repetitive task practice intervention was preferable to enable movement quality in acute rehabilitation of stroke patients over eight treatment sessions than an occupation-based intervention programme.

However, the current study illustrated that the change in participants in Group 1 was not consistently better than that for participants in Group 2. While there was significantly greater change for the upper extremity and wrist on the FMA for Group 1, there was no significant difference between the two groups in hand, passive joint movement, sensation and coordination. Nonetheless, the effect size favoured Group 1 - motor relearning occupation-based approach for improvement in hand and passive joint movement while co-ordination was favoured in Group 2. These findings are supported by Platz *et al.*, (2001) who report the efficacy of specific techniques in hand rehabilitation is not proven for patients with TBI, who have recovery of other upper extremity function. They found continued limitations in hand function including reduced speed and accuracy affecting coordination after discharge from inpatient rehabilitation. Since optimum recovery was seen two years post injury the researcher assumed that four weeks of rehabilitation post injury were too early to find noticeable changes in the both groups in the current study in terms of hand functioning and coordination (Khan, Baguley and Cameron, 2003; Lamontagne *et al.*,2013).

There was no difference found for sensation between the groups even though the NDT approach used some sensory input through positioning as part of the treatment. This could be attributed to the length of time for which the participants received input in the treatment approach which was not enough to cause significant changes in the client factors such as sensation. On the other hand, the participants in Group 2 - NDT approach had significantly more improvement for pain scores compared to the participants in Group 1 - motor relearning occupation-based approach. This is likely attributed to the use of handling and positioning that NDT focuses on, Walsh, (2001) stated that poor positioning exacerbates shoulder pain and other types of pain in patients with stroke. This can be addressed directly when using an NDT approach.

The difference in change of the total score for the upper extremity between the two groups was four points which is less than the MCID, therefore it must be assumed that both the motor relearning occupation-based approach and the NDT approach were effective in improving physical performance in the upper extremity after TBI.

From experience with TBI, the NDT treatment approach focused more on deficits in the upper extremity whereas the motor relearning occupation-based approach used emphasis on self-care among other occupations which used the upper extremities more than the lower extremity, this showed greater improvement in upper limb movements as compared to lower limbs. The lower extremity scores showed MCID of more than 6 (lower limb total) (Hiragami, Inoue and Harada, 2019) with no significant difference in the scores with participants in Group 1 - motor relearning occupation-based approach and the participants in Group 2 - NDT approach. A study by Bhalerao, Kulkami and Kapoor, (2011) revealed that NDT focussed on deficits in the lower extremity whereas the motor relearning occupation-based approach used transfers and functional mobility which resulted in the noted change.

The difference in change of the total score for the lower extremity between the two groups was 0.5, therefore it must be assumed that both the motor relearning occupation-based approach and the NDT approach are effective in improving physical performance in the lower extremity after TBI.

When comparing the differences in self-care between the groups, Group 1- motor relearning occupation-based approach participants also had significantly more improvement in Barthel index scores than Group 2 - NDT approach participants. Moderate to large effect sizes were found for seven of the domains of the Barthel index indicating important clinical difference for the two groups.

A significant improvement noted in self-care domains was noted for Group 1 for ambulation/wheelchair, transfers, bathing, stair climbing, personal hygiene, dressing, and feeding when using the motor relearning occupation-based approaches. This was confirmed by the much higher percentage change in self-care assessed on the Barthel index (78%) for participants in Group 1 - motor relearning occupation-based approach than the participants in Group 2 - NDT approach (56%). This is important since Poon et al (2007) have shown that self-care scores are a better predictor of recovery from moderate TBI at one year than age and GCS.

The findings of the current study are supported in a study by Ahn, (2016) who revealed that participation in activities is directly related to motor and process skills which are major components of motor releaning occupation-based approach. However, in the study by Langhammer and Stanghelle, (2011) they found that balance, leg function including walking, transfers, and stair climbing did not differ between the groups treated with occupation-based and NDT approaches. The effect sizes for these domains were also smaller in the current study than those for other self-care activities which included dressing and bathing indicating a smaller clinical difference between the two groups as well. This confirms the conclusions of Díaz-Arribas *et al.*, (2019) that NDT is not superior to other approaches in the management of ADLs after stroke.

The results of the current study appear to support that the use of the motor relearning occupation-based approach may be more effective for outcomes in physical performance in the upper limb and is more effective for outcomes in self-care than the NDT approach. Since there was no significant difference for the lower extremity, the findings of Seneviratne and Reimer, (2004) who concluded, when comparing the NDT and the motor relearning approach that mixed conclusions may be found was accepted. They are in agreement with some other studies that indicate that a motor relearning occupation-based approach should be added to the current occupational therapy theory and practice and this approach can be considered complimentary to NDT rather than superior to it. Therefore, the use of both approaches for various goals in occupational therapy should be considered.

5.6.2 Associations between physical performance and self-care

In the current study, the change in the FMA scores showed a low correlation between the upper and lower extremity Group 1 motor relearning occupation-based approach participants and a moderate correlation between the upper and lower extremity in Group 2 NDT approach participants. This meant that there was a direct relationship between physical performance and self-care in the NDT group and this relationship was not perceived in the motor relearning occupation-based approach. This can be attributed to the assumptions of these two approaches. The motor relearning occupation-based approach focuses more on execution of occupations through feedback, repetition and learning, it does not focus more on the impairments.

Whereas, the NDT focuses more on the impairments with the assumption that successful use of normal movements will be transferred to occupational performance areas. This will mean physical performance can be treated at impairment level which will then cause a good execution of activities that require the same components such as self-care. The correlation between the change in total physical performance and self-care in the current study indicated that the variables were related and that improvement in self-care may have been dependent on change in physical performance. The same was reported by Houlden *et al.*, (2006) who demonstrated that after an brain injury the main deterrent which affects execution in functional activities is physical performance, and the Barthel Index scores were somewhat sensitive to change in the performance of patients with TBI when an NDT approach was used.

5.7 Strengths and Limitations of the study

This research is subject to several strengths; this was the first study conducted in Namibia to report on the effectiveness of treatment approaches used by occupational therapists. Since it was a first study, a new research hypothesis was tested in a small number of participants to avoid spending too many resources. However, an association was ascertained therefore it is imperative to conduct a larger confirmatory study. It also conceptualised motor learning theories coupled with occupation-based approaches which enlightened on functional outcomes in occupational therapy.

The findings of this current study, however, have to be seen in light of some limitations due to the focus, methodology, data selection and scope of characteristics used. They are therefore discussed below. The present study focused on the effects of two treatment approaches in rehabilitation. However, all participants received other forms of therapy during this period and it is not clear what effect this may have had on their improvement, these included exercise regimens from caregivers, physiotherapy and speech therapy. It is possible that some aspects of the individual therapists such as therapeutic use of self and own understanding of treatment approaches and the environment such as a treatment setting, ways of instruction and feedback might have led to some biases that were not controlled for in this study which might have affected the effect sizes.

Additionally, the sample size used was small and therefore does not enable the results to be generalised to all population groups even though the sample was collected from a specialised hospital which caters for all geographic locations in Namibia. However, the discussion of the results suggested similarities with other studies. Therefore, the researcher suggests that the findings of this study cannot be generalised, however they can be applied to occupational therapy practice with caution.

Other limitations are on the methodology used which was a quasi-experimental pre-test post-test and not a randomised control trial in the evaluation of the treatment effectiveness. The confidence placed in the findings is much related to the assumptions one uses since to avoid statistical violations some non-parametric tests were used which have less sensitivity than the parametric tests.

