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EFFECTS OF MODIFIED CONSTRAINT-INDUCED MOVEMENT THERAPY UPPER AND LOWER LIMBS ON FUNCTIONAL MOBILITY IN STROKE PATIENTS: A RANDOMISED CONTROLLED TRIAL

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ABSTRACT

Background: Stroke is prevalent and poses significant healthcare challenges, emphasizing the need for effective rehabilitation strategies. While Combined Modified Constraint-Induced Movement Therapy (mCIMT) has shown potential in improving both upper and lower limb functions, its overall impact on motor function, mobility, and quality of life remains inadequately explored.

Objective: This study evaluated the efficacy of Combined mCIMT (CO), which targets both upper and lower limbs, compared to CIMT focusing solely on the lower limb (LL) or upper limb (UL), in enhancing motor function, mobility, and quality of life in stroke patients.

Materials and Methods: In a randomized trial conducted at the Physiotherapy Clinic, Murtala Mohammed Specialist Hospital, Kano, 46 stroke patients were assigned to one of three groups: Combined mCIMT (CO, n=16), Lower Limb mCIMT (LL, n=15), or Upper Limb mCIMT (UL, n=15). Each intervention was administered daily for 2 hours, 5 days a week, over 4 weeks. Outcomes were assessed using the Lower Limb Motor Activity Log, Fugl-Meyer Assessment, and Stroke Impact Scale. Data were analyzed using ANOVA, Kruskal-Wallis, and Wilcoxon Signed Rank tests.

Results: All groups exhibited significant improvements in motor function, lower limb use, balance, and quality of life ($P > 0.05$). Notably, the LL group showed significantly greater improvements compared to the CO and UL groups.

Conclusion: Modified LL CIMT was more effective in enhancing motor function, mobility, and quality of life in stroke patients than Combined or UL-specific mCIMT approaches.

Keywords: *Stroke; Constraint-Induced Movement Therapy; Motor Function; Mobility; Balance; Quality of Life*

INTRODUCTION

Stroke is a global health concern and a leading cause of long-term disability in adults (Tedla *et al*., 2022). It is particularly prevalent in developing countries, affecting diverse age groups and both sexes (Reddy *et al.*, 2022). In Nigeria, the pooled crude incidence and prevalence of stroke are 26.0 per 100,000 and 6.7 per 1,000, respectively, with higher rates among men than women (Abdullahi, 2021). The rising incidence of stroke, combined with growing healthcare challenges in low- and middle-income countries, underscores the need for effective rehabilitation techniques to improve recovery outcomes.

Advances in neuroscientific research have led to the development of new approaches in stroke rehabilitation. Constraint-Induced Movement Therapy (CIMT) is a technique that improves motor function after a stroke (Abdullahi *et al.*, 2021). CIMT originated from studies on rhesus monkeys that suffered sensory deafferentation of a forelimb, developed learned non-use, and were forced to use the impaired limb by constraining the unimpaired limb for days (Menezea-Oliveira *et al.*, 2021). This technique was later adapted for human stroke patients, showing promising results (Abdullahi *et al.*, 2021).

Understanding the concepts of learned "non-use" in the upper limb (UL) and "misuse" in the lower limb (LL), along with the principles of neuroplasticity, provides a strong theoretical basis for implementing combined modified CIMT (mCIMT) for both upper and lower limbs in patients with hemiplegic stroke. Research supports CIMT's effectiveness in promoting cortical activation, expanding brain areas, and facilitating functional reorganization in stroke patients (Wang *et al.*, 2012; Abdullahi *et al*., 2021; Menezea-Oliveira *et al.*, 2021).

Numerous studies have demonstrated that CIMT for the UL can improve spontaneous UL use after a stroke (Wolf *et al.*, 2006; Taub *et al.*, 1993). Similarly, adapted forms of CIMT for the LL have successfully treated LL deficits (Taub et al., 1999). Regardless of the affected body part, CIMT can improve reduced UL use or maladaptive LL use using functional activities (Mark *et al.*, 2013).

