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Integrating Music Therapy with Physical Therapy for Motor Function and Quality of Life in Cerebral Palsy. A Narrative Review

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Abstract

Introduction: Cerebral Palsy refers to a group of neurological disorders that appear in infancy or early childhood, permanently affecting body movements and muscle coordination. As the most common cause of disability in children, cerebral palsy impacts mobility, posture, and motor skills. Physiotherapy has shown efficacy in improving motor abilities, while music therapy leverages therapeutic music applications to engage and modify cerebral processes. Combining physiotherapy and music therapy may yield synergistic benefits, offering comprehensive rehabilitation for individuals with cerebral palsy. This study synthesizes existing literature on the role of music therapy as an adjunct to conventional interventions. **Methodology:** The PubMed database was searched for articles published between 2013 and 2023, focusing on randomized controlled trials, experimental studies, and systematic reviews. Relevant Medical Subject Headings (MeSH) terms included music therapy, physiotherapy, cerebral palsy, rhythmic auditory stimulation (RAS), and patterned sensory enhancement (PSE). Articles in non-English languages and abstracts without full text were excluded. **Conclusion:** Analysis of six articles revealed that music therapy, when combined with physiotherapy, improved motor function and quality of life for individuals with cerebral palsy. Music therapy emerged as a valuable component of rehabilitation, emphasizing its potential for clinical application.

Keywords: Rhythmic Auditory Stimulation, Rehabilitation, Neurological Disorders, Therapeutic Music Applications

1 Introduction

Cerebral palsy (CP) encompasses a spectrum of non-progressive neurological disorders caused by abnormalities in the developing brain, leading to permanent impairments in movement, posture, and motor function[1]. These deficits may be accompanied by sensory impairments, learning challenges, and orthopedic complications, contributing to limited independence in daily activities. In India, CP affects 1.5 to 4 per 1,000 live births[2]. Effective rehabilitation programs are critical to enhance motor skills and promote functional independence.

Music therapy, defined by the World Federation of Music Therapy, as the professional application of music and its elements to address physical, emotional, cognitive, and social needs. Neurologic music therapy evidence-based methods, such as PSE, therapeutic instrumental music performance (TIMP), and RAS, to improve motor planning, coordination, and communication. These methods harness the brain's neuroplasticity, facilitating motor and sensory integration through structured musical interventions. This study examines the combined efficacy of music therapy and

physiotherapy, emphasizing the need for broader clinical adoption of music-based interventions.

2 Methodology

The study aimed to systematically evaluate the effectiveness of combining music therapy and physiotherapy interventions in improving motor functions and quality of life among individuals with cerebral palsy. Specific objectives included synthesizing evidence on the impact of these interventions on motor functions and quality of life, as well as evaluating their feasibility and acceptability.

A narrative literature review was employed as the research design, utilizing the PubMed database as the primary data source. Articles published between 2013 and 2023 were included, with a focus on full-text studies in English that incorporated both music therapy and physiotherapy as interventions. The search strategy involved Key Medical Subject Headings (MeSH) terms such as "Music Therapy," "Physiotherapy," "Cerebral Palsy," "Rhythmic Auditory Stimulation," and "Patterned Sensory Enhancement" were employed to retrieve relevant studies. The review prioritized randomized controlled trials, experimental designs, and systematic reviews while excluding studies with limited or irrelevant outcomes. This comprehensive methodology ensured a targeted and systematic approach to evaluating the intersection of music therapy and physiotherapy for cerebral palsy rehabilitation. Fig. 1 shows the methodology of the review.

