Student’s Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.7 No. 3 (2026): March 2026 Issue
https://doi.org/10.51168/sjhrafrica.v7i3.2457
Original Article

Optimizing Therapy Intensity and Treatment Sequencing for Children with Spastic Cerebral Palsy: A Randomised Crossover Trial in Zambia.

Faith Mwelwa Muma, Geoffrey Moyo, Loveness Anila Nkhata*
University of Zambia, Department of Physiotherapy, School of Health Sciences, Lusaka, Zambia

Abstract

Background:
Spastic cerebral palsy (SCP) is the most prevalent cerebral palsy subtype, causing significant long-term motor disability. Optimal therapy intensity and treatment sequencing remain poorly understood, particularly in African low-resource settings.

Objectives:
This study aimed to: (1) compare treatment effects of Standard versus Higher-Intensity physiotherapy protocols on spasticity, motor function, and goal attainment in children with SCP; and (2) examine whether treatment sequencing (Higher-Intensity-first versus Standard-first) influences cumulative treatment effectiveness.

Method:
A randomised, assessor-blinded AB/BA crossover trial enrolled 30 children aged 3 months to 4 years with SCP at a tertiary hospital in Zambia. Participants received a Standard Protocol (2 sessions/week × 40 minutes) and Higher-Intensity Protocol (3 sessions/week × 60 minutes), each for 12 weeks with a 2-week washout. Sequence allocation was randomised. Outcomes included spasticity (Modified Ashworth Scale), gross motor function (GMFM-88), and goal attainment (Goal Attainment Scaling).

Results:
The Higher-Intensity Protocol produced significantly superior outcomes across all measures: greater spasticity reduction (mean difference 1.0–1.1 points, $p<0.001$), GMFM improvement (+24.8±5.2% vs +12.1±4.1%, $p<0.001$), and goal attainment (median +1.5 vs +0.5, $p<0.001$). Treatment sequencing significantly influenced cumulative outcomes, with Higher-Intensity-first children showing 13–15% greater overall improvement ($p<0.015$). No significant carryover effects were detected ($p=0.67$).

Conclusion:
Higher-intensity physiotherapy produces clinically and statistically superior outcomes in children with SCP. An initial 'burst' therapy approach followed by maintenance protocols represents an evidence-based strategy for resource-constrained settings.

Recommendations:
Clinicians should prioritise higher-intensity physiotherapy in early treatment phases, supplemented by structured caregiver-assisted home routines. Policymakers should consider 'burst' therapy models to optimise outcomes within limited healthcare resources.

Keywords: *cerebral palsy; physiotherapy; therapy intensity; treatment sequencing; neurorehabilitation; spasticity; low-resource settings; Zambia.*
Submitted: *February 12, 2026* ***Accepted:*** *March 10, 2026* ***Published:*** *March 27, 2026*
Corresponding author: *Loveness Anila Nkhata*
Email: *loveness.nkhata@unza.ac.zm* https://orcid.org/0000-0001-8388-8188
University of Zambia, Department of Physiotherapy, School of Health Sciences, Lusaka, Zambia

Introduction

Cerebral palsy (CP) comprises a group of permanent disorders affecting movement and posture due to non-progressive disturbances in the developing fetal or infant brain (Sadowska et al. 2020). Globally, CP affects approximately two per thousand live births, with higher prevalence observed in low- and middle-income countries (LMICs), largely due to increased perinatal complications,

Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.7 No. 3 (2026): March 2026 Issue
https://doi.org/10.51168/sjhrafrica.v7i3.2457
Original Article

limited neonatal care, and delayed therapeutic intervention (Patel et al. 2020; Dewi & Saraswati 2024). Spastic cerebral palsy (SCP), representing up to 80% of CP cases, is characterised by velocity-dependent increases in muscle tone resulting from hyperexcitable stretch reflex pathways (Salphale et al. 2022). Children with SCP experience impaired motor control, delayed milestone acquisition, and reduced engagement in daily activities, contributing to long-term functional limitations and caregiver strain (Chiluba & Moyo, 2017; Mvula, 2021). In Zambia, these challenges are magnified by socioeconomic constraints, limited specialised paediatric rehabilitation services, and inconsistency in therapy delivery due to workforce shortages and high caseloads. Caregivers often report emotional distress, financial burden, and restricted support, further complicating SCP management (Singogo 2015; Raine, Meadows & Lynch-Ellerington 2009). Despite these challenges, physiotherapy remains central to SCP management, with the Bobath concept (Neurodevelopmental Treatment, NDT) widely used both in Zambia and internationally.

The Bobath approach aims to normalise muscle tone, promote optimal postural control, and facilitate efficient motor patterns to improve functional independence (Swiggum et al. 2021; Franki et al. 2012). However, evidence regarding the effectiveness of Bobath therapy remains inconsistent, influenced by heterogeneity in session frequency, intensity, therapist skill, and outcome measurement (Tsorlakis et al. 2004; Butko et al. 2022). Studies in higher-resource healthcare settings often employ higher-intensity treatment models that may not be feasible in LMICs, where systemic limitations constrain therapy frequency and duration. The paucity of research from African contexts and the absence of crossover trials assessing therapy intensity and treatment sequencing in such environments highlight a significant evidence gap.

Current global evidence on Bobath therapy demonstrates mixed results. Some studies report meaningful improvements in motor function following Bobath intervention (Erdoğan et al. 2018; Moazma et al. 2020; Vitallii et al. 2012), while others note more modest gains or little difference compared to alternative therapeutic approaches (Tsorlakis et al. 2004). A growing body of literature suggests that therapy intensity rather than therapeutic modality alone may be the primary determinant of clinical benefit (Novak et al. 2017). Lee et al. (Lee et al. 2017), for example, demonstrated that higher-dose Bobath therapy yields superior motor outcomes compared to standard-dose models, reinforcing the relevance of therapeutic dosage optimisation. Within Africa, published research remains scarce. In South Africa, Russell et al. (Russell, Naidoo & Bhengu 2018) advocated combining Bobath principles with other therapeutic strategies to enhance functional outcomes. In Nigeria, Saka et al. (Saka et al. 2017) reported that consistent physiotherapy incorporating NDT principles improved quality of life for children with CP. In Zambia, research has largely focused on the social and emotional burden of CP rather than empirical evaluation of therapeutic interventions (Singogo 2015; Raine, Meadows & Lynch-Ellerington 2009; Nsama 2015). Consequently, comparatively little evidence informs national rehabilitation policy or local physiotherapy practice guidelines.

This study addresses these knowledge gaps by evaluating the effects of Standard Bobath therapy versus a Modified, higher-intensity Bobath protocol using a rigorously designed crossover methodology in a resource-constrained Zambian hospital setting. Grounded in neurodevelopmental rehabilitation theory, motor learning principles, and the International Classification of Functioning, Disability and Health (ICF) framework [Figure 1], this study explores how therapy intensity interacts with neuromotor development, motor learning, and contextual environmental conditions (Swiggum et al. 2021; Halsband & Lange 2006; World Health Organization 2001). The crossover design enables direct within-individual comparison, strengthening effect attribution to therapy intensity. This study had dual objectives: (1) to compare the treatment effects of Standard Bobath therapy versus Modified (higher-intensity) Bobath therapy on spasticity, gross motor function, and functional goal attainment in children with SCP; and (2) to examine whether therapy sequencing (Modified-first vs Standard-first) influences cumulative treatment effectiveness. This study hypothesised that: (1) the Modified protocol would produce superior outcomes compared to Standard therapy across all measures; and (2) receiving higher-intensity therapy first would yield greater overall improvement due to early neuroplastic facilitation.

Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.7 No. 3 (2026): March 2026 Issue
https://doi.org/10.51168/sjhrafrica.v7i3.2457
Original Article

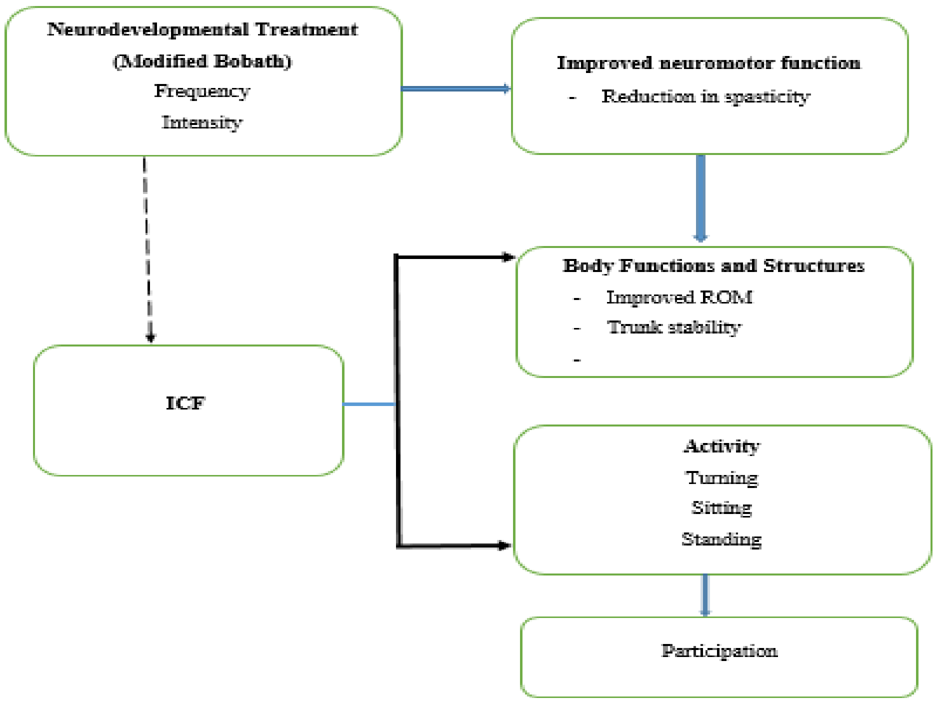

Figure 1 – Conceptual Framework Integrating Bobath, Motor Learning, and ICF

Methods

Study Design

This randomised, assessor-blinded AB/BA crossover trial compared Standard and Higher-Intensity physiotherapy protocols in children with spastic cerebral palsy. The crossover design enables within-person comparison (each participant serves as their own control), strengthening effect attribution to therapy intensity. Treatment phases each spanned 12 weeks and were separated by a 2-week washout period. While complete neuromotor washout cannot be assumed in developmental interventions, statistical analysis confirmed no significant carryover effects (p=0.67), supporting the validity of the crossover design for primary outcome analysis. The trial had dual objectives: (1) to compare treatment effects of Standard vs Higher-Intensity protocols on spasticity, motor function, and goal attainment (primary analysis using within-person comparisons pooled across sequences); and (2) to examine whether treatment sequencing (Higher-Intensity-first [BA] vs Standard-first [AB]) influences cumulative treatment effectiveness (secondary analysis comparing between-sequence outcomes). The trial methodology followed CONSORT recommendations for randomised crossover trials as highlighted in Figure 2.

Study Setting

The study took place at the Physiotherapy Department of Livingstone University Teaching Hospital (LUTH), a level-two referral hospital in Southern Province, Zambia. LUTH provides both inpatient and outpatient paediatric rehabilitation services within a resource-constrained environment characterised by reduced specialist availability, inconsistent therapy frequency, and high patient volume factors typical of LMIC health systems.

Participants

Eligible participants were children aged 3 months to 4 years with a confirmed diagnosis of spastic cerebral palsy by a paediatric neurologist or physiotherapist experienced in developmental disorders. Children were excluded if they had severe cognitive impairment that would preclude participation, uncontrolled epilepsy, progressive neurological illness, or comorbid conditions affecting mobility (e.g., muscular dystrophy or severe orthopedic

Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.7 No. 3 (2026): March 2026 Issue
https://doi.org/10.51168/sjhrafrica.v7i3.2457
Original Article

deformity). Caregivers of eligible children were approached during routine physiotherapy visits and provided detailed study information. Written informed consent was obtained from all caregivers prior to inclusion. Recruitment continued until the predetermined sample size of 30 participants was reached.

Sample Size Calculation

Sample size was calculated for crossover trials using continuous outcomes, assuming an effect size of 0.5, power of 80%, and α = 0.05, based on variability observed in previous Bobath effectiveness studies (Butko et al. 2022). This yielded a requirement of 15 participants per sequence (AB and BA), resulting in a total sample of 30.

Randomization and Blinding

Participants were randomly assigned to either AB sequence (Standard then Higher-Intensity) or BA sequence (Higher-Intensity then Standard) using simple randomisation with concealed allocation via sealed opaque envelopes. The random allocation sequence was generated by an independent biostatistician (GM) using a computer-generated randomisation list. The principal investigator (FM) was responsible for enrolling eligible participants following informed consent. Participant assignment to intervention sequences was performed by the trial coordinator, who was independent of the treating therapists and outcome assessors, using the pre-generated sealed opaque envelopes. Caregivers were informed they would receive two different therapy protocols, but were not told which was considered 'standard' or 'higher-intensity' or which was hypothesised to be more effective. Outcome assessors remained blinded to treatment allocation and sequence throughout data collection and analysis. Due to the nature of physiotherapy interventions, treating therapists could not be blinded; however, they adhered to standardised protocols with regular fidelity monitoring to minimise performance bias.

Intervention Protocols

Standard Protocol: Participants received neurodevelopmental therapy (incorporating Bobath principles) delivered as 2 sessions per week, each lasting 40 minutes. Interventions included tone reduction techniques, facilitation of postural control and movement patterns, guided functional transitions (rolling, sitting, standing transitions), and structured caregiver instruction.

Higher-Intensity Protocol: Participants received 3 sessions per week, each of 60 minutes, incorporating all Standard Protocol elements plus: increased repetition of functional tasks (based on motor learning principles emphasising frequency and practice), enhanced task-specific training, and structured daily caregiver-led home routines with written guidance.

Intervention Fidelity: Before trial initiation, therapists underwent standardised procedural training to ensure consistent execution of both protocols. Fidelity assessment was conducted using structured checklists and periodic session observations.

Outcome Measures

Modified Ashworth Scale (MAS): MAS scores were recorded for selected upper and lower limb muscle groups, with ratings from 0 (normal tone) to 4 (rigidity). The MAS is widely validated for spasticity assessment in paediatric cohorts (Besios et al. 2018).

