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Effectiveness of Music Therapy as an Adjunct with Modified-Constraint Induced Movement Therapy in Upper Limb Function in Post Stroke Patients

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Abstract

Background: Stroke is a leading cause of long-term disability, with upper limb dysfunction being a major determinant of reduced independence and quality of life. Modified Constraint-Induced Movement Therapy (m-CIMT) is an evidence-based intervention for upper limb motor recovery, while music therapy has emerged as a promising adjunct that stimulates neuroplasticity, enhances motivation, and improves emotional well-being. Integrating these two approaches may yield synergistic effects on post-stroke rehabilitation.

Methods: Eleven post-stroke patients meeting inclusion criteria were recruited through convenient sampling. Participants received a combined intervention of music therapy and m-CIMT, consisting of three hours of daily restraint of the unaffected limb and structured functional tasks (pegboard and box-and-block activities) performed over two weeks, with concurrent exposure to rhythmic music (Pachelbel's Canon in D). Upper limb motor function was assessed pre- and post-intervention using the Fugl-Meyer Assessment of Upper Extremity (FMA-UE) and Wolf Motor Function Test (WMFT).

Results: Significant improvements were observed in upper limb motor recovery following the combined intervention. FMA-UE scores increased from baseline to post-test with high statistical significance ($p < 0.001$). WMFT functional activity scores also improved significantly ($p < 0.001$), while WMFT time scores did not change significantly. Patients tolerated the intervention well and reported positive engagement with music-assisted training.

Conclusion: The integration of music therapy with m-CIMT significantly enhances upper limb function in post-stroke patients. This combined approach is feasible, motivating, and clinically valuable, offering a cost-effective adjunct to standard neurorehabilitation. Larger randomized controlled trials with longer follow-up are warranted to confirm these preliminary findings.

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Keywords: Music Therapy, Stroke Rehabilitation, Modified Constraint-Induced Movement Therapy, Fugl-Meyer Assessment.

Introduction

Stroke remains a leading cause of long-term disability worldwide, contributing substantially to functional dependence, reduced quality of life, and socioeconomic burden (Feigin *et al*., 2014; Langhorne *et al*., 2011) [2, 8]. Among the sequelae of stroke, upper limb dysfunction is particularly debilitating, as it restricts independence in activities of daily living (ADLs) and often persists despite conventional rehabilitation efforts (Pollock *et al*., 2014) [13]. The persistence of upper limb impairment underscores the need for innovative and engaging interventions that promote motor recovery, enhance motivation, and support long-term

adherence to therapy (Winstein *et al*., 2003) [22]. Constraint-Induced Movement Therapy (CIMT) has been one of the most influential approaches in upper limb rehabilitation, as it directly addresses the phenomenon of "learned non-use" by constraining the unaffected limb and engaging the affected side in intensive, task-oriented training (Taub *et al*., 2006) [20]. Modified CIMT (m-CIMT) has been developed to increase feasibility by reducing training intensity while maintaining clinical effectiveness (Page & Levine, 2007; Wolf *et al*., 2008) [10, 23]. However, while CIMT-based interventions have demonstrated efficacy, patient adherence can be limited due to the demanding nature of the protocol and the monotony of repetitive exercises.

Music therapy has emerged as a promising adjunct in neurorehabilitation, offering multisensory stimulation that engages auditory, motor, and emotional networks (Wu *et al*., 2025) [24]. Neuroimaging studies demonstrate that rhythm and melody can drive plastic changes in motor and language networks, supporting recovery after stroke (Altenmüller & Schlaug, 2015; Särkämö *et al*., 2014) [1, 17]. Interventions such as rhythmic auditory stimulation, therapeutic instrumental performance, and singing-based protocols have been shown to improve coordination, motor control, and even linguistic recovery (Schneider *et al*., 2007; Impellizzeri *et al*., 2024) [18, 5]. Beyond motor outcomes, music therapy also contributes to psychological well-being by reducing post-stroke depression and improving quality of life (Rushing *et al*., 2019; Poćwierz-Marciniak & Bidzan, 2017) [15, 12]. This dual impact on motor and emotional recovery highlights music's unique therapeutic potential.