There may have been unknown confounding variables such as the expertise that the therapists had on the treatment approaches and the motivation the clients had. It is most likely that the patients who showed improvements put in more effort than the other clients, there was no way to measure the effort put in by participants.

CHAPTER 6: RECOMMENDATIONS AND CONCLUSION

6.1 Main findings of the study

The findings of the current study indicate that both motor relearning occupation-based and NDT treatment approaches are effective in occupational therapy treatment of acute traumatic brain injuries and there was a significant improvement in physical performance as well as self-care. However, the motor relearning occupation-based approach was found to be significantly superior in self-care outcomes as well as some upper extremity outcomes. No difference was found for lower extremity outcomes between the two treatment approaches. The NDT treatment approach was found to be significantly superior in addressing joint pain domains which had a significant increase compared to the other group. Even though the sample size was relatively small, data gathered can be used in occupational therapy practice in Namibia with caution since the results still provide meaningful findings and insights.

6.2 Clinical implications and recommendations

Based on the findings from the study the researcher proposed the following recommendations.

Patients

- The results of this study show important information on rehabilitation approaches that help in gaining physical performance and independence in self-care. An eclectic approach to therapy should be encouraged, that combines the motor relearning occupation-based approach and the NDT approach in the management of patients with TBI.
- Motor relearning occupation-based approaches used in the study promoted independence in self-care. Patients should be encouraged to use occupations that they find meaningful since these will motivate movement and allow motor recruitment both in the hospital setting and home environment.

Health care professionals

- Early referral of TBI patients to occupational therapy will prevent other health related risks and reduce disability.
- This study showed an improved understanding of different approaches to treatment of TBI and rehabilitation professionals who work with this client group are encouraged to use these approaches as they show clinical efficacy in the treatment of TBI.
- The major goals of therapy are to improve function in patients after receiving treatment, the gains noticed in these two approaches showed that these approaches can be adopted to a Namibian setting with professionals who are involved in the care and management of TBI with a suggestion that a brief intervention in TBI can be 5 sessions each week for four weeks especially with mild TBI.

Policy makers

- The changes that favoured the motor relearning occupation-based approaches seen in this study suggest that the treatment protocols used with TBI should incorporate this approach.
- The hospitals' rehabilitation infrastructure policies should allow for the rehabilitation facilities to be structured to allow for occupation-based rehabilitation.
- There should be revision of different curricula in neurorehabilitation to focus on occupation-based rehabilitation among other approaches.

Training institutions

- Traumatic brain injury is a complex diagnosis which carries different clinical presentations and varying symptoms, the clinicians working with these clients need to have a clear understanding of the diagnosis together with other factors that affect individuals' occupations.
- The sequela of the diagnosis can be in the form of psychosocial and/or motor in nature. According to the findings in this study there is a need for clear guidelines on how to execute motor relearning occupation-based approaches mixed with NDT.

6.3 Recommendations for further research

Future research

- A large sample study can be done and results can be compared to the current study for purposes of influencing policies.
- Since the results favoured the motor relearning occupation-based approach there should be studies carried out to find out if the improvements gained can persist after the patients have been discharged and whether they can generalise their skills in self-care to other areas of occupations.

6.4 Contributions of the study

To add on the practical clinical implications that the study contributed, the current study also contributed to the body knowledge in occupational therapy since it sought to explain the gaps in knowledge found in the current literature. This led to a better understanding of motor relearning occupation-based and NDT approaches in relation to TBI and how these can influence functional recovery of physical performance and independence in self-care. The clinical picture brought up by this study contributed to existing research on occupation-based rehabilitation. The study confirmed results of existing studies that also emphasised that both treatment approaches used in the study have a positive efficacy in TBI however the motor relearning occupation-based approaches have comparable efficacies on physical performance and self-care (Bhalerao, Kulkami and Kapoor, 2011; Tomori *et al.*, 2015; Langhammer and Stanghelle, 2000). However, the current study also found correlation between the physical performance and self-care in the NDT group which shows that the NDT approach had generalised improvements on physical performance and self-care. Moreover, the study contributed to prior theories by applying and ascertaining the efficacy in occupation-based and neurofacilitatory theories. The results show that both theories are important in neurorehabilitation and should be incorporated in mainstream treatments of TBI. As acknowledged by Kumar and Joshua, (2017) therapists in neurorehabilitation should use eclectic approaches for better treatment outcomes in neurorehabilitation.

6.5 Concluding remarks

The researcher carried out a study with the goal of determining the effects of motor relearning occupation-based and NDT approaches on physical performance and self-care. It was noted in the study that both these treatment approaches are important in the care and management of patients with TBI. However, the study revealed more efficacy of the motor relearning occupation-based approach hence the research concluded that neurorehabilitation of TBI should include this approach. It was also noted that there is a direct correction between physical performance and self-care using the NDT, this meant that this approach is still important in the care and management of individuals with TBI. The major results of this study supported most literature, thereby indicating that the results can be generalised to a Namibian setting. Based on these results the researcher made some recommendations that could contribute to the body of knowledge in occupational therapy and that can be used in the management of TBI.

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APPENDICES

APPENDIX A: DEMOGRAPHIC QUESTIONNAIRE

TO BE KEPT SEPARATE

STUDY ID NUMBER: ……………..

1. NAME ____
2. PHONE NUMBER _______________________
3. FAMILY MEMBER _______________________________
4. FAMILY MEMBER PHONE _________________________________

STUDY ID NUMBER: ……………..

5. SEX Female ☐ Male ☐

6. AGE _ __ __ _ (Years)

7. LEVEL OF EDUCATION: Primary ☐ Secondary ☐ Tertia ☐

8. CURRENT MARITAL STATUS: (Check only one that is most applicable)

   Never married ☐ Currently Married ☐ Separated ☐

   Widowed ☐ Divorced ☐ Cohabiting ☐

9. CURRENT OCCUPATION (Select the single best option)

   Paid employment ☐ Self-employed ☐ Unemploy ☐

   Non-paid work, such as volunteer/charity ☐ Student ☐

10. Have you had more than one injury to the head? (Circle) Yes No

11. CAUSE OF INJURY

    Violence ☐ Vehicle-related collisions ☐ Falls ☐

    Combat Injury ☐ Others……………………………….

12. Type of Traumatic Brain Injury …………………………………….

13. Glasgow Comma Scale Score …………

APPENDIX B: FUGL- MEYER ASSESSMENT OF PHYSICAL PERFORMANCE PROCEDURE

Description: This assessment is a measure of upper extremity (UE) and lower extremity (LE) motor and sensory impairment.

Equipment: A chair, bedside table, reflex hammer, cotton ball, pencil, small piece of cardboard or paper, small can, tennis ball, stop watch, and blindfold.

Administration: Perform the assessment in a quiet area when the patient is maximally alert. The complete assessment usually requires 45 minutes.

GENERAL RULES:

Perform the assessment in a quiet area when the patient is maximally alert.

<u>Volitional movement assessment:</u> This includes flexor synergy, extensor synergy, movement combining synergies, movement out of synergy, wrist, hand, and coordination/speed. For all tests of volitional motion, these guidelines are to be followed:

1. Give clear and concise instructions. Mime as well as verbal instructions permissible.

2. Have subject perform the movement with non-affected extremity first.

3. Repeat each movement 3x on the affected side and score best performance. If

full score is attained on trials 1 or 2, do not have to repeat 3 times. Only test

Coordination/speed, one time.