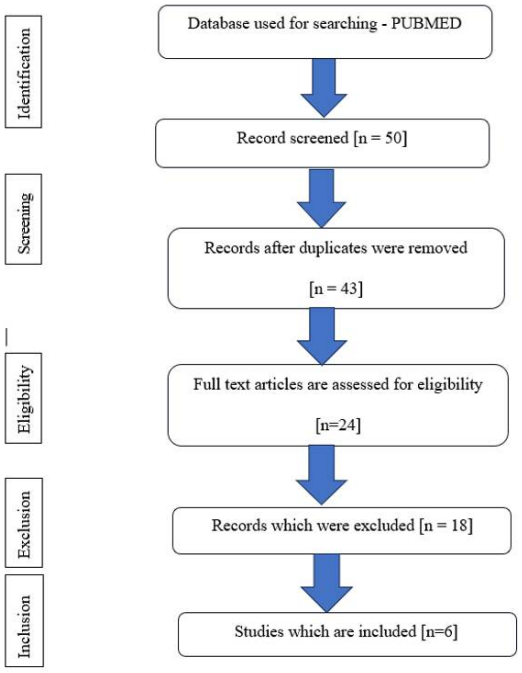

Fig. 1: Selection methodology for included studies

The role of music therapy in cerebral palsy (CP) rehabilitation has garnered increasing attention due to its capacity to enhance motor and cognitive functions. This review synthesizes findings from studies investigating the synergistic effects of music therapy and physiotherapy, offering insights into mechanisms, clinical implications, and research gaps.

3 Neurologic Mechanisms

Music therapy leverages neuroplasticity (the brain's ability to reorganize itself) by engaging auditory-motor coupling. Techniques such as RAS improve motor timing and coordination, while PSE uses music's temporal and spatial patterns to facilitate motor planning. Therapeutic instrumental music performance enhances fine motor skills by combining music and motor activities, engaging neural pathways critical for sensorimotor integration. These mechanisms highlight music therapy's unique ability to promote motor learning through repetitive and engaging stimuli.

4 Evidence from Systematic Reviews and Meta-Analyses

A systematic review by Vinolo-Gil *et al.* involving 234 participants demonstrated that combining RAS, PSE, and TIMP with physiotherapy improved motor outcomes, such as step length, balance, and knee extension power[5]. Similarly, Yanagiwara *et al.* conducted a meta-analysis that showed significant enhancements in Gross Motor Function Measure (GMFM) scores, indicating that music therapy supports functional gains in daily activities. Despite these promising results, heterogeneity in methodologies and outcome measures limits generalizability[6].

Bilinc Dogruoz Karatekin *et al.*: This experimental study assessed the effect of music therapy on the upper extremity motor functions of adolescents with CP. Using techniques such as TIMP, participants demonstrated improvements in grip strength, finger selectivity, and overall hand motor skills after three months of piano training. Assessments were conducted using the Manual Ability Classification System (MACS), the Wooden Box Block Test (BBT), and the Jamar hand dynamometer, confirming significant functional gains. This study highlighted the critical role of TIMP in enhancing fine motor skills, underscoring the importance of structured and engaging music interventions[3].

Tze-Hsuan Wang *et al.*: This randomized controlled trial explored the impact of a six-week home-based PSE program for children with spastic diplegia. Participants in the PSE group showed enhanced gross motor capacity and self-care abilities. Individualized musical interventions were adjusted biweekly, incorporating movement-specific music tempos. Results highlighted significant improvements in walking speed and motor function in the PSE group compared to

controls. This research also emphasized the caregiver's role in facilitating consistent and effective home-based interventions[4].

Maria Jesus Vinolo-Gil *et al.*: This systematic review analyzed eight trials involving 234 participants with CP, aged 4 to 52. Music therapy techniques, including RAS, PSE, and TIMP, were integrated with physiotherapy. Improvements in step length, balance, and knee extension power were reported, demonstrating the combined therapy's potential to enhance motor outcomes. This study provided a comprehensive view of how multiple therapy modalities can complement each other to optimize rehabilitation[5].

Sohei Yanagiwara *et al.*: A meta-analysis of eight studies assessed the role of music therapy in improving functional abilities. Techniques such as RAS and PSE were shown to positively influence gross motor function and daily activities. Notably, music therapy enhanced scores on the Wee-FIM (Functional Independence Measure for children) and GMFM scales. The research also pointed to the need for further longitudinal studies to evaluate sustained benefits[6].

Seoyon Yang *et al.*: A narrative review synthesized findings from 15 studies to evaluate NMT methods, such as RAS, TIMP, and PSE. Results indicated enhanced gait control, pelvic motion, and motor function. These interventions were particularly effective in improving both fine and gross motor skills in patients with CP. The review highlighted the versatility of NMT methods across diverse patient needs and age groups[7].

Tommao Liuzzi *et al.*: Conducted an experimental study assessing the Euterpe Method's (EM) influence on children's quality of life and neuroplasticity. EM-based music therapy sessions promoted sleep quality, emotional regulation, and parent-child bonding, as evidenced by neuroimaging data and standardized questionnaires. These findings underscore the method's holistic benefits. Additionally, the study emphasized the role of personalized sound interventions in fostering neuroplasticity and emotional well-being[8].

Karatekin *et al.*: Carried out a randomized controlled study to explore the impact of Therapeutic Instrumental Music Performance on upper limb motor abilities in adolescents diagnosed with cerebral palsy. The research involved nine participants (mean age 12.3±1.6 years), who underwent 40-minute one-on-one piano-based TIMP sessions twice weekly over a period of three months. The intervention included activities such as finger warm-up exercises, bilateral hand coordination, and learning to play selected musical pieces. Assessments were done using tools like the Jamar hand dynamometer for grip strength, the Box and Block Test and Nine-Hole Peg Test for gross and fine motor skills, and MIDI software for analysing finger pressing forces. The results indicated meaningful gains in hand strength, finger control, and coordination, particularly in the fourth and fifth digits. The authors concluded that individualized TIMP sessions could contribute to improving hand function in this population. Although the sample size was limited, the improvements observed were statistically significant, indicating the promise of this approach[9].

Wang *et al.*: Conducted a randomized controlled trial to evaluate the effectiveness of a home-based PSE program in children aged 5 to 13 years with spastic diplegia (GMFCS levels I–III). A total of 36 participants were randomly assigned to either a PSE plus exercise group or an exercise-only control group, with both groups receiving a 6-week caregiver-supervised intervention involving sit-to-stand resistance training performed three times per week. The PSE group used rhythmic, pre-recorded music matched to the movement tempo. Outcome measures included the GMFM dimensions D and E, the Pediatric Evaluation of Disability Inventory (PEDI), one-repetition maximum (1-RM) sit-to-stand strength, and 10-meter walking speed. Significant improvements were observed in both groups, but the PSE group showed greater gains in GMFM standing, walking dimensions, and overall goal scores, with effects maintained at 6- and 12-week follow-ups. Although no group differences were seen in PEDI self-care or walking speed, both groups improved in mobility and functional strength. The findings suggest that integrating PSE into a home-based exercise routine, with active caregiver involvement, can enhance gross motor outcomes in children with spastic diplegia[10].

Liuzzi *et al.*: Investigated the Euterpe Method a personalized music therapy approach in a randomized controlled design involving 25 children with cerebral palsy compared to 10 controls. The researchers combined behavioural questionnaires with functional MRI (fMRI) to explore neural changes underlying observed improvements. After intervention, the fMRI revealed enhanced functional connectivity in brain regions associated with emotional regulation and sleep wake cycles in the treatment group. These neuroimaging findings coincided with significant gains in sleep quality, emotional control, and perceived closeness between parent and child, as captured by validated tools like the Sleep Disturbance Scale for Children and temperament and quality-of-life inventories. No such changes were noted in the control group. This dual approach objective neuroimaging and caregiver-reported clinical metrics demonstrates that the Euterpe Method promotes neuroplastic adaptations alongside meaningful emotional and relational benefits[11].

PEDro Rating Scale for Reviewed Articles are shown in Table. 1.

Table 1: PEDro Rating Scale for Reviewed Articles

Study	PEDro Score	Criteria Met	Comments
Bilinc Dogruoz Karatekin *et al.*[3]	7/10	Random allocation, baseline comparability, adequate follow-up	Demonstrated significant functional gains in fine motor skills via TIMP. Limited by small sample size.
Tze-Hsuan Wang *et al.*[4]	8/10	Random allocation, blinding of assessors, intention-to-treat analysis	Highlighted caregiver involvement in PSE interventions. Robust methodology but lacked long-term follow-up.
Maria Jesus Vinolo-Gil *et al.*[5]	6/10	Systematic review, inclusion of diverse study designs	Comprehensive review but heterogeneity in study designs and outcomes.
Sohei Yanagiwara *et al.*[6]	7/10	Comprehensive search, meta-analysis, appropriate statistical analysis	Focused on functional measures, but limited by variations in intervention protocols.
Seoyon Yang *et al.*[7]	6/10	Inclusion of diverse intervention methods, narrative synthesis	Effective synthesis but narrative design limits generalizability.
Tommao Liuzzi *et al.*[8]	8/10	Experimental design, neuroimaging validation, parental reporting	Strong evidence for neuroplasticity but requires replication in broader contexts.

5 Integration with Theoretical Frameworks

Motor learning theories and mirror neuron system activation provide a basis for understanding the success of music therapy. Rhythmic cues in music act as external guides, enhancing motor planning and execution. Furthermore, mirror neuron systems may facilitate imitation and learning through music-based tasks, especially in children.

6 Discussion

The integration of music therapy with conventional physiotherapy presents a compelling, multidimensional approach to rehabilitation for individuals with CP. This review synthesises existing literature, affirming that combining these modalities can significantly enhance motor function, emotional well-being, and overall quality of life.

6.1 Neurological Mechanisms and Therapeutic Modalities

Music therapy's efficacy is largely attributed to its capacity to harness the brain's neuroplasticity, which is the brain's ability to reorganise itself by forming new neural connections. Key NMT techniques engage auditory-motor coupling, providing a foundation for improved motor learning and sensory integration.

- Rhythmic Auditory Stimulation utilises rhythmic cues to improve motor timing and coordination. This technique guides movements, effectively serving as an external pace-setter for motor planning and execution.
- Patterned Sensory Enhancement employs music's temporal and spatial patterns to facilitate complex motor planning and sequential movements. Wang *et al.* (2021) demonstrated this through a 6-week home-based PSE program for 36 children (aged 5 to 13 years) with spastic diplegia (GMFCS levels I–III). Participants, supervised by caregivers, engaged in sit-to-stand resistance training three times per week, using rhythmic, pre-recorded music matched to movement tempo. This intervention led to significant gains in GMFM standing and walking dimensions, as well as overall goal scores, with effects sustained at 6 and 12-week follow-ups[10].
- Therapeutic Instrumental Music Performance enhances fine motor skills by integrating music performance with motor activities. This technique directly engages neural pathways vital for sensorimotor integration through repetitive and engaging stimuli. For example, Bilinc Dogruoz Karatekin *et al.* (2020) conducted an experimental study with nine adolescents (mean age 12.3 ± 1.6 years) with CP, who underwent 40-minute piano-based TIMP sessions twice weekly over a period of three months. Assessments using tools like the Manual Ability Classification System, the Wooden Box Block Test and the Jamar hand dynamometer confirmed significant improvements in grip strength, finger selectivity, and overall hand motor skills, particularly in the fourth and fifth digits. The mirror neuron system also plays a role, facilitating imitation and learning through music-based tasks, especially pertinent in paediatric rehabilitation[3].

6.2 Evidenced Clinical Benefits

A growing body of evidence supports the effectiveness of music therapy as an adjunct to physiotherapy in CP rehabilitation. Systematic reviews and meta-analyses, such as those by Vinolo-Gil *et al.* (involving 234 participants) and Yanagiwara *et al.*, have shown that combining NMT techniques like RAS, PSE, and TIMP with physiotherapy leads to improved motor outcomes, including enhanced step length, balance, and knee extension power. Notably, music therapy positively influenced GMFM scores, indicating functional gains in daily activities, and also enhanced scores on the Wee-FIM (Functional Independence Measure for Children) scales[5, 6]. A narrative review by Yang *et al.* further indicated that NMT methods significantly enhanced gait control, pelvic motion, and both fine and gross motor skills in CP patients[7].

Beyond direct motor improvements, music therapy offers significant psychological benefits. Interventions have shown to increase patient motivation, aid emotional regulation, and foster stronger parent-child bonding. Liuzzi *et al.* (2022)

explored the Euterpe Method, a personalised music therapy approach, in a randomized controlled design involving 25 children with cerebral palsy compared to 10 controls. Their study validated the method's impact on neuroplasticity using a dual approach of behavioural questionnaires (e.g., Sleep Disturbance Scale for Children, temperament and quality-of-life inventories) and functional MRI (fMRI). The fMRI revealed enhanced functional connectivity in brain regions associated with emotional regulation and sleep-wake cycles in the treatment group. These neuroimaging findings correlated with improved sleep quality, emotional control, and perceived parent-child closeness, underscoring the holistic benefits of personalised sound interventions[8].

6.3 Clinical Implementation and Considerations

For broader clinical adoption, the implementation of music therapy requires a multifaceted approach. Clinicians should develop individualised music therapy programmes that are tailored to each patient's specific needs, preferences, and functional goals. Integrating music therapists within multidisciplinary teams, including physiotherapists, occupational therapists, and caregivers, is essential for a comprehensive rehabilitation strategy. Furthermore, training programmes should be developed to equip therapists with expertise in NMT techniques like TIMP, PSE, and RAS.

To enhance accessibility and engagement, especially in underserved areas, contextual appropriateness is crucial. This includes incorporating culturally relevant music and exploring innovative delivery methods such as virtual reality or mobile applications for remote therapy sessions. Active caregiver involvement is also paramount; training parents to support home-based therapy sessions can ensure consistency and sustained engagement, as highlighted by Wang *et al.* Subsidies or funding mechanisms are also crucial to make therapy accessible in low-income settings.

6.4 Current Limitations and Research Gaps

Despite the promising findings, the current body of evidence exhibits several limitations that warrant critical consideration. A significant concern is the heterogeneity in methodologies and outcome measures across studies, which restricts the generalisability of results and complicates direct comparisons. Many studies also reported small sample sizes and often focus on specific age groups, further limiting the broader applicability of their findings.

Crucially, there is a pervasive lack of long-term follow-up data to ascertain the sustained benefits of music therapy for CP rehabilitation. This makes it challenging to understand the enduring impact of these interventions. Another critical gap is the absence of standardised protocols for music therapy, tailored to the diverse needs of children with CP. This lack of consensus impedes the replication of studies and the establishment of universally applicable guidelines.

Furthermore, limited research exists on the integration of music therapy with other therapeutic modalities beyond physiotherapy, and its cumulative impact. Socio-cultural and economic factors significantly influence therapy accessibility and effectiveness in diverse settings, yet these are often not adequately addressed in current research. Finally, while the evidence is highly encouraging, it is important to note that music therapy is currently better positioned as an adjunct to conventional therapies like physiotherapy, rather than a standalone treatment for CP.

6.5 Future Directions

To solidify the evidence base and facilitate wider implementation, future research should prioritise several key areas. Larger, more diverse studies with standardised protocols are essential to validate efficacy and optimise application. Longitudinal studies are needed to evaluate the sustained benefits of music therapy interventions. Investigations into innovative technologies, such as virtual reality-based music interventions, could pave the way for more accessible and engaging therapeutic options. Finally, research should also explore cost-effective models for resource-limited settings and address socio-cultural barriers to ensure equitable access to these beneficial interventions.

The evolving landscape of Cerebral Palsy (CP) rehabilitation increasingly integrates music therapy, leveraging its scientifically grounded application of neuroplasticity to enhance motor function and improve quality of life. Evidenced through techniques like RAS, PSE, and TIMP, approach demonstrates promising gains. However, the field, while promising, is still in its early stages of development; further rigorous research, particularly with standardised protocols and larger cohorts, is essential to address methodological heterogeneity and fully unlock music therapy's therapeutic potential in CP rehabilitation.

7 Conclusion

Music therapy significantly enhances motor functions, emotional well-being, and quality of life for individuals with cerebral palsy. Its integration with physiotherapy offers a multidimensional approach to rehabilitation, emphasizing its potential for clinical application. Establishing standardized protocols and addressing accessibility challenges will be crucial for its broader implementation.

8 Disclosure

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Author's Contribution: Rakshitha: Study design, literature search & review, manuscript preparation. **Sarulatha Haridass:** Study design, literature search, manuscript edit and review, corresponding author.

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