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Literature Review

Utilizing Music Therapy for Enhanced Recovery from Neurologic Disease Complications

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Abstract

Neurologic music therapy (NMT) has proven instrumental in aiding recovery from complications in patients with a diverse range of neurologic diseases. Integrating music and virtual reality with standard rehabilitation therapies enhances patient compliance and makes therapy more enjoyable. The act of listening to music not only reduces epileptiform discharges but also amplifies brain plasticity. Moreover, music induces discernible variations in brain anatomy between musicians and non-musicians. As a cost-effective intervention, music therapy significantly contributes to the accelerated and efficient recovery of post-stroke patients, particularly when applied promptly after the event. Substantial evidence supports the integration of music into rehabilitation programs, facilitating the recovery of hand function, dexterity, spatial movement, cognitive function, mood, coordination, stride length, and memory. Techniques such as learning words as lyrics, melodic intonation therapy, and singing play crucial roles in expediting recovery for aphasic patients. Recognized by the World Rehabilitation Federation, NMT therapists are valuable members of the rehabilitation team. The approval of NMT as an effective, evidence-based treatment method underscores its significance in enhancing patient outcomes.

***Keywords:** Neurologic diseases; Music; Rehabilitation; Neurologic music therapy; Stroke*

Introduction

Integrating music into regular rehabilitation programs not only enhances initial recovery but also contributes to sustained improvement even after the cessation of treatment. Disabilities arising from various neurologic disorders, work-related injuries, and trauma such as motor vehicle accidents and sports injuries can have profound physical, emotional, and financial implications for patients and their families. Identifying and implementing strategies that complement traditional rehabilitation therapy are crucial for optimizing functional recovery and improving overall quality of life.

Neurologic music therapy (NMT), in facilitating patients' recovery, plays a vital role in achieving positive outcomes. The following examines the evidence base that underscores the significance of incorporating music into conventional rehabilitation approaches. It delves into the neurobiological foundation of NMT, explores its history and applications, and reviews the supporting evidence for its effectiveness in aiding recovery from a broad spectrum of complications associated with specific neurological diagnoses.

Literature Review

Time is a central coordinative unit of motor control and the related concept of entrainment is important to consider in any discussion about motor function. Entrainment is the synchronization or frequency locking, of two oscillating objects. The stronger "oscillator" locks the weaker into its frequency. When both oscillating bodies have equivalent energy, the systems approach each other.

The more rapid system slows and the slower system accelerates until they lock into a common movement period. The function of rhythmic entrainment in rehabilitative training and learning was established by Thaut and colleagues in the early 1990s [1]. The firing rates of auditory neurons, triggered by auditory rhythm and music, entrain the firing patterns of motor neurons, thus driving the motor system into different frequency levels [1]. There are two additional mechanisms in regard to entrainment that are clinically significant. The first is that auditory stimulation primes the motor system to a state of readiness to move which facilitates the motor response quality [1].

Secondly, entrainment impacts changes in motor planning and execution. Rhythmic stimuli create a stable anticipatory time scale or motor template and anticipation is a critical element in improving movement quality [1].

Rhythm provides precise anticipatory time cues for the brain to plan and prepare for motor tasks. Rhythmic cues can provide comprehensive information to the brain for optimizing and reprogramming movement [1].

The auditory system has a wide distribution of neural connections to motor centers in the spinal cord, brainstem, subcortical, and cortical levels [2-4].

In auditory entrainment (the basis of NMT), the motor period entrains to the period of the auditory rhythm. This not only influences movement timing but also modulates patterns of muscle activation and control of movement in space [5]. Rhythmic cuing for upper extremity movement or for full body coordination in hemiparetic stroke patients [6-11] and children with cerebral palsy [12,13] is an effective rehabilitation strategy. Emerging research shows that speech rate control benefits from rhythmic entrainment using rhythm and music [14-18]. This improves rate dependent aspects of speech such as intelligibility, oral motor control, articulation, voice quality, and respiratory strength. The brain's ability to use entrainment to re-program the execution of a motor pattern also makes rhythmic entrainment an important potential tool for motor rehabilitation [19,20].

Music is defined as a complex, temporally structured sound language which stimulates and integrates brain neuronal pathways in a music-specific way [21]. It affects sensory, motor, perceptive-cognitive and emotional circuits simultaneously [21]. An improved understanding of the scientific foundation of music and its application in rehabilitation is emerging along with new technologies that monitor brain function during musical exposure and production [22].

NMT to address sensory, motor and cognitive dysfunction has been employed in a wide variety of neurologic diseases and cases of developmental delay [22]. Watching, hearing, and performing specific actions during musical activity activates the inferior frontal gyrus, Broca's area. This area integrates sensory-motor information and has multi-modal reception characteristics [22]. Musicians have more gray matter volume in Broca's area than non-musicians [22].

Learning verbal material through song activates different neural networks than learning through verbal presentation does [22]. Music with its metro-rhythmic parameters can play an important role in sensorimotor rehabilitation [22]. Music has also become an important modality in treating epileptic children ever since Frances Rusher et al. discovered the “Mozart effect” which will be discussed later [22]. NMT [23] research has progressed from a social science model to a neuroscience model with applications for clinical practice [21]. Neurological and emotional responses stimulated by music lead to measurable therapeutic effects. This is the basis for music therapy [21,24-26].

Listening to music and playing a musical instrument engage motor and multi-sensory networks, induce changes within those networks and foster linking between distant but functionally related brain regions [27]. Repeated exposure and experience create new and efficient connections between neurons in the brain. This rewiring process is integral to the brