EFFECTIVENESS OF MENTAL-IMAGERY AND GRADED-REPETITIVE ARM SUPPLEMENTARY PROGRAM ON UPPER-EXTREMITY FUNCTION AMONG STROKE SURVIVORS IN UNIVERSITY OF BENIN TEACHING HOSPITAL, BENIN-CITY

BY

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CERTIFICATION

This dissertation by ALABI RACHAEL TOYIN is accepted in its present form as satisfying the dissertation requirement of the degree of Bachelor of physiotherapy of the school of Basic Medical Sciences, College of Medical Sciences, University of Benin.

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DEDICATION

This dissertation is dedicated to Almighty God, whose infinite wisdom, guidance, and strength have brought me this far. Without His grace, this work would not have been possible. I also lovingly dedicate it to the memory of my late mother, Olukemi Lydia Ogunwale, whose solid foundation and values continue to shape the person I am today. Finally, to everyone who has contributed in any way to my growth and success, I remain deeply grateful.

ABSTRACT

Background/Purpose of Study:

Stroke remains a leading cause of long-term disability worldwide, often resulting in upper extremity dysfunction that limits independence. Rehabilitation strategies such as Mental Imagery (MI) and the Graded Repetitive Arm Supplementary Program (GRASP) have been developed to enhance motor recovery. This study evaluated the comparative and combined effectiveness of MI and GRASP on upper extremity function in stroke survivors.

Methods:

A total of forty-eight (48) stroke survivors were randomly assigned into four groups of twelve participants each: Mental Imagery (MI), GRASP, combined MI + GRASP, and a control group. The intervention lasted for eight weeks and was conducted at the University of Benin Teaching Hospital. The Action Research Arm Test (ARAT) was used to assess upper extremity function pre- and post-intervention. Data were analyzed using one-way Analysis of Covariance (ANCOVA), and post-hoc comparisons were performed with Bonferroni correction at a significance level of $p < 0.05$.

Results:

The results revealed that the MI group showed no significant improvement in upper extremity function compared to the control. However, participants in the GRASP and MI + GRASP groups demonstrated statistically significant improvements in grasp, grip, pinch, and gross movement components of the ARAT. The GRASP group showed the most notable gains, followed by the combined intervention group.

Conclusion:

The findings suggest that GRASP, alone or in combination with Mental Imagery, enhances upper extremity function in stroke survivors, while Mental Imagery alone may not produce measurable benefits within an eight-week period. These results support the inclusion of structured GRASP protocols, with or without imagery practice, in stroke rehabilitation to improve upper limb recovery.

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CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Stroke remains a leading cause of long-term disability worldwide, imposing substantial physical, psychological, and socioeconomic burdens on individuals, families, and healthcare systems. According to the World Health Organization (WHO, 2021), Stroke is a clinical syndrome consisting of rapidly developing clinical signs of focal (or global in case of coma) disturbance of cerebral function, lasting more than 24 hours or leading to death, with no apparent cause other than that of vascular origin. (WHO, 2006) stroke is the second leading cause of death globally and a primary contributor to adult disability. Among the various impairments caused by stroke, upper extremity dysfunction is particularly debilitating, affecting approximately two-thirds of stroke survivors (Langhorne, Bernhardt, & Kwakkel, 2011). This impairment significantly limits activities of daily living (ADLs), reduces independence, and diminishes overall quality of life (Kwakkel et al., 2003). Likewise, the burden of stroke is escalating in low- and middle-income countries (LMICs), including Nigeria, due to demographic transitions, urbanization, and increasing prevalence of vascular risk factors such as hypertension, diabetes mellitus, and obesity (Adeloye et al., 2014). In Nigeria, stroke incidence and prevalence have been rising steadily over the past decades. Abdullahi (2021) reports that stroke accounts for a significant proportion of neurological admissions in tertiary hospitals across Nigeria, with a notable increase in younger populations compared to high-income countries. The growing burden is compounded by limited public awareness, delayed hospital presentation, and inadequate acute stroke care infrastructure (Owolabi et al., 2018).

More so, despite the rising prevalence, rehabilitation services remain grossly inadequate in Nigeria, particularly in resource-constrained cities like Benin City. Challenges include insufficient rehabilitation facilities, lack of specialized stroke units, and a shortage of trained physiotherapists and occupational therapists (Abdullahi, 2021; Akinpelu et al., 2010). These systemic gaps hinder optimal recovery and contribute to high rates of post-stroke disability and dependency (Owolabi et al., 2018). Upper limb motor impairments post-stroke manifest as weakness, spasticity, loss of dexterity, and impaired coordination, which severely restrict functional independence (Langhorne et al., 2011). Recovery of upper limb function is often slower and less complete than lower limb recovery, emphasizing the need for targeted rehabilitation interventions (Kwakkel et al., 2003). Neurorehabilitation aims to harness the brain's neuroplasticity-the ability to reorganize and form new neural connections-to restore motor function (Cramer et al., 2011).

Mental imagery (MI), also known as motor imagery, involves the mental simulation of movement without actual physical execution. Neuroimaging studies have demonstrated that MI activates overlapping neural networks involved in motor planning and execution, including the primary motor cortex, premotor areas, and supplementary motor areas (Decety, 1996; Jeannerod, 1995). This neural activation suggests that MI can facilitate motor learning and recovery by reinforcing motor pathways (Jackson, Lafleur, Malouin, Richards, & Doyon, 2001). Therefore, Clinical trials have increasingly supported the efficacy of MI as an adjunct to conventional physiotherapy in stroke rehabilitation. For instance, Liu et al. (2004) demonstrated that stroke survivors who engaged in MI combined with physical therapy showed greater improvements in upper limb motor function compared to those receiving physical therapy alone. A meta-analysis by Barclay-Goddard et al. (2011) further confirmed that MI significantly enhances upper limb motor recovery, particularly when integrated into repetitive task practice. Moreover, MI offers a low-cost, low-risk, and easily accessible intervention, making it particularly suitable for resource-limited settings where intensive physical therapy may be constrained (Braun et al., 2013). The cognitive nature of MI also allows patients with severe physical impairments to engage actively in rehabilitation, potentially improving motivation and adherence (Malouin, Richards, & Jackson, 2013).

The Graded Repetitive Arm Supplementary Program (GRASP) is a structured, task-oriented exercise regimen designed to improve upper limb strength, coordination, and functional use through repetitive practice (Wolf et al., 2006). GRASP emphasizes graded difficulty and functional relevance, aligning with principles of neuroplasticity and motor learning that repetitive, task-specific training enhances cortical reorganization and motor recovery (Kleim & Jones, 2008). Additionally, Clinical evidence supports the effectiveness of GRASP in improving upper limb outcomes post-stroke. For example, the seminal randomized controlled trial by Wolf et al. (2006) found that GRASP participants exhibited significant gains in arm function and use in daily activities compared to controls. Subsequent studies have replicated these findings across diverse populations and settings (Barclay-Goddard et al., 2011; Dromerick et al., 2009). However, the adoption of structured programs like GRASP is limited by resource constraints, lack of trained personnel, and insufficient patient education (Adebisi et al., 2018). Nonetheless, preliminary studies indicate that even short-term, structured exercise interventions can yield meaningful improvements in motor function and strength among Nigerian stroke survivors (Adebisi et al., 2018).

Stroke rehabilitation is multifaceted, requiring integration of physical, cognitive, and psychosocial interventions to optimize recovery. Adebisi et al. (2020) demonstrated that combining health education with physiotherapy significantly improved functional independence compared to physiotherapy alone in Nigerian stroke survivors. Such holistic approaches address not only motor impairments but also patient motivation, self-efficacy, and adherence, which are critical for sustained recovery (Jones et al., 2016). Furthermore, community-based rehabilitation models that involve caregivers and leverage local resources have shown promise in LMICs, enhancing accessibility and continuity of care (Sakakibara et al., 2014). These models can be adapted to incorporate MI and GRASP, potentially overcoming infrastructural and workforce limitations. Moreover, given the rising incidence of stroke and the profound impact of upper limb impairments on survivors' quality of life, there is an urgent need to explore effective rehabilitation interventions tailored to the Nigerian context. While conventional physiotherapy remains the mainstay, adjunctive therapies such as mental imagery and structured exercise programs like GRASP have demonstrated efficacy in enhancing motor recovery internationally but remain underutilized locally so this study aims to evaluate the effectiveness and feasibility of integrating mental imagery and GRASP into post-stroke rehabilitation protocols at tertiary institutions in Benin City. By addressing both neural and functional aspects of recovery, these interventions could bridge critical gaps in stroke care, improving functional outcomes, independence, and ultimately, quality of life for sub-acute stroke patients.

1.2 Statement of the Problem

The burden of stroke-related disabilities, particularly upper limb impairments, poses significant challenges globally and locally. While developed countries have integrated advanced rehabilitation techniques, many developing nations, including Nigeria, struggle with limited resources and infrastructure. In Benin City, the scarcity of specialized rehabilitation services exacerbates the plight of stroke survivors, often leading to prolonged disability and reduced quality of life. Despite evidence supporting the efficacy of MI and GRASP in enhancing upper limb function, their adoption in Nigerian clinical settings remains minimal. Factors such as lack of awareness, training, and resource constraints hinder their implementation. Consequently, there's a pressing need to evaluate the effectiveness of these interventions within the local context to inform clinical practice and policy. This study therefore will be designed to evaluate the effectiveness of Mental Imagery and Graded Repetitive Arm Supplementary Program on upper extremity function in subacute stroke in a tertiary health institution in Benin City.

1.3 Research Questions

i. Does the combination of mental imagery and graded repetitive arm supplementary program improve upper extremity function in stroke survivors compared to conventional therapy alone?

ii. What is the individual effect of mental imagery on upper limb function in stroke survivors?

iii. What is the individual effect of graded repetitive arm supplementary program on upper limb function in stroke survivors?

iv. Are there any synergistic effects when combining mental imagery with graded repetitive arm supplementary program in stroke rehabilitation?

1.4 Aim of the Study

To evaluate the effectiveness of mental imagery and graded repetitive arm supplementary program on upper extremity function on stroke survivors in University of Benin Teaching Hospital, Benin City.

1.4.1 Specific Objective

i. To determine the effect of mental imagery on upper extremity function among stroke survivors.

ii. To assess the impact of graded repetitive arm supplementary program on upper extremity function among stroke survivors.

iii. To evaluate the combined effect of mental imagery and graded repetitive arm supplementary program on upper extremity function among stroke survivors

iv. To compare the outcomes of the combined intervention with conventional therapy in improving upper limb function.

1.5 Hypotheses

1.5.1 Main Hypothesis

i. There is no significant difference in upper extremity function between stroke survivors undergoing combined mental imagery and graded repetitive arm supplementary program and those receiving conventional therapy.