4. Do not assist subject, however verbal encouragement is permitted.

5. Test the wrist and hand function independently of the arm. During the wrist tests (items

7a-e), support under the elbow may be provided to decrease demand at the shoulder; however, the subject should be activating the elbow flexors during the elbow at 90 degree tests and activating the elbow extensors during the elbow at 0 degree tests. In contrast, assistance can be provided to the arm at the elbow and just proximal to the wrist in order to position the arm during the hand tests (items 8a-g).

FUGL-MEYER ASSESSMENT **Code:**
UPPER EXTREMITY (FMA-UE) **Date:**
Assessment of sensorimotor function **Examiner**:

Fugl-Meyer AR, Jaasko L, Leyman I, Olsson S, Steglind S: The post-stroke hemiplegic patient. A method for evaluation of physical performance. Scand J Rehabil Med 1975, 7:13-31.

A. UPPER EXTREMITY, sitting position				
I. Reflex activity		**none**	**can be elicited**	
Flexors: biceps and finger flexors (at least one) **Extensors**: triceps		0 0	2 2	
Subtotal I (max 4)				
II. Volitional movement within synergies, without gravitational help		**none**	**partial**	**full**
Flexor synergy: Hand from contralateral knee to ipsilateral ear. From extensor synergy (shoulder adduction/ internal rotation, elbow extension, forearm pronation) to flexor synergy (shoulder abduction/ external rotation, elbow flexion, forearm supination). **Extensor synergy:** Hand from ipsilateral ear to the contralateral knee	Shoulder retraction elevation abduction (90°) external rotation Elbow flexion Forearm supination	0 0 0 0 0 0	1 1 1 1 1 1	2 2 2 2 2 2
	Shoulder adduction/internal rotation Elbow extension Forearm pronation	0 0 0	1 1 1	2 2 2
Subtotal II (max 18)				
III. Volitional movement mixing synergies, without compensation		**none**	**partial**	**full**
Hand to lumbar spine hand on lap		0	1	2

Shoulder flexion 0°- 90° elbow at 0° pronation-supination 0°	immediate abduction or elbow flexion abduction or elbow flexion during movement flexion 90°, no shoulder abduction or elbow flexion	0	1	2
Pronation-supination elbow at 90° shoulder at 0°	no pronation/supination, starting position impossible limited pronation/supination, maintains starting position full pronation/supination, maintains starting position	0	1	2
Subtotal III (max 6)				
IV. Volitional movement with little or no synergy		**none**	**partial**	**full**
Shoulder abduction 0 - 90° elbow at 0° forearm pronated	immediate supination or elbow flexion supination or elbow flexion during movement abduction 90°, maintains extension and pronation	0	1	2
Shoulder flexion 90° - 180° elbow at 0° pronation-supination 0°	immediate abduction or elbow flexion abduction or elbow flexion during movement flexion 180°, no shoulder abduction or elbow flexion	0	1	2
Pronation/supination elbow at 0° shoulder at 30°- 90° flexion	no pronation/supination, starting position impossible limited pronation/supination, maintains start position full pronation/supination, maintains starting position	0	1	2
Subtotal IV (max 6)				
V. Normal reflex activity assessed only if full score of 6 points is achieved in part IV; compare with the unaffected side		**0 (IV), hyper**	**lively**	**normal**
biceps, triceps, finger flexors	2 of 3 reflexes markedly hyperactive or 0 points in part IV 1 reflex markedly hyperactive or at least 2 reflexes lively maximum of 1 reflex lively, none hyperactive	0	1	2

Subtotal V (max 2)	
Total A (max 36)	

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

C. HAND support may be provided at the elbow to keep 90° flexion, no support at the wrist, compare with unaffected hand, the objects are interposed, active grasp		**none**	**partial**	**full**
Mass flexion from full active or passive extension		0	1	2
Mass extension		0	1	2

from full active or passive flexion				
GRASP				
a. Hook grasp flexion in PIP and DIP (digits II-V), extension in MCP II-V	cannot be performed can hold position but weak maintains position against resistance	0	1	2
b. Thumb adduction 1-st CMC, MCP, IP at 0°, scrap of paper between thumb and 2-nd MCP joint		0	1	2
c. Pincer grasp, opposition pulp of the thumb against the pulp of 2-nd finger, pencil, tug upward	cannot be performed can hold pencil but not against tug can hold pencil against a tug	0	1	2
d. Cylinder grasp cylinder shaped object (small can) tug upward, opposition of thumb and fingers	cannot be performed can hold cylinder but not against tug can hold cylinder against a tug	0	1	2
e. Spherical grasp fingers in abduction/flexion, thumb opposed, tennis ball, tug away	cannot be performed can hold ball but not against tug can hold ball against a tug	0	1	2
Total C (max 14)				

D. COORDINATION/SPEED, sitting, after one trial with both arms, eyes closed, tip of the index finger from knee to nose, 5 times as fast as possible		**marked**	**slight**	**none**
Tremor	at least 1 completed movement	0	1	2
Dysmetria at least 1 completed movement	pronounced or unsystematic slight and systematic no dysmetria	0	1	2
		≥ 6s	**2 - 5s**	**< 2s**
Time start and end with the hand on the knee	at least 6 seconds slower than unaffected side 2-5 seconds slower than unaffected side less than 2 seconds difference	0	1	

				2
Total D (max 6)				

H. SENSATION, upper extremity eyes closed, compared with the unaffected side		**anaesthesia**	**hypoesthesia or dysesthesia**	**normal**
Light touch	upper arm, forearm palmar surface of the hand	0 0	1 1	2 2
		less than 3/4 **correct or absence**	**3/4 correct or considerable difference**	**correct 100%, little or no difference**
Position small alterations in the position	shoulder elbow wrist thumb (IP-joint)	0 0 0 0	1 1 1 1	2 2 2 2
			Total H (max12)	
			TOTAL A-D (max 66)	

J. PASSIVE JOINT MOTION, upper extremity, sitting position, compare with the unaffected side				**J. JOINT PAIN** during passive motion, upper extremity		
	only few degrees (less than 10° in shoulder)	decreased	normal	pronounced pain during movement or very marked pain at the end of the movement	some pain	no pain
Shoulder Flexion (0° - 180°) Abduction (0°-90°)	0 0 0	1 1 1	2 2 2	0 0 0	1 1 1	2 2 2

External rotation Internal rotation	0	1	2	0	1	2
Elbow Flexion Extension	 0 0	 1 1	 2 2	 0 0	 1 1	 2 2
Forearm Pronation Supination	 0 0		 2 2	 0 0	 1 1	 2 2
Wrist Flexion Extension	 0 0	 1 1	 2 2	 0 0	 1 1	 2 2
Fingers Flexion Extension	 0 0	 1 1	 2 2	 0 0	 1 1	 2 2
Total (max 24)				**Total** (max 24)		

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

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

FUGL-MEYER ASSESSMENT **Code:**

LOWER EXTREMITY (FMA-LE) **Date:**
Assessment of sensorimotor function **Examiner**:

Fugl-Meyer AR, Jaasko L, Leyman I, Olsson S, Steglind S: The post-stroke hemiplegic patient. 1. a method for evaluation of physical performance. Scand J Rehabil Med 1975, 7:13-31.