Recent trials and case studies further underscore the versatility of music-based interventions. For example, music-motor therapy applications such as "GotRhythm" have explored rhythm-based training via mobile technology, though adherence challenges remain in clinical practice (Hankinson *et al*., 2022) [4]. Similarly, neurologic music therapy has been adapted for aphasia recovery, showing significant linguistic and neuroplastic gains (Impellizzeri *et al*., 2024) [5]. In community and resource-limited settings, culturally tailored music interventions have been successfully implemented, demonstrating feasibility, engagement, and patient satisfaction (Rajagopal *et al*., 2024) [14]. Collectively, these findings indicate that music therapy not only facilitates neuroplasticity but also provides an enjoyable, motivating environment that may increase participation and adherence to therapy.

Given these complementary mechanisms, integrating music therapy with m-CIMT may yield synergistic benefits by combining the proven motor retraining of CIMT with the auditory-motor coupling and motivational effects of music. Prior systematic reviews support the use of music-supported therapy for upper limb rehabilitation (Galvis & King, 2023) [3], and feasibility studies indicate its adaptability in both clinical and home-based programs (Street *et al*., 2015) [19]. However, limited empirical evidence exists on the combined application of music therapy and m-CIMT. Therefore, the present study was designed to evaluate the effectiveness of this integrated approach on upper limb motor function in post-stroke patients, with the hypothesis that the dual intervention would result in greater functional improvements than m-CIMT alone.

Research Method

Study Design and Duration: This study was designed as a pre- and post-test experimental trial conducted over one year between 2022 and 2023.

Study Setting: The intervention and assessments were carried out at the Department of Physiotherapy, Sardar Bhagwan Singh University, Balawala, Dehradun, Uttarakhand, and at affiliated clinical centres including the Advance Neurorehabilitation and Rejuvenation Centre and the College OPD.

Ethical Considerations: Prior approval was obtained from the Institutional Ethical Committee of Sardar Bhagwan Singh University. Written informed consent was secured from all participants before enrolment, and confidentiality of patient information was maintained throughout the study.

Participants: A total of eleven post-stroke patients were recruited using convenient sampling. Both male and female participants aged between 24 and 70 years were included.

Inclusion criteria: Patients in the acute or sub-acute stage of stroke; ability to extend at least 10° at the metacarpophalangeal and interphalangeal joints and 20° at the wrist; Modified Ashworth Scale grade ≤ 2; Mini-Mental State Examination score > 17; and Brannstrom recovery stages 2–3 for the hand and 4–5 for the arm.

1. **Exclusion criteria:** Uncooperative patients, those with moderate-to-severe pain, or with additional neurological/musculoskeletal impairments interfering with upper limb rehabilitation.
2. **Intervention Protocol:** The experimental group received a combination of Modified Constraint-Induced Movement Therapy (m-CIMT) and music therapy. The unaffected limb was restrained for three hours per day using an arm sling, while the affected limb was trained through two functional activities.

The pegboard activity emphasized repetitive reaching, grasping, and releasing movements, while the box-and-block activity focused on gross motor function, grip strength, and coordination. Each activity was performed for thirty minutes with short rest intervals, totalling three hours of practice daily. The sessions were conducted five days per week for two consecutive weeks.

Throughout the intervention, patients were exposed to structured background music (Pachelbel's Canon in D), providing rhythmic auditory stimulation and improving patient motivation.

Outcome Measures

1. **Upper limb motor function was assessed using two standardized outcome measures:** Fugl-Meyer Assessment of Upper Extremity (FMA-UE): Evaluates reflex activity, synergy, grasp, coordination, and voluntary control of the affected limb (Figure 1).
2. **Wolf Motor Function Test (WMFT):** Measures both task completion time and quality of functional ability during standardized tasks.

