ORIGINAL ARTICLE

Comparative effects of modified constraint induced movement therapy with motor relearning program on balance among stroke patients

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Abstract

Background: Stroke often leads to permanent balance problems and are major causes of death and disability across the globe. Techniques such as physiotherapy involving motor relearning program (MRP) and modified constraint-induced movement therapy (MCIMT) help in the recovery of motor functions after a stroke. MCIMT involves repetitive movements using the affected limb in order to increase neuroplasticity, whereas MRP helps in relearning motor functions. This study was carried out to compare the effects of motor relearning program and modified constraint induced movement therapy on balance among stroke patients.

Material and methods: This quasi-experimental study was conducted at Care Physiotherapy Clinic, Lahore, with 20 purposively selected participants. Inclusion criteria involved ischemic stroke patients (≥5 months), aged 35–55, cognitively stable, able to stand independently, and receiving regular therapy. Participants were divided into two groups (mCIMT and MRP), and balance outcomes were assessed using the Berg Balance Scale. Interventions were conducted 3 days a week for eight weeks, with outcomes measured at baseline, 4 weeks, and 8 weeks.

Results: Both groups exhibited significant improvements in BBS scores over time. However, MCIMT group showed greater improvement in balance (BBS=$p<0.05$) compared to MRP group at the end of the study.

Conclusion: This study concluded that there was significant difference between both groups but the group receiving modified constraint induced movement therapy showed more pronounced improvement in balance compared to patients receiving motor relearning program.

Keywords: Balance, Modified Constraint-Induced Movement Therapy, Motor Relearning Program, Rehabilitation, Stroke

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INTRODUCTION

Stroke, a neurological impairment brought on by an acute trauma of the central nervous system linked to a vascular source, such as cerebral infarction, intracerebral hemorrhage, or subarachnoid hemorrhage, is one of the leading causes of disability and mortality globally. According to the WHO, 15 million people worldwide get a stroke every year. Five million of them pass away, and an additional five million suffer from post-stroke disabilities.[1]

Stroke causes a number of neurological dysfunctions including loss of balance. Vestibular system uses certain cerebral pathways for maintaining the equilibrium of the body and is important in balance maintenance.[2] Impairments linked to balance range from 16.7% to 83% according to data gathered in several reports.[3] More than one third of survivors of the stroke require aid in their daily activities and fifty percent of them face long term disability.[4]

mCIMT is a treatment regime for stroke referring to a specific treatment for the improvement of the motor disability of the limb that is targeted combining movement constraint, behavior shaping and massed practice. Many studies have shown the effectiveness of mCIMT in treatment of the motor loss linked to the upper extremity among chronic stroke patients.[5] But only a few studies have shown the effects of mCIMT on disabilities of lower limb and locomotion deficits among stroke patients in sub-acute phase. A study led by Bandopadhay et.al. in 2024 concluded that modified constraint induced movement therapy with restraint is effective for improvement of both gait and balance.[6] Another study conducted by Umar Lawan et.al. compared the effectiveness of modified constraint induced movement therapy on upper and lower limbs and found out that lower limb improved more with modified constraint induced movement therapy. [7]

MRP is the rehabilitative approach that has been used occasionally for the post stroke patients. Motor Learning Theory forms the basis of this approach providing retraining functional skills by providing practical guidelines. [8]

Stroke causes a number of neurological dysfunctions including loss of balance. Impaired balance can severely limit a person's ability to carry out routine tasks that raise their risk of falling. There are a number of physiotherapy approaches for rehabilitation of the impairments including modified constraint induced movement therapy and motor relearning program. mCIMT forces the use of the weakened side, potentially promoting neuroplasticity and motor recovery. MRPs focus on re-learning specific movement patterns. By comparing these approaches, it can be found that the intensive use of mCIMT may or may not lead to greater improvement in balance compared to MRP for stroke patients.