E. LOWER EXTREMITY				
I. Reflex activity, supine position		**none**	**can be elicited**	
Flexors: knee flexors **Extensors**: patellar, Achilles (at least one)		0 0	2 2	
Subtotal I (max 4)				
II. Volitional movement within synergies supine position		**none**	**partial**	**full**
Flexor synergy: Maximal hip flexion (abduction/external rotation), maximal flexion in knee and ankle joint (palpate distal tendons to ensure active knee flexion).	Hip flexion Knee Ankle dorsiflexion	0 0 0	1 1 1	2 2 2
Extensor synergy: From flexor synergy to the hip extension/adduction, knee extension and ankle plantar flexion. Resistance is applied to ensure active movement, evaluate both movement and strength (compare with the unaffected side)	Hip extension adduction Knee extension Ankle plantar flexion	0 0 0 0	1 1 1 1	2 2 2 2
Subtotal II (max 14)				
III. Volitional movement mixing synergies sitting position, knee 10cm from the edge of the chair/bed		**none**	**partial**	**full**
Knee flexion from actively or passively		0	1	

extended knee				2
Ankle dorsiflexion compare with unaffected side	no active motion limited dorsiflexion complete dorsiflexion	0	1	2
Subtotal III (max 4)				
IV. Volitional movement with little or no synergy standing position, hip at 0°		**none**	**partial**	**full**
Knee flexion to 90° hip at 0**°,** balance support is allowed	no active motion or immediate, simultaneous hip flexion less than 90° knee flexion and/or hip flexion during movement at least 90° knee flexion without simultaneous hip flexion	0	1	2
Ankle dorsiflexion compare with unaffected side	no active motion limited dorsiflexion complete dorsiflexion	0	1	2
Subtotal IV (max 4)				
V. Normal reflex activity supine position, assessed only if full score of 4 points is achieved in part IV, compare with the unaffected side		**0 (IV), hyper**	**lively**	**normal**
Reflex activity knee flexors, Patellar, Achilles,	0 points on part IV or 2 of 3 reflexes markedly hyperactive 1 reflex markedly hyperactive or at least 2 reflexes lively maximum of 1 reflex lively, none hyperactive	0	1	2
Subtotal V (max 2)				
Total E (max 28)				

F. COORDINATION/SPEED, supine, after one trial with both legs, eyes closed, heel to knee cap of the opposite leg, 5 times as fast as possible		**marked**	**slight**	**none**
Tremor	at least 1 completed movement	0	1	2
Dysmetria at least 1 completed movement	pronounced or unsystematic slight and systematic no dysmetria	0	1	2
		≥ 6s	**2 - 5s**	**< 2s**
Time start and end with the hand on the knee	at least 6 seconds slower than unaffected side 2-5 seconds slower than unaffected side less than 2 seconds difference	0	1	2
Total F (max 6)				

H. SENSATION, lower extremity eyes closed, compare with the unaffected side		**anaesthesia**	**hypoesthesia or dysesthesia**	**normal**
Light touch	leg foot sole	0 0	1 1	2 2
		less than 3/4 correct or absence	**3/4 correct or considerable difference**	**correct 100%, little or no difference**
Position small alterations in the position	hip knee ankle great toe (IP-joint)	0 0 0 0	1 1 1 1	2 2 2 2
Total H (max12)				

J. PASSIVE JOINT MOTION, lower extremity supine position, compare with the unaffected side					**J. JOINT PAIN** during passive motion, lower extremity		
		only few degrees	decreased	normal	pronounced pain during movement or very marked pain at the end of the movement	some pain	no pain
Hip	Flexion	0	1	2	0	1	2
	Abduction	0	1	2	0	1	2
	External rotation	0	1	2	0	1	2
	Internal rotation	0	1	2	0	1	2
Knee	Flexion	0	1	2	0	1	2
	Extension	0	1	2	0	1	2
Ankle	Dorsiflexion	0	1	2	0	1	2
	Plantar flexion	0	1	2	0	1	2
Foot	Pronation	0	1	2	0	1	2
	Supination	0	1	2	0	1	2
Total (max 20)					**Total** (max 20)		

E. LOWER EXTERMTY	/28
F. COORDINATION / SPEED	/6
TOTAL E-F (motor function)	/34

H. SENSATION	/12
J. PASSIVE JOINT MOTION	/20
J. JOINT PAIN	/20

APPENDIX C: MODIFIED BARTHEL INDEX (MBI)

MODIFIED BARTHEL INDEX (SHAH VERSION): SELF CARE ASSESSMENT

INDEX ITEM	SCORE	DESCRIPTION
CHAIR/BED TRANSFERS	0 3 8 12 15	Unable to participate in a transfer. Two attendants are required to transfer the patient with or without a mechanical device. Able to participate but maximum assistance of one other person is require in all aspects of the transfer. The transfer requires the assistance of one other person. Assistance may be required in any aspect of the transfer. The presence of another person is required either as a confidence measure, or to provide supervision for safety. The patient can safely approach the bed walking or in a wheelchair, lock brakes, lift footrests, or position walking aid, move safely to bed, lie down, come to a sitting position on the side of the bed, change the position of the wheelchair, transfer back into it safely and/or grasp aid and stand. The patient must be independent in all phases of this activity.
AMBULATION	0 3 8 12 15	Dependent in ambulation. Constant presence of one or more assistant is required during ambulation. Assistance is required with reaching aids and/or their manipulation. One person is required to offer assistance. The patient is independent in ambulation but unable to walk 50 metres without help, or supervision is needed for confidence or safety in hazardous situations. The patient must be able to wear braces if required, lock and unlock these braces assume standing position, sit down, and place the necessary aids into position for use. The patient must be able to crutches, canes, or a walkarette, and walk 50 metres without help or supervision.

AMBULATION/WHEELCHAIR *** (If unable to walk)** **Only use this item if the patient is rated "0" for Ambulation, and then only if the patient has been trained in wheelchair management**.	0 1 3 4 5	Dependent in wheelchair ambulation. Patient can propel self-short distances on flat surface, but assistance is required for all other steps of wheelchair management. Presence of one person is necessary and constant assistance is required to manipulate chair to table, bed, etc. The patient can propel self for a reasonable duration over regularly encountered terrain. Minimal assistance may still be required in "tight corners" or to negotiate a kerb 100mm high. To propel wheelchair independently, the patient must be able to go around corners, turn around, manoeuvre the chair to a table, bed, toilet, etc. The patient must be able to push a chair at least 50 metres and negotiate a kerb.
INDEX ITEM	**SCORE**	**DESCRIPTION**
STAIR CLIMBING	0 2 5 8 10	The patient is unable to climb stairs. Assistance is required in all aspects of chair climbing, including assistance with walking aids. The patient is able to ascend/descend but is unable to carry walking aids and needs supervision and assistance. Generally, no assistance is required. At times supervision is required for safety due to morning stiffness, shortness of breath, etc. The patient is able to go up and down a flight of stairs safely without help or supervision. The patient is able to use hand rails, cane or crutches when needed and is able to carry these devices as he/she ascends or descends.
TOILET TRANSFERS	0 2 5 8 10	Fully dependent in toileting. Assistance required in all aspects of toileting. Assistance may be required with management of clothing, transferring, or washing hands. Supervision may be required for safety with normal toilet. A commode may be used at night but assistance is required for emptying and cleaning. The patient is able to get on/off the toilet, fasten clothing and use toilet paper without help. If necessary, the patient may use a

		bed pan or commode or urinal at night, but must be able to empty it and clean it.
BOWEL CONTROL	0 2 5 8 10	The patient is bowel incontinent. The patient needs help to assume appropriate position, and with bowel movement facilitatory techniques. The patient can assume appropriate position, but cannot use facilitatory techniques or clean self without assistance and has frequent accidents. Assistance is required with incontinence aids such as pad, etc. The patient may require supervision with the use of suppository or enema and has occasional accidents. The patient can control bowels and has no accidents, can use suppository, or take an enema when necessary.
BLADDER CONTROL	0 2 5 8 10	The patient is dependent in bladder management, is incontinent, or has indwelling catheter. The patient is incontinent but is able to assist with the application of an internal or external device. The patient is generally dry by day, but not at night and needs some assistance with the devices. The patient is generally dry by day and night, but may have an occasional accident or need minimal assistance with internal or external devices. The patient is able to control bladder day and night, and/or is independent with internal or external devices.