Fuzaro *et al.* (2012) reported that mCIMT for the UL improves balance, function, mobility, and health-related quality of life (HRQoL) in stroke patients. Kim and Kwon (2012) found that mCIMT for the UL enhances coordination between the upper and lower limbs during the gait cycle. Improving the affected arm's function influences the contralateral arm, leading to increased range of motion and positive changes in balance, function and mobility post-stroke (Fuzaro *et al.*, 2012). Kim and Cha (2015) investigated the effects of CIMT for the UL combined with gait training on balance in stroke patients. They found that improved balance enhanced gait patterns, increased gait speed, and improved walking ability, which reduced participation restrictions and improved quality of life. These findings support the theoretical basis for a combined CIMT protocol targeting both the upper and lower limbs. The combined mCIMT protocol offers potential training advantages by systematically delivering various treatment modes to encourage the use of affected limbs.

Currently, studies combining CIMT protocols for both the upper and lower limbs has not been encountered. Therefore, this study aims to determine whether combining these protocols can effectively improve function, mobility, balance, and quality of life in stroke patients.

MATERIALS AND METHODS

Participants and study design

The study involved 46 stroke patients recruited from the Out-patient Physiotherapy Clinic at Murtala Mohammed Specialist Hospital, Kano, Nigeria. Participants were randomly allocated into three groups: Combined CIMT for both upper and lower limbs (CO, n=16), CIMT for lower limbs (LL, n=15), and CIMT for upper limbs (UL, n=15). They underwent 20 treatment sessions over four weeks, five times a week. This was a single-blind randomized controlled trial registered with the Pan African Clinical Trial Registry (PACTR201611001646207) and adhered to CONSORT guidelines (Figure 1). Ethical approval was granted by the University of Ibadan/University College Hospital (UI/EC/14/0101) and Murtala Mohammed Specialist Hospital (HMB/GEN/488/VOL.I). Informed consent was obtained, and participants could withdraw at any time.

Study procedures

Stroke patients attending the Out-patient physiotherapy Clinic at the hospital were reviewed weekly and included in the study if they met the eligibility criteria (Taub *et al.*, 1993; Vearrier *et al.*, 2005; Wolf et al., 2006).

The Inclusion criteria were as follows:

(1) Patients with stroke who had their first stroke within 6 months before the study, with minimal or no cognitive impairment based on the ability to comprehend and execute 3-word commands. These commands should be clear, concise, and

representative of daily activities, such as "Pick up the pen" or "Stand up and clap."

(2) (2) Patients with stroke who had minimal active range of motion of 10º for wrist extension, 10º for abduction/extension of the thumb and at ≥2 additional digits, 90º for shoulder flexion and abduction, 45º for shoulder external rotation, 30º for elbow extension, 45º for forearm supination and pronation, wrist extension, and finger extension of all digits.

(3) (3) Ability for hip and knee flexion on the affected side; ability to move from sitting to standing independently; ability to sustain body weight on the affected side and walk ≥10m with or without support

(4) (4) Willingness to participate in combined mCIMT for the upper and lower limbs.

Exclusion criteria were as follows:

(1) Spasticity in the affected upper or lower limb >2 on the Modified Ashworth Scale with 0–4 rating

(2) Patients with stroke with excessive pain in the affected upper or lower limb (≥6) on a 10-point visual analogue scale

(3) Patients with stroke with uncontrolled hypertension or congestive heart failure

(4) Patients with stroke with pre-existing neurological conditions unrelated to stroke or musculoskeletal issues.

Randomization and Group Allocation

Patients were randomly allocated to one of three treatment groups: CO (combined upper and lower limbs), LL (lower limb only), or UL (upper limb only) (Figure 1). Randomization was achieved using sealed opaque envelopes, ensuring that participants did not know the group labels. Each participant was allocated to the group they picked, without replacement, and subsequent participants were similarly assigned.

Outcome Measures and Assessments

Outcome Measure

Lower Extremity Motor Activity Log (LE-MAL): This semi-structured interview evaluates the use of the affected lower limb in daily activities and identifies issues such as learned non-use or misuse. It includes a functional performance (FP) subscale with 14 items rated on an 11-point Likert scale. The LE-MAL FP subscale has demonstrated high reliability (test-retest correlation of 0.94) and a strong correlation with the Stroke Impact Scale (r=0.87, P<0.01) (Riegle *et al.,* 2003; Duncan *et al.,* 1999). Higher scores indicate better real-world use of the affected limb.

Fugl-Meyer Motor Assessment Scale (FMA/FM-B): This performance-based scale measures motor impairment, with a maximum score of 34 for the lower limb (Fugl-Meyer et al., 1975). It is highly reliable and valid, with the FM-B subscale for balance performance showing a validity score of r=0.84. Recent revisions have updated parachute reaction items while preserving the original scoring criteria (Hsueh *et al.*, 2001).