Fig 1: Fugl-Meyer Assessment

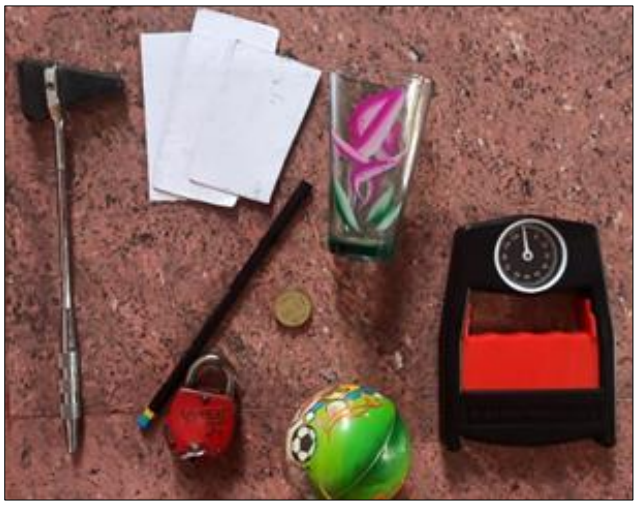

Fig 2: Basic equipment used in assessment

Fig 3: Basic equipment used in activity

Fig 4: Pegboard activity

Instruments and Materials: Standardized equipment was employed to perform the assessments. For the FMA-UE, tools included a reflex hammer, pencil, scrap of paper, coin, small cylinder, glass, tennis ball, goniometer, and stopwatch (Figure 2). For the WMFT, instruments such as a pegboard, wooden blocks, adjustable table, weight cuffs, unopened can, lock and key, towel, and basket were used (Figures 3 and 4).

Procedure: At baseline, patients were assessed using FMA-UE and WMFT prior to the start of the intervention. The combined music therapy and m-CIMT protocol was then administered for two weeks as described. At the end of the intervention, patients were re-assessed using the same outcome measures to determine post-test performance.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using SPSS software (version 29). Descriptive statistics (mean ± standard deviation) were calculated, and pre- and post-test scores were compared using paired t-tests. A p-value < 0.05 was considered statistically significant.

Results

Data were analysed using mean, standard deviation, and paired t-tests with a significance level of $p < 0.05$.

Table I and figure 5 presents the comparison of pre- and post-intervention Fugl-Meyer Assessment (FMA-UE) scores. The mean score increased from 31.63 ± 8.16 at baseline to 40.18 ± 10.71 after two weeks of therapy. The paired t-test revealed a highly significant improvement ($t = 7.50$, $p = 0.00002$), indicating substantial gains in upper limb motor function following the intervention.

Table II and figure 6 summarizes the results of the Wolf Motor Function Test (WMFT). The functional activity score improved significantly from 27.00 ± 14.06 to 41.09 ± 16.23 ($t = 7.21$, $p = 0.000026$). However, the WMFT time

component showed no statistically significant difference (Pre: 86.6 ± 39.08; Post: 92.55 ± 52.19; t = 1.27, p = 0.238).

Table 1: Pre- and Post-Comparison of Fugl-Meyer Assessment (FMA-UE)

Measure	Pre-test (Mean ± SD)	Post-test (Mean ± SD)	*t*-value	*p*-value	Result
FMA-UE Score	31.63 ± 8.16	40.18 ± 10.71	7.502	0.00002	Significant

Table 2: Pre- and Post-Comparison of Wolf Motor Function Test (WMFT)

Measure	Pre-test (Mean ± SD)	Post-test (Mean ± SD)	*t*-value	*p*-value	Result
WMFT – Time (sec)	86.60 ± 39.08	92.55 ± 52.19	1.273	0.238	Not Significant
WMFT – Functional Score	27.00 ± 14.06	41.09 ± 16.23	7.207	0.000026	Significant