MATERIAL AND METHODS

This study was a quasi-experimental study conducted at Care Physiotherapy Clinic, New Chauburji Park, Lahore. A total of 20 participants were selected for the study through a purposive sampling technique. Participants who had an ischemic stroke at least 5 months ago; Cognitively stable patients with Mini-Mental State Examination scores of 24 or more.[9] Male and female patients of age 35-55 years; Patients with hemiparesis who were able to stand independently and patients receiving passive and active assisted ROM exercises since their stroke were included in the study, and patients with a history of neurological deficits, severe joint contractures, or severe neglect dyslexia were not included in the study. Twenty participants were divided into two groups: 10 were assigned to the mCIMT group, and 10 were assigned to the MRP group. No randomization was done. The sampling technique used was purposive sampling and critical t-test was used in G Power Tool (version 3.1.9.7) with balance as the variable and Berg Balance Test as the outcome measuring tool. (10) Mean± S.D (Group 1)= 35.03± 6.606 and Mean ± S.D (group 2)= 44.47±5.174. (10) for the sample calculation. The sample size was calculated to be 24 in total, with Actual Power = 0.9609699, Level of significance maintained= 95%, and Effect size = 1.591. Sample size was calculated to be 24, but 4 were lost during follow-up, so 20 patients were studied and were divided into two groups of 10 each. Assessors in this study were blinded.

Priority was given to each person's rights and dignity. The subjects were not harmed by the research method. Accurate information to patients was provided and written consent was taken from the subjects. At every stage, the confidentiality of the subject's information was upheld. The university's ethical commission granted its approval. The university's authorization letter has the IRB number IRB-USA/FAHS/2024/882.

Consent to participants: The stroke patients had given their written consent. During the data collection process, all applicable regulations and procedures were adhered to.

Availability of data and materials: Data will be made available upon request. All of the dataset files will be submitted by the relevant author.

After obtaining informed consent, a baseline assessment of each participant was performed. Vital signs of the patients were monitored at the start of every session, after every 4 tasks in every session, and at the end of every session. All interventions were administered by trained physiotherapy personnel with prior knowledge of both modified constraint-induced movement therapy (mCIMT) and motor relearning program (MRP). To ensure consistency, a predefined intervention protocol was followed for both groups. However, no formal inter-therapist reliability assessment or standardized training calibration sessions were conducted. Participant adherence was monitored through session attendance and active participation during treatment sessions. Only those participants who completed the full intervention protocol (3 sessions per week for 8 weeks) were included in the final analysis. Treatment fidelity was maintained by implementing a structured, phase-wise intervention protocol for both mCIMT and MRP groups, with each phase lasting two weeks and clearly defined exercises and progressions. All sessions followed a consistent format, including warm-up (conventional therapy), task-specific training, and progression based on predefined phases. All participants in each group were given the same protocol to ensure uniformity.

Intervention:

Conventional Treatment (Both Groups)

Each group began every session with a routine that included 15 minutes of normal therapy. This involved manual muscle stretching of the lower limbs where each stretch was held for 30 seconds over three repetitions, followed by TheraBand resistance exercises performed in two sets of ten. The resistance levels were slowly increased based on patient improvement from yellow to green in eight weeks. [11]

mCIMT group:

The training sessions lasted for 30 min and were held thrice a week in eight weeks' duration. Patients were made to wear a knee extension brace in their unaffected leg throughout the period. Weeks one and two involved developing basic confidence where patients were required to walk in all directions including uphill and downhill. The level of difficulty was raised during weeks three and four where patients had to perform heel strike walking, overcome low obstacles, and change directions through verbal command. Week five and six involved stair walking, object picking up in the middle of walking, and object throwing during walking.[12]

MRP Group:

This exercise regimen had the same routine of thirty minutes three times per week over eight weeks. First, in the first two weeks, exercises were done while sitting, which included trunk rotation, lateral bends, all directional reach, and sit-to-stand movement repetitions. Second, during weeks three and four, the patient is required to perform exercises in the upright position, including single leg stance, raising heels and toes, and knee extension. Third, in weeks five and six, exercise includes walking for ten meters forward, backward, and sideways to improve his gait. Lastly, in weeks seven and eight, exercises include complex braiding steps, heel-to-toe walk, and head movements during walking.[13]

RESULTS

Demographic information as well as other variables associated with the subjects belonging to MRP and mCIMT categories is depicted in Table-I. The variables are: age, gender, level of education, BMI, occupation, residence, medical history, and side of paresis.

BBS Scores comparison between mCIMT and MRP at baseline, 4 weeks, and 8 weeks is presented in Table-II below with p-values demonstrating statistical significance. Baseline score did not show any significant difference between the two groups ($p=0.517$). However, after 4 weeks ($p=0.039$) and 8 weeks ($p=0.008$), mCIMT showed statistically higher score improvement. These results suggest mCIMT may be more effective than MRP in improving balance in sub-acute stroke patients.

