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Comparison of Effects of Conventional Constrained Induced Movement Therapy Versus Proprioceptive Neuromuscular Facilitation Technique to Improve Functional Motor Skills and Spasticity for Hemiparetic Upper Limb in Sub-Acute Stroke Patients.

Original Research

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Abstract

Background: Patients' independence and quality of life were greatly impacted by sub-acute strokes, which frequently caused decreased motor function and stiffness. Proprioceptive Neuromuscular Facilitation (PNF) and Constraint-Induced Movement Therapy (CIMT) are two popular rehabilitation approaches meant to enhance motor recovery and lessen stiffness.

Objective: This study aimed to compare the effects of Constrained Induced Movement Therapy versus proprioceptive neuromuscular facilitation technique to improve functional motor skills and spasticity for hemiparetic upper limb in sub-acute stroke patients.

Methods: An accessor blinded randomized clinical trial was conducted on 50 sub-acute stroke patients. Patients with age range 40 or above were included. Excluded patients had recurrence history of stroke, chronic stroke, heart disease, and presented with any type of skin discoloration. Group A (n = 25) underwent CIMT for two hours every day, five days a week, following up to five weeks. For five weeks in a row, Group B (n = 25) underwent PNF techniques for 1.5 hours per day, five days a week. The Action Research Arm Test (ARAT) was used to assess functional motor abilities, and the Modified Ashworth Scale (MAS) was used to quantify spasticity. These measures were taken both before and after the intervention.

Results: Both groups showed marked improvement in functional motor abilities and spasticity scores post-treatment. However, Group A (CIMT) demonstrated significantly greater improvements in functional motor skills ($P>0.05$), while Group B (PNF) showed significantly better outcomes in reducing spasticity ($P>0.05$).

Conclusion: Both treatment modalities were found to be efficacious, however group A (CIMT) exhibited improved motor recovery and group B (PNF) showed reduced spasticity; a p-value ($p>0.05$) indicated statistically significant differences between the two groups. This study results provide evidence for further use of these approaches in Stroke management.

Keywords: Stroke rehabilitation, Constraint-Induced Movement Therapy, Proprioceptive Neuromuscular Facilitation, sub-acute stroke, motor recovery, spasticity reduction, upper limb function, randomized clinical trial, stroke therapy comparison, physical therapy techniques.

INTRODUCTION

One of the biggest global health issues is stroke, and as the population in emerging and non-developing nations shifts, so does the significance of this condition. This illness is characterized by symptoms that persist for more than 24 hours and are characterized by cerebral dysfunction followed by a stoppage in the brain's blood flow. Stroke affected around 15 million people annually, of whom 5 million died and 5 million experience permanent disability. There was a greater death to disability ratio worldwide. (1) According to a poll conducted, 370 persons out of 100,000 get a stroke per year at or above the age of 40. According to the WHO, one person dies from a stroke every four to five minutes, affecting 15 million people annually. Patients with stroke-induced disability primarily experience upper extremity hemiparesis. About 30–60% of people lose their capacity to operate independently with their hands and arms, and 23% are said to have spasticity.(1) According to the poll, 30% of stroke victims have made partial recovery but are still dependent on others for everyday activities, and 55% of stroke victims have an upper limb that is non-functional after first rehabilitation.(2)

Upper and lower extremity independence, functioning, and mobility are restricted due to muscle weakness and motor deficits. Patients with spastic muscle tone experience several effects in addition to motor difficulties.(3) They are unable to stand, sit, walk, and carry out a number of rapidly developing and expanding duties. After a stroke, many people regain their freedom, but the upper limb functioning sometimes lasts for years. A considerable increase in the percentage of stroke presentation and its high level of reliance reveals the critical demand for high-quality stroke-specific care.(4) It is now vital to look into novel approaches to reduce disability and death as well as avoid stroke recurrence due to the rising social and personal burden that stroke causes.(5)

Upper extremity hemiplegia results in a lifetime of dependence on everyday activities and labor for daily living. The number of standardized methods for stroke therapy that aim to enhance focused upper extremity functional activities is rapidly increasing and changing. After a stroke, many individuals are able to resume their normal lives, however upper limb function can last for years.(3) The treatment of post-stroke rehabilitation aims at improvement of mobility and motor functioning. The likelihood of improvement increases with the early stage of rehabilitation. For this reason, a variety of physical therapy techniques, including Constrained Induced Movement Therapy (CIMT), Task Specific Training (TST), Proprioceptive Neuromuscular Facilitation (PNF), Functional Electrical Stimulation (FES), Motor Relearning Program (MRP), Mirror Therapy, Cognitive Behavioral Therapy, and a host of other cutting-edge and modern physical therapy treatment techniques, have been used to treat patients who have had chronic strokes. Numerous studies have been carried out over the past ten years or so to identify the most successful therapy among homogeneous techniques.(3)