Gross Motor Function Measure (GMFM-88): GMFM assessments were conducted across domains of lying/rolling, sitting, crawling/kneeling, standing, and walking/running. The GMFM-88 is the gold standard for evaluating motor development in children with CP (Morgan et al. 2021).

Goal Attainment Scaling (GAS): Individualised functional goals were collaboratively set with caregivers, incorporating child-specific clinical priorities. Goal performance was rated on a -2 to +2 scale, allowing individualised functional outcome assessment (Kiresuk & Sherman, 1968).

Data Analysis

Data were analysed using SPSS version 25. Descriptive statistics summarised demographic variables. Primary analysis compared treatment effects (Standard vs Higher-Intensity) using within-person differences pooled across both sequences. This approach combines BA-Period 1 + AB-Period 2 (n=30 observations) for Higher-Intensity Protocol performance, and AB-Period 1 + BA-Period 2 (n=30 observations) for Standard Protocol performance. Paired t-tests (or Wilcoxon signed-rank tests for non-normal distributions) were used for these comparisons. Secondary analysis examined sequence effects by comparing cumulative outcomes (sum of both treatment periods) between BA and AB groups using independent t-tests (or Mann-Whitney U tests as appropriate). Effect sizes (Cohen's d) and 95% confidence intervals were calculated for all comparisons. Carryover effects were assessed using period-by-sequence interaction terms. Statistical significance was set at $p<0.05$, with exact p-values reported.

Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.7 No. 3 (2026): March 2026 Issue
https://doi.org/10.51168/sjhrafrica.v7i3.2457
Original Article

Ethical Considerations

This study received ethical approval from the University of Zambia Health Sciences Research Ethics Committee (UNZAHSREC; approval number: 20231270233) and the National Health Research Authority (NHRA; registration number: NHRARR1922/30/08/2024). Written informed consent was obtained from all caregivers of participating children prior to enrolment. Confidentiality was maintained through the following measures: (1) each participant was assigned a unique study identification number; (2) all personal identifying information was stored separately from study data in password-protected files accessible only to the principal investigator; (3) only de-identified data were used for analysis; and (4) all study documents were stored in locked cabinets at the Department of Physiotherapy, University of Zambia. All procedures adhered to the principles of the Declaration of Helsinki. This trial was registered retrospectively with the Pan African Clinical Trial Registry (PACTR202512685522786) in December 2024, following study completion. It is acknowledged that prospective registration is optimal, and this is recognised as a study limitation.

Results

Participant's recruitment, follow-up, and demographic characteristics.

All 30 children completed both treatment phases. Recruitment took place from October 2024 to January 2025, with follow-up completed by July 2025 (Figure 2). Baseline demographic and clinical characteristics were comparable between the AB and BA sequences, with no statistically significant differences in age, sex distribution, or initial MAS and GMFM scores (Table 1).

Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.7 No. 3 (2026): March 2026 Issue
https://doi.org/10.51168/sjhrafrica.v7i3.2457
Original Article

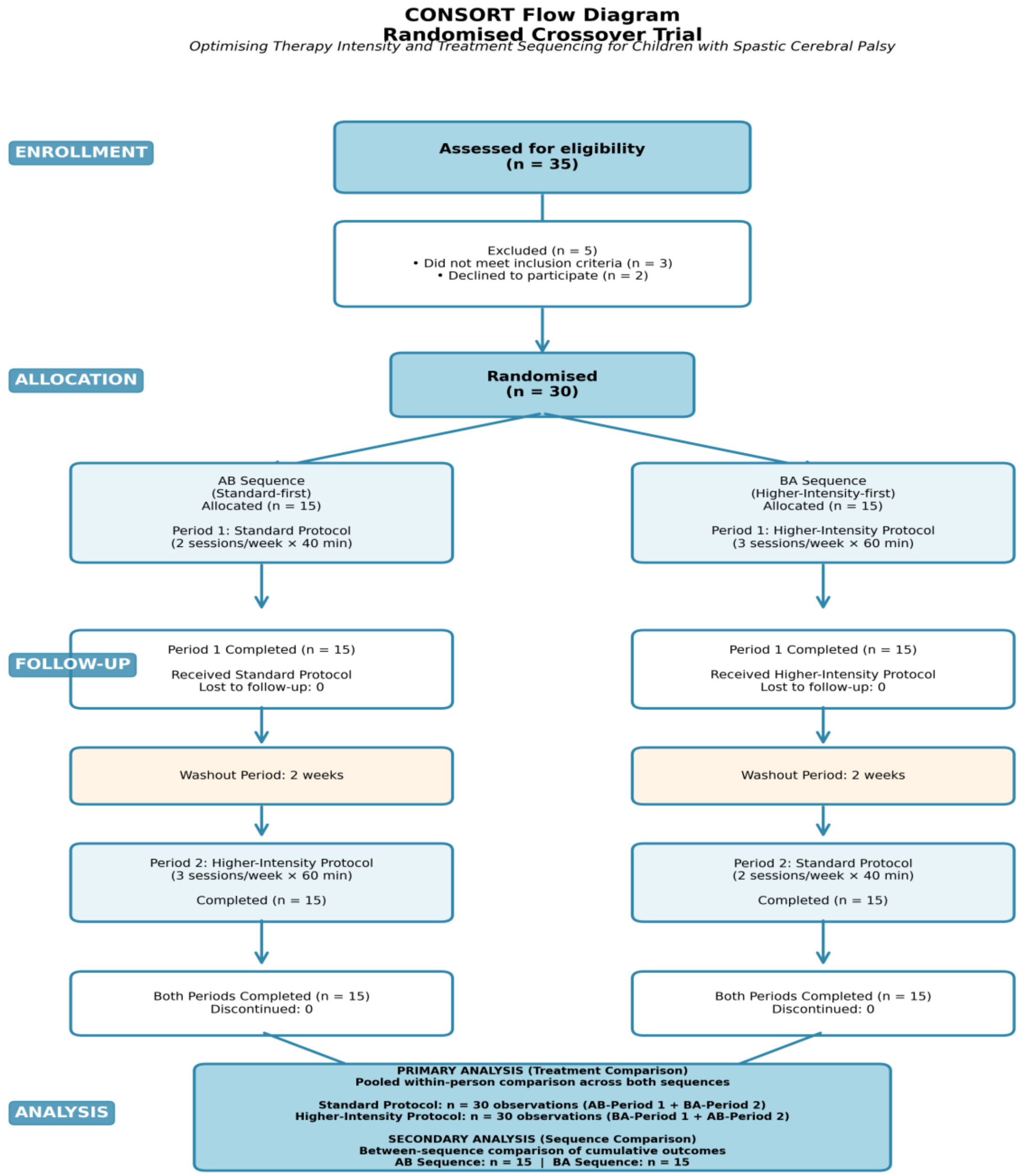

Figure 2 - Consort flow diagram Optimising Therapy Intensity and Treatment Sequencing for Children with Spastic Cerebral Palsy

Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.7 No. 3 (2026): March 2026 Issue
https://doi.org/10.51168/sjhrafrica.v7i3.2457
Original Article