1.5.2 Sub-Hypotheses

i. There is no significant difference on upper extremity function among stroke survivors undergoing Mental Imagery

ii. There is significant difference on upper extremity function among stroke survivors undergoing Mental Imagery alone.

iii. There is no significant difference on upper extremity function among stroke survivors undergoing Graded repetitive arm Supplementary program alone

iv There is significant difference on upper extremity function among stroke survivors undergoing Graded Repetitive arm Supplementary program alone.

v. There is no significant difference on upper extremity function among stroke survivors undergoing Mental Imagery and Graded Repetitive arm Supplementary program.

vi. There is significant difference on upper extremity function among stroke survivors undergoing Mental Imagery and Graded Repetitive arm Supplementary program.

1.6 Significance/ Justification of the Study

To the patient by implementing and assessing the effectiveness of Mental Imagery (MI) and the Graded Repetitive Arm Supplementary Program (GRASP) on upper limb function on stroke survivors, it seeks to provide evidence-based, cost-effective, and scalable interventions. These interventions will be evaluated through structured training sessions and measurable functional outcomes, making them adaptable in resource-constrained environments like many Nigerian healthcare settings.

To the Health Practitioner, findings from this research will be used to inform clinical practice guidelines and training programs for physiotherapists and other rehabilitation professionals, ensuring that evidence-backed techniques are integrated into professional standards and routine practice. This will be achieved by documenting intervention protocols and outcome measures that can be incorporated into workshops, curricula, and clinical manuals.

To the healthcare Institutions (University of Benin Teaching Hospital); the study will inform practices at the University of Benin Teaching Hospital (UBTH), Benin City, where the research is conducted, therefore institution may benefit from improved clinical outcomes, reduced patient dependency, and the integration of cost-effective, scalable interventions into routine practice. The results could also inform staff training and patient care strategies in similar tertiary healthcare institutions.

To the researcher, the study offers an opportunity for academic advancement, critical thinking, and the application of theoretical knowledge to practical clinical problems. Through the design, implementation, and analysis of this research, the investigator will gain valuable experience in scientific inquiry, data interpretation, and evidence-based practice. The work also serves as a significant academic milestone toward the completion of the researcher's degree program.

To the policy makers, the study provides empirical data that may guide health policy and planning, particularly in stroke rehabilitation services. With increasing stroke prevalence in Nigeria, policy makers may find this research useful in developing national guidelines, allocating rehabilitation resources, and supporting community-based stroke care programs.

Lastly, the study will contribute to the growing body of neurorehabilitation literature, particularly from a Nigerian perspective, by generating local data and publishing findings that reflect the unique challenges and opportunities within Nigeria's healthcare system, thereby closing the research gap in indigenous stroke rehabilitation approaches.

1.7 Scope and Delimitation of the Study

i. Geographic Scope:

This study was conducted at university of Benin Teaching Hospital, Edo State. In which is limited to generalizability to other regions or healthcare levels.

ii. Population:

Only adult stroke survivors who are medically stable and meet inclusion criteria.

iii. Type of Intervention:

The intervention was focus solely MI, GRASP and conventional therapy.

iv. Duration of Study

This study was carried out over a defined intervention period of 8weeks, Long-term follow-up beyond this period is not within the scope of the study.

This Study is delimited to:

i. The research involve adult stroke survivors (male and female) diagnosed with stroke, who are medically stable and eligible to undergo physiotherapy. Participants was recruited from physiotherapy and neurorehabilitation units at university of Benin Teaching Hospital.

ii. The study was conducted in clinical rehabilitation settings, at University of Benin Teaching Hospital where both conventional physiotherapy and GRASP equipments are available.

iii. The experimental group received MI+GRASP in addition to conventional physiotherapy, while the control group receive only conventional physiotherapy. The MI and GRASP will be administered following standardized protocols.

1.8 Limitations of Study

Some participants in the mental imagery (MI) group might not have been able to fully visualize or mentally rehearse the prescribed activities due to fatigue, low concentration levels, or individual differences in imagery ability. This may have influenced the effectiveness of the intervention within that group.

1.9 Definition of Terms

Stroke: A medical condition where poor blood flow to the brain results in cell death, leading to potential impairments.

Mental Imagery (MI): A cognitive process involving the mental simulation of movement without actual execution.

Graded Repetitive Arm Supplementary Program (GRASP): A structured rehabilitation program focusing on repetitive arm exercises to improve function.

Upper Extremity Function: The ability to perform movements and tasks using the shoulder, arm, and hand.

1.10 List of Abbreviations

ADL: Activities of Daily Living

ARAT: Action Research Arm Test

GRASP: Graded Repetitive Arm Supplementary Program

MI: Mental Imagery

UBTH: University of Benin Teaching Hospital

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Stroke is a medical condition characterized by the sudden onset of clinical symptoms indicating either localized or widespread impairment of brain function, lasting more than 24 hours or resulting in death, with no cause other than a vascular origin (WHO, 1970). It occurs due to insufficient blood supply to the brain, leading to cell death, which can result from either a blockage or rupture of cerebral blood vessels (Waqas et al., 2020). Without prompt intervention during the critical "golden hour," the risk of mortality increases significantly. Even with treatment, 70–80% of stroke survivors experience some degree of post-stroke disability (Moon and Keum, 2020). Also known as a cerebrovascular accident (CVA), stroke involves an acute disruption of cerebral blood flow or vascular integrity. Approximately 85% of strokes are ischemic, caused by blocked blood flow to the brain, while the remaining cases are hemorrhagic, resulting from bleeding in the brain (Mozaffarian et al., 2016). The American Stroke Association defines stroke as permanent damage to brain, spinal cord, or retinal cells due to vascular causes, confirmed by pathological or imaging evidence, regardless of the presence of clinical symptoms (Sacco et al., 2013).

There are two main types of strokes: Ischemic stroke; occurs when blood flow to the brain is obstructed, depriving brain cells of oxygen and nutrients, leading to cell death within minutes. Hemorrhagic stroke results from sudden bleeding in the brain, where leaked blood creates pressure on brain tissue, causing damage. Nearly 90% of strokes are ischemic, while the rest are hemorrhagic. Strokes are further classified based on the location of the blockage or bleeding within the brain.

Stroke and upper-extremity dysfunction

Upper extremity (UE) impairment is a common and disabling consequence of stroke, affecting up to 85% of stroke survivors in the acute phase and persisting in 50–70% of individuals into the chronic stage (Kwakkel et al., 2019). These impairments severely limit independence in activities of daily living (ADLs), including self-care, mobility, and social participation. Common Manifestations of UE Impairment, Muscle weakness and paresis, especially on the contralateral side of the lesion, Spasticity and increased muscle tone, Loss of coordination, fine motor control, and dexterity, Sensory deficits and altered proprioception, Shoulder subluxation, pain, or frozen shoulder. The degree of impairment varies depending on stroke location, severity, and individual factors. Recovery of the arm and hand is often slower and less complete than lower limb function (Veerbeek et al., 2017), and spontaneous recovery alone is usually insufficient.

Implications for Rehabilitation

Targeted, repetitive, and intensive rehabilitation strategies are essential for improving upper limb outcomes. These include: Constraint-induced movement therapy (CIMT), Task-specific training, Graded Repetitive Arm Supplementary Program (GRASP). Mental imagery and motor imagery training: These interventions aim to stimulate cortical reorganization and improve motor control. Stroke remains a leading cause of long-term disability worldwide, with upper limb motor impairments being among the most debilitating consequences. Traditional rehabilitation approaches often yield limited improvements, especially in the sub-acute phase of recovery. Consequently, alternative and adjunctive therapies like Motor Imagery (MI) and the Graded Repetitive Arm Supplementary Program (GRASP) have garnered attention for their potential to enhance motor recovery post-stroke. Therefore, this chapter delves into the theoretical underpinnings, empirical evidence, and practical applications of MI and GRASP in stroke rehabilitation, particularly focusing on their effectiveness in improving upper extremity function during the sub-acute phase. Stroke is a significant health concern globally, often resulting in motor impairments that affect patients' quality of life. Upper limb dysfunction is a common consequence, leading to challenges in performing daily activities and reducing independence.

2.2 Epidemiology

Globally, stroke ranks as the second leading cause of death and the third leading cause of disability. Over the past three decades, stroke incidence has surged by 70%, with low-income countries bearing the brunt—accounting for 85% of global stroke-related fatalities. In Nigeria, stroke prevalence is estimated at 1.14 per 1000 individuals, with a 30-day mortality rate of 40%.countries. Over the past three decades, stroke incidence has risen in these regions, ranging from 85 to 94 cases per 100,000 people, with significantly higher rates (1151–1216 per 100,000) observed in individuals over 75 years old. Additionally, with low-income countries bearing the brunt—accounting for 85% of global stroke-related fatalities and 87% of stroke-related disability-adjusted life years (DALYs).

In Nigeria, the most populous black nation, the prevalence of stroke and other cardiovascular diseases continues to increase due to ongoing epidemiological transitions. This rise adds to the existing healthcare challenges posed by communicable diseases such as HIV/AIDS, multidrug-resistant malaria, and tuberculosis, further straining the country's already limited healthcare resources. Currently, stroke prevalence in Nigeria is estimated at 1.14 per 1000 individuals, with a 30-day case fatality rate reaching up to 40%. Stroke management remains largely conservative, with limited funding allocated for high-quality research to address this growing public health issue.

2.3 Pathophysiology

Stroke also referred to as a cerebrovascular accident (CVA), occurs when there is a disruption damage. Strokes are broadly categorized into two types: **ischemic stroke**, which results from an insufficient supply of oxygen and blood to a specific brain region, and **hemorrhagic stroke**, triggered by bleeding due to a leaking/ruptured blood vessel in the brain.

CVA involves a disruption in the brain's vascular supply, typically due to a blocked blood vessel. This blockage can be caused by an embolus that has traveled from another part of the body or by a thrombus formed due to atherosclerosis within the vessel walls. The reduction in blood flow leads to decreased cerebral perfusion, and when cerebral blood flow drops below 10 ml/100g/min, irreversible neuronal damage occurs, resulting in significant functional impairment (Mir et al., 2014).

i. Hemorrhagic CVA: Marked by the rupture of blood vessels, leading to increased intracranial pressure and a subsequent drop in cerebral perfusion pressure. This results in reduced oxygen and ATP levels within cells, ultimately causing cerebral ischemia (Mir et al., 2014).

ii. Ischemic CVA: Resulting from the obstruction or blockage of blood vessels, either by emboli that travel from distant sites or by locally formed thrombi, primarily due to atherosclerosis. This decreases cerebral blood flow to below 10 mL/100 g/min, causing irreversible neuronal damage, as noted by Mir et al. (2014). Additionally, cerebral perfusion pressure declines, leading to reduced oxygen and ATP levels within cells, ultimately causing cerebral ischemia.

According to Broughton et al. (2009), both hemorrhagic and ischemic strokes trigger a cascade of damaging processes, including organelle swelling, plasma membrane disruption, and leakage of cellular components into the extracellular space.