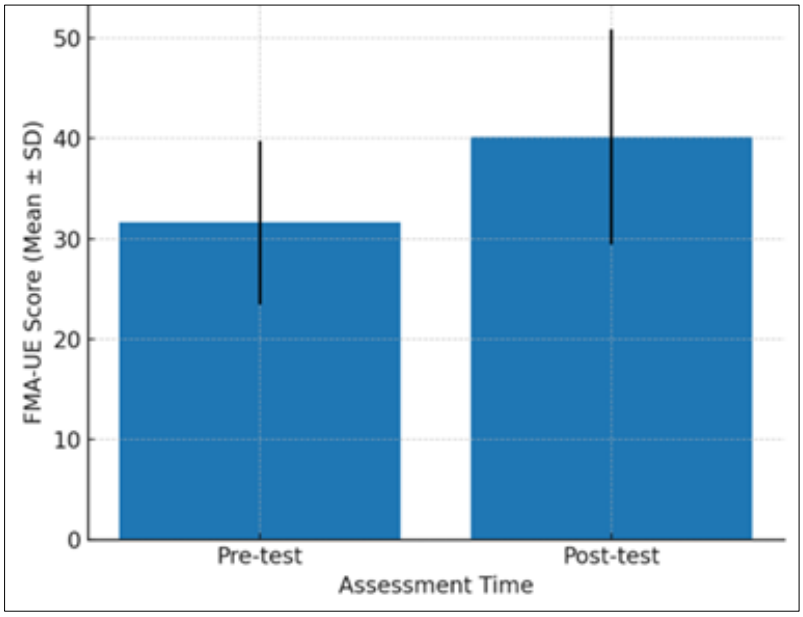

Fig 5: Pre- and Post-Comparison of Fugl-Meyer Assessment (FMA-UE)

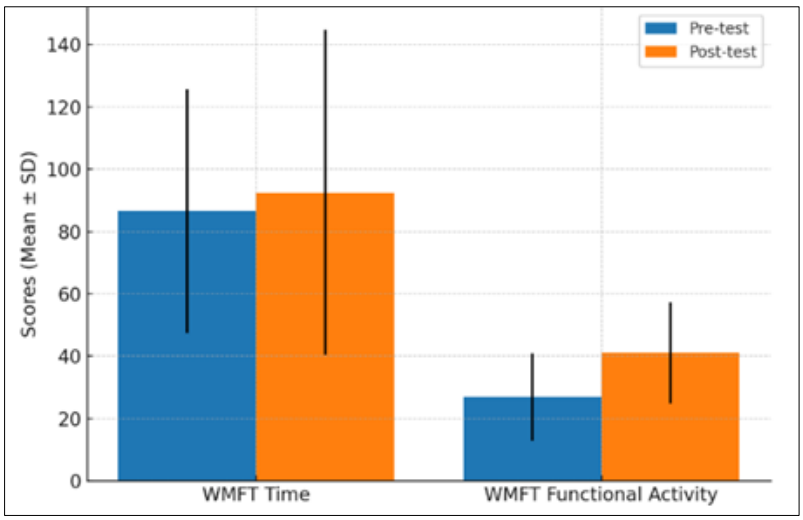

Fig 6: Pre- and Post-Comparison of WMFT (Time and Functional Activity)

Discussion

The present study examined the combined effect of music therapy and modified constraint-induced movement therapy (m-CIMT) on upper limb function in post-stroke patients. Significant improvements were observed in Fugl-Meyer Assessment of Upper Extremity (FMA-UE) scores and functional ability in the Wolf Motor Function Test (WMFT), indicating that the integrated intervention enhanced motor recovery. However, no significant improvement was detected in WMFT task completion times, suggesting that gains in movement quality may precede measurable changes in speed. These results align with earlier findings that CIMT and its modified versions promote functional recovery through the principle of overcoming "learned non-use" (Taub *et al*., 2006; Page & Levine, 2007) [20, 10], while also highlighting the potential of music therapy to augment motor relearning through rhythmic entrainment and multisensory engagement (Altenmüller & Schlaug, 2015; Thaut *et al*., 2007) [21].

