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Impact Of Beat Frequency in Rhythmic Auditory Stimulation un The Effectiveness of Motor Imagery in Stroke Rehabilitation

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ABSTRACT

Background: Motor Imagery (MI) combined with Rhythmic Auditory Stimulation (RAS) is an emerging approach in stroke rehabilitation. However, the optimal tempo for RAS remains unclear. This study evaluates the impact of beat frequency slow (50 bpm) vs fast (90 bpm) on motor outcomes when used with MI in stroke rehabilitation, while using a CIMT group as constant for comparison.

Methods: Forty post-stroke patients were randomized into three groups. Group A (n=20) received CIMT. Group B1 (n=10) practiced MI with slow RAS (50 bpm), and Group B2 (n=10) with fast RAS (90 bpm). All interventions lasted 16 weeks. STREAM and MMT scores were recorded at baseline and at the end of treatment.

Results: All groups showed significant improvement. However, Group B1 (slow RAS) showed better coordination and motor planning outcomes than B2 (fast RAS). CIMT group showed overall higher muscle strength gains.

Conclusion: Slow rhythmic cues (50 bpm) enhanced the effectiveness of Motor Imagery more than fast rhythms. Beat frequency should be considered in RAS-based stroke rehabilitation protocols.

1. INTRODUCTION

Stroke remains one of the leading causes of long-term disability worldwide[1]. Upper limb motor dysfunction affects a majority of stroke survivors[2]. Rehabilitation methods such as Constraint-Induced Movement Therapy (CIMT) and Motor Imagery (MI) have demonstrated significant benefits in neuroplastic recovery[3–4].

MI involves mentally simulating movement without actual physical motion[5]. Research shows that MI activates brain regions similar to those used during real movement, such as the primary motor cortex, SMA, and cerebellum[6–7]. Its use in stroke therapy improves motor coordination and function[8].

Rhythmic Auditory Stimulation (RAS), a neurologic music therapy technique, delivers auditory beats to synchronize and guide movement. It has proven effective in enhancing gait, timing, and coordination in stroke patients[9–10]. Combining MI with RAS may amplify motor recovery by stimulating both temporal and spatial aspects of movement planning[11].

The beat frequency (tempo) of RAS could play a pivotal role. Faster tempos may enhance automaticity, while slower beats may encourage precise motor planning by providing extended mental rehearsal time[12–13]. This study compares the impact of slow versus fast RAS tempos in MI-based rehabilitation and benchmarks their outcomes against a CIMT group.

2. MATERIALS AND METHODS

A total of 40 patients diagnosed with hemiparesis due to MCA stroke were included in this randomized controlled trial. Patients were divided into three groups:

- Group A (n=20): Received Constraint-Induced Movement Therapy (CIMT).
- Group B1 (n=10): Received Motor Imagery (MI) with slow Rhythmic Auditory Stimulation (50 beats per minute).
- Group B2 (n=10): Received MI with fast Rhythmic Auditory Stimulation (90 beats per minute).

The present study was approved from institutional ethical committee (PMU/PMCH/IEC/2024/267). The age group of 40–70 years, Brunnstrom stage ≥ 3, first-ever stroke, medically stable condition was included for present study. Patients with cognitive impairment, severe aphasia, or hearing loss were excluded. Outcome measures used were the STREAM (Stroke Rehabilitation Assessment of Movement) and MMT (Manual Muscle Testing) scales. Assessments were recorded at baseline and at the end of the 16-week intervention period.

3. PROCEDURE

Group A underwent CIMT protocol where the unaffected upper limb was constrained for most waking hours, while the affected limb was trained through shaping and task-specific practice for 1 hour/day, 5 days/week, over 16 weeks. Group B1 and B2 received guided MI sessions with rhythmic auditory stimulation. Participants listened to either slow (50 bpm) or fast (90 bpm) beats using headphones while mentally rehearsing functional upper limb tasks under therapist guidance. Sessions lasted for 1 hour/day, 5 days/week, for 16 weeks. Verbal feedback was used to ensure imagery vividness and accuracy.

4. RESULTS

All three groups demonstrated improvement in STREAM and MMT scores. Group A (CIMT) showed the most significant improvements in muscle strength and range of motion ($p < 0.01$). Among the MI + RAS groups, Group B1 (slow RAS) had better outcomes in motor coordination and task performance ($p < 0.05$), while Group B2 (fast RAS) showed improvements that were significant but relatively lower. The results suggest that slower rhythmic cues facilitate better motor imagery outcomes than faster beats, possibly due to enhanced cortical synchronization and motor planning.

5. DISCUSSION

This study supports existing literature that Motor Imagery, especially when paired with rhythmic auditory input, promotes neuroplasticity and functional recovery after stroke. The comparison between slow and fast RAS frequencies suggests that lower tempo may be more conducive to focused, deliberate motor planning, particularly for hemiparetic patients.

These results align with prior research showing that MI stimulates motor-related brain regions, and that auditory cues enhance timing and movement fluidity[14]. Slow tempos (50 bpm) allow patients more cognitive space to mentally visualize movements, likely improving task execution[12–13]. CIMT remains the gold standard for strength and ROM restoration[15]. CIMT, as expected, led to significant motor gains due to repeated use of the affected limb, which induces cortical remapping. However, the group receiving MI + slow RAS also showed robust gains, suggesting that non-physical methods can complement or even substitute physical therapy when applied correctly. The enhanced outcome in Group B1 highlights the need to individualize RAS tempo during MI training in clinical practice.

6. LIMITATION OF STUDY

- Small sample size per MI subgroup
- Lack of long-term follow-up beyond 16 weeks.
- No neuroimaging used to confirm cortical change.
- Cognitive and psychological measures were not assessed

7. CONCLUSION

Motor Imagery combined with Rhythmic Auditory Stimulation is an effective rehabilitation tool in post-stroke recovery. The

tempo of RAS significantly influences the effectiveness of MI, with slower rhythms (50 bpm) yielding better functional outcomes than faster beats. These findings suggest that RAS frequency should be customized to optimize patient outcomes. Further research with larger samples and neurophysiological validation is recommended.

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