Stroke Impact Scale (SIS) Version 3.0: The SIS is a 59-item self-report questionnaire assessing health-related quality of life (HRQoL) post-stroke (Duncan *et al.*, 1999). It includes eight domains: strength, hand function, mobility, daily living activities, memory and thinking, communication, emotion, and social participation. The SIS is reliable, with Cronbach's alpha values ranging from 0.86 to 0.90. Scores range from 0 to 100, with higher scores indicating better HRQoL.

Assessment

All patients were assessed at baseline into the study with respect to the following Outcomes: Lower limb motor function (LLMF) and Balance was assessed using the Fugl-Meyer Motor Assessment Scale; lower limb use (LLU) with the Lower Extremity Motor Activity Log; Quality of life with Stroke Impact Scale. Assessment was also performed at baseline, two weeks, and four weeks post- interventions.

Intervention Protocols

Upper Limb Group (UL, n=15): Participants in the UL group performed task-oriented activities focused on manipulating, grasping, picking, holding, and moving objects to improve fine motor skills, grasp and reach, sensory function, and proximal control (Page *et al.*, 2002; Yen *et al.*, 2005; Wang *et al.*, 2012); (Appendix A). No physical restraint was applied to the unaffected limb.

Lower Limb Group (LL, n=15): Participants in the LL group performed task-oriented activities focused on functional mobility, ambulation, and static and dynamic balance tasks (Vearrier *et al.*, 2005). Physical restraint was not required, but compensatory strategies were discouraged, and symmetry of movement and reciprocal gait were emphasized (Appendix B).

Combined Group (CO, n=16): The CO group received both upper and lower limb CIMT, targeting reduced use of the upper limb and maladaptive use of the lower limb. The combined mCIMT protocol for both upper and lower limbs was selected and refined from the individual protocols (Appendix C). Participants were disciplined to use the paretic limbs during shaping without the need for physical restraints on the unaffected limb.

Data Analysis

Descriptive and non-parametric statistical methods were used. Analysis of Variance (ANOVA) was used to assess associations between treatment groups and participant characteristics. Friedman's ANOVA was utilized for within-group comparisons of the effects of different treatment programmes on participant scores. The Wilcoxon signed-rank test served as the post-hoc analysis to identify significant differences found in Friedman's F-ratios. The Kruskal-Wallis test was used for between-group comparisons, with the Mann-Whitney U-test applied for post-hoc analysis. Alpha level set at ≤ 0.05.

RESULTS

A total of 46 participants completed the four-week programme: CO (n=16), LL (n=15), and UL (n=15). The dropout pattern is illustrated in Figure 1. There were no significant differences in the socio-demographic and physical characteristics of participants across the three groups (P>0.05). However, differences emerged in the distribution of clinical profiles by stroke subtype. Specifically, the CO and UL groups had a higher proportion of individuals with ischemic stroke, while the LL group had a higher proportion of individuals with haemorrhagic stroke (Table 1).