Table-III shows within-group BBS score comparisons for mCIMT and MRP from baseline to 4th and 8th weeks, with both groups showing significant improvement ($p < 0.001$). The mCIMT group demonstrated greater mean changes at each interval compared to MRP. This indicates that mCIMT may be more effective in improving balance in sub-acute stroke patients over time.

Table-IV presents the main and interaction effects of BBS scores over time for both mCIMT and MRP groups using repeated measures ANOVA. Over time, both groups' balance improved statistically significantly ($p < 0.001$), with very large effect sizes ($\eta^2 = 0.972$ for mCIMT and 0.960 for MRP). The higher F-value and effect size in the mCIMT group indicate a stronger treatment effect compared to the MRP group.

Table-I: Demographics details of the included participants

Variable	mCIMT Group (n = 10)	MRP Group (n = 10)
Mean Age (years)	42.70 ± 6.42	46.70 ± 6.42
Gender	Male: 6 (60%) Female: 4 (40%)	Male: 7 (70%) Female: 3 (30%)
Education	Elementary: 3 (30%) High School: 4 (40%) Bachelor's: 2 (20%) Master's: 1 (10%)	Elementary: 3 (30%) High School: 2 (20%) Bachelor's: 3 (30%) Master's: 1 (10%) No Education: 1 (10%)
Mean Weight (kg)	70.20 ± 10.92	72.20 ± 9.64
Mean Height (feet)	5.62 ± 0.34	5.74 ± 0.20
BMI Status	Underweight: 1 (10%) Normal: 5 (50%) Overweight: 4 (40%)	Underweight: 1 (10%) Normal: 5 (50%) Overweight: 3 (30%) Obese: 1 (10%)
Employment Status	Employed: 6 (60%) Unemployed: 2 (20%) Retired: 2 (20%)	Employed: 6 (60%) Unemployed: 4 (40%)
Living Condition	With Partner: 3 (30%) With Family: 7 (70%)	With Partner: 1 (10%) With Family: 9 (90%)
Comorbidities	Hypertension: 4 (40%) Diabetes: 4 (40%) Anxiety/Depression: 2 (20%)	Hypertension: 5 (50%) Diabetes: 2 (20%) Anxiety/Depression: 2 (20%) Dementia: 1 (10%)
Side of Paresis	Left: 3 (30%) Right: 7 (70%)	Left: 4 (40%) Right: 6 (60%)

Table-II: Between Group Analysis

Variable		**MCIMT group**	**MRP group**	**Significance**
		Mean ± SD	Mean ± SD	p- value
BBS	Baseline	24.20 ± 2.22	24.80 ± 2.53	0.517
	4 weeks	35.40 ± 2.84	32.30 ± 3.37	0.039
	8 weeks	48.70 ± 3.34	42.10 ± 3.51	0.008

Table III: Within-Group Analysis

Variable		**mCIMT Group**			**MRP Group**		
		Mean ± S.D	M.D	p-value	Mean ± S.D	M.D	P value
BBS	Baseline to 4th week	24.20 ±2.22 35.40 ± 2.84	-11.20	<0.001	24.80 ± 2.53 32.30 ± 3.37	-7.50	<0.001
	4th week to 8th week	35.40 ± 2.84 48.70 ± 3.34	-13.30	<0.001	32.30 ± 3.37 42.10 ± 3.51	-9.80	<0.001
	Baseline to 8th week	24.20 ± 2.22 48.70 ± 3.34	24.50	<0.001	24.80 ± 2.53 42.10 ± 3.51	17.30	<0.001

Table IV: Interaction Effect of BBS for mCIMT and MRP group

Group	Variable	F-value	η^2 (Effect Size)	p-value	Mean Square	df	Sum of Squares
mCIMT Group	BBS (Time)	309.299	0.972	<0.001	495.853	1.576	781.267
MRP Group*	BBS (Time)	216.561	0.960	<0.001	364.720	1.764	643.267

DISCUSSION

The primary aim of this study was to determine whether modified constraint induced movement therapy offers greater balance recovery than a motor relearning program in sub-acute stroke patients, and the findings clearly point in one direction. Both interventions were delivered through structured, progressive protocols over eight weeks. At baseline, the two groups were virtually identical in balance performance, with BBS scores of 24.20 ± 2.22 and 24.80 ± 2.53 for the mCIMT and MRP groups respectively. By the fourth week, a meaningful gap had already opened between them, and by the close of the 8-week program, the mCIMT group reached a mean BBS score of 48.70 ± 3.34 against 42.10 ± 3.51 in the MRP group ($p<0.05$). Both groups demonstrated highly significant within-group change over time, yet the overall mean difference of 24.50 in the mCIMT group clearly outpaced the 17.30 gain seen in MRP.