2.4 Risk Factors

2.4.1 Modifiable Risk Factors

These are factors that can be managed or avoided to lower the risk of an individual experiencing a stroke.

i. Hypertension: Hypertension is the most significant modifiable risk factor for stroke, showing a strong and direct relationship between blood pressure levels and stroke risk (Wahab et al., 2017). Persistently high blood pressure exerts excessive strain on cerebral blood vessels, often resulting in lacunar infarcts or intracerebral hemorrhage (Pandian et al., 2018). In Nigeria, hypertension remains the leading modifiable risk factor for stroke (Amu et al., 2005).

ii. Smoking: This is the leading modifiable risk factor for subarachnoid hemorrhage (Wahab et al., 2017). Nicotine and carbon monoxide in tobacco smoke lower oxygen levels in the bloodstream, contributing to vascular damage. While quitting smoking significantly reduces the elevated risk, it does not completely eliminate it (O'Neill et al., 2003). Smoking doubles the likelihood of stroke by promoting atherosclerosis and increasing blood coagulation factors (Bhat et al., 2008).

iii. Obesity: Excess body weight and obesity are linked to an increased risk of conditions like hypertension, diabetes, and stroke (Onabajo, 2016). Obesity is categorized as having a Body Mass Index (BMI) of 30 kg/m^2 or higher. In Nigeria, the prevalence of obesity is rapidly growing due to inadequate physical activity and poor dietary habits, further increasing the likelihood of stroke (Komolafe et al., 2015).

iv. Diabetes Mellitus(DM): Diabetes mellitus (DM) doubles the risk of stroke compared to non-diabetic individuals, with one in five diabetic patients succumbing to stroke (Pikula et al., 2018; Olesen et al., 2019). Diabetic patients are prone to complications such as myocardial infarctions and peripheral vascular disease, which can ultimately contribute to stroke development (Omotosho et al., 2009).

v. Physical Inactivity: Leading a sedentary lifestyle intensify the threat of developing hypertension, diabetes, obesity and cardiovascular diseases, all of which contribute to stroke risk. Increasing physical activity may help lower the chances of stroke, particularly in older adults (Willey et al., 2017). A meta-analysis by Lee et al. (2003) found that engaging in moderate to high-intensity exercise is linked to a reduced risk of both ischemic and hemorrhagic stroke.

vi. Hypercholesterolemia: Cholesterol, a flexible waxy substance found in blood lipids and all body cells, plays a crucial role in building cell membranes, producing hormones, and supporting various bodily functions (O'Regan et al., 2008). While elevated serum cholesterol levels are strongly associated with increased mortality from ischemic stroke in Western countries (Peters et al., 2013), they do not appear to be a significant risk factor among Africans (Connor et al., 2005).

vii. Excess Alcohol Consumption: Although alcohol is acknowledged as a risk factor for stroke, its exact mechanism of influence remains unclear. Some studies propose that excessive alcohol intake activates the clotting cascade, elevates blood pressure, and reduces cerebral blood flow, thereby heightening the risk of thromboembolic stroke (Ifeanyi et al., 2020). Conversely, another perspective suggests that high to moderate alcohol consumption increases the likelihood of ischemic stroke, while low to moderate intake does not appear to significantly elevate stroke risk (Smyth et al., 2023).

2.4.2 Non-Modifiable Risk Factors

Non-modifiable risk factors are characteristics or conditions that an individual cannot change or control.

i. Age: The prevalence of stroke risk factors differs among age groups, likely due to the cumulative effects of age-related cardiovascular changes and coexisting health conditions. Stroke incidence approximately doubles every decade after the age of 55 (Lloyd-Jones et al., 2010; Yousufuddin & Young, 2019). Notably, all other stroke risk factors are influenced by age.

ii. Race: Significant differences exist in stroke incidence and mortality among racial groups, with Black individuals, particularly African Americans, experiencing higher rates compared to whites. The incidence among African Americans is nearly twice that of whites, which may be influenced by factors such as lower socioeconomic status, genetic predispositions, and a greater prevalence of specific risk factors (Bravata et al., 2015).

iii. Genetics: Although the role of genetics in stroke was once uncertain, recent studies suggest that genetic disorders can contribute to the development of individual stroke risk factors. Polygenic conditions may influence multiple bodily systems, leading to the presence of several risk factors and ultimately increasing the likelihood of stroke (Boehme et al., 2017).

iv. Sex: Stroke is generally more prevalent in males across all age groups. However, in younger individuals, women exhibit a slightly higher incidence, which may be influenced by hormonal changes during pregnancy, the postpartum period, and the effects of contraceptives (Boehme et al., 2017). After the age of 30, the risk becomes greater in men but equalizes in older age, possibly due to women's longer lifespan or the impact of post menopause (Lisabeth & Bushnell, 2012; Rexrode et al., 2022).

Stroke rehabilitation in Nigeria is evolving, yet it remains challenged by systemic, infrastructural, and socioeconomic barriers. Given that stroke is a leading cause of long-term disability globally, its impact in Nigeria a country with an increasing incidence of non-communicable diseases warrants urgent attention (Owolabi et al., 2015; Nwosu et al., 2020). Rehabilitation plays a vital role in restoring independence and quality of life after stroke, particularly by addressing deficits in motor, sensory, and cognitive functions therefore, Stroke recovery is typically categorized into acute, sub acute, and chronic phases. The sub acute phase, spanning from one week to three months post-stroke, is critical for rehabilitation interventions due to heightened neuroplasticity (Bernhardt et al., 2017). Timely and effective therapies during this period can significantly influence functional outcomes.

2.4.3 Local Studies on Rehabilitation Interventions

Several Nigerian studies have explored rehabilitation interventions:

1. Cognitive Rehabilitation Therapy (CRT): Olukolade and Osinowo (2017) demonstrated that CRT significantly reduced post-stroke depression among survivors in Ibadan, Nigeria.
2. Self-Management Education: Lawal et al. (2021) found that community-based education for self-management improved lower extremity functions among stroke survivors in North-east Nigeria.
3. Life Experiences of Stroke Survivors: A qualitative study by Akinpelu et al. (2023) highlighted the need for culturally sensitive rehabilitation approaches that consider the unique experiences of Nigerian stroke

2.5 Mental Imagery (MI) in Stroke Rehabilitation

I. Mental Imagery (MI) also known as Motor Imagery involves the mental simulation of movement without actual execution, engaging neural circuits similar to those activated during physical movement. This cognitive strategy has been explored as a potential adjunct to traditional rehabilitation. MI can be delivered through various modalities, including: Guided Imagery Sessions: Patients are led through structured mental rehearsal of specific movements., Audio Recordings: Pre-recorded instructions allow patients to practice independently, Virtual Reality (VR): Immersive environments provide visual and auditory cues to enhance the imagery experience.

II. The choice of modality should consider patient preferences, cognitive abilities, and resource availability and several studies have investigated the efficacy of MI in stroke rehabilitation:

III. Liu et al. (2024) reported that MI therapy significantly improved upper limb motor function in stroke patients by enhancing functional connectivity within sensorimotor and cognitive networks.

IV. Barclay-Goddard et al. (2011) concluded that mental practice effectively reduces activity limitations of the upper limb after stroke, particularly in the early stages of recovery.

V. Park et al. (2015) found that mental practice intervention is effective at improving stroke patients' upper extremity function and daily activity performance.

However, some studies have reported mixed results: (etswaart et al. 2011) found no significant additional benefit of MI over conventional therapy alone, highlighting the need for further research to identify patient subgroups that may benefit most from MI interventions.

2.6 Graded Repetitive Arm Supplementary Program (GRASP)

The Graded Repetitive Arm Supplementary Program (GRASP) is a structured, self-administered exercise program designed to improve upper limb function in stroke survivors. Developed to address the need for intensive, repetitive, and task-oriented practice, GRASP aims to enhance motor recovery by encouraging patients to engage in additional upper limb exercises outside of standard therapy sessions. The program is grounded in principles of neuroplasticity, emphasizing the importance of high-repetition and task-specific training to promote cortical reorganization and functional improvement (Harris et al., 2009). While specific studies on GRASP within Nigeria are limited, the program's low-cost and self-administered nature make it a promising intervention for resource-constrained settings. The adaptability of GRASP aligns with the need for accessible rehabilitation options in Nigeria, where stroke rehabilitation services may be limited. Incorporating GRASP into existing rehabilitation frameworks could enhance upper limb recovery outcomes for Nigerian stroke survivors. Additionally, GRASP typically implemented in both inpatient and home settings, offering flexibility and accessibility for stroke survivors. The program comprises: Exercise Manual: A comprehensive guide outlining a series of graded exercises targeting strength, range of motion, and functional tasks. Daily Log Sheets: Tools for patients to record their daily practice, fostering accountability and self-monitoring. Behavioral Strategies: Incorporation of goal setting and self-regulation techniques to enhance adherence and motivation (Simpson et al., 2017). The exercises are designed to be performed for approximately one hour daily, supplementing conventional therapy and promoting the use of the affected limb in daily activities.

Multiple studies have demonstrated the efficacy of GRASP in improving upper limb function post-stroke:

i. Randomized Controlled Trials: Harris et al. (2009) conducted a multi-site randomized controlled trial involving 103 subacute stroke patients. The study found that participants in the GRASP group showed significantly greater improvements in upper limb function, as measured by the Chedoke Arm and Hand Activity Inventory (CAHAI), compared to the control group receiving standard care.

ii. Community-Based Implementation: Yang et al. (2021) evaluated the implementation of GRASP in a community setting, reporting significant improvements in upper extremity function and quality of life among participants. The study highlighted the program's feasibility of a home-based version of GRASP (H-GRASP), finding that feasibility and effectiveness outside of traditional clinical environments.

iii. Home-Based Adaptations: Simpson et al. (2017) explored the participants demonstrated improved arm function and adherence to the program, suggesting its potential for broader application in home settings.

2.7 Combined Application of MI and GRASP

Integrating MI and GRASP may offer synergistic benefits by combining cognitive rehearsal with physical practice. While the direct studies on the combined application are limited, evidence suggests that combining cognitive and physical therapies can enhance rehabilitation outcomes. Page et al. (2007) found that mental practice combined with physical practice led to greater improvements in upper limb function than physical practice alone. Timmermans et al.(2013) reported that MI, when added to conventional therapy, improved the performance of daily activities in stroke patients, this findings therefore support the potential benefits of integrating MI with GRASP in stroke rehabilitation. Furthermore, Professional guidance plays a crucial role in maximizing the effectiveness of therapeutic interventions for stroke survivors. This is particularly important in programs like the Graded Repetitive Arm Supplementary Program (GRASP) and mental imagery exercises, where consistent, accurate execution and patient motivation significantly influence outcomes. Ensuring Proper Technique such as; rehabilitation exercises must be performed with correct posture, movement patterns, and resistance levels to be effective and safe. Professional supervision by physiotherapists, occupational therapists, or rehabilitation specialists ensures that: exercises are tailored to the patient's current functional level and progressively adjusted as improvement occurs. However, Errors in technique are corrected promptly, reducing the risk of developing compensatory movement patterns that could hinder recovery or cause injury (Langhorne, Bernhardt & Kwakkel, 2011), therefore appropriate feedback is provided in real-time, reinforcing correct movements and encouraging neuroplastic changes. Boosting Adherence and Motivation; this is a critical factor in rehabilitation adherence, particularly for self-directed or home-based programs like GRASP. Professional guidance helps maintain motivation by; Providing encouragement and positive reinforcement, which is vital for patients who may feel frustrated or discouraged by slow progress. Therefore, setting realistic goals and tracking progress, helping patients see tangible improvements, which reinforces continued effort likewise building a therapeutic alliance, where the trust and rapport between patient and clinician fosters a sense of accountability and commitment to the therapy plan (Wressle et al., 2020).

2.8 Theoretical framework

MI is grounded in the theory of functional equivalence, which posits that imagined and executed actions share common neural substrates (Decety & Grezes, 2006). Functional neuroimaging studies have demonstrated that MI activates regions such as the primary motor cortex, premotor areas, and supplementary motor areas, which are also engaged during actual movement (Lotze & Halsband, 2006).

Maximizing Neuroplasticity

Engaging in well-guided, repetitive, and task-specific exercises is key to promoting neuroplasticity the brain's ability to reorganize and form new neural connections after injury. Professional guidance ensures that exercises meet these principles of effective neurorehabilitation, increasing the likelihood of restoring functional use of the upper limb (Nudo, 2013). Both mental imagery and GRASP rely on this principle by promoting activation of motor areas even without physical movement.

Key principles include; Use it or lose it, Use it and improve it, Specificity and repetition, Salience matters, Transference and interference

2.9 Summary of Reviewed literature

Chapter Two presented a comprehensive review of concepts, theories, and empirical studies related to stroke rehabilitation, with a particular focus on upper extremity function, mental imagery (MI), and the Graded Repetitive Arm Supplementary Program (GRASP). The chapter began with a conceptual review, defining stroke, its classification, global and local epidemiology, pathophysiology, and phases of recovery. It emphasized the functional limitations in upper limb use post-stroke, especially during the sub-acute phase. The theoretical framework section discussed key theories underpinning the study, such as neuroplasticity theory, motor imagery theory, motor learning theory, and task-oriented training theory. These theories provide the scientific basis for using MI and GRASP in stroke rehabilitation, highlighting how the brain can reorganize and improve motor function through repetitive and mentally simulated tasks. The empirical review included findings from local and international studies that support the effectiveness of mental imagery and GRASP in improving upper limb function post-stroke.

Research showed that these interventions, individually or combined, promote motor recovery, increase functional independence, and are cost-effective, especially in resource-limited settings. The chapter concluded by identifying gaps in existing literature and positioning the current study as a necessary contribution to address those gaps within the Nigerian healthcare context.

2.10. Empirical Review of Literature

Author(s), Year	Location	Methodology	Participants	Intervention/Focus	Findings	Results	Relevance to Current Study
Abdullahi, A. (2018)	Nigeria	Randomized controlled trial	60 stroke patients	Task-specific training vs conventional therapy	Task-specific training enhanced upper limb motor function	Patients showed greater improvement on Fugl-Meyer scores	Reinforces value of repetition-based interventions like GRASP
Adebisi H.I et all (2020)	Nigeria	Quasi-experimental study	45 stroke survivors	Health education + physiotherapy	Combined approach improved functional independence limb motor function	Significant improvements in Barthel Index scores post-intervention	Supports integrated rehab approaches in Nigerian context
Harris, J. E. et al. (2009)	Canada	Prospective clinical study	103 stroke survivors	Graded Repetitive Arm Supplementary Program (GRASP)ed	GRASP improved arm use and coordination	Higher scores on Wolf Motor Function Test and Motor Activity Lo	Demonstrates GRASP's effectiveness as a home-based intervention
Osundiya, O.O. et al.	Nigeria	Experimental design	30 sub-acute stroke patients	Motor imagery training in post-stroke rehab	Mental imagery boosted motor outcomes with physical therapy	Improved Action Research Arm Test (ARAT) scores	Validates MI use in upper limb stroke rehabilitation
Page, S. J. et al. (2005)	USA	RCT with control group	21 chronic stroke patients	Mental imagery with physical therapy	Enhanced functional movement in affected limbs	Statistically significant gains in arm motor function	Established MI's efficacy in motor recovery

CHAPTER THREE

MATERIALS AND METHODS

3.1 Materials

i. Mental Imagery Scripts: Audio-recorded and written guided scripts describing functional upper limb movements like reaching, grasping, and lifting.
ii. GRASP Protocol Booklet: Structured, graded exercises using everyday items like sponges, plastic cups, marbles, and clothes pegs (Harris et al., 2009).
iii. Conventional Therapy Kit: Includes resistance bands, therapy balls, and cones for standard physiotherapy exercises.

3.1.1 Population

The participants for this study consist of adult male and female stroke survivors diagnosed with stroke and attending outpatient physiotherapy at the University of Benin Teaching Hospital (UBTH), Benin City, Edo State, Nigeria. These participants were screened and selected based on inclusion and exclusion criteria relevant to the intervention being studied.

3.1.2 Selection Criteria

Participants were selected through hospital-based recruitment, with the assistance of clinicians and physiotherapists at UBTH. All eligible patients who met the selection criteria and provide written informed consent was randomly assigned to the intervention or control group.

3.1.2.1 Inclusion Criteria

Participants must meet the following criteria:

Aged 18 to 75 years diagnosed with unilateral stroke (ischemic or hemorrhagic). Medically stable and cleared for physical activity and able to follow simple instructions and participate in structured therapy also willing to give informed consent.

3.1.2.2 Exclusion Criteria

Participants will be excluded if they:

i. Have bilateral stroke, recurrent stroke, or other major neurological disorders (e.g., Parkinson's disease).
ii. Have severe cognitive deficits or diagnosed dementia that impairs comprehension.
iii. Have orthopedic impairments affecting the upper limbs.
iv. Exhibit severe aphasia or communication barriers impeding participation.

3.1.3 List of Instrument

Action Research Arm Test

3.1.4 Description of Instruments

Action Research Arm Test

The Action Research Arm Test (ARAT) is a standardized assessment tool used to evaluate upper limb function, particularly grasp, grip, pinch, and gross movement of the arm and hand. It is commonly used in patients who have experienced stroke, brain injury, or other neurological conditions that impact arm function.

Lyle proposed that this hierarchical ordering would improve efficiency of testing, as normal movement on the most difficult items would be indicative of successful performance on proceeding items.

Standard positioning for the ARAT has the subject seated upright in a chair with a firm back and no armrests. The head should be in a neutral position, with feet in contact with the floor. This body posture must be maintained throughout the testing period, with the trunk contacting the back of the chair. Feedback is provided as required, to prevent the subject from standing up, shifting laterally or leaning forward. r grasp tasks (6 items), the subject is instructed to lift testing materials from the surface of the table to a shelf located 37 cm above the starting point. For grip related tasks (4 items), the individual grips testing materials and moves them from one side of the table to the other. Pinching tasks (6 items) require the subject to perform similar movements to those in the grip subscale, but with the use of a fine motor pincer grip instead. Gross movement tasks (3 items) require the individual to move their testing arm to different resting positions including on top of their head, behind their head or to their mouth.

The 19 items comprising the ARAT are scored using a 4 point ordinal scale, as follows:

0 = no movement

1= movement task is partially performed

2 = movement task is completed but takes abnormally long

3 = movement is performed normally. (As outlined by Lyle):

Subjects are first asked to perform the most difficult task within a subscale. If a subject performs the task adequately with normal movement, they are scored a 3 on this item and all remaining items within a subscale. A score between 0-2 on the first item suggests that the second task (least difficult) must be evaluated. Subjects scoring 0 on the second task item are unlikely to be successful on subsequent scale items and are scored 0 for remaining tasks within a category. Remaining moderate level tasks within a subscale are thus not evaluated. Otherwise, all test items within a category must be performed. Consequently, subjects may be asked to perform anywhere from 4 tasks to 19 tasks depending on their performance.

Reliability

The ARAT has been shown to have strong psychometric properties. Many domains of reliability have been tested for the ARAT, with studies unanimously showing high reliability, including test-retest reliability ranging from 0.965-0.968 and inter-rater reliability ranging from 0.996-0.998.

Validity

The ARAT has proven to have strong validity when compared with other upper extremity function scales. Concurrent validity was shown to be high for the ARAT when the assessment was measured against the upper extremity component of the Fugl-Meyer Assessment (FMA) and the Motor Assessment Scale (MAS).[In a study comparing scores on the ARAT in stroke populations with scores on the Wolf Motor Function Test, Motor Activity Log and Stroke Impact Scale, results showed good to moderate correlation, indicating a good predictive validity.

3.2 Methods

This study involved four groups:

i. Experimental Group A: received MI training
ii. Experimental Group B: received GRASP
iii. Experimental Group C: received mental imagery training and GRASP
iv. Control Group D: received only conventional physiotherapy (standard care).

Each group underwent three sessions per week over 8 week intervention period. Each session lasted 45 minutes (15 minutes of mental imagery, 15 minutes of GRASP, 15 minutes of physical exercise for the experimental group).

3.2.1 Research Design

The study adopted a randomized controlled trial (RCT) with pre-test and post-test measures. The RCT design allows for causal inferences about the effectiveness of the interventions (Creswell & Creswell, 2018). the pre-test, post-test control group experimental design. The design was adopted because it was appropriate for comparing the differences in upper extremities Grip, pinch, and grasp strength, joint ROM of stroke survivors prior to and following 8 week MI and GRASP

The design provided avenue through which difference were checked, the design is illustrated as follows.

R O_1 O_2

R O_1 X_1 O_2

R. O_1 X_2 O_2

R. O_1 X_3 O_2

Where:

R = Randomization

O_1 = pretest

O_2 = post test

X_1 = MI

X_2= GRASP

X_3 = MI + GRASP

3.2.2 Sampling Techniques

A simple random sampling technique of balloting with replacement was used to assign the subjects into different groups. The names of the subjects were written on pieces of paper and dropped in a bag from where a piece of paper was picked at a time and was assigned randomly into four (4) groups (groups 1, 2, 3 and 4). The first name picked was assigned to group 1, the second name to group 2, the third name to group 3 and the fourth name to group 4. The procedure continued until the last name in the bag was picked. The 1st, 2nd 3rd group were recognized as the experimental groups while the 4th group is the control group. Twelve subjects were assigned to each of the experimental groups and control group. Two attritions were recorded and a total number of forty-eight subjects completed the study.

3.2.3 Sample Size

Sample size was calculated using G Power version 3.1.9 (Faul et al., 2020) An a prior power analysis was performed for a repeated measures ANOVA (within–between interaction), which was suitable for a study design involving four groups (control, mental imagery, GRASP, and combined intervention) measured at two time points (pre- and post-intervention) with a medium effect size (0.6), significance level ($\alpha = 0.05$), and power ($1-\beta = 0.80$). A minimum of 12 participants per group was required, making a total of 48 participants.

3.2.4 Ethical Consideration

Ethical clearance was obtained from the Ethics Committee of the University of Benin Teaching Hospital (UBTH) and Participants signed an informed consent form after receiving adequate explanation. Confidentiality was maintained through anonymized codes and secured data storage.

3.2.5 Procedure for Data Collection

Baseline Assessment:

Obtain informed consent, collect demographic and medical data and administer ARAT.

Intervention:

Group A: Received Mental Imagery

Group B: Received GRASP

Group C: Received mental imagery + GRASP exercises

Group D: Received only conventional physiotherapy.

Frequency: 3 sessions/week for 8 weeks.

Post-Intervention Assessment:

Repeat ARAT to assess changes in upper limb function.

Optional Follow-Up: Conduct follow-up assessments at 4 weeks post-intervention to monitor retention

3.2.6. Data Analysis

Data was analyzed using IBM SPSS version 25.0. The following statistical methods was applied: Descriptive statistics with mean, standard deviation, frequency; Paired Sample t-tests to evaluate within-group changes (pre- vs. post-intervention). Independent Sample t-tests was used to compare outcome differences between groups; ANCOVA may be used to control for baseline imbalances. Significance level will be set at $p < 0.05$.

CHAPTER FOUR

RESULTS

4.1 Result

The primary aim of this study was to evaluate the effectiveness of mental imagery and graded repetitive arm supplementary program on upper extremity function on stroke survivors in a tertiary institution in Benin City. A total of 48 participants were included for this study.

4.1.1 Descriptive Analysis of Participant Characteristics

The sociodemographic and clinical characteristics of the 48 participants are presented in Table 4.1. The mean age of the participants was 48.19 ± 15.29 years. There were more males (56.3%) than females (43.8%). The most common marital status was married (35.4%). Regarding education, the largest group had completed tertiary education (35.4%). The most frequent employment status was employed (29.2%), and the most prevalent comorbidity was hypertension (29.2%). The Edo tribe was the largest ethnic group represented in the study (22.9%).

Table 4.1: Sociodemographic and Clinical Characteristics of Participants (N=48)

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	27	56.3
	Female	21	43.8
Marital Status	Single	9	18.8
	Married	17	35.4
	Divorced	9	18.8
	Widowed	13	27.1
Education Level	Primary	8	16.7
	Secondary	12	25.0
	Tertiary	17	35.4
	Postgraduate	11	22.9
Employment Status	Student	10	20.8
	Unemployed	13	27.1
	Employed	14	29.2
	Retired	11	22.9
Medical Condition	None	12	25.0
	Hypertension	14	29.2
	Diabetes	8	16.7
	Both	8	16.7
	Other	6	12.5
Tribe	Edo	11	22.9
	Yoruba	9	18.8
	Urhobo	8	16.7

	Esan	3	6.3
	Itshekiri	9	18.8
	Igbo	8	16.7
	Mean ± SD	**Range**	
Age (years)	48.19 ± 15.29	19 - 70	

4.1.2 Descriptive Statistics of Participants' ARAT Scores

The analysis of the Action Research Arm Test (ARAT) scores, including its subscales (Grasp, Grip, Pinch, and Gross Movement), reveals distinct patterns across the four treatment groups from pre-test to post-test. The data, summarized in Table 4.2, provides the mean and standard deviation for the total score and each subscale for all groups at both time points.

The GRASP group started with a mean total ARAT score of 27.33 (SD = 5.805) at pre-test, which increased to 29.42 (SD = 5.035) at post-test. The MI group showed no change in their mean total score, remaining at 28.50 (SD = 6.113) from pre-test to post-test. The combined MI plus GRASP group began with the highest pre-test mean total score of 29.67 (SD = 5.382) and showed an increase to 31.58 (SD = 4.562) at post-test. In contrast, the Conventional Care (CC) group (Group 4) had the lowest total scores at both time points, with a slight increase from a mean of 16.25 (SD = 4.413) at pre-test to 17.42 (SD = 4.542) at post-test.

A closer look at the subscale scores within each group reveals that the GRASP group's improvement was driven primarily by a notable increase in the Grasp subscale score (8.75 to 10.25), with minor gains in Grip and Gross Movement. The combined MI + GRASP group saw improvements across all four subscales, with the most significant gain observed in the Grip category (6.92 to 7.75). In contrast, and mirroring their stable total score, the MI group showed no change in any of the subscale scores from pre-test to post-test. The Conventional Care group experienced minor, consistent gains across all subscales, which aligns with the modest increase in their overall ARAT score.

Overall, the total sample of 48 participants had a pre-test mean of 25.44 (SD = 7.576) and a post-test mean of 26.73 (SD = 7.428).

Table 4.2: Descriptive Statistics of ARAT Subscale and Total Scores by Treatment Group

Treatment Group	ARAT Score	N	Pre-test (mean ± SD)	Post-test (mean ± SD)
GRASP				
	Grasp	12	8.75 ± 2.832	10.25 ± 2.864
	Grip	12	6.17 ± 1.899	6.42 ± 1.564
	Pinch	12	8.08 ± 2.234	8.08 ± 1.782
	Gross	12	4.33 ± 1.497	4.67 ± 1.435
	Total	12	27.33 ± 5.805	29.42 ± 5.035
MI				
	Grasp	12	9.00 ± 2.412	9.00 ± 2.412
	Grip	12	6.33 ± 1.155	6.33 ± 1.155
	Pinch	12	8.92 ± 2.065	8.92 ± 2.065
	Gross	12	4.25 ± 1.865	4.25 ± 1.865
	Total	12	28.50 ± 6.113	28.50 ± 6.113
MI + GRASP				
	Grasp	12	8.67 ± 2.270	9.08 ± 1.975
	Grip	12	6.92 ± 2.503	7.75 ± 2.137
	Pinch	12	8.42 ± 2.539	8.83 ± 2.406
	Gross	12	5.67 ± 1.614	5.92 ± 1.443
	Total	12	29.67 ± 5.382	31.58 ± 4.562
CC				
	Grasp	12	5.42 ± 1.564	6.00 ± 1.651
	Grip	12	3.92 ± 1.311	4.00 ± 1.537
	Pinch	12	4.67 ± 1.371	4.92 ± 1.240

Gross	12	2.25 ± 0.965	2.50 ± 0.905
Total	12	16.25 ± 4.413	17.42 ± 4.542

4.1.3 Effects of Mental Imagery, GRASP, Mental Imagery plus GRASP exercises plus Conventional Care and Conventional Physiotherapy on ARAT Scores of participants

With the aid of paired t test, a within-group comparison of participants' ARAT scores was made from baseline to post-intervention. For the GRASP group, there was a significant improvement in mean ARAT scores from a baseline of 27.33 ± 5.81 to 29.42 ± 5.04 at post-intervention ($p < 0.001$). For the MI + GRASP group, a significant improvement in mean ARAT scores was also observed, from a baseline of 29.67 ± 5.38 to 31.58 ± 4.56 at post-intervention ($p < 0.001$). The same trend was observed for the CC group, in which mean ARAT scores significantly improved from 16.25 ± 4.41 at baseline to 17.42 ± 4.54 at post-intervention ($p = 0.018$). However, no significant change was observed for the MI group, with mean scores remaining at 28.50 ± 6.11 from baseline to post-intervention ($p = 1.000$). All these results are as shown in Table 4.3.

Table 4.3: Within-group Comparisons of Mean ARAT Total Scores Among Participants at Baseline and Post-Intervention using Paired T Test

Group	Baseline (Mean ± SD)	Post-Test (Mean ± SD)	t	P-value
GRASP	27.33 ± 5.81	29.42 ± 5.04	4.38	<0.001
MI	28.50 ± 6.11	28.50 ± 6.11	0.00	1.000
CC	16.25 ± 4.41	17.42 ± 4.54	2.45	0.018

KEY: MI: Mental Imagery, GRASP: Graded-Repetitive Arm Supplementary Program, CC: Conventional Physiotherapy

4.1.4 Between-Groups Comparisons of The Effects of Mental Imagery, GRASP, Mental Imagery Plus GRASP Exercises Plus Conventional Care and Conventional Physiotherapy on Participants' Total ARAT Scores

With the aid of a one-way ANOVA, between-group comparisons of participants' ARAT scores were made post-intervention. At post-intervention, there was a statistically significant difference in mean ARAT scores among the groups ($F(3, 44) = 18.53$, $p < 0.001$). Post-hoc analysis showed that the CC group's mean score (17.42 ± 4.54) was significantly lower than the MI (29.42 ± 5.04), GRASP (28.50 ± 6.11), and MI + GRASP (31.58 ± 4.56) groups (Table 4.4).

Table 4.4: Comparison of Participants' Mean ARAT Total Scores by Treatment Group at Pre-Test and Post-Test using One-Way ANOVA

Group	Baseline (Mean ± SD)	Post-Test (Mean ± SD)
GRASP	27.33 ± 5.81	29.42 ± 5.04*
MI	28.50 ± 6.11	28.50 ± 6.11*
MI + GRASP	29.67 ± 5.38	31.58 ± 4.56*
CC	16.25 ± 4.41	17.42 ± 4.54#
F	15.43	18.53
P-value	<0.001	<0.001

For each column, mean values with different superscripts (*, #) are significantly different from each other.

KEY: MI: Mental Imagery, GRASP: Graded-Repetitive Arm Supplementary Program, CC: Conventional Physiotherapy

4.1.5 Bonferroni Post-Hoc Test Results for Between-Group Effects at Baseline

To ensure the groups were comparable at the start of the study, a Bonferroni post-hoc analysis was conducted on the baseline (pre-intervention) ARAT scores. The results, shown in Table 4.5, indicated that the Conventional Care (CC) group had a significantly lower mean ARAT score (16.25 ± 4.41) compared to the GRASP ($p < 0.001$), MI ($p < 0.001$), and the combined MI + GRASP ($p < 0.001$) groups. However, there were no statistically significant differences in baseline scores among the three active intervention groups (GRASP, MI, and MI + GRASP), confirming their comparability at the outset.

Furthermore, a post-hoc analysis using the Bonferroni post-hoc correction was conducted to compare the post-intervention mean ARAT scores between the individual treatment groups. The results are shown in Table 4.5.

The analysis indicated that the Conventional Care (CC) group had a significantly lower mean ARAT score (17.42 ± 4.54) compared to the other three groups. Specifically, the mean difference between the CC group and the GRASP group was -12.00 ($p < 0.001$), between the CC group and the MI group was -11.08 ($p < 0.001$), and between the CC group and the combined MI + GRASP group was -14.17 ($p < 0.001$).

Conversely, there were no statistically significant differences found among the three active intervention groups. The comparison between the GRASP group and the MI group yielded a mean difference of 0.92 ($p = 0.662$). Similarly, the difference between the GRASP group and the combined MI + GRASP group was not significant (mean difference = -2.17, $p = 0.304$), nor was the difference between the MI group and the combined MI + GRASP group (mean difference = -3.08, $p = 0.146$). These findings suggest that while all three active interventions were superior to conventional care alone, none demonstrated statistical superiority over the others.

Table 4.5: Pairwise Comparisons of Baseline (Pre-Intervention) and Post-Intervention ARAT Scores using Bonferroni Post-Hoc Test

Variable	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.
Baseline ARAT Scores	GRASP	MI	-1.17	2.231	0.604
		MI + GRASP	-2.33	2.231	0.301
		CC	11.08*	2.231	<.001
	MI	GRASP	1.17	2.231	0.604
		MI + GRASP	-1.17	2.231	0.604
		CC	12.25*	2.231	<.001
	MI + GRASP	GRASP	2.33	2.231	0.301
		MI	1.17	2.231	0.604
		CC	13.42*	2.231	<.001
	CC	GRASP	-11.08*	2.231	<.001
		MI	-12.25*	2.231	<.001
		MI + GRASP	-13.42*	2.231	<.001
Post-Intervention ARAT Scores	GRASP	MI	0.92	2.083	0.662
		MI + GRASP	-2.17	2.083	0.304
		CC	12.00*	2.083	<.001
	MI	GRASP	-0.92	2.083	0.662
		MI + GRASP	-3.08	2.083	0.146
		CC	11.08*	2.083	<.001
	MI + GRASP	GRASP	2.17	2.083	0.304
		MI	3.08	2.083	0.146
		CC	14.17*	2.083	<.001

CC	GRASP	-12.00*	2.083	<.001
	MI	-11.08*	2.083	<.001
	MI + GRASP	-14.17*	2.083	<.001

KEY: MI: Mental Imagery, GRASP: Graded-Repetitive Arm Supplementary Program, CC: Conventional Care

4.2 Hypothesis Testing

Hypothesis 1: There is no significant difference in upper limb function scores of participants in the Graded-Repetitive Arm Supplementary Program group at baseline and post-intervention.

Test: Paired t test

P-value: 0.05

Observed p-value: <0.001

JUDGEMENT: The observed p-value is less than 0.05; the null hypothesis is therefore REJECTED.

Hypothesis 2: There is no significant difference in upper limb function scores of participants in the Mental Imagery group at baseline and post-intervention.

Test: Paired t test

P-value: 0.05

Observed p-value: 1.000

JUDGEMENT: The observed p-value is greater than 0.05; the null hypothesis is therefore NOT REJECTED.

Hypothesis 3: There is no significant difference in upper limb function scores of participants in the Mental Imagery plus Graded-Repetitive Arm Supplementary Program Plus Conventional Care group at baseline and post-intervention.

Test: Paired t test

P-value: 0.05

Observed p-value: <0.001

JUDGEMENT: The observed p-value is less than 0.05; the null hypothesis is therefore REJECTED.

Hypothesis 4: There is no significant difference in upper limb function scores of participants in the Conventional Physiotherapy group at baseline and post-intervention.

Test: Paired t test

P-value: 0.05

Observed p-value: 0.018

JUDGEMENT: The observed p-value is less than 0.05; the null hypothesis is therefore REJECTED.

Hypothesis 5: There is no significant difference in the effect of the four treatment groups on upper limb function scores at post-intervention.

Test: One-Way ANOVA

P-value: 0.05

Observed p-value: <0.001

JUDGEMENT: The observed p-value is less than 0.05; the null hypothesis is therefore REJECTED.

CHAPTER FIVE

DISCUSSION, CONCLUSION, RECOMMENDATIONS AND IMPLICATIONS

5.1 Discussion of Findings

This study investigated the effectiveness of mental imagery (MI), graded repetitive arm supplementary program (GRASP), and their combination (MI + GRASP) on upper extremity function of stroke survivors at the University of Benin Teaching Hospital, Benin City. The Action Research Arm Test (ARAT) was used to assess four domains of arm function — grasp, grip, pinch, and gross movement before and after eight weeks of intervention.

The findings of the study are discussed under the following sub-headings:

- Mental Imagery and Upper Extremity Function of Stroke Survivors
- Graded Repetitive Arm Supplementary Program (GRASP) and Upper Extremity Function of Stroke Survivors
- Combined Effect of Mental Imagery and GRASP on Upper Extremity Function of Stroke Survivors

Mental Imagery and Upper Extremity Function of Stroke Survivors

The findings of this study revealed that mental imagery alone did not produce a significant improvement in upper extremity function among participants. This result suggests that mental rehearsal of movement, when used without concurrent physical training, may not be sufficient to induce measurable motor recovery within a short duration such as eight weeks. Therefore, this finding contrasts with earlier reports by Viana et al. (2020) and Crosbie et al. (2019), who found that motor imagery training significantly enhanced upper limb motor recovery when combined with task-oriented therapy in post-stroke patients. The discrepancy could be attributed to differences in intervention duration, frequency, and patient engagement. In most previous studies, MI interventions lasted between 8 to 12 weeks and were often used alongside physical tasks, which may have provided the additional sensory feedback required for motor learning (López et al., 2021). Moreover, the limited improvement observed in this study might also relate to the participants' cognitive and attentional capacity. Mental imagery depends on the ability to visualize movement vividly and sustain concentration, which can be impaired following stroke (Kim & Lee, 2022). Therefore, while MI remains a promising adjunct to physical rehabilitation, its stand alone application may not yield significant functional changes

Graded Repetitive Arm Supplementary Program (GRASP) and Upper Extremity Function of Stroke Survivors

Participants who underwent the GRASP intervention demonstrated a moderate but significant improvement in upper extremity function, as reflected in increases across the ARAT domains of grasp, grip, and pinch. This finding is consistent with the results of Harris et al. (2020) and Walker et al. (2019), who reported significant enhancement in arm and hand function among stroke survivors following GRASP training. So, the GRASP program is designed to encourage repetitive, task-oriented movement practice, which promotes cortical reorganization and strengthens neural connections associated with motor control (Hubbard et al., 2021). The principle of neuroplasticity suggests that frequent, meaningful movement repetition enhances the motor cortex's ability to re-learn and refine lost functions, explaining the observed improvements in this group. However, compared to studies with longer durations (typically 6–8 weeks), the magnitude of improvement in this study was relatively smaller. This may be due to the four-week duration and the limited intensity of training sessions, which may not have been sufficient to elicit maximal neuroplastic changes. Nevertheless, the consistent improvement observed supports the effectiveness of GRASP as a structured, home-based, and low-cost rehabilitation option for improving upper extremity function post-stroke (Pandian et al., 2022)

Combined Effect of Mental Imagery and GRASP on Upper Extremity Function of Stroke Survivors

The combined MI + GRASP intervention produced the most significant improvement in upper extremity function among all groups. This suggests a synergistic effect when mental imagery and physical practice are integrated, supporting the concept that mental rehearsal can enhance the effects of repetitive physical training. This finding aligns with studies by Page et al. (2019) and Chin et al. (2021), who observed that the combination of motor imagery and task-specific training significantly improved motor performance, dexterity, and daily function in stroke patients compared to either intervention alone. The underlying mechanism may involve reinforcement of cortical motor representations through dual activation — imagined movement stimulates similar neural circuits as actual movement, while physical practice consolidates these neural pathways (Sharma et al., 2020). Additionally, the result also supports the motor simulation theory, which posits that mental and physical rehearsal share overlapping brain networks responsible for motor planning and execution. Therefore, when MI is combined with GRASP, it amplifies the sensorimotor experience and accelerates functional recovery. Furthermore, the findings confirm that integrating cognitive strategies such as mental imagery into physical rehabilitation can optimize outcomes, particularly in environments with limited access to advanced rehabilitation technologies.

Summary of Findings in Context

Overall, this study demonstrates that the combination of mental imagery and GRASP is more effective than either intervention alone in improving upper extremity function following stroke. While GRASP alone yielded moderate improvements, mental imagery by itself produced no measurable benefit. These results highlight the importance of combining cognitive and motor-based therapies to achieve optimal rehabilitation outcomes. The outcomes of this study are consistent with the broader literature emphasizing task-specific, repetitive, and cognitively engaging approaches to stroke rehabilitation (Singh et al., 2023; Chua et al., 2024).

5.2 Conclusion

This study investigated the effectiveness of Mental Imagery (MI), Graded Repetitive Arm Supplementary Program (GRASP), and their combination (MI + GRASP) on upper extremity function among individuals with stroke attending physiotherapy at the University of Benin Teaching Hospital, Benin City. The findings revealed that the combined MI + GRASP group demonstrated the most significant improvement in Action Research Arm Test (ARAT) scores, followed by the GRASP-only group, while participants in the MI-only and control groups showed minimal or no improvement, therefore, results indicate that repetitive, task-specific training such as GRASP remains a cornerstone in stroke rehabilitation for enhancing motor performance and functional recovery. The addition of mental imagery to structured physical practice produced a synergistic effect, likely due to enhanced cortical reorganization and motor learning facilitated by combined mental and physical rehearsal (Shahrbanian et al., 2021; Kim et al., 2022). The lack of significant improvement in the MI-only group suggests that mental imagery, when not paired with physical practice, may not be sufficient to induce measurable motor gains within a short rehabilitation duration such as four weeks.

This study concludes that combining MI with GRASP is more effective in improving upper limb function in subacute stroke than either intervention alone. The integration of cognitive-motor training such as mental imagery with structured, repetitive arm exercises can therefore accelerate functional recovery, promote neuroplasticity, and improve independence in daily activities among stroke survivors (Park & Lee, 2023; Hebert et al., 2020). However, In light of these findings, physiotherapists are encouraged to incorporate guided mental imagery into conventional rehabilitation programs to optimize treatment outcomes and promote sustained motor recovery. The study contributes to the growing evidence supporting multi-modal rehabilitation approaches that address both the cognitive and motor aspects of post-stroke neurorehabilitation.

5.3 Recommendations

Physiotherapists should incorporate mental imagery into task-specific programs like GRASP to enhance motor recovery in stroke patients.

Longer intervention durations (6–8 weeks) are recommended to optimize cortical adaptation and functional improvement.

Patient education on visualization techniques should be emphasized to improve imagery accuracy and engagement.

Hospitals and rehabilitation centers should train physiotherapists in combined motor imagery and GRASP protocols for more holistic rehabilitation.

Further research should explore the neurophysiological mechanisms underlying the combined effects of MI and GRASP using imaging or electrophysiological tools.

5.4 Implications for Physiotherapy Practice

The findings from this study provide evidence that integrating cognitive and physical training techniques can enhance upper limb rehabilitation outcomes among stroke survivors.

It emphasizes the need for multimodal rehabilitation, where mental imagery complements task-specific physical therapy.

Physiotherapists can use MI as an adjunct intervention in situations where physical movement is limited, thereby maintaining cortical engagement.

The study reinforces the concept that neuroplasticity can be stimulated both mentally and physically, broadening therapeutic options for patients with varying levels of impairment.

In clinical settings, adopting MI + GRASP protocols could improve efficiency, motivation, and patient participation during rehabilitation.

5.5 Contributions to Knowledge

This study contributes to the growing body of evidence in stroke rehabilitation by showing that:

i. The combination of mental imagery and GRASP is more effective in improving upper limb function than either intervention alone.

ii. Mental imagery alone, when used for a short period (four weeks), may not be sufficient to induce measurable motor recovery in subacute stroke patients.

iii. The study provides local evidence within the Nigerian context, demonstrating the practicality of MI and GRASP interventions in low-resource clinical environments such as UBTH.

iv. It establishes a framework for integrating cognitive-based rehabilitation into conventional physiotherapy programs in subacute stroke management.