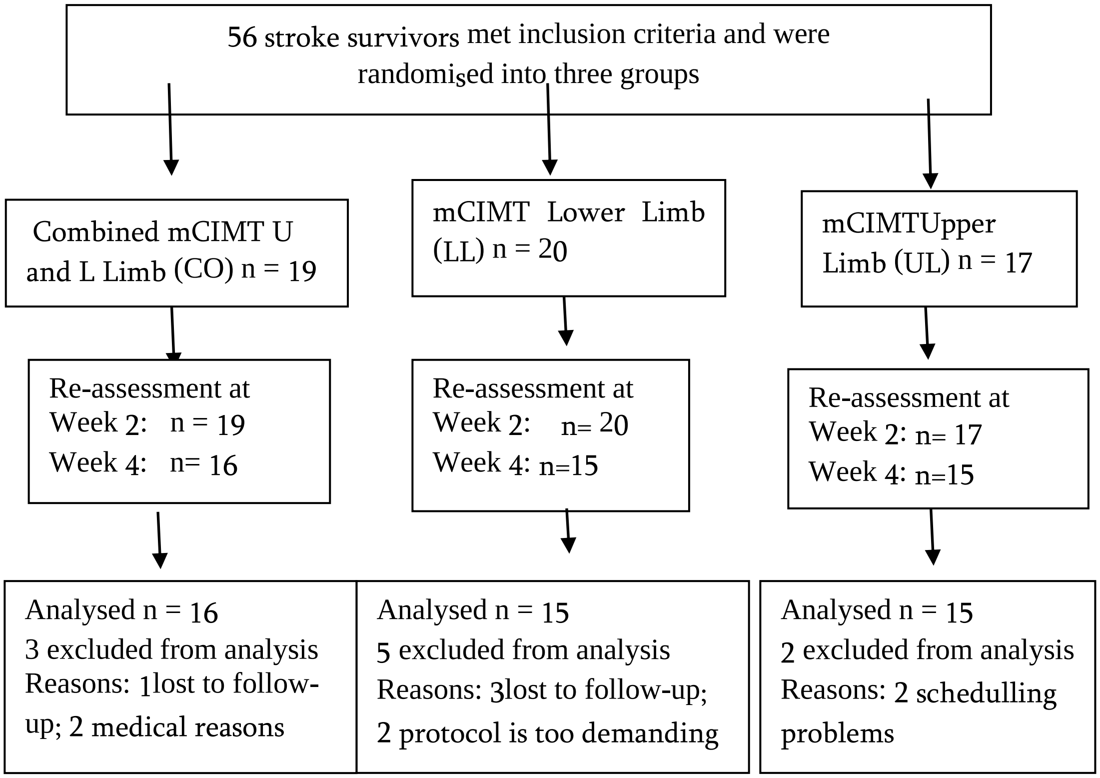

Figure 1. Flow chart of participants' recruitment and participation

Within-Group Comparison

Repeated measures ANOVA was conducted to compare the participants' median scores on lower limb motor function, lower limb use, and balance within the CO, LL, and UL groups across different time points. The results, shown in Table 2, indicate significant improvements in all groups for lower limb motor function, lower limb use, and balance from baseline to week 2, from week 2 to week 4, and from baseline to week 4.

Between-Groups Comparison

The Kruskal–Wallis test was employed to compare median scores for lower limb motor function, lower limb use, and balance among the CO, LL, and UL groups at baseline, week 2, and week 4. To identify significant differences between the groups, post-hoc analysis was performed using the Mann–Whitney U test. The results of these comparisons are presented in Table 3.

Effects of CO, LL, and UL Treatments on Participants' HRQoL

The study results revealed that all three treatment regimens had a significant impact on the health-related quality of life (HRQoL) of hemiparetic stroke patients, as assessed by the Stroke Impact Scale (SIS). Although there were no significant differences between the CO, LL, and UL groups in the domains of strength, emotion, mobility, hand function, and participation, significant differences were observed in the domains of activities of daily living, memory/thinking, communication, and perceived stroke recovery, as measured by the visual analogue scale (SIS-VAS).

Table 1. Association Between Treatment Groups and Participant Characteristics

	CO	LL	UL	X^2	P
(Mean ± SD)					
Age (years)	53.69±9	45.33±9.15	51.07±10.47	3.74	0.057
Stroke onset	13.87±6.42	14.13±4.24	15.07±471	0.95	0.396
Sex					
Male	9	11	7	2.26	0.323
Female	7	14	8		
Education					
Pre-secondary	4	5	5	11.55	0.073
Secondary	4	4	9		
Post-secondary	8	6	1		
Affectation side					
Right	7	8	7	0.29	0.862
Left	9	7	8		
Stroke types					
Ischaemic	12	4	9	7.58	0.023*
Haemorrhagic	4	11	6		

Key: *Indicates significant difference at α= 0.05
CO= Combined modified CIMT Upper and Lower limbs
LL= Modified CIMT Lower Limb
UL= Modified CIMT Upper Limb

Table 2. Within-Group Comparison of Clinical Variables Across the Three Time Points

Study groups	Baseline Median (IQR)	2 Weeks Median (IQR)	4 Weeks Median (IQR)	X^2	P value
CO					
Motor Function	20.00(10.00) [a]	26.00(7.00) [b]	29.00(5.00) [c]	16.69	0.001*
Lower Limb Use	3.57(0.93) [a]	4.36(0.86) [b]	4.57(0.93) [b]	23.72	0.001*
Balance	9.00(3.00) [a]	11.00(1.00) [b]	12.00(1.00) [c]	27.52	0.001*
LL					
Motor Function	15.50(5.8) [a]	25.00(2.00) [b]	29.50(2.5) [c]	28.22	0.001*
Lower Limb Use	3.54(1.10) [a]	4.86(0.8) [b]	5.68(1.20) [c]	20.37	0.001*
Balance	9.00(2.00) [a]	11.00(2.00) [b]	13.00(2.00) [c]	28.16	0.001*
UL					
Motor Function	18.00(7.00) [a]	24.00(7) [b]	26.00(4.00) [c]	20.98	0.001*
Lower Limb Use	4.14(1.10) [a]	3.92(2.00) [b]	4.50(1.70) [b]	11.20	0.001*
Balance	9.00(5.00) [a]	11.00(3.00) [b]	12.00(2.00) [c]	19.88	0.001*

*Indicates significant difference at $\alpha = 0.05$

Post hoc: Superscripts (a, b, c) for a particular variable: Median values with different superscripts are significantly different; while those with the same superscripts are not significantly different.

Key: CO= Combined modified CIMT Upper and Lower limbs

LL= Modified CIMT Lower Limb

UL= Modified CIMT Upper Limb

IQR = Inter-Quartile Range

Table 3. Between-Groups Comparison of Clinical Variables, Outcomes at Baseline, Week 2, and Week 4

Clinical Variables	Time frame	CO Median (IQR)	LL Median (IQR)	UL Median (IQR)	K	p-value
Motor function	Week 0	20.00(10.00)	15.50(5.80)	18.00(7.00)	3.121	0.211
	Week 2	26.00(7.00)	25.00(2.00)	24.00(7.00)	2.982	0.225
	Week 4	29.00(5.00) [a]	29.50(2.50) [b]	26.00(4.00) [b]	10.15	0.005*
Lower limb use	Week 0	3.57(0.93)	3.54(1.10)	4.14(1.10)	0.693	0.707
	Week 2	4.36(0.86)	4.86(0.80)	3.92(2.00)	4.048	0.132
	Week4	4.57(0.93) [a]	5.68(1.20) [b]	4.50(1.70) [b]	7.738	0.021*
Balance	Week 0	9.00(3.00)	9.00(2.00)	9.00(5.00)	0.575	0.756
	Week 2	11.00(1.00)	11.00(2.00)	11.00(3.00)	0.014	0.993
	Week 4	12.00(1.00)	13.00(2.00)	12.00(2.00)	3.461	0.177

*Indicates significant difference at $\alpha = 0.05$

Post hoc: Superscripts (a, b, c) for a particular variable: Median values with different superscripts are significantly different; while those with the same superscripts are not significantly different.

Key:

CO= Combined modified CIMT upper and lower limbs

LL= Modified CIMT Lower Limb

UL= Modified CIMT Upper Limb

n = Number of participants in the group

IQR = Inter-Quartile Range

Table 4. Between-Group Comparison of Participants' HRQoL Treatment Outcomes at Baseline, Week 2, and Week 4

Domain	Time frame	CO (n=16) Median (IQR)	LL (n=15) Median (IQR)	UL (n=15) Median (IQR)	K	p-value
Strength	Week 0	30.00(30.00)	32.50(8.75)	50.00(15.00)	8.520	0.014
	Week 2	50.00(20.00)	50.00(20.00)	50.00(5.00)	0.250	0.880
	Week 4	50.71(17.14)	57.50(20.00)	55.00(20.00)	1.597	0.450
Memory	Week 0	34.29(0.86) [a]	25.21(14.29)	25.21(14.29)	8.447	8.447
	Week 2	42.86(25.71) [a]	52.86(16.43) [b]	52.86(16.43) [b]	19.78	19.78
	Week4	37.78(15.56)	61.43(27.86) [b]	61.43(27.86) [b]	8.695	8.695
Emotion	Week 0	44.44(6.67)	38.89(10.56)	40.00(11.11)	0.350	0.814
	Week 2	46.67(6.67)	42.22(12.22)	42.22(4.44)	0.750	0.752
	Week4	46.00(15.00)	46.67(12.22)	46.67(8.89)	0.120	0.942
Comunctn	Week 0	28.57(22.86)	34.29(16.43)	31.43(20.00)	1.299	0.522
	Week 2	45.71(14.29)	50.00(24.29)	45.71(20.00)	4.902	0.086
	Week4	48.57(5.71) [a]	60.00(20.71) [b]	48.57(20.00) [a]	6.036	0.049*
ADLs	Week 0	110(140.00)	160(130.00)	140.0(80.00)	1.165	0.558
	Week 2	220(100.00) [a]	240(75.00) [b]	160(150.00) [b]	14.74	0.001*
	Week4	230(120.00)	260(127.50)	220.0(90.00)	0.161	0.006*
Mobility	Week 0	37.78(15.56)	44.44(20.56)	37.78(20.0)	0.759	0.684
	Week 2	51.11(13.33)	58.89(18.33)	46.67(11.11)	5.622	0.060
	Week 4	57.78(15.56)	58.89(17.22)	51.11(20)	4.635	0.099
Hand function	Week 0	37.14(25.71)	27.14(25.00)	31.43(14.29)	6.080	0.048
	Week 2	37.14(14.29)	34.29(31.43)	34.29(8.57)	0.217	0.897
	Week 4	45.71(14.29)	42.86(27.86)	37.14(5.71)	1.620	0.445
Participatn	Week 0	35.50(20.00)	37.50(28.75)	30.00(20.00)	1.117	0.572
	Week 2	42.50(17.50)	42.50(11.25)	42.50(20.00)	0.422	0.810
	Week 4	47.50(20.00)	50.00(10.00)	42.50(20.00)	5.082	0.079
Stroke recovery	Week 0	50.00(30.00)	70.00(10.00) [b]	50.00(10.00)	1.187	0.552
	Week 2	60.00(20.00) [a]	80.00(17.50) [b]	60.00(10.00) [b]	9.186	0.010*
	Week 4	70.00(10.00) [a]	53.75(25.00)	60.00(10.00) [b]	18.40	0.001*

*Indicates significant difference at $\alpha = 0.05$

Post hoc: Superscripts (a, b, c) for a particular variable: Median values with different superscripts are significantly different; while those with the same superscripts are not significantly different.

Key:

CO = Combined Modified CIMT Upper and Lower limbs

LL = Modified CIMT Lower Limb

UL = Modified CIMT Upper Limb

n = Number of participants in the group

IQR = Inter-Quartile Range

DISCUSSION

This study investigated the effects of modified Constraint-Induced Movement Therapy (mCIMT) on function, mobility, balance, and health-related quality of life (HRQoL) in stroke patients. The results indicated no significant differences in baseline measures for lower limb motor function, lower limb use, balance, and HRQoL, suggesting that the groups were comparable at the beginning of the intervention. Consequently, any observed differences over time can be attributed to the specific effects of the treatment interventions.

The CO group demonstrated significant improvements in balance. This protocol, which targets both upper and lower limbs simultaneously, appears to enhance functional mobility and balance control. These findings are consistent with prior research combining intensive gait training with upper limb CIMT, which has been shown to improve static and dynamic balance in stroke patients (Kim & Cha, 2015). Arya *et al.* (2014) also observed a positive relationship between motor function in both limbs and balance control.

The enhanced lower limb uses and balance observed in the CO group suggest increased utilization of the affected limb by stroke patients. Although the combined mCIMT approach for both limbs is not documented, it presents a comprehensive rehabilitation strategy that may improve overall rehabilitation recovery time and improve functional mobility. In contrast, the LL group showed superior median scores in lower limb motor function, lower limb use, and balance, aligning with previous studies on CIMT for lower limbs (Ding *et al.*, 2013; Vearrier *et al.*, 2005; Marklund & Klässbo, *2006;* Yu *et al.*, 2015). The enhanced outcomes in the LL group could be due to the greater focus and intensity of lower limb training compared to the CO group, which split the training between both limbs.

The UL group also showed significant improvements, highlighting the critical role of upper limb motor function in functional mobility and balance. Stroke patients with affected upper limbs often struggle with movements necessary for balance maintenance, impacting their ability to perform protective reactions (Acar & Karatas, 2010). This study supports the evidence that arm swinging during gait aids lower limb movements and balance. Improvements observed in the UL group may also positively influence lower limb motor function and balance.

The observed secondary improvements in motor function, mobility and balance in the UL group can be explained by Zipp and Winning's (2012) theory, which posits that enhancements in upper limb function positively impact lower limb function. Kim and Kwon (2012) also demonstrated that mCIMT for the upper limb improves coordination between the upper and lower limbs, and Fuzaro *et al.* (2012) supported this by showing positive changes in mobility and balance resulting from upper limb mCIMT. Improvements in lower limb motor function correlated with better HRQoL, supporting Fuzaro *et al.* (2012), who found that enhanced lower limb motor function leads to better ADL outcomes. Similar results have been observed in other mCIMT studies using the SIS to measure HRQoL (Dettmers *et al.*, 2005; Wu *et al.*, 2007).

Regarding HRQoL, significant differences were noted in the domains of activities of daily living (SIS-ADL), memory/thinking (SIS-mem), and communication (SIS-comm). The CO and LL groups achieved higher scores in the SIS-ADL domain compared to the UL group. ADLs such as transferring, dressing, and walking are particularly challenging for stroke patients (Peurala *et al.*, 2007). Kwakkel and Wagenaar (2002) emphasized the benefits of high-intensity training for both upper and lower limbs on ADL, walking ability, and dexterity. The CO group's approach, which integrated intensity and task specificity, likely contributed to these improvements.

In the emotion (SIS-emotn) domain, despite general evidence that exercise positively affects mood (Eng *et al.,* 2003), this study did not find significant changes. The LL group showed the most notable improvements in memory/thinking and communication, with the CO group following, and the UL group showing the least improvement. The greater increases in median scores for the LL group suggest that intensive physical activities, such as LL CIMT, may have broader cognitive and psychosocial benefits. However, it is unclear whether the social interactions during therapy influenced communication outcomes in the LL group. All three groups demonstrated significant improvement in perceived stroke recovery, as measured by the visual analogue scale (SIS-VAS).

Limitations of the Study

One significant limitation was the challenge in recruiting stroke patients who met the eligibility criteria for both upper and lower limb involvement. This issue may limit the generalizability of the study's findings, as the sample may not fully represent the broader stroke patient population.

CONCLUSION

Modified Constraint-Induced Movement Therapy (mCIMT) for the lower limbs (LL) showed significant therapeutic benefits in improving function, mobility and quality of life for stroke patients. These promising results suggest that LL mCIMT could be a valuable component of stroke rehabilitation. However, further research and clinical trials are needed to validate these findings and refine evidence-based practices in physiotherapy for stroke rehabilitation.

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UPPER LIMB PROTOCOL Sample day (Dada and Sanya, 2011)

I. The participant sits on a chair. A building block is placed on a table in front of him/her, about midline of his/her body. The participant pushes the building block as far as he/she can to the left and right sides with the affected hand.

II.The participant sits on a chair with the affected hand on a table in front of him/her. He/She then stretches his arm fully to carry a cup placed at arm's length on the table by extending the elbow (to the side). The shoulders are kept level to prevent leaning with the trunk.

III. The participant sits on a chair and places the forearm on a table placed on the affected arm side (the forearm is parallel to the edge of the table). He/She uses the hand to push a building block just behind the dorsum of the hand as far as he/she can to the side and back to the starting point. The elbow should be kept on the table throughout the task.

IV. The participant sits on a chair with the affected hand on his/her lap. He/She then attempts to lift a plastic bottle on a table in front of him/her and bring it close to his/her lips with a cylindrical grasp (Plate 3.5). An overhand grasp is not allowed for this task. The task is repeated with a water-filled plastic bottle if the participant can do it.

V. The participant sits on a chair with the affected hand on his/her lap and attempts to pick up a ball from a plate and drop it in another plate beside the first plate; both plates are placed on a table in front of him/her.

VI. The participant sits on a chair with the affected hand on his/her lap and attempts to pick up a pencil from a table in front of him/her using a 3-jaw chuck grasp and/or hold (thumb and first two fingers) for a count of 6 before returning it to the starting position.

VII**.** The participant sits on a chair with the affected hand on his/her lap and attempts to pick up buttons of different sizes using a pincer grasp (pads of thumb and index finger opposed). The buttons will be picked up from the top of the table and not over the edge of the table.

VIII**.**The participant sits on a chair and picks up two checkers, each at opposite ends of an eight-square box draught (boxes 1 and 8), and arranges/places them in the centre boxes (4 and 5). The task can be executed by picking up either the checker on the left or the right first.

IX**.** Using a pincer grasp on the near edge of playing cards, the participant attempts to flip over ten cards arranged in a straight line. This task is done by sliding the front edge of the card just past the front edge of the table with some or all of the fingers and then grasping the card edge protruding over the table edge between the palmar surfaces of the thumb and index finger. The cards can be flipped over from side to side or from front to end. The cards do not have to be straightened or adjusted after they have been turned over.