The observed improvements are consistent with evidence that music-based interventions can facilitate neuroplasticity and improve functional outcomes in stroke survivors. Schneider *et al*. (2007) [18] demonstrated that music-supported therapy

enhanced fine motor skills by providing auditory feedback during repetitive tasks, while Särkämö *et al*. (2014) [17] showed structural brain changes associated with daily music listening during recovery. More recent work by Galvis and King (2023) [3] confirmed in a systematic review and meta-analysis that music-applied therapies significantly improved upper extremity motor function, supporting the rationale for incorporating music into structured rehabilitation protocols. In the current study, the use of Pachelbel's Canon as rhythmic auditory stimulation likely provided external timing cues, consistent with prior evidence that rhythm enhances motor coordination and synchronization (Ruotsalainen *et al*., 2022; Knight & Rickard, 2001) [16, 7].

Beyond motor outcomes, music therapy offers psychosocial benefits that may indirectly support rehabilitation. Post-stroke depression and emotional distress are common barriers to recovery, reducing engagement and functional outcomes (Rushing, 2019) [15]. Evidence from both acute and subacute phases of stroke recovery suggests that active music therapy can elevate mood and reduce depressive symptoms (Rushing *et al*., 2021; Lee *et al*., 2017) [15]. Similarly, Poćwierz-Marciniak and Bidzan (2017) [12] demonstrated that structured music therapy improved quality of life by enhancing vitality, mental health, and communication. These findings complement our observation that patients tolerated and engaged positively with the intervention, suggesting that music may have motivated greater adherence to repetitive task practice during m-CIMT.

However, our study did not demonstrate significant improvements in WMFT task execution speed within the two-week intervention. Similar findings were noted by Winstein *et al*. (2003) [22], where motor quality improved before measurable gains in speed were evident. This may indicate that prolonged or higher-intensity interventions are necessary to translate improvements in motor control into faster task performance. Furthermore, trials such as Hankinson *et al*. (2022) [4] using digital music-motor interventions highlight that adherence remains a critical challenge, particularly in clinical environments with competing therapeutic demands.

The feasibility of music therapy in diverse contexts is supported by studies conducted in both technologically advanced and resource-limited settings. For example, Rajagopal *et al*. (2024) [14] demonstrated the adaptability of neurologic music therapy within rural Indian communities, using culturally relevant approaches to foster engagement. Similarly, digital innovations such as the ReWin application have emphasized the importance of context-sensitive rehabilitation strategies in India, showing that scalable technology-assisted approaches are feasible but must be adapted to patient needs (Kamalakannan *et al*., 2022) [6]. These insights are particularly relevant to our study, as integration of music therapy with conventional physiotherapy may represent a cost-effective, culturally adaptable strategy for stroke rehabilitation in low- and middle-income countries.

Despite promising findings, this study has limitations. The small sample size, short intervention duration, and absence of a control group restrict the generalizability of results. Moreover, the reliance on a single type of musical stimulus (Pachelbel's Canon) may limit conclusions about the optimal selection of music for motor rehabilitation, as individual preference and cultural relevance strongly influence engagement and outcomes (Parada-Cabaleiro *et al*., 2020) [11]. Future research should address these gaps through larger randomized controlled trials, exploration of culturally tailored music selections, and investigation of long-term outcomes, including functional independence and psychosocial well-being.

Overall, the present study contributes to the growing evidence base supporting integrative neurorehabilitation approaches. By combining the proven motor retraining benefits of m-CIMT with the motivational and neuroplastic effects of music therapy, this intervention offers a promising avenue to optimize upper limb recovery post-stroke.

Conclusion

This study demonstrated that the integration of music therapy with modified constraint-induced movement therapy (m-CIMT) significantly improves upper limb motor recovery and functional ability in post-stroke patients. The findings highlight that while movement quality and control can improve within a short intervention period, improvements in task execution speed may require longer training durations. Given its low cost, non-invasive nature, and ease of integration into clinical practice, music therapy can be considered a valuable adjunct to physiotherapy-based stroke rehabilitation. Further large-scale randomized trials are recommended to validate and extend these findings.

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Conflict of Interest: The authors declare no conflicts of interest.

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