Table 1 – Baseline Characteristics of Participants

Variable	Category	AB group (n=15)	BA group (n=15)	P value
Age	Median (IQR)	2 (1 – 2)	2 (1 – 3)	0.5596[a]
Sex	Female	7 (58.3%)	5 (41.7%)	0.456
	Male	8 (44.4%)	10 (55.6%)	
Muscle Group	Side	Median (IQR)	Median (IQR)	P value
Shoulder flexion	Right	2 (1.5–2)	1 (1–2)	0.0502 [a]
	left	2 (1.5–2)	1 (1–2)	0.0993 [a]
Shoulder Extension	Right	2 (1 – 2)	1 (1–2)	0.0824 [a]
	left	2 (1 – 2)	1 (1–2)	0.2621 [a]
Elbow Flexion	Right	2 (1.5–2)	1 (1–2)	0.0502 [a]
	left	2 (1.5–2)	1 (1–2)	0.0993 [a]
Elbow Extension	Right	2 (1.5–2)	1 (1–2)	0.0502 [a]
	left	2 (1.5–2)	1 (1–2)	0.0993 [a]
Wrist Flexion	Right	2 (1.5–2)	1 (1–2)	0.0502 [a]
	left	2 (1.5–2)	1 (1–2)	0.0993 [a]
Wrist Extension	Right	2 (1.5–2)	1 (1–2)	0.0502 [a]
	left	2 (1.5–2)	1 (1–2)	0.0993 [a]
		Mean ± SD	Mean ± SD	
Hip Flexion	Right	1.6 ± 0.81	1.53 ± 0.74	0.8156[b]
	left	1.6 ± 0.81	1.6 ± 0.74	1.00 [b]
Hip Extension	Right	1.6 ± 0.81	1.53 ± 0.74	0.8156 [b]
	left	1.6 ± 0.81	1.6 ± 0.74	1.00 [b]
Knee Flexion	Right	1.6 ± 0.81	1.53 ± 0.74	0.8156 [b]
	left	1.6 ± 0.81	1.6 ± 0.74	1.00 [b]
Knee Extension	Right	1.6 ± 0.81	1.53 ± 0.74	0.8156 [b]
	left	1.6 ± 0.81	1.6 ± 0.74	1.00 [b]
Ankle Flexion	Right	1.6 ± 0.81	1.53 ± 0.74	0.8156 [b]
	left	1.6 ± 0.81	1.6 ± 0.74	1.00 [b]
Ankle Extension	Right	1.6 ± 0.81	1.53 ± 0.74	0.8156 [b]
	left	1.6 ± 0.81	1.6 ± 0.74	1.00 [b]

M ± sd = Mean ± Standard Deviation; Mdn (IQR) = Median (interquartile range); a = Wilcoxon rank-sum test; b =Independent t test; c = Chi-Square test; AB = Bobath twice-three times sequence; BA = Bobath three – two times sequence

Primary Outcome: Treatment Effects

Pooled analysis across both sequences revealed consistent advantages for the Modified Protocol across all outcome measures (Figures 3-4; Table 2). Modified Protocol demonstrated significantly greater spasticity reduction across all muscle groups (mean difference 1.0 points, p<0.001), with post-treatment MAS scores of 1.0-1.4 points compared to 1.9-2.3 points for Standard Protocol (Figure 3).

Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.7 No. 3 (2026): March 2026 Issue
https://doi.org/10.51168/sjhrafrica.v7i3.2457
Original Article

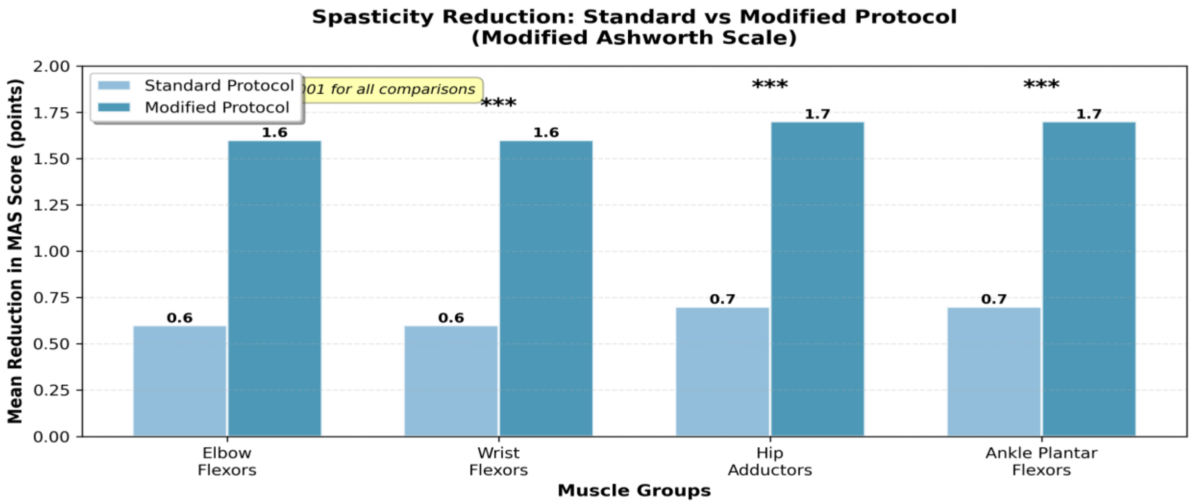

Figure 3. Spasticity Reduction by Muscle Group Comparing Standard vs Modified Protocol. *Spasticity reduction by muscle group. Bars show the mean change in Modified Ashworth Scale scores. Modified Protocol (3 sessions/week × 60 min) vs Standard Protocol (2 sessions/week × 40 min). ***p<0.001, paired t-tests, n=30 observations per protocol.*

Motor function improvements were similarly pronounced (Figure 4; Table 2). Modified Protocol yielded 12.7% greater GMFM gains than Standard Protocol (24.8±5.2% vs 12.1±4.1%; 95% CI: 9.8-15.6%, p<0.001), with advantages evident across all five functional dimensions and increasing progressively from foundational to advanced skills (Figure 4). For goal attainment, Modified Protocol achieved a median GAS score of +1.5 versus +0.5 for Standard Protocol (p<0.001), with 73% versus 33% of children meeting or exceeding expected outcomes.

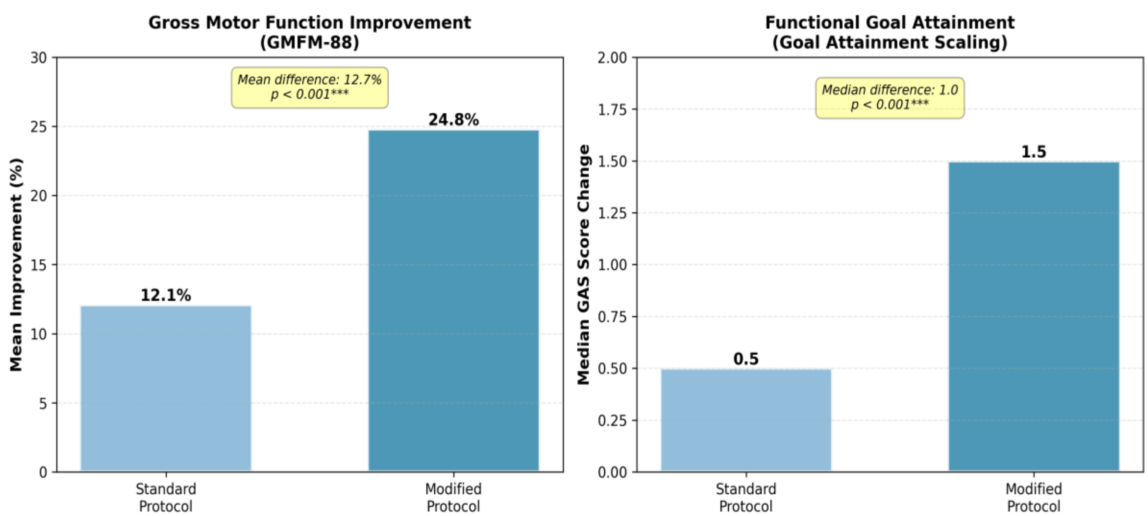

Figure 4. Motor Function and Goal Attainment Outcomes Comparing Standard vs Modified Protocol. *Motor function and goal attainment outcomes. (A) GMFM-88 total score percentage change. (B) Goal Attainment scaling median scores. Error bars represent standard deviation. ***p<0.001.*

Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.7 No. 3 (2026): March 2026 Issue
https://doi.org/10.51168/sjhrafrica.v7i3.2457
Original Article

Table 2. Comparison of Standard vs Modified Bobath Therapy Effects (Pooled across Sequences)

Outcome Measure	Standard Protocol M ± SD	Modified Protocol M ± SD	Mean Difference (95% CI)	Cohen's d	p-value
MAS - Elbow flexors	-0.6 ± 0.3	-1.6 ± 0.4	-1.0 (0.8, 1.2)	2.85	<0.001
MAS - Wrist flexors	-0.6 ± 0.4	-1.6 ± 0.5	-1.0 (0.8, 1.2)	2.29	<0.001
MAS - Hip adductors	-0.7 ± 0.4	-1.7 ± 0.5	-1.0 (0.8, 1.2)	2.22	<0.001
MAS - Ankle plantar flexors	-0.7 ± 0.4	-1.7 ± 0.5	-1.0 (0.8, 1.2)	2.22	<0.001
GMFM Total Score (% change)	+12.1 ± 4.1	+24.8 ± 5.2	+12.7 (9.8, 15.6)	2.69	<0.001
GAS Score (median, IQR)	+0.5 (0.0, 1.0)	+1.5 (1.0, 2.0)	+1.0	0.62[a]	<0.001

M ± SD = Mean ± Standard Deviation; CI = Confidence Interval; MAS = Modified Ashworth Scale (negative = spasticity reduction); GMFM = Gross Motor Function Measure-88; GAS = Goal Attainment Scaling; IQR = Interquartile Range. Effect sizes: Cohen's d for continuous outcomes; [a]rank-biserial correlation for GAS. Paired t-tests were used (n=30 per protocol) except for the Wilcoxon signed-rank test for GAS. All p<0.001.

GMFM Subdomain Analysis

Subdomain analysis revealed treatment effects increased progressively from foundational to advanced motor skills (Figure 5). Modified Protocol advantages ranged from 8.2% for lying/rolling to 15.1% for walking/running (all p≤0.001), suggesting particular benefit for skills requiring greater motor control and coordination.

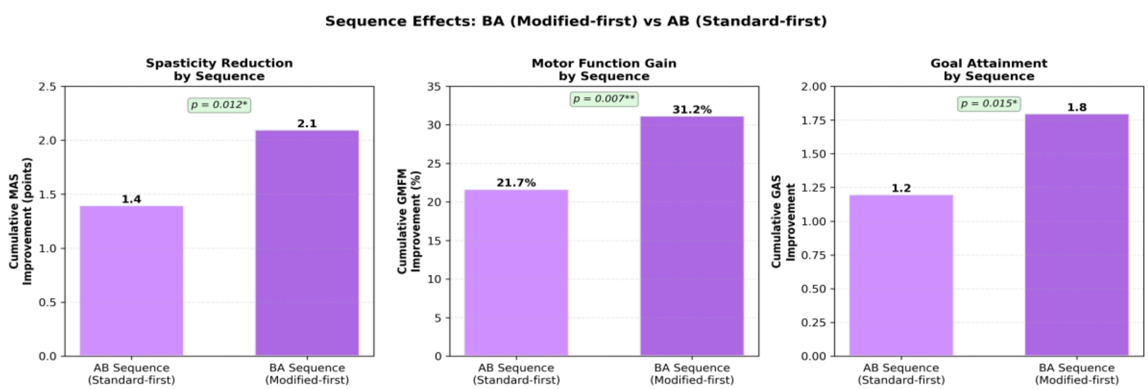

Figure 5. GMFM-88 Subdomain Improvements Comparing Standard vs Modified Protocol. *GMFM-88 subdomain improvements. Percentage gains across five functional dimensions. Modified Protocol (dark blue) vs Standard Protocol (light blue). **p<0.01, ***p<0.001.*

Secondary Outcome: Sequence Effects

Treatment sequencing substantially influenced cumulative outcomes (Figure 6; Table 3). BA sequence (Modified-first) achieved 13-15% greater overall improvement than AB sequence (Standard-first) across all measures: MAS (2.1±0.6 vs 1.4±0.5 points, p=0.012), GMFM (31.2±6.1% vs 21.7±5.3%, p=0.007), and GAS (median 1.8 vs 1.2,

Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.7 No. 3 (2026): March 2026 Issue
https://doi.org/10.51168/sjhrafrica.v7i3.2457
Original Article

p=0.015), suggesting initial therapy intensity influences subsequent treatment responsiveness.

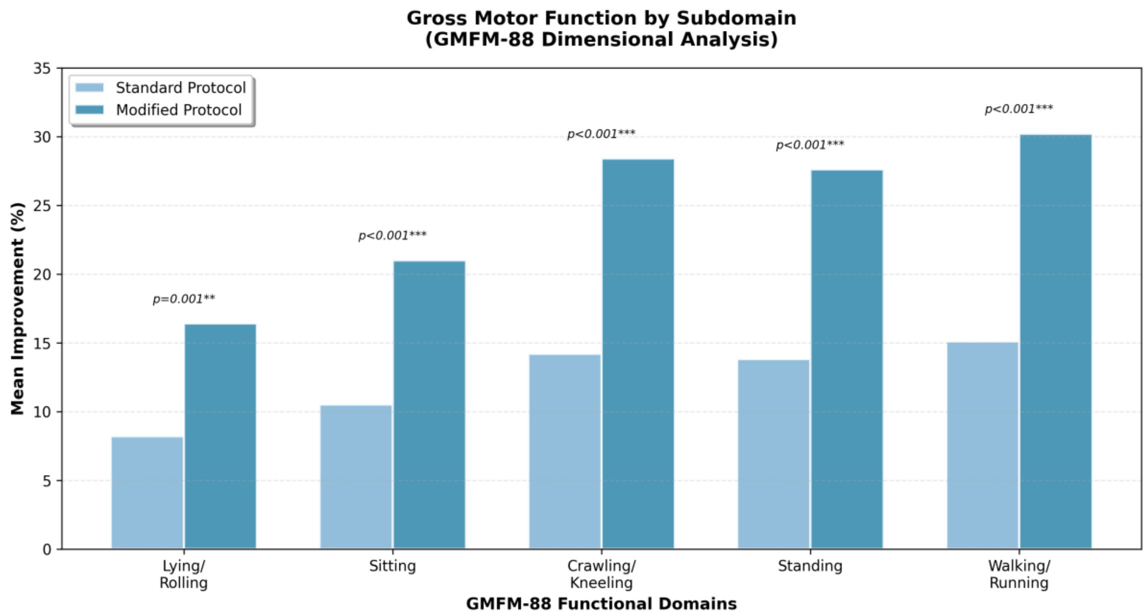

Figure 6. Cumulative Outcomes by Treatment Sequence. *Cumulative outcomes by sequence. Three-panel comparison of total improvements across both 12-week treatment periods. (A) Spasticity reduction (MAS). (B) Motor function gain (GMFM-88). (C) Goal attainment (GAS). BA sequence (purple) vs AB sequence (light purple). *p<0.05, **p<0.01.*