The advantage of mCIMT over MRP can be understood through its core mechanism of action. When the unaffected limb is restrained, the patient has to use the paretic side for all functional tasks. Over time, this forced engagement rebuilds corticospinal drive to the affected lower extremity, and stimulates cortical reorganization in areas governing motor output.[5] A research by Aloraini et al. showed that at baseline, the mean values for BBS of participants receiving modified CIMT were 40.3 ± 3.3, and at 3 months follow-up was 48.1 ± 1.7, which shows significant improvement. It supports this study, which also shows significant improvement in values of BBS with a mean value at baseline of 24.20 ± 2.22 and at the 8th week of 48.70 ± 3.34 in patients given modified constraint-induced movement therapy. [14]

Park et al. (2024) studied electromyography-triggered constraint-induced movement therapy in chronic stroke patients and observed BBS scores rise from 30.56 ± 7.88 to 35.05 ± 7.27. (15) The gains reported there are less than those recorded in the present study, where the mCIMT group moved from 24.20 ± 2.22 to 48.70 ± 3.34 over the same duration. Part of this discrepancy likely reflects chronicity: sub-acute stroke patients, as recruited here, retain considerably more neuroplastic potential than those in the chronic phase. In another study, Ghrouz et al. (2024) recorded a mean BBS change of 13.78 ± 2.85 across eight weeks of motor relearning, (13) which is less than the mean difference of 17.30 seen in the present MRP group. The broad consistency across these independent datasets adds confidence to the interpretation that MRP yields reliable, if comparatively moderate, balance gains in stroke rehabilitation.

Naz et al. (2022) offered one of the more directly comparable MRP datasets, recruiting sub-acute stroke patients and observing BBS scores climb from 23.34 ± 6.70 at baseline to 44.47 ± 5.17 after completing the motor relearning program.[10] The near identical baseline profile and clinical setting make this study a particularly useful reference point: the MRP group in the present study started at 24.80 ± 2.53 and ended at 42.10 ± 3.51, a trajectory that tracks closely with the Naz et al. data. This consistency across two independent trials with sub-acute patients, strengthens the argument that the improvements observed here are genuine and reproducible rather than sampling or measurement.

Ghrouz (2023) reported MRP-driven BBS improvement from 36.94 ± 5.53 to 50.72 ± 3.79 across eight weeks. [16] The higher post-treatment values in that study compared to the present MRP group (42.10 ± 3.51) are not surprising given the better initial balance function of participants in that study. Previous research conducted in 2023 by Sakshi Jaitly et al. found that the mean of BBS at baseline was 33.88 ± 7.12 and at the 3rd follow-up at 4th week was 39.53 ± 5.92 for patients given constraint-induced movement therapy, which shows significant improvement. It supports this study, which also shows significant improvement in values of BBS with a mean value at baseline of 24.20 ± 2.22 and at the 8th week of 48.70 ± 3.34 in patients given modified constraint-induced movement therapy. [17]

What this study contributes to the current body of research is not the demonstration of effectiveness for either of the methods but a head-to-head comparison conducted in the same clinical setting among the same patients using the same criteria. The group using the mCIMT approach demonstrated significant improvements earlier than those in the MRP group and were able to sustain this throughout week eight indicates that there may be more to this approach than time. mCIMT as implemented here required little more than a knee extension brace and a clearly defined task progression. Future research should investigate whether the balance benefits observed extend beyond the intervention period and whether combined protocols incorporating elements of both approaches might offer further advantage.

CONCLUSION

In comparison to patients undergoing a motor relearning program, the group getting modified constraint induced movement therapy demonstrated the most noticeable improvement in balance, according to the study's conclusion that there was a significant difference between the two groups (mCIMT and MRP).

LIMITATIONS

The use of purposive sampling introduces a risk of selection bias which limits the generalizability of the findings to the broader stroke population.

Fundings: No source of funding was involved.

CONFLICT OF INTEREST

The authors affirm that they have no conflicts of interest with regard to the article's publication. The writers also don't have any conflicting interests.

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