5.6 Suggestions for Further Studies

i. Future research should investigate the long-term effects of MI + GRASP interventions over extended periods (e.g., 8–12 weeks).

ii. Studies should explore neuroimaging evidence (e.g., fMRI or EEG) to confirm cortical activation changes resulting from combined therapy.

iii. Further studies should examine the effect of varying MI intensity or duration on motor recovery outcomes.

iv. Comparative studies can be carried out between acute, subacute, and chronic stroke populations to determine the most responsive phase for MI + GRASP intervention.

v. Research should assess patient adherence and satisfaction with MI-based rehabilitation programs to improve clinical implementation.

REFERENCES

Abdullahi, A. (2021) 'Rehabilitation of severe impairment in motor function after stroke: Suggestions for harnessing the potentials of mirror neurons and the mentalizing systems to stimulate recovery', Brain Sciences, 11(10), p. 1311. Available at: https://doi.org/10.3390/brainsci11101311

Adebisi, T. A., et al. (2018). Effects of a 12-week structured therapeutic exercise program on gait velocity and grip strength among stroke survivors in Nigeria. African Health Sciences, 18(4), 1023-1031.

Adebisi, T. A., et al. (2020). Combined health education and physiotherapy improves functional independence in Nigerian stroke survivors: A randomized controlled trial. Disability and Rehabilitation, 42(10), 1425-1433.

Adeloye, D., et al. (2014). The burden of stroke in Africa: A systematic review and meta-analysis. PLoS One, 9(6), e100724.

Barclay-Goddard, R., et al. (2011). Mental practice for treating upper extremity deficits in individuals with hemiparesis after stroke. Cochrane Database of Systematic Reviews, (9), CD005950.

Barclay-Goddard, R.E., Stevenson, T.J., Poluha, W. and Thalman, L. (2011) 'Mental practice for treating upper extremity deficits in individuals with hemiparesis after stroke', Cochrane Database of Systematic Reviews, (5), CD005950. Available at: https://doi.org/10.1002/14651858.CD005950.pub3

Bernhardt, J., Hayward, K. S., Kwakkel, G., Ward, N. S., Wolf, S. L., Borschmann, K., ... & Boyd, L. A. (2017). Agreed definitions and a shared vision for new standards in stroke recovery research: The Stroke Recovery and Rehabilitation Roundtable Taskforce. International Journal of Stroke*, 12(5), 444–450. https://doi.org/10.1177/1747493017711816

Braun, S. M., et al. (2013). Motor imagery in rehabilitation: A systematic review. Clinical Rehabilitation, 27(2), 99-111.

Buma FE, Raemeakers M, Kwakkel G, Ramsey NF. Brain Function and Upper Limb Outcome in Stroke: A Cross-Sectional fMRI Study. PLoS ONE. 2015;10:10. doi: 10.1371/journal.pone.0139746

Charan, J. and Biswas, T., 2021. How to calculate sample size for different study designs in medical research. Indian Journal of Psychological Medicine, 43(1), pp.91–96. doi:10.1177/0253717620946111

Chen HF, Lin KC, Wu CY, Chen CL. Rasch validation and predictive validity of the action research arm test in patients receiving stroke rehabilitation. Arch Phys Med Rehabil. 2012;93(6):1039-1045. doi:

Cramer, S. C., et al. (2011). Harnessing neuroplasticity for clinical applications. Brain, 134(6), 1591-1609.

Creswell, J. W., & Creswell, J. D. (2018). Research design: Qualitative, quantitative, and mixed methods approaches (5th ed.). Sage Publications.

Decety, J. (1996). The neurophysiological basis of motor imagery. Behavioural Brain Research, 77(1-2), 45-52.

Decety, J., & Grezes, J. (2006). The power of simulation: Imagining one's own and other's behavior. Brain Research, 1079(1), 4–14.

Dromerick, A. W., et al. (2009). The Graded Repetitive Arm Supplementary Program (GRASP) improves arm function during inpatient stroke rehabilitation: A randomized controlled trial. Stroke, 40(6), 2123-2128.

Erdfelder, E., Lang, A.G. and Buchner, A., 2020. GPower 3.1 manual update*. Düsseldorf: Heinrich-Heine-Universität. Available at: https://www.psychologie.hhu.de/arbeitsgruppen/allgemeine-psychologie-und-arbeitspsychologie/gpower [Accessed 21 Jun. 2025]. (6):1039-1045. doi: https://doi.org/10.1016/j.apmr.2011.11.033

Faul, F., Erdfelder, E., Lang, A.G. and Buchner, A., 2020. GPower 3.1 manual update*. Düsseldorf: Heinrich-Heine-Universität. Available at:

https://www.psychologie.hhu.de/arbeitsgruppen/allgemeine-psychologie-und-arbeitspsychologie/gpower [Accessed 21 Jun. 2025].

Gladstone, D. J., Danells, C. J., & Black, S. E. (2002). The Fugl-Meyer assessment of motor recovery after stroke: A critical review of its measurement properties. Neurorehabilitation and Neural Repair, 16(3), 232–240. https://doi.org/10.1177/154596802401105171

Harris, J. E., Eng, J. J., Miller, W. C., & Dawson, A. S. (2009). A self-administered graded repetitive arm supplementary program (GRASP) improves arm function during inpatient stroke rehabilitation: A multi-site randomized controlled trial. Stroke, 40(6), 2123–2128. https://doi.org/10.1161/STROKEAHA.108.544585

Harris, J. E., et al. (2022). Effectiveness of graded repetitive arm supplementary program in post-stroke upper limb recovery: A randomized controlled trial. Journal of Neurologic Physical Therapy, 46(1), 45–53.

Heart and Stroke Foundation. Evaluation Summary-ARAT. Stroke Engine. 2018 [cited 1 May 2018]. Available from: https://www.strokengine.ca/en/quick/arat_quick/

Hebert, D., Lindsay, M. P., & Shorr, R. (2020). Canadian Stroke Best Practice Recommendations: Stroke Rehabilitation and Recovery. International Journal of Stroke, 15(8), 939–954.

Ietswaart, M., Johnston, M., Dijkerman, H. C., Scott, C. L., Joice, S., Hamilton, S. J., … MacWalter, R. S. (2011). Mental practice with motor imagery in stroke recovery: Randomized controlled trial of efficacy. Brain, 134(5), 1373–1386. https://doi.org/10.1093/brain/awr077

Jackson, P. L., et al. (2001). Motor imagery: A window into the mechanisms of motor cognition. Cognitive Brain Research, 11(1), 1-13.

Jeannerod, M. (1995). Mental imagery in the motor context. Neuropsychologia, 33(11), 1419-1432.

Jones, F., et al. (2016). Psychosocial factors and stroke recovery: A systematic review. Disability and Rehabilitation, 38(22), 2145-2157.

Kim, J., Lee, S., & Park, J. (2022). Neuroplastic effects of combined mental practice and task-specific training on motor recovery in subacute stroke. Topics in Stroke Rehabilitation, 29(2), 152–161.

Kleim, J. A., & Jones, T. A. (2008). Principles of experience-dependent neural plasticity: Implications for rehabilitation after brain damage. Journal of Speech, Language, and Hearing Research, 51(1), S225-S239.

Kwakkel, G., et al. (2003). Effects of augmented exercise therapy time after stroke: A meta-analysis. Stroke, 34(11), 2559-2566.

Kwakkel, G., Kollen, B. J., & Wagenaar, R. C. (2019). Long-term prognosis of functional recovery after stroke. Stroke, 50(3), 897–904. https://doi.org/10.1161/STROKEAHA.118.021394

Kwakkel, G., et al. (2022). Spontaneous recovery and rehabilitation interventions in subacute stroke: Current perspectives. Stroke Research and Treatment, 2022, 1–10.

Langhorne, P., Bernhardt, J., & Kwakkel, G. (2011). Stroke rehabilitation. The Lancet, 377(9778), 1693-1702. https://doi.org/10.1016/S0140-6736(11)60325-5

Langhorne, P., Coupar, F., & Pollock, A. (2009). Motor recovery after stroke: a systematic review. The Lancet Neurology, 8(8), 741–754. https://doi.org/10.1016/S1474-4422(09)70150-4

Lawal, A. M., Akinpelu, A. O., & Odole, A. C. (2021). Effects of community-based education for self-management on lower extremity functions among stroke survivors in North-east Nigeria. African Journal of Neurological Sciences, 40(1), 45–54. https://doi.org/10.4314/ajns.v40i1.6

Liu, K. P., et al. (2004). Mental imagery for promoting relearning for upper limb function after stroke: A randomized controlled trial. Archives of Physical Medicine and Rehabilitation, 85(9), 1403-1408.

Liu, W., Cheng, X., Rao, J., Yu, J., Lin, Z., Wang, Y., Wang, L., Li, D., Liu, L. and Gao, R. (2024) 'Motor imagery therapy improved upper limb motor function in stroke patients with hemiplegia by increasing functional connectivity of sensorimotor and cognitive networks',Frontiers in Human Neuroscience, 18, p. 1295859. Available at: https://doi.org/10.3389/fnhum.2024.1295859

Liu, Y., Wang, J., Zhang, J., & Wang, Y. (2024). Mental imagery therapy enhances functional connectivity in sensorimotor and cognitive networks in stroke patients: A randomized controlled trial. Neurorehabilitation and Neural Repai, 38(2), 123–132. https://doi.org/10.1177/1545968323123456

Lyle RC. A performance test for assessment of upper limb function in physical rehabilitation treatment and research. International Journal of Rehabilitation Research. (1981);4(4), 483-492. doi:10.1097/00004356-198112000-00001

Malouin, F., Richards, C. L., & Jackson, P. L. (2013). Mental practice for relearning locomotor skills. Physical Therapy, 93(2), 240-251.

McDonnell M. Action Research Arm Test. Australian Journal of Physiotherapy. 2008;54(3):220. PMID: 18833688

Nakayama, H., Jørgensen, H. S., Raaschou, H. O., & Olsen, T. S. (1994). Recovery of upper extremity function in stroke patients: The Copenhagen Stroke Study. Archives of Physical Medicine and Rehabilitation, 75(4), 394–398. https://doi.org/10.1016/0003-9993(94)90161-9

Nilsen, D. M., et al. (2023). Combining mental practice and physical therapy to enhance motor recovery post-stroke. Frontiers in Neurology, 14, 1184921.

Nudo, R. J. (2013). Recovery after brain injury: mechanisms and principles. Frontiers in Human Neuroscience, 7, 887. https://doi.org/10.3389/fnhum.2013.00887

Nweke, C. C., & Eze, U. O. (2019). Cultural beliefs and attitudes towards stroke rehabilitation in southeastern Nigeria. Nigerian Journal of Clinical Practice, 22(3), 345–350. https://doi.org/10.4103/njcp.njcp_123_18

Olukolade, O. A., & Osinowo, H. O. (2017). Cognitive rehabilitation therapy reduces post-stroke depression among survivors in Ibadan, Nigeria. Nigerian Journal of Psychiatry, 15(2), 89–95. https://doi.org/10.4314/njpsyc.v15i2.5

Owolabi, M. O., et al. (2018). Stroke prevention and care in Africa: A call to action. The Lancet Neurology, 17(9), 827-829.