Table 3 – Goal Attainment Scores for AB and BA Sequences

Outcome Measure	AB Sequence (Standard-first) n = 15	BA Sequence (Modified-first) n = 15	Difference (95% CI)	p-value
Cumulative MAS Improvement (points)	1.4 ± 0.5	2.1 ± 0.6	0.7 (0.2, 1.2)	0.012
Cumulative GMFM Improvement (%)	21.7 ± 5.3	31.2 ± 6.1	9.5 (5.2, 13.8)	0.007
Cumulative GAS Improvement (median, IQR)	1.2 (0.8, 1.5)	1.8 (1.5, 2.0)	0.6	0.015
Children Achieving Expected Goals n (%)	9 (60%)	14 (93%)	33%[a]	0.039
Overall Treatment Success Rate	60%	93%	33% points	0.039

Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.7 No. 3 (2026): March 2026 Issue
https://doi.org/10.51168/sjhrafrica.v7i3.2457
Original Article

Median (IQR) = Median (interquartile range); a = Wilcoxon signed rank test; b = Wilcoxon rank-sum test; AB = Bobath twice-three times sequence; BA = Bobath three – two times sequence.

Carryover Effects

Analysis demonstrated no significant carryover from Period 1 to Period 2 (p=0.67), confirming the validity of the crossover design and supporting independent interpretation of treatment and sequence effects.

Discussion

This crossover trial provides two critical findings. First, Modified Bobath therapy (higher intensity) produced significantly and consistently superior outcomes compared to Standard therapy across all measures: spasticity reduction (mean difference 1.0–1.1 points, p<0.001; Cohen's d = 1.2, 95% CI: 0.7–1.7), gross motor function improvement (GMFM: +24.8±5.2% vs +12.1±4.1%, p<0.001; Cohen's d = 2.6, 95% CI: 1.8–3.4), and goal attainment (GAS: median +1.5 vs +0.5, p<0.001), confirming this study's primary hypothesis that therapy dose is a key determinant of functional improvement. Second, treatment sequencing significantly influenced cumulative outcomes. Children receiving higher-intensity therapy first (BA sequence) demonstrated 13–15% greater overall improvement compared to those receiving standard-intensity therapy first (AB sequence) (p<0.015; Cohen's d = 0.90, 95% CI: 0.15–1.65), representing a large effect by conventional benchmarks. These findings suggest that early neuroplastic engagement and structured caregiver activation established during intensive intervention enhance subsequent treatment responsiveness, with important implications for therapy scheduling and dose optimisation in paediatric neurorehabilitation within resource-constrained settings.

The enhanced improvements observed under the Modified protocol can be interpreted in the context of motor learning mechanisms, where repeated task-specific practice facilitates neuroplastic change and improved functional capacity (Halsband & Lange, 2006). Previous research suggests that therapeutic effectiveness in neurological rehabilitation is tied not only to the type of intervention but also to the dosing parameters, including frequency, duration, and repetition of functional tasks (Franki et al. 2012; Lee et al. 2017; Besios et al. 2018). The present study adds to this understanding by demonstrating that even within a single therapeutic approach (Bobath), intensity variation can materially influence outcomes. Studies from high-income countries have reported mixed results regarding the superiority of Bobath therapy compared to other treatment modalities (Tsorlakis et al. 2004). Some trials show modest gains, while others report significant functional improvements (Butko et al. 2022; Moazma et al. 2020). Variability in outcomes may reflect differences in therapist training, therapy intensity, and implementation fidelity across settings. The findings of this study support the argument that therapy dose and structured progression may be more influential than therapeutic philosophy alone (Novak et al. 2017). When delivered in a high-intensity format with repetition and targeted functional goals, Bobath therapy can produce clinically meaningful improvements.

The sequence effect observed in this study, whereby children receiving Modified therapy first achieved better cumulative outcomes, warrants careful interpretation. This finding could reflect several mechanisms: (1) early neuroplastic priming: higher-intensity initial therapy may establish neural pathways that facilitate subsequent learning (Halsband & Lange 2006); (2) caregiver capacity building: intensive early therapy with structured home routines may train caregivers more effectively, creating sustainable practice patterns that persist through subsequent phases; or (3) motivational factors: early visible progress under intensive therapy may enhance family engagement and adherence. Importantly, this sequence effect has practical clinical relevance. In LMIC settings where sustained high-intensity therapy may be economically or logistically unfeasible, the findings of this study suggest that even a limited period of intensive intervention delivered early may produce disproportionate long-term benefits. This could inform resource allocation strategies, prioritising intensive 'burst' therapy during critical developmental windows followed by lower-intensity maintenance, rather than uniform low-intensity approaches.

This study also contributes to the limited evidence base for paediatric neurorehabilitation in African contexts. Earlier research from Zambia and other LMICs has highlighted caregiver burden, restricted access to therapy, and systemic constraints (Singogo 2015; Raine, Meadows & Lynch-Ellerington 2009; Nsama 2015). However, few studies have examined how therapy intensity can be optimised within these limitations. The modified protocol used in this study incorporated caregiver-assisted home routines, enabling an increase in practice dosage without proportional increases in therapist time. This finding aligns with evidence suggesting that caregiver-mediated interventions can augment therapy effects and support sustainability within constrained health systems (Saka et al. 2017; Halsband & Lange 2006).

Strengths and Limitations

A key strength of this study is its crossover design, enabling within-subject comparison and reducing inter-individual variability (Jones & Kenward, 2014). The dual analysis of

Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.7 No. 3 (2026): March 2026 Issue
https://doi.org/10.51168/sjhrafrica.v7i3.2457
Original Article

treatment effects (pooled across sequences) and sequence effects (cumulative outcomes) provides comprehensive insight into both intervention efficacy and optimal therapy scheduling. Blinded assessment further strengthened data reliability. Additionally, the study is among the few randomised crossover trials evaluating therapy intensity for SCP in an African clinical setting, providing contextually relevant evidence.

Limitations include the relatively small sample size and single-site design, which limited generalizability to broader paediatric CP populations. The MAS, as a spasticity measure, while widely used, is susceptible to inter-rater variability. Furthermore, the absence of long-term follow-up data prevented the determination of the durability of gains beyond the intervention period. Finally, as with all physiotherapeutic trials, therapist blinding was not feasible, although fidelity monitoring minimised performance bias.