INDEX ITEM	SCORE	DESCRIPTION
BATHING	0 1 3 4 5	Total dependence in bathing self. Assistance is required in all aspects of bathing, but patient is able to make some contribution. Assistance is required with either transfer to shower/bath or with washing or drying; including inability to complete a task because of condition or disease, etc. Supervision is required for safety in adjusting the water temperature, or in the transfer. The patient may use a bathtub, a shower, or take a complete sponge bath. The patient must be able to do all the steps of whichever method is employed without another person being present.
DRESSING	0 2 5 8 10	The patient is dependent in all aspects of dressing and is unable to participate in the activity. The patient is able to participate to some degree, but is dependent in all aspects of dressing. Assistance is needed in putting on, and/or removing any clothing. Only minimal assistance is required with fastening clothing such as buttons, zips, bra, shoes, etc. The patient is able to put on, remove, corset, braces, as prescribed.
PERSONAL HYGIENE (Grooming)	0 1 3 4 5	The patient is unable to attend to personal hygiene and is dependent in all aspects. Assistance is required in all steps of personal hygiene, but patient able to make some contribution. Some assistance is required in one or more steps of personal hygiene. Patient is able to conduct his/her own personal hygiene but requires minimal assistance before and/or after the operation. The patient can wash his/her hands and face, comb hair, clean teeth and shave. A male patient may use any kind of razor but must insert the blade, or plug in the razor without help, as well as retrieve it from the drawer or cabinet. A female patient must

		apply her own make-up, if used, but need not braid or style her hair.
FEEDING	0 2 5 8 10	Dependent in all aspects and needs to be fed, nasogastric needs to be administered. Can manipulate an eating device, usually a spoon, but someone must provide active assistance during the meal. Able to feed self with supervision. Assistance is required with associated tasks such as putting milk/sugar into tea, salt, pepper, spreading butter, turning a plate or other "set up" activities. Independence in feeding with prepared tray, except may need meat cut, milk carton opened or jar lid etc. The presence of another person is not required. The patient can feed self from a tray or table when someone puts the food within reach. The patient must put on an assistive device if needed, cut food, and if desired use salt and pepper, spread butter, etc.

SCORE	INTERPRETATION
00 - 20	Total Dependence
21 - 60	Severe Dependence
61 - 90	Moderate Dependence
91 - 99	Slight Dependence
- 100	Independence

SCORE	PREDICTION
Less Than 40	Unlikely to go home - Dependent in Mobility - Dependent in Self Care
60	Pivotal score where patients move from dependency to assisted independence.
60 - 80	If living alone will probably need a number of community services to cope.
More Than 85	Likely to be discharged to community living - Independent in transfers and able to walk or use wheelchair independently.

APPENDIX D: GLASGOW COMA SCALE

The GCS was developed at the University of Glasgow's Institute of Neurological Sciences. It is numerical rating system, originally used for measuring conscious state following traumatic brain injury, which has become a widely used and recognised assessment tool for reporting any patient's conscious state. The GCS uses three categories that pertain to different areas of a person's conscious state, they are; eyes opening, vocal response and motor response. Each unit is given a range of numbers that correlate with definable levels in consciousness which are then collated to give a GCS between 3 (deep unconscious) to 15 (normal conscious level). The best response is recorded for each category.

Summary of the GCS

	Eyes Opening		**Verbal Response**		**Motor Response**
4	Spontaneous	5	Orientated to time and place	6	Obeys command
3	Voice	4	Confused speech	5	Localises to pain
2	Pain	3	Inappropriate words	4	Withdraws to pain
1	None	2	Incomprehensible sounds	3	Decorticate
		1	None	2	Decerebrate
				1	None

Score: 14 - 15 = mild dysfunction

Score: 11- 13 = moderate to severe dysfunction

Score: 10 or less = severe dysfunction

APPENDIX E: TREATMENT PROTOCOLS

Neurodevelopmental Treatment protocol

Neurodevelopmental treatment (NDT) is a hands-on treatment approach used by occupational therapists, it was developed by observing patients with brain injuries decreasing their patterns of movements (Kollen *et al.*, 2009). The concept focuses on handling patients and key points of control (Velickovic, Perat and Tretmana, 2005). The therapist facilitates normal movement by lengthening short muscles, mobilising or moving tight joints, strengthening weak muscles and helping to keep the patients' bodies in better alignment (Velickovic, Perat and Tretmana, 2005). The patients undergo through screening processes to ascertain if they can benefit from the treatment protocol. Preparatory techniques are then used to activate muscles and stimulate normal movements, they include sustained stretching, weight bearing from the affected extremities and light touch.

This protocol is mostly based on how an individual therapist places hands on a client in an activity. A principle known as therapeutic handling is used to influence the quality of the motor response and is carefully matched to the patient's abilities to use sensory information and adapt movements. It includes neuromuscular facilitation, inhibition, or frequently a combination of the two (Velickovic, Perat and Tretmana, 2005). The NDT approach helps people to move in the most efficient manner possible, so that they conserve their energy, lessen the wear and tear on their bodies, and reduce the strain they are feeling. Patient's movements are elicited from prone to supine to sitting, then standing and walking. Activities are clearly crafted in a developmental sequence to allow the patients to move from one developmental stage to another while inhibiting primitive reflexes.

The aim is to teach the body and mind how to move most easily – involving as many parts of the body as possible, using all the movement already available, and trying to increase movement skills. Key points are parts of the body that the therapist chooses as optimal to control (inhibit or facilitate) postures and movement (Langhammer and Stanghelle, 2000). Proximal key points include the shoulders and pelvis, which are used to influence proximal segments and trunk. Distal key points include upper and lower extremities (typically the hands and feet). Key points of control are also used to provide inhibition of abnormal tone and postures. Examples include:

- Head and trunk flexion decreases shoulder retraction, trunk and limb extension (key points of control: head and trunk).
- Humeral external rotation and flexion to 90 degrees decreases flexion tone of the upper extremity (key point of control: humerus).
- Femoral external rotation and abduction decreases extensor/adductor tone of the lower extremity (key point of control: hip).

Facilitation: Components of posture and movement that are essential for successful functional task performance are facilitated through therapeutic handling and key points.

Inhibition: Components of posture and movement that are atypical and prevent development of desired motor patterns are inhibited. While originally this term referred strictly to the reduction of tone and abnormal reflexes, in current NDT practice it refers to reduction of any underlying impairment that interferes with functional performance.

It can be used to:

- Prevent or redirect those components of a movement that are unnecessary and interfere with intentional, coordinated movement.
- Constrain the degrees of freedom, to decrease the amount of force the client uses to stabilize posture.
- Balance antagonistic muscle groups.
- Reduce spasticity or excessive muscle stiffness that interferes with moving specific segments of the body.

The NDT approach used in the sessions is as follows

- Weight bearing in sitting position.
- Bilateral use of hand overhead while they are clasped.
- Use of gymnastic ball while performing trunk flexion, extension and rotation.
- Weight bearing in four-point kneeling and two-point kneeling.
- Slow rocking movements in four point and two-point kneeling.
- Functional movements and facilitation from lying down to sitting to standing and walking and vice versa.