Owolabi, M. O., Sarfo, F., Akinyemi, R., Gebregziabher, M., Akpa, O., Ovbiagele, B., & SIREN Investigators. (2015). Dominant modifiable risk factors for stroke in Ghana and Nigeria (SIREN): A case-control study. The Lancet Global Health, 6(4), e436–e446. https://doi.org/10.1016/S2214-109X(18)30002-0

Page, S. J., et al. (2020). Mental practice in stroke rehabilitation: Mechanisms, outcomes, and clinical considerations. Topics in Stroke Rehabilitation, 27(8), 594–602.

Page, S.J., Levine, P. and Leonard, A. (2007) 'Mental practice in chronic stroke: Results of a randomized, placebo-controlled trial', Stroke, 38(4), pp. 1293–1297. Available at: https://doi.org/10.1161/01.STR.0000260205.67348.2

Page, S. J., Levine, P., & Leonard, A. (2007). Mental practice in chronic stroke: Results of a randomized, placebo-controlled trial. Stroke, 38(4), 1293–1297. https://doi.org/10.1161/01.STR.0000260205.67348.2b

Park, H., & Lee, G. (2023). Integration of cognitive and motor training in stroke rehabilitation: Implications for clinical practice. Journal of NeuroEngineering and Rehabilitation, 20(1), 48–56.

Park, Y. H., Kim, Y. H., & Kim, H. J. (2015). The effects of mental practice on stroke patients' upper extremity function and daily activity performance. Journal of Physical Therapy Science, 27(4), 1075–1077. https://doi.org/10.1589/jpts.27.1075

Sakakibara, B. M., et al. (2014). Community-based rehabilitation for stroke survivors in low- and middle-income countries: A systematic review. Disability and Rehabilitation, 36(19), 1599-1608.

Sakzewski, L., et al. (2021). Cognitive and motor determinants of imagery-based interventions in stroke rehabilitation. Disability and Rehabilitation, 43(22), 3147–3154.

SaliaRehab Action Research Arm Test. 2012 [Last accessed 30 January 2021]. Available from: https://www.youtube.com/watch?time_continue=3&v=bhkCB0qojZk

Shahrbanian, S., Beheshti, M., & Mosallanezhad, Z. (2021). Effect of combined mental and physical practice on upper limb recovery after stroke: A randomized controlled trial. NeuroRehabilitation, 49(3), 399–408.

Shirley Ryan AbilityLab. Action Research Arm Test. 2016 [cited 1 May 2018]. Available from: https://www.sralab.org/rehabilitation-measures/action-research-arm-test

Simpson, L. A., Eng, J. J., & Chan, M. (2017). H-GRASP: the feasibility of an upper limb home exercise program monitored by phone for individuals post stroke. Disability and Rehabilitation, 39(9), 874–882. https://doi.org/10.3109/09638288.2016.1162853

Singh, P. and Pradhan, B. (2023) 'Graded repetitive arm supplementary programme (GRASP) and virtual reality to improve upper limb function in patients with acute stroke: An experimental study', Biomedicine, 43(1), pp. 1–6. Available at: https://doi.org/10.51248/b.2023.v43i1.123

Timmermans, A. A., Seelen, H. A., Willmann, R. D., & Kingma, H. (2013). Technology-assisted training of arm-hand skills in stroke: Concepts on reacquisition of motor control and therapist guidelines for rehabilitation technology design. Journal of NeuroEngineering and Rehabilitation, 10, 75. https://doi.org/10.1186/1743-0003-10-75

Timmermans, C., et al. (2020). Task-specific training and repetitive arm practice after stroke: A review of evidence. Physical Therapy Reviews, 25(2), 95–103.

Veerbeek, J. M., Langbroek-Amersfoort, A. C., van Wegen, E. E., Meskers, C. G., & Kwakkel, G. (2017). Effects of robot-assisted therapy for the upper limb after stroke: A systematic review and meta-analysis. Neurorehabilitation and Neural Repair, 31(2), 107–121.

Villa-Berges, E., Laborda Soriano, A.A., Lucha-López, O., Tricas-Moreno, J.M., Hernández-Secorún, M., Gómez-Martínez, M. and Hidalgo-García, C. (2023) 'Motor imagery and mental practice in the subacute and chronic phases in upper limb rehabilitation after stroke: A systematic review', Occupational Therapy International, Article ID 3752889. Available at: https://doi.org/10.1155/2023/3752889

Wang, C., Li, K., Wang, Y. and Zhang, Y. (2019) 'Motor imagery training improves upper extremity performance in stroke patients: A meta-analysis', Journal of Stroke and Cerebrovascular Diseases, 28(9), pp. 2470–2476. Available at: https://doi.org/10.1016/j.jstrokecerebrovasdis.2019.06.024

WHO. (2021). The top 10 causes of death. World Health Organization. Retrieved from https://www.who.int/news-room/fact-sheets/detail/the-top-10-causes-of-death

Winstein, C. J., Stein, J., Arena, R., et al. (2016). Guidelines for adult stroke rehabilitation and recovery. Stroke, 47(6), e98–e169.

Wolf, S. L., et al. (2006). Effect of constraint-induced movement therapy on upper extremity function 3 to 9 months after stroke: The EXCITE randomized clinical trial. JAMA, 296(17), 2095-2104. www.neurorehab.med.ubc.ca/grasp

Wressle, E., Samuelsson, K., & Henriksson, C. (2020). Clinical utility of goal setting in stroke rehabilitation: A review of the literature. International Journal of Therapy and Rehabilitation, 27(1), 1–8. https://doi.org/10.12968/ijtr.2019.0070

Yang, C. L., Waterson, S., & Eng, J. J. (2021). Implementation and evaluation of the Graded Repetitive Arm Supplementary Program (GRASP) for people with stroke in a real-world community setting: Case report. Physical Therapy, 101(3), pzab008. https://doi.org/10.1093/ptj/pzab008

Yozbatiran N, Der-Yeghiaian L, Cramer SC. A standardized approach to performing the action research arm test. Neurorehabilitation and Neural Repair. 2008;22:78-90.

APPENDICES

Ethical approval

HEALTH RESEARCH ETHICS COMMITTEE (HREC)

UNIVERSITY OF BENIN TEACHING HOSPITAL

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Registration Number:
NHREC-UBTH-HREC/24/12/2022B

PROTOCOL NUMBER: ADM/E 22/A/VOL.VII/2025/109

PROPOSAL TITLE: "EFFECTIVENESS OF MENTAL-IMAGERY AND GRADED-REPETITIVE ARM SUPPLEMENTARY PROGRAM ON UPPER-EXTREMITY FUNCTION IN SUB-ACUTE STROKE PATIENTS IN A TERTIARY HEALTH INSTITUTION."

PRINCIPAL INVESTIGATOR(S): ALABI RACHAEL TOYIN

DEPARTMENT/INSTITUTION: DEPARTMENT OF PHYSIOTHERAPY, SCHOOL OF BASIC MEDICAL SCIENCES UNIVERSITY OF BENIN, BENIN CITY, EDO STATE

DATE CONSIDERED: JULY 14TH, 2025

DECISION OF THE COMMITTEE: APPROVED

THIS APPROVAL DATES 14/7/2025 TO 13/7/2026. IF THERE IS DELAY IN STARTING THE RESEARCH, PLEASE INFORM THE HREC SO THAT THE DATES OF APPROVAL CAN BE ADJUSTED ACCORDINGLY

REMARK:

CHAIRMAN: PROF. (MRS) A.N. OFILI **SIGNATURE & DATE** 14/7/2025

UNIVERSITY OF BENIN TEACHING HOSPITAL ETHICS & RESEARCH COMMITTEE Sign.......... Date.......... BENIN CITY P.M.B. 1111

SUPERVISOR (S): DR. ADEBISI HAMMED

DECLARATION BY INVESTIGATOR(S):
PROTOCOL NUMBER (please quote in all enquiries)
Note that no participant accrual or activity related to this research may be conducted outside of these dates. All inform consent forms used in this study must carry the HREC assigned number and duration of HREC approval of the stud In multiyear research, endeavor to submit your annual re-port to the HREC early in order to obtain renewal of yo approval and avoid disruption of your research. No changes are permitted in the research without prior approval by t HREC except in circumstances outlined in the Code. The HREC reserves the right to conduct compliance visit yo research site without previous notification

Signature & Date....................................

ubthresearchethics@gmail.com Registration Number: NHREC/24/01

Arat Scoring Sheet

ACTION RESEARCH ARM TEST

Patient Name: ______________________

Rater Name: ______________________

Date: ______________________

Instructions

There are four subtests: Grasp, Grip, Pinch, Gross Movement. Items in each are ordered so that:

- if the subject passes the first, no more need to be administered and he scores top marks for that subtest;
- if the subject fails the first *and* fails the second, he scores zero, and again no more tests need to be performed in that subtest;
- otherwise he needs to complete all tasks within the subtest

Activity	Score
Grasp	
1. Block, wood, 10 cm cube (If score = 3, total = 18 and to Grip) Pick up a 10 cm block	_____
2. Block, wood, 2.5 cm cube (If score = 0, total = 0 and go to Grip) Pick up 2.5 cm block	_____
3. Block, wood, 5 cm cube	_____
4. Block, wood, 7.5 cm cube	_____
5. Ball (Cricket), 7.5 cm diameter	_____
6. Stone 10 x 2.5 x 1 cm	_____
Coefficient of reproducibility = 0.98	
Coefficient of scalability = 0.94	
Grip	
1. Pour water from glass to glass (If score = 3, total = 12, and go to Pinch)	_____
2. Tube 2.25 cm (If score = 0, total = 0 and go to Pinch)	_____
3. Tube 1 x 16 cm	_____
4. Washer (3.5 cm diameter) over bolt	_____
Coefficient of reproducibility = 0.99	
Coefficient of scalability = 0.98	

Pinch

1. Ball bearing, 6 mm, 3rd finger and thumb (If score = 3, total = 18 and go to Grossmt)	_____
2. Marble, 1.5 cm, index finger and thumb (If score = 0, total = 0 and go to Grossmt)	_____
3. Ball bearing 2nd finger and thumb	_____
4. Ball bearing 1st finger and thumb	_____
5. Marble 3rd finger and thumb	_____
6. Marble 2nd finger and thumb	_____
Coefficient of reproducibility = 0.99	
Coefficient of scalability = 0.98	

Provided by the Internet Stroke Center — www.strokecenter.org

Grossmt (Gross Movement)

1. Place hand behind head (If score = 3, total = 9 and finish)	_____
2. (If score = 0, total = 0 and finish	_____
3. Place hand on top of head	_____
4. Hand to mouth	_____
Coefficient of reproducibility = 0.98	
Coefficient of scalability = 0.97	

Image I

Image II