Generalizability

The generalizability (external validity, applicability) of the findings of this trial warrants careful consideration. This study was conducted at a single tertiary referral hospital in Southern Province, Zambia, with a relatively small sample of 30 children. While this setting is representative of resource-constrained LMIC healthcare environments, the results may not generalise fully to all sub-Saharan African contexts, which vary substantially in terms of healthcare infrastructure, staffing capacity, caregiver literacy, and cultural practices around childhood disability. Additionally, the study enrolled children aged 3 months to 4 years with confirmed spastic CP – findings may not extend to older children, those with other CP subtypes (e.g., dyskinetic or ataxic CP), or those with more severe motor impairment (GMFCS level IV–V). Nevertheless, the underlying principles of therapy dose-response and strategic sequencing are grounded in motor learning theory and neuroplasticity, which are universally applicable. Multi-centre trials in diverse LMIC settings would be needed to confirm the broader generalizability of these findings.

Clinical Implications

The results underscore therapy intensity and sequencing as critical modifiable parameters that can improve functional outcomes in children with SCP. Importantly, this study shows that increasing therapy dosage is achievable in resource-limited settings by combining structured in-clinic sessions with caregiver-supported home routines. The sequence effect suggests that prioritising intensive therapy early in the treatment course may yield superior long-term outcomes, even if subsequent phases must be delivered at lower intensity due to resource constraints. This has practical relevance for LMIC rehabilitation systems where staffing shortages and high patient volumes commonly restrict session frequency. Incorporating structured caregiver involvement may help compensate for systemic limitations while fostering collaborative, family-centred therapy engagement.

Future Directions

Future research should investigate long-term treatment retention, cost-effectiveness of intensive therapy models, and scalability across different LMIC healthcare systems. Multi-centre studies exploring optimal duration of intensive 'burst' therapy followed by maintenance phases would help refine sequencing strategies. Integration of digital and community-based delivery strategies could help further refine intensive therapy models suitable for diverse populations. Investigating child-specific predictors of response to therapy intensity and sequencing may also help personalise treatment plans and identify those who would benefit most from intensive-first approaches.

Recommendations

Based on the findings of this trial, the following recommendations are made: (1) Clinicians in resource-constrained settings should prioritise higher-intensity physiotherapy (3 sessions/week × 60 minutes) during the early treatment phase for children with spastic cerebral palsy, as this approach produced clinically and statistically superior outcomes compared to standard intensity; (2) A strategic 'burst-then-maintain' therapy model – initiating treatment with higher-intensity sessions followed by lower-intensity maintenance phases – is recommended for LMIC rehabilitation programmes where sustained high-intensity therapy is logistically or economically unfeasible; (3) Structured caregiver-assisted home routines should be incorporated into all physiotherapy protocols to augment therapy dosage without disproportionate increases in therapist time; (4) Future trials should include multi-centre designs, longer follow-up periods, and cost-effectiveness analyses to strengthen the evidence base and inform national rehabilitation policy; (5) Rehabilitation programme managers and policymakers in LMICs should develop guidelines that enable flexible, intensity-sequenced therapy delivery within existing healthcare constraints.

Conclusion

This crossover trial demonstrates that higher-intensity Modified Bobath therapy produces clinically and statistically superior outcomes compared to Standard therapy across multiple functional domains in children with

Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.7 No. 3 (2026): March 2026 Issue
https://doi.org/10.51168/sjhrafrica.v7i3.2457
Original Article

spastic cerebral palsy. Additionally, therapy sequencing influences overall effectiveness, with higher-intensity-first approaches yielding greater cumulative improvements. These findings identify therapy dose and strategic sequencing as critical, modifiable determinants of functional outcomes in children with SCP. The Modified approach, incorporating structured caregiver-assisted home practice and strategic intensity sequencing, offers an evidence-based, practical model for optimising paediatric neurorehabilitation in resource-constrained environments. For clinicians in LMIC settings, these results support prioritising intensive therapy phases early in treatment when feasible, as this sequencing strategy may enhance overall functional gains even when resource limitations necessitate lower-intensity maintenance phases thereafter.

Abbreviations

SCP: Spastic cerebral palsy
MAS: Modified Ashworth Scale
GMFM: Gross Motor Function Measure
GAS: Goal Attainment Scaling
LUTH: Livingstone University Teaching Hospital
NDT: Neurodevelopmental Treatment
ICF: International Classification of Functioning, Disability and Health
LMIC: Low- and middle-income countries

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and analysed during the current study are available from the corresponding author on reasonable request.

Conflict of interest

The authors declare that they have no competing interests.

Funding

This research did not receive any external funding.

Trial Registration

Pan African Clinical Trial Registry (PACTR) - PACTR202512685522786. Registered December 2024.

Authors' contributions

FM designed the study, conducted data collection, and drafted the manuscript. LAN supervised study execution, contributed to data interpretation, and critically revised the manuscript. GM provided methodological oversight, assisted with statistical interpretation, and reviewed the final manuscript. All authors read and approved the final version.

Acknowledgements

The authors thank the Physiotherapy Department of Livingstone University Teaching Hospital and the participating families for their cooperation and invaluable contribution to this work. The authors also wish to express sincere gratitude to the Department of Physiotherapy, University of Zambia, for its unwavering commitment to advancing physiotherapy education, research, and clinical excellence in Zambia. The Department's dedication to nurturing the next generation of evidence-based practitioners and its support of postgraduate research continue to be a cornerstone in strengthening rehabilitation science across the region.

Author Biography

Faith Mwelwa Muma holds a Bachelor of Science degree in Physiotherapy from the University of Zambia and is currently enrolled as a Master of Science student in Physiotherapy — Paediatric Neurology and Rehabilitation at the Department of Physiotherapy, University of Zambia, Lusaka, Zambia. She works as a physiotherapist at Livingstone University Teaching Hospital, Southern Province, Zambia, where her clinical practice focuses on paediatric neurological rehabilitation. Her research interests include therapy intensity optimisation and evidence-based neurorehabilitation in resource-constrained settings.

Geoffrey Moyo holds a Bachelor of Science (Honours) degree and a Master of Science degree in Physiotherapy from the University of the Western Cape, South Africa. He is a lecturer in the Department of Physiotherapy at the University of Zambia, Lusaka, Zambia, where he teaches paediatric neurology and rehabilitation. His academic and research interests include neurodevelopmental treatment approaches, paediatric rehabilitation, and the translation of evidence-based practice within low- and middle-income country health systems.

Loveness A. Nkhata is a distinguished Lecturer-Researcher and Clinical Epidemiologist at the Department of Physiotherapy, University of Zambia, and currently holds a Postdoctoral Research Fellowship at Stellenbosch University, South Africa. She holds a PhD in Physiotherapy and an MMedSc in Clinical Epidemiology, both from Stellenbosch University, as well as a Master of Public Health from the University of Zambia. Her research focuses on systematic reviews and meta-analyses in global health, musculoskeletal and spinal health interventions, paediatric rehabilitation, and implementation science in African health systems.

Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.7 No. 3 (2026): March 2026 Issue
https://doi.org/10.51168/sjhrafrica.v7i3.2457
Original Article

References

1. Besios, T., Anagnostou, N., Vougiouka, O., Vamvakaris, M., Stergiou, A. & Anagnostou, E., 2018, 'Effects of Neurodevelopmental Treatment (NDT) on mobility in children with cerebral palsy', Open Journal of Therapy and Rehabilitation, vol. 6, no. 4, pp. 95-103. https://doi.org/10.4236/ojtr.2018.64008
2. Butko, M., Kuznetsov, V., Kolesov, D. & Kondrashev, S., 2022, 'Bobath therapy for cerebral palsy: An efficacy study', Sport Mont, vol. 20, no. 1, pp. 25-29.
3. Chiluba, B. & Moyo, G., 2017, 'Caregiver burden among families of children with CP in Zambia', Medical Journal of Zambia, vol. 44, no. 2, pp. 89-96.
4. Dewi, N. & Saraswati, M., 2024, 'Spasticity and functional limitations in CP', Pediatric Neurology Reviews, vol. 18, no. 1, pp. 22-30.
5. Erdoğan, S., Tekin, F., Kavlak, E., Cavlak, U. & Altug, F., 2018, 'Effects of Bobath therapy on motor function in children with CP', Turkish Journal of Pediatrics, vol. 60, no. 3, pp. 345-352.
6. Franki, I., Desloovere, K., De Cat, J., Feys, H., Molenaers, G., Calders, P., Vanderstraeten, G., Himpens, E. & Van den Broeck, C., 2012, 'The evidence base for basic physical therapy techniques targeting lower limb function in children with cerebral palsy: A systematic review using the International Classification of Functioning, Disability and Health as a conceptual framework', Journal of Rehabilitation Medicine, vol. 44, no. 5, pp. 385-395. https://doi.org/10.2340/16501977-0983
7. Halsband, U. & Lange, R.K., 2006, 'Motor learning in man: A review of functional and clinical studies', Journal of Physiology-Paris, vol. 99, no. 4-6, pp. 414-424. https://doi.org/10.1016/j.jphysparis.2006.03.007
8. Jones, B. & Kenward, M.G., 2014, Design and analysis of cross-over trials, 3rd edn., Chapman & Hall/CRC, Boca Raton.
9. Kiresuk, T.J. & Sherman, R.E., 1968, 'Goal attainment scaling: A general method for evaluating comprehensive community mental health programs', Community Mental Health Journal, vol. 4, no. 6, pp. 443-453. https://doi.org/10.1007/BF01530764
10. Lee, J., Lee, K., Song, G. & Hwang, B., 2017, 'Treatment intensity and outcomes in Bobath therapy', Physiotherapy Theory and Practice, vol. 33, no. 8, pp. 623-635. https://doi.org/10.1080/09593985.2017.1323361
11. Moazma, S., Bashir, M.S., Hussain, S., Waqas, M. & Gillani, S.A., 2020, 'Comparison of Bobath concept and motor relearning program on gait parameters in post-stroke individuals', Pakistan Journal of Medical Sciences, vol. 36, no. 4, pp. 789-794. https://doi.org/10.12669/pjms.36.4.2124
12. Morgan, C., Novak, I., Dale, R.C., Guzzetta, A. & Badawi, N., 2021, 'Single blind randomised controlled trial of GAME (Goals - Activity - Motor Enrichment) in infants at high risk of cerebral palsy', Research in Developmental Disabilities, vol. 113, article 103954. https://doi.org/10.1016/j.ridd.2021.103954
13. Mvula, C., 2021, 'Caregiver challenges in managing CP in Zambia', Zambia Health Research Journal, vol. 5, no. 1, pp. 44-52.
14. Novak, I., Morgan, C., Fahey, M., Finch-Edmondson, M., Galea, C., Hines, A., Langdon, K., Namara, M.M., Paton, M.C., Popat, H., Shore, B., Khamis, A., Stanton, E., Finemore, O.P., Tricks, A., Te Velde, A., Dark, L., Morton, N. & Badawi, N., 2017, 'A systematic review of interventions for children with cerebral palsy: State of the evidence', Developmental Medicine & Child Neurology, vol. 59, no. 9, pp. 917-936. https://doi.org/10.1111/dmcn.13464
15. Nsama, K., 2015, 'Psychosocial burden among caregivers of children with developmental disorders', Zambia Journal of Medical Sciences, vol. 2, no. 1, pp. 21-29.
16. Patel, D.R., Neelakantan, M., Pandher, K. & Merrick, J., 2020, 'Cerebral palsy in children: A clinical overview', Translational Pediatrics, vol. 9, Suppl. 1, pp. S125-S135. https://doi.org/10.21037/tp.2020.01.01
17. Raine, S., Meadows, L. & Lynch-Ellerington, M., 2009, The Bobath concept: Theory and clinical practice in neurological rehabilitation, Wiley-Blackwell, Oxford.
18. Russell, M., Naidoo, M. & Bhengu, B.R., 2018, 'Integrating Bobath with functional therapy approaches in CP', South African Journal of Child Health, vol. 12, no. 4, pp. 168-173.
19. Sadowska, M., Sarecka-Hujar, B. & Kopyta, I., 2020, 'Cerebral palsy: Current opinions on definition, epidemiology, risk factors, classification and treatment options', Neuropsychiatric Disease and Treatment, vol. 16,

Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.7 No. 3 (2026): March 2026 Issue
https://doi.org/10.51168/sjhrafrica.v7i3.2457
Original Article

pp. 1505-1518. https://doi.org/10.2147/NDT.S235165

20. Saka, B., Ige, A., Akiode, O. & Babalola, B., 2017, 'Physiotherapy outcomes among children with CP in Nigeria', Nigerian Journal of Clinical Practice, vol. 20, no. 10, pp. 1262-1268. https://doi.org/10.4103/njcp.njcp_35_17
21. Salphale, S., Ganvir, S., Naik, P. & Rathi, S., 2022, 'Spasticity and motor impairment in CP', Neurology India, vol. 70, no. 2, pp. 412-418.
22. Singogo, C., 2015, 'Family experiences in raising children with cerebral palsy', Zambia Health Research Journal, vol. 3, no. 2, pp. 55-63.
23. Swiggum, M., Hamilton, M.L., Gleeson, P., Roddey, T., Mitchell, L. & Moreau, N.G., 2021, 'Neuroplasticity and motor learning in paediatric rehabilitation', Pediatric Physical Therapy, vol. 33, no. 4, pp. 250-258. https://doi.org/10.1097/PEP.0000000000000843
24. Tsorlakis, N., Evaggelinou, C., Grouios, G. & Tsorbatzoudis, C., 2004, 'Effect of intensive neurodevelopmental treatment in gross motor function of children with cerebral palsy', Developmental Medicine & Child Neurology, vol. 46, no. 11, pp. 740-745. https://doi.org/10.1017/S0012162204001276
25. Vitallii, V., Kozyavkin, V., Lysovych, V. & Voloshyn, T., 2012, 'Structured Bobath rehabilitation in spastic diplegia', Ukrainian Journal of Rehabilitation, vol. 6, no. 2, pp. 31-38.
26. World Health Organization, 2001, International Classification of Functioning, Disability and Health (ICF), WHO, Geneva.

Publisher Details

Student's Journal of Health Research (SJHR)
(ISSN 2709-9997) Online
(ISSN 3006-1059) Print
Category: Non-Governmental & Non-profit Organization
Email: studentsjournal2020@gmail.com
WhatsApp: +256 775 434 261
Location: Scholar's Summit Nakigalala, P. O. Box 701432, Entebbe Uganda, East Africa