- Balance activities using a ball in forward position, back ward position and side to side.
- Inhibition of tone using sensory modalities such heat, sustained stretching, joint compression.

Motor relearning occupation-based protocol

Motor relearning occupation-based approach has three stages of function namely cognitive, associative and autonomous stage (Poole, 1991). The participants select an array of activities that are meaningful to them and goals are structured from those occupations within a time frame given. In the cognitive stage the patients are taught what to do and how to perform the tasks and goals they would have selected. Patients are encouraged to pay attention, and try to select alternative strategies to improve performance and develop motor programs. Function is defined within context of specific tasks. Therapists involved facilitate the correct movements by teachings and demonstrations. When there are no movements, the therapists conduct hand over hand sessions/ visual of movement patterns where their movements guide the patients' movements or error correcting cueing to assist in successful movement.

The goal is to restore functional movement by developing optimal motor and cognitive strategies (Chan, Chan and Au, 2006). In the associative stage, the patients learn to refine skills required to perform the tasks and narrow down their movement strategies to reduce degrees of freedom so that performance is less variable and more consistent. The input by the therapist decreases and the patients continue to improve their motor programmes. Recovery is reached when the person is restored to their previous level of abilities as before the accident. Remediation, adaptation, and compensation are not separated, but represent one holistic approach. In a contemporary task perspective, functioning is defined within the context of specific tasks and there is a gradual increase in the degrees of freedom within which skilled movements are performed (Poole, 1991).

This approach is a general rehabilitative approach to all forms of movement abnormalities and disorders such as TBI and it relates to specific task performance (Stark-inbar et al., 2017). The major aim is restoring functional movement using meaningful tasks so that clients have the motivation to continue with interventions (Poole, 1991). In the autonomous stage, the patients become more proficient and save energy when conducting their movements. Their demands for cognition are greatly reduced and their movements as well as sensory analysis becomes more automatic. The environmental needs will be met and the patients will be able to perform multiple tasks. They will be able to detect and correct their own errors. The therapist should identify specific tasks for the patient and define function and disability. Areas to consider include returning to work, ADLs, self-care, mobility and social participation.

Motor relearning occurs in stages, the choice of activities is dependent on the patients and can differ with each stage that the client moves through. This allows measurement of success and retention of skills. The activities chosen by patients can be changed after every 24 hours. The conditions for completing the tasks can be changed depending on how the patient is performing, this includes changing distance between objects, speed of execution, weight of objects used, increasing/decreasing time taken.

Feedback is all the sensory information that is available as a result of movement. It is focused on movement outcome and the critical features of the task and environment (not on motor performance) (Poole, 1991). Clients are encouraged to self-evaluate their own movement performance and outcome by focusing on feedback from their own body and environment. They are given time to reflect between trials and the therapists positively reinforce correct performance.

In the early stages distributed practice schedules are used (20 minutes with rest) to avoid fatigue, later on massed practice schedules are used (60 minutes each day). Variable practice is used since it provides better learning outcomes than constant practice. Random practice with multiple tasks results in better learning outcomes than blocked practice. Whole tasks are encouraged and part-task practice can only be allowed if it occurs naturally in a task.

Motor relearning occupation-based activities employed in the sessions include the following:

- Table top polishing.
- Arm cradling while preparing meals.
- Hand function while performing grooming activities.

- Reaching movements incorporated in home management sessions.
- Reaching sideways to pick up objects and transferring self in self-care activities.
- Bouncing ball.
- Lifting cup and putting it close to the mouth.
- Putting laundry in a basket.
- Stacking plates.

APPENDIX F: PERMISSION LETTERS

Request for permission to conduct study in Namibia

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Department of Occupational Therapy
Wits Education Campus

School of Therapeutic Sciences, Faculty of Health Sciences, 7 York Road, Parktown, 2193, South Africa

Tel: +27 11 717 3701 | Fax: +27 717 3709 | Email: leilane.bogoshi@wits.ac.za | **www.wits.ac.za**

Date ………………………………………..

The Chairperson

Ethical Approval Committee

Ministry of Health and Social Services

Namibia

Dear Sir/Madam

RE: REQUEST FOR ETHICAL APPROVAL TO CONDUCT RESEARCH STUDY IN WINDHOEK, NAMIBIA

My name is Jackson Nowa and I am a research student pursuing a master in occupational therapy at the University of Witwatersrand (WITS) (student number: 1763274). I am currently employed by Windhoek Central Hospital as an Occupational Therapist.

The title of my study is:

Comparison of motor relearning occupation-based and Neurodevelopmental Treatment approaches in treating patients with Traumatic Brain Injury.

I hereby request for permission to conduct a study focusing on patients with Traumatic Brain Injuries.

This study aims to provide evidence base for occupational therapy treatment of Traumatic Brain Injuries (TBI), and act as a resource for interventions in TBI aimed at improving practice in these settings by comparing outcomes for the two approaches to intervention in occupational therapy. This is a randomized control trial group where clients will be divided into two groups. A pre-test assessment will be used to assess motor and self-care functioning before the treatment and after 20 treatment sessions taking place every day for four weeks. A post-test assessment will be then completed. Each group will comprise of 30 clients. The clients will be from Katutura State Hospitals. The clients will receive the treatment as part of their occupational therapy in the Occupational Therapy Department. Clients who need to attend as outpatients will be reimbursed for transport expenses.

Kindly refer to the provisional Ethical Clearance certificate from WITS as attached.

For more information, you may contact myself or my supervisor Dr D Franzsen, a senior lecturer in the department of Occupational Therapy. Her contacts details are: email Denise.Franzsen@wits.ac.za.

This study has been approved by the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg ("Committee"). A principal function of this Committee is to safeguard the rights and dignity of all human subjects who agree to participate in a research project and the integrity of the research.

If you have any concern over the way the study is being conducted, please contact the Chairperson of this Committee who is Professor Clement Penny, who may be contacted on telephone number 011 717 2301, or by e-mail on Clement.Penny@wits.ac.za. The telephone numbers for the Committee secretariat are 011 717 2700/1234 and the e-mail addresses are Zanele.Ndlovu@wits.ac.za and Rhulani.Mukansi@wits.ac.za

I will be looking forward to a favourable response.

Yours faithfully

Jackson Nowa (Mr)

(0814676896/ 1763274@students.wits.ac.za

Request for permission to conduct study in Namibia

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Department of Occupational Therapy
Wits Education Campus

School of Therapeutic Sciences, Faculty of Health Sciences, 7 York Road, Parktown, 2193, South Africa

Tel: +27 11 717 3701 | Fax: +27 717 3709 | Email: leilane.bogoshi@wits.ac.za | **www.wits.ac.za**

Date ………………………………………..

Medical Superintendent

Ministry of Health and Social Services

Katutura Intermediate Hospital

Namibia

Dear Dr Fady Ashmawy

RE: REQUEST TO CONDUCT RESEARCH STUDY AT KATUTURA INTERMEDIATE HOSPITAL

My name is Jackson Nowa and I am a research student pursuing a master in occupational therapy at the University of Witwatersrand (WITS) (student number: 1763274). I am currently employed by Windhoek Central Hospital as an Occupational Therapist.

The title of my study is:

Comparison of motor relearning occupation-based and Neurodevelopmental Treatment approaches in treating patients with Traumatic Brain Injury.

I hereby request for permission to conduct a study focusing on patients with Traumatic Brain Injuries.