X**.** Using the ulnar edge of the unaffected hand to hold down a medium-sized purse, the participant attempts to open the lid of the purse that is fastened with a Velcro with the affected hand.

XI. Holding a pen, the participant attempts to write his/her name and home address in a notebook placed on a table in front of him/her.

Dada, O.O and Sanya, A.O. 2011. Constraint-induced movement therapy: Determinants and Correlates of Duration of Adherence to restraint use among Stroke survivors with hemiparesis. *Disability,CBR and Inclusive Development* 22.3:15-27

LOWER LIMB PROTOCOL Sample day (Vearrier et al. 2005)

A. Impairment: 15% of training day (20 mins)

1. Strengthening: progressive resistance exercises, closed chain activities.
2. Range of motion/stretches: particularly gastrocnemius, soleus, hamstrings, and hip flexors.
3. Aerobic conditioning—recumbent bicycle, treadmill.

B. Functional limitation: 70% of training day (1hr24mins). Variability of practice is emphasized, so activities are interspersed.

1. Balance activities: weight shifting tasks – catching and kicking, standing on a rocker board/foam eyes open/ closed, lifting boxes; negotiating crowded busy hallways.
2. Functional training: Transfers: emphasis on equal loading of the legs, decreased reliance on arms, transferring to either side. Gait training: emphasis on removing/minimizing orthoses (ankle-foot orthosis to an air splint) and assistive devices, treadmill use, promotion of even weight shift, symmetrical step lengths, reducing compensatory strategies. Gait training indoors/outdoors, obstacle/small space negotiation, ambulating backwards/sidestepping. Stairs/Curbs/Ramps: emphasis on reciprocal pattern and decreased reliance on hand railing.
3. Education: integration of skills covered during training into everyday living.

C. Disability – 10% of training day (10 mins) Community ambulation, problem solving community barriers, skills for hobbies of choice.

D. Rests – 5% of training day (6mins)

E. Feedback – verbal, tactile, visual (videotape), and auditory (limb load monitor).

Vearrier LA, Langan J, Shumway-Cook A. An intensive massed practice approach to retraining balance post-stroke. *Gait and Posture*. 2005. 22:154–1

Typical days programme

Combined Upper and Lower protocol

A)The motor activities for the affected upper limb will be done as follows (each activity will be repeated ten times wherever possible):

1. With the patient sitting on a chair, a building block will be placed about the midline of his body, on a table in front of him; he will push the building block as far as he can to the left and right sides with the affected hand.
2. With the patient sitting on a chair and the affected hand on a table in front of him, he will stretch his arm fully to carry a cup placed at an arm's length on the table by extending the elbow (to the side). Shoulders will be kept level to prevent leaning with the trunk.
3. With the patient sitting on a chair, affected hand on laps he will attempt to lift a plastic bottle on a table in front of him and will bring it close to lips with a cylindrical grasp. An overhand grasp will not be allowed for this task. The task will be repeated for a water-filled plastic bottle if subject can.
4. With the patient sitting on a chair, affected hand on laps, he will attempt to pick a ball in a plate and drop it in another plate beside the first plate, both placed on a table in front
5. The participant sitting on a chair with the affected hand on the laps will attempt to pick up buttons of different sizes using a pincer grasp (pads of thumb and index finger opposed). The buttons will be picked up on the table and not over the edge of the table.
6. Holding a pen, the patient will attempt to write his name and home address on a notebook which will be placed on a table in front of him
7. Progression will be by withdrawing assistance given, increasing the complexity of task and the speed of carrying out the task.

(B) Repitative task oriented practice for the use of lower limb

8. Impairement: **a.**Strengthening: progressive resistance exercises, closed chain activities. **b**. Range of motion/stretches: particularly gastrocnemius, soleus, hamstrings, and hip flexors. **c.** Assistive and resistive exercises PNF lower limb
9. Functional limitation: **a.** Balance: Balance activities: weight shifting tasks- catching and kicking, standing on a foam eyes open/ closed, lifting objects from floor; **b**. Functional training: Functional training: Weight transfers: emphasis on equal loading of the legs, transferring to either side. Overground gait training, promotion of even weight shift, symmetrical step lengths,. Gait training indoors, ambulating backwards/forward sideways; side stepping. Stairs climbing: emphasis on reciprocal pattern and decreased reliance on hand railing.