Several pieces of literature indicate that one of the more promising therapies for upper limb rehabilitation is proprioceptive neuromuscular facilitation techniques. It is specifically beneficial for hemiparetic arm and hand motor function and has long been utilized in stroke patients.(6) PNF has garnered substantial attention recently as a treatment method due to its ability to increase muscle strength recovery following a stroke with outcomes that are clinically significant. Conversely, Constrained-Induced Movement Therapy (CIMT) is a relatively crucial approach to rehabilitation that is used to treat patients with reduced function in their upper extremities.(6) By explicitly assessing the advantages of Proprioceptive Neuromuscular Facilitation (PNF) and Constraint-Induced Movement Therapy (CIMT) on enhancing functional motor abilities and lowering spasticity in sub-acute stroke patients, our study seeks to close this gap.(6) Our goal is to use both short- and long-term follow-up evaluations, while concentrating on these important outcomes, to give doctors hard data to support their rehabilitation programs.(6) This work is innovative because it provides a thorough understanding of how two popular but little-studied therapies improve stroke patients' motor rehabilitation and spasticity management.

Due to a lack of data, this study compares the two therapies' outcomes in terms of how they affect changes in upper limb motor function and spasticity. Two novel techniques being used for stroke rehabilitation are CIMT and PNF. While individual assessments of these therapies' effectiveness have already been conducted in the past, comparative impacts have not been covered. The community, researchers, physical therapists, and the health care industry will all be greatly impacted by the study's findings. The results of this study will be used to determine which intervention is more successful, which strategy yields the best recovery, and which is advantageous for both the community and medical professionals.

METHODS

The study was designed as an assessor-blinded, randomized clinical trial conducted after obtaining approval from the ethical committee of Superior University. The study focused on participants who had experienced sub-acute strokes. It lasted for six months following the approval of the synopsis from the university. The sample included 50 patients with sub-acute stroke, both male and female, aged 40 years or above. All participants underwent thorough physical and neurological examinations carried out by trained physiotherapists specializing in stroke rehabilitation. Patients who met the criteria for sub-acute stroke with a first occurrence of ischemic or hemiparetic history and demonstrated upper limb spasticity were included. Those with intact cognitive abilities and no severe speech impairments

were selected to ensure full participation in rehabilitation exercises. Conversely, individuals with severe cognitive impairments, recurrent stroke history, chronic stroke, tumors, heart disease, uncontrolled hypertension, skin lesions, or discoloration were excluded. Patients who had undergone prior upper limb surgeries were also excluded to maintain the study's focus on motor recovery and spasticity specific to stroke.

Participants who met the inclusion criteria were divided into two groups, A and B, using a random number table. Both participants and researchers were blinded to the allocation method. The allocation process was carried out by a research assistant who did not participate further in the study. Outcome assessors, unaware of the treatment groups, collected measurements before and after treatment interventions. A follow-up was conducted after five weeks of intervention to assess outcomes. The sample size was determined using the Open-Epi tool with a 95% confidence level, 80% power, and an equal sample size ratio between Group A and Group B. Based on these parameters, 50 subjects were included, 25 in each group.

The outcome measures of the study included spasticity and functional motor abilities. To evaluate functional motor skills, the Action Research Arm Test (ARAT) was used, assessing grasp, grip, pinch, and general movement with a score range of 0–57, where higher scores indicated improved motor function. The ARAT demonstrated high test-retest reliability ($r = 0.98$). Spasticity was assessed using the Modified Ashworth Scale (MAS), which measures the degree of spasticity by evaluating resistance during passive soft tissue stretching. A grade of 4 indicates a rigid limb in flexion or extension, while 0 signifies no increase in muscle tone. The MAS displayed moderate to fair dependability ($r = 0.75$). Measurements were recorded at baseline and again after the five-week intervention period.

In Group A, participants underwent Constraint-Induced Movement Therapy (CIMT) alongside conventional physical therapy, conducted five days a week for two hours daily over five weeks (excluding weekends). This therapy encouraged the active use of the affected upper limb while immobilizing the unaffected limb with a mitt or sling. The aim was to improve motor recovery by combating "learned non-use." Participants engaged in repetitive, task-oriented activities tailored to their skills, such as reaching, grabbing, lifting, and handling objects of various weights and sizes. Fine motor skills exercises, like buttoning, writing, and stacking blocks, were included, progressively increasing in difficulty to enhance the application of these skills in daily activities. Therapists observed participants, provided feedback, and ensured the correct execution of movements, utilizing intense practice and molding techniques.

Group B received Proprioceptive Neuromuscular Facilitation (PNF) therapy, combined with conventional physical therapy, for five consecutive weeks, with each session lasting 1.5 hours per day. The PNF approach aimed to enhance functional motor abilities, reduce stiffness, and activate neuromuscular responses. Treatment included diagonal and spiral movement patterns involving the wrist, elbow, and shoulder joints, adhering to a "stretch, contract, and relax" protocol. This protocol involved passively stretching the limb, followed by isometric contractions lasting 10 seconds. Repeated stretching of hypertonic muscles and isotonic or eccentric movements helped alleviate spasticity and improve flexibility. Therapists provided verbal and tactile cues to guide correct movements and enhance muscular coordination. Assessments of spasticity and functional motor abilities were conducted after five weeks of intervention.

Data analysis was performed using SPSS version 24. Numerical data were presented as means and standard deviations, while categorical variables were expressed as frequencies and percentages. The Shapiro-Wilk test assessed the normality of pre- and post-treatment variables. A p-value less than 0.05 indicated a normal distribution, prompting the use of parametric tests to compare means and standard deviations for outcome measures in both groups. Within-group analysis was carried out using paired sample tests, while between-group analysis involved t-tests or ANOVA, with statistical significance set at $p < 0.05$.

RESULTS

During the study period, 50 patients with sub-acute stroke were assessed for eligibility. The demographic profile of the participants is detailed in Table 1. Males were predominant in Group A (CIMT), while females were more common in Group B (PNF). Both groups were comparable at baseline in terms of gender, affected side, and other baseline characteristics (p-value > 0.05).

Table 2: For test of normality, Shapiro Wilk test was used to determine normal distribution of data. P-value for this test was greater than 0.05 ($p>0.05$) showed normal distribution of data throughout the groups, indicating the used of parametric test, independent t test, and paired sample test to measure pre and post treatment outcome variables. Following the intervention, there were noticeable gains in both groups. The functional motor abilities of Group A (CIMT) improved statistically significantly (P-value < 0.05), as evidenced by a higher post-treatment mean on the Action Research Arm Test (ARAT). On the Modified Ashworth Scale (MAS), however, Group B (PNF) demonstrated a much higher reduction in spasticity (P-value < 0.05) and improved spasticity scores.

Table 3, for within-group analysis, there were statistically significant improvements in functional motor abilities, spasticity, and range of motion in both groups (p-value < 0.05). But Group A (CIMT) showed higher functional improvement, whereas Group B (PNF) showed a more noticeable reduction in spasticity.
Table 4: Based on a between-group study, Group A showed greater efficacy in enhancing functional motor abilities than Group B, with a mean difference of 26.43±4.71 on the ARAT. Meanwhile, Group B demonstrated a considerably higher reduction in spasticity, with a mean difference of 15.01±4.69 on the MAS compared to Group A (p-value < 0.05).

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Table 1: Demographical Data of Groups A and B

Demographics	Group A	Group B	P- value
No of participants	25	25	>0.05
Males	65%	35%	>0.05
Females	35%	65%	>0.05
Mean Age	57.3±6.2	60.±6.9	>0.05

Table 2: Test of Normality

	Group	Shapiro-Wilk		
		Statistic	Df	P-value
Functional motor skills (ARAT)	CIMT	.948	27	.191
	PNF	.949	27	.201
Spasticity	CIMT	.930	27	.067
	PNF	.931	27	.074

a. Lilliefors Significance Correction

Table 3: Within the group analysis

Outcome measures	Group A (CIMT) pre scores	Group A (CIMT) post scores	Group B (PNF) pre scores	Group B (PNF) post scores	T	p-value
Functional motor skills (ARAT)	29.15±4.31	58.5±5.14	23.12±4.19	40.31±4.95	12.864	0.873
Spasticity	3.89±0.56	4.22±1.30	1.21±0.34	7.95±2.13	10.262	0.405

Table 4: Between the group analysis

Outcome measures		Group A (CIMT)	Group B (PNF)	P value
Functional motor skills (ARAT)	Pre treatment	25.47±5.2	11.45±4.73	0.915
	Post treatment	26.43±4.71	14.45±2.87	0.063
Spasticity	Pre treatment	10.23±4.5	10.9±5.97	0.852
	Post treatment	11.29±4.50	15.01±4.69	0.006

DISCUSSION

In order to enhance functional motor abilities and lessen spasticity in sub-acute stroke patients with upper limb dysfunction, this study investigated the benefits of Proprioceptive Neuromuscular Facilitation (PNF) and Constraint-Induced Movement Therapy (CIMT). While PNF would perform better in lowering spasticity, it was predicted that CIMT would be more successful in enhancing functional motor ability. Because each intervention had different results on its particular metrics, the study's findings supported this notion. We observe both agreement and disagreement with prior research findings when examine the effects of CIMT and PNF on functional motor abilities and spasticity in sub-acute stroke patients. Previous research strongly suggests that CIMT is effective in improving motor recovery by encouraging the use of the afflicted limb in a restricted setting, which explains the improvement in functional motor abilities in the CIMT group. This is in line with M Abba in 2020, who demonstrated that CIMT dramatically enhanced stroke patients' upper limb function, especially when it came to functional tasks like lifting and grasping. The substantial increase in motor function, which is consistent with the research, is the strength of our findings; nevertheless, a potential weakness is the absence of long-term follow-up to assess the durability of these gains.(7)