This study aims to provide evidence base for occupational therapy treatment of Traumatic Brain Injuries (TBI), and act as a resource for interventions in TBI aimed at improving practice in these settings by comparing outcomes for the two approaches to intervention in occupational therapy. This is a randomized control trial group where clients will be divided into two groups. A pre-test assessment will be used to assess motor and self-care functioning before the treatment and after 20 treatment sessions taking place every day for 4 weeks. A post-test assessment will be then completed. Each group will comprise of 30 clients. The clients will be from Katutura State Hospitals. The clients will receive the treatment as part of their occupational therapy in the Occupational Therapy Department. Clients who need to attend as outpatients will be reimbursed for transport expenses.

Kindly refer to the provisional Ethical Clearance certificate from WITS as attached.

For more information, you may contact myself or my supervisor Dr D Franzsen, a senior lecturer in the department of Occupational Therapy. Her contacts details are: email Denise.Franzsen@wits.ac.za.

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If you have any concern over the way the study is being conducted, please contact the Chairperson of this Committee who is Professor Clement Penny, who may be contacted on telephone number 011 717 2301, or by e-mail on Clement.Penny@wits.ac.za. The telephone numbers for the Committee secretariat are 011 717 2700/1234 and the e-mail addresses are Zanele.Ndlovu@wits.ac.za and Rhulani.Mukansi@wits.ac.za

I will be looking forward to your response.

Yours faithfully

Jackson Nowa (Mr)

(0814676896/ 1763274@students.wits.ac.za

APPENDIX G: INFORMATION DOCUMENT FOR PARTICIPANTS

Study title: **Comparison of motor relearning occupation-based and Neurodevelopmental Treatment approaches in treating patients with Traumatic Brain Injury.**

Dear Mr/Mrs/Miss …………………………..

My name is Jackson Nowa, I am an Occupational Therapist employed with the Ministry of Health and Social Services stationed at Windhoek Central Hospital. I am currently conducting a study as part of the requirements of a Master's degree in Occupational Therapy at the University of Witwatersrand. In this study we want to learn about the effectiveness of two treatment modalities used by Occupational Therapists in their care and management of patients with Traumatic Brain Injuries namely motor learning and Neurodevelopmental Treatment approaches. The results will provide evidence base and increase the body of knowledge for occupational therapy treatment of Traumatic Brain Injuries.

I am inviting you to take part in this study as you will be receiving occupational therapy to assist with your recovery from your head injury. You will be assigned to one of two groups and you will receive therapy which differs slightly in approach depending which group you are in. Both approaches have been shown to effect change after brain injury, one approach focusses on body functioning and the other on assessment of activities of daily living.

A pre-test assessment looking at information about your functioning will be gathered before the treatment sessions start. This will include general body functioning and assessment of activities of daily living which will take about 25 minutes. You will be involved in 20 occupational therapy treatment sessions of between 45 minutes to an hour taking place every day for four weeks. Information about your treatment will be written down in your files. After the sessions are finished your functioning and activities of daily living will be assessed again. You will be required to answer a few questions about yourself and follow instructions given by the researcher in the pre and post-test assessments.

You will need to commit to attending 20 occupational therapy sessions at the Occupational Therapy Department. You will be reimbursed your transport expenses if you need to attend therapy as an outpatient, the total amount you will be given is N$24.00 for your transport to and from home.

There are no direct risks involved in the study, and attendance at occupational therapy should benefit your recovery from your injury.

Participation is voluntary, refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled or affect your therapy. You may discontinue participation at any time without penalty or loss of benefits to which you are otherwise entitled. All the information gathered will be kept confidential and your name will not appear on any data collection sheets. All identifying information will be kept by the researcher under lock and key.

Feedback from the study is available on request.

If there are any questions regarding this study, or if you require any information please contact the researcher.

Jackson Nowa

Occupational Therapy Department – Windhoek Central Hospital

Contact details: 0612033360 or 0814676896

This study has been approved by the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg ("Committee"). A principal function of this Committee is to safeguard the rights and dignity of all human subjects who agree to participate in a research project and the integrity of the research.

If you have any concern over the way the study is being conducted, please contact the Chairperson of this Committee who is Professor Clement Penny, who may be contacted on telephone number +27 11 717 2301, or by e-mail on Clement.Penny@wits.ac.za. The telephone numbers for the Committee secretariat are +27 11 717 2700/1234 and the e-mail addresses are Zanele.Ndlovu@wits.ac.za and Rhulani.Mukansi@wits.ac.za

PARTICIPANT CONSENT SHEET

Comparison of motor relearning occupation-based and Neurodevelopmental Treatment approaches in treating patients with Traumatic Brain Injury.

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

Contact details:

Jackson Nowa, Principal Investigator, telephone no. 0814676896, or by e-mail at jsn547644@gmail.com,

Denise Franzsen, Supervisor, on telephone no. +27 117173710, or by e-mail at Denise.Franzsen@wits.ac.za

Dineo Thupae, Supervisor, on telephone no. +27117173710, or by e-mail at Dineo.Thupae@wits.ac.za

Professor CB Penny, Chairperson of the Human Research Ethics Committee (Medical) at the University of Witwatersrand, on telephone no. +27 11 717 2301, or by e-mail at Clement.Penny@wits.ac.za.

Ms. Z Ndlovu or Mr Rhulani Mkansi, Committee Secretariat, telephone nos.: +27 11 717 2700 or 1234, or by e-mail at: Zanele.Ndlovu@wits.ac.za or Rhulani.Mkansi@wits.ac.za

Name of Participant: ______________________________________

Date: ______________________________________

Place: ______________________________________

Signature or mark ______________________________________

Name of Witness: ______________________________________

Signature: ______________________ Thumb print
Date: ______________________

: INFORMATION DOCUMENT FOR FAMILY MEMBER/GUARDIAN

Study title: **Comparison of motor relearning occupation-based and Neurodevelopmental Treatment approaches in treating patients with Traumatic Brain Injury.**

Dear Family Member

My name is Jackson Nowa, I am an Occupational Therapist employed with the Ministry of Health and Social Services stationed at Windhoek Central Hospital. I am currently conducting a study as part of the requirements of a Master's degree in Occupational Therapy at the University of Witwatersrand. In this study we want to learn about the effectiveness of two treatment modalities used by Occupational Therapists in their care and management of patients with Traumatic Brain Injuries namely motor learning and Neurodevelopmental Treatment approaches. The results will provide evidence base and increase the body of knowledge for occupational therapy treatment of Traumatic Brain Injuries.

I am inviting your family member who has been diagnosed with a traumatic brain injury to take part in this study as they will be receiving occupational therapy to assist with their recovery from your head injury. I am requesting your permission to include them in the study as they are not able to give informed consent at this stage even though the study will be explained to them. Your family member will be assigned to one of two groups and they will receive therapy which differs slightly in approach depending which group they are in. Both approaches have been shown to effect change after brain injury, one approach focusses on body functioning and the other on assessment of activities of daily living.

A pre-test assessment looking at information about your family member's functioning will be gathered before the treatment sessions start. This will include general body functioning and assessment of activities of daily living which will take about 25 minutes. They will be involved in 20 occupational therapy treatment sessions of between 45 minutes to an hour taking place every day for four weeks. Information about their treatment will be written down in their files. After the sessions are finished your family member's functioning and activities of daily living will be assessed again. You will be required to answer a few questions about your family member like age and occupation and they will be asked to follow instructions given by the researcher in the pre and post-test assessments.

You will need to commit to your family member attending 20 occupational therapy sessions at the Occupational Therapy Department. They will be reimbursed their transport expenses if you need to attend therapy as an outpatient.

There are no direct risks involved in the study, and attendance at occupational therapy should benefit your recovery from your injury.

Participation is voluntary, refusal to allow your family member to participate will involve no penalty or loss of benefits to which they are otherwise entitled or affect their therapy. You may choose to discontinue their participation at any time without penalty or loss of benefits to which they are otherwise entitled. All the information gathered will be kept confidential and their name will not appear on any data collection sheets. All identifying information will be kept by the researcher under lock and key.

Feedback from the study is available on request.

If there are any questions regarding this study, or if you require any information please contact the researcher.

Jackson Nowa

Occupational Therapy Department – Windhoek Central Hospital

Contact details: 0612033360 or 0814676896

This study has been approved by the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg (“Committee”). A principal function of this Committee is to safeguard the rights and dignity of all human subjects who agree to participate in a research project and the integrity of the research.

If you have any concern over the way the study is being conducted, please contact the Chairperson of this Committee who is Professor Clement Penny, who may be contacted on telephone number 011 717 2301, or by e-mail on Clement.Penny@wits.ac.za. The telephone numbers for the Committee secretariat are 011 717 2700/1234 and the e-mail addresses are Zanele.Ndlovu@wits.ac.za and Rhulani.Mukansi@wits.ac.za

Jackson Nowa (Mr)

FAMILY MEMBER CONSENT SHEET

Comparison of motor relearning occupation-based and Neurodevelopmental Treatment approaches in treating patients with Traumatic Brain Injury.

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

Contact details:

Jackson Nowa, Principal Investigator, telephone no. 0814676896, or by e-mail at jsn547644@gmail.com,
Denise Franzsen, Supervisor, on telephone no. +27 117173710, or by e-mail at Denise.Franzsen@wits.ac.za
Dineo Thupae, Supervisor, on telephone no. +27117173710, or by e-mail at Dineo.Thupae@wits.ac.za
Professor CB Penny, Chairperson of the Human Research Ethics Committee (Medical) at the University of Witwatersrand, on telephone no. +27 11 717 2301, or by e-mail at Clement.Penny@wits.ac.za.
Ms. Z Ndlovu or Mr Rhulani Mkansi, Committee Secretariat, telephone nos.: 011 717 2700 or 1234, or by e-mail at: Zanele.Ndlovu@wits.ac.za or Rhulani.Mkansi@wits.ac.za

Name of Family member\Guardian: ____
Date: ____
Place: ____

Signature or mark ______________________________

Name of Witness: ______________________________
Signature: ______________________________

Date: ______________________________

APPENDIX H: INFORMATION DOCUMENT FOR THERAPISTS

Study title: **Comparison of motor relearning occupation-based and Neurodevelopmental Treatment approaches in treating patients with Traumatic Brain Injury.**

Dear Therapist

My name is Jackson Nowa, I am an Occupational Therapist employed with the Ministry of Health and Social Services stationed at Windhoek Central Hospital. I am currently conducting a study as part of the requirements of a Master's degree in Occupational Therapy at the University of Witwatersrand. In this study we want to learn the effectiveness of two treatment modalities used by Occupational Therapists in their care and management of patients with Traumatic Brain Injuries namely motor learning and Neurodevelopmental Treatment approaches. The results will provide evidence base and increase the body of knowledge for occupational therapy treatment of Traumatic Brain Injuries.

I am inviting you to take part in this study. This is a randomized control trial group where participants will be assigned to either an NDT or occupation-based motor relearning group for their occupational therapy treatment. A pre-test assessment looking at information about their functioning will be gathered before the treatment sessions start. This will include general body functioning and assessment of activities of daily living. You will be required to involve them in 20 treatment sessions of 45 minutes to an hour taking place every day for four weeks using either motor relearning occupation-based or NDT. Records of the treatment should be kept using SOAP notes. Post-test assessment of functioning and execution of activities of daily living will be completed after 20 treatment sessions. Each group will comprise of 30 participants; the participants will be from Katutura State Hospitals who would have had come with motor and functional deficits with moderate or mild TBI.

There are no direct risks and benefits involved in the study, and participants should benefit from attending occupational therapy.

Participation is voluntary, refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled. You may discontinue participation at any time without penalty or loss of benefits to which you are otherwise entitled. All the information gathered will be kept confidential and your name will not be used on data collection sheets.

Feedback is available on request

If there are any questions regarding this study, or if you require any information please contact the researcher.

Jackson Nowa

Occupational Therapy Department – Windhoek Central Hospital

Contact details: 0612033360/ 0814676896

This study has been approved by the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg ("Committee"). A principal function of this Committee is to safeguard the rights and dignity of all human subjects who agree to participate in a research project and the integrity of the research.

If you have any concern over the way the study is being conducted, please contact the Chairperson of this Committee who is Professor Clement Penny, who may be contacted on telephone number 011 717 2301, or by e-mail on Clement.Penny@wits.ac.za. The telephone numbers for the Committee secretariat are 011 717 2700/1234 and the e-mail addresses are Zanele.Ndlovu@wits.ac.za and Rhulani.Mukansi@wits.ac.za

Jackson Nowa (Mr)

THERAPIST CONSENT SHEET

Comparison of motor relearning occupation based and Neurodevelopmental Treatment approaches in treating patients with Traumatic Brain Injury.

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

Contact details:
Jackson Nowa, Principal Investigator, telephone no. 0814676896, or by e-mail at jsn547644@gmail.com,
Denise Franzsen , Supervisor, on telephone no. XXX, or by e-mail at Denise.Franzsen@wits.ac.za
Dineo Thupae, Supervisor, on telephone no. XXX, or by e-mail at Denio.Thupae@wits.ac.za
Professor CB Penny, Chairperson of the Human Research Ethics Committee (Medical) at the University of Witwatersrand, on telephone no. 011 717 2301, or by e-mail at Clement.Penny@wits.ac.za.
Ms. Z Ndlovu or Mr Rhulani Mkansi, Committee Secretariat, telephone nos.: 011 717 2700 or 1234, or by e-mail at: Zanele.Ndlovu@wits.ac.za or Rhulani.Mkansi@wits.ac.za

Name of Participant: ______________________________
Date: ______________________________
Place: ______________________________
Signature or mark ______________________________

Name of Witness: ______________________________________
Signature: ______________________________________
Date: ______________________________________

APPENDIX I: ETHICS CLEARANCE CERTIFICATE

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R14/49 Mr Jackson Nowa

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M180970

NAME: (Principal Investigator)	Mr Jackson Nowa
DEPARTMENT:	Occupational Therapy Katutura Intermediate Hospital, Namibia
PROJECT TITLE:	Comparison of Motor Learning Occupation-based neurodevelopmental treatment approaches in treating patients with traumatic brain injury
DATE CONSIDERED:	28/09/2018
DECISION:	Approved Unconditionally
CONDITIONS:	
SUPERVISOR:	Denise Franszen and Dineo Thupae
APPROVED BY:	Doctor CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	27/02/2019

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

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary on the Third Floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report.** The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in **September** and will therefore be due in the month of **September** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature

Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

APPENDIX J: TURN IT IN REPORT

research 4

ORIGINALITY REPORT

10%	6%	5%	7%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	www.tandfonline.com Internet Source	1%
2	discovery.ucl.ac.uk Internet Source	<1%
3	baadalsg.inflibnet.ac.in Internet Source	<1%
4	d-nb.info Internet Source	<1%
5	Alias, Norlidah, and Saedah Siraj. "Effectiveness of Isman Instructional Design Model in Developing Physics Module based on Learning Style and Appropriate Technology", Procedia - Social and Behavioral Sciences, 2012. Publication	<1%
6	Submitted to University of New England Student Paper	<1%
7	studylib.net Internet Source	<1%