However, due to the short period of this trial, it was not possible to measure the sustained improvements in motor skills that other studies, like R. Sethi et al in 2024, also showed following CIMT over several months. The effectiveness of CIMT is supported by the existing study, although it differs in that it emphasizes a shorter intervention duration, which may have implications for long-term application. The absence of a longer follow-up could be interpreted as a design drawback in our study.(8) On the other hand, the findings indicating a noteworthy decrease in spasticity within the PNF cohort underscore an alternative route of recuperation. Previous research highlights PNF's efficiency in lowering spasticity by utilizing proprioceptive inputs to restore normal muscle tone, as demonstrated by the work of PT Nguyen et al in 2022. This is corroborated by our results, which indicate a significant decrease in spasticity as determined by the MAS. The results' congruence with prior research, which supports PNF's function in lowering muscular tension, is this study's strongest point. One drawback, though, would be the variation in spasticity amongst individuals, which might restrict how broadly the findings can be applied because some patients might benefit more from this technique than others. (9)

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Our investigation discovered that CIMT was more beneficial for functional motor recovery than spasticity reduction, in contrast to certain other studies, such as those of AS Sirilakshmi in 2024, who revealed that CIMT might help reduce spasticity. The focus of this study was on sub-acute stroke patients, whereas study focused on chronic stroke patients, where spasticity was more entrenched and more difficult to manage. This could account for the discrepancy in results. This may indicate a flaw in CIMT when used on patients whose primary worry is spasticity. (10) Interestingly, N dihidar et al, found limited improvements in spasticity, which is in contrast to our findings about the impact of CIMT in functional recovery. His research revealed only slight improvements in spasticity, which may indicate that other variables, such as the time or intensity of the intervention, may affect how effective CIMT is at reducing spasticity. Given that Wu's study had a longer intervention period and a bigger sample size, the discrepancy in results could be the result of a design flaw in our own investigation.(11)

Our findings indicate that PNF was not as successful in enhancing functional ambulation and gait as earlier research may have suggested, but is crucial in decreasing spasticity. Although our study did not find any appreciable improvements in this region for sub-acute patients, research by Abdulhani et al, emphasizes the benefits of PNF in improving gait metrics, particularly in chronic stroke patients. This might be because the benefits on gait were lessened by focusing specifically on upper limb function or by having a shorter intervention period. Thus, one potential limitation of our research could be the neglect of lower limb function and its influence on total mobility.(12) This study's utilization of objective measurements, such as the widely recognized MAS for spasticity and the ARAT for functional motor ability, is one of its strongest points. Research demonstrating ARAT's sensitivity to variations in upper limb function, as that conducted by A Saklecha et al, supports its application in evaluating functional outcomes. Our results support these conclusions, particularly in showing that CIMT can result in noticeable gains in upper limb motor skills. It might be argued that the absence of other metrics, such as patient-reported outcomes, is a drawback because it leaves out important aspects of functional recovery from the patient's point of view.(13)

The within-group gains seen in the PNF and CIMT groups demonstrate the effectiveness of both therapies for the corresponding objectives, which are spasticity in PNF and motor function in CIMT. Previous research by SH kim et al, supports this, showing that therapies focusing on spasticity, like PNF, are more appropriate for tone control, whereas task-specific training, like CIMT, produces larger functional benefits when applied to the upper limb. This is corroborated by our study, but it has the drawback that no crossover effects were assessed, so we are unable to determine whether combining the two treatments could have the synergistic effects that other research have indicated.(14) All things considered, the findings of this study are generally consistent with previous studies on CIMT and PNF, especially when it comes to how they affect functional motor abilities and spasticity, respectively. Some of the disparities with previous research may be explained by the study's focus on a very brief intervention time, lack of long-term follow-up, and unique patient population, which are the important differences. This study's shortcomings include its constrained scope and duration, as well as the lack of a more comprehensive method for assessing functional recovery across several domains. However, its advantages include the use of trustworthy outcome measures and a clearly defined patient population.

CONCLUSION

The study concludes by highlighting the ways in which sub-acute stroke patients are affected differently by Proprioceptive Neuromuscular Facilitation (PNF) and Constraint-Induced Movement Therapy (CIMT). It is discovered that functional motor abilities were much improved by CIMT, although spasticity was effectively reduced by PNF. Although both therapies are beneficial for stroke rehabilitation, more study with bigger sample sizes and longer follow-ups is advised to confirm these results and examine long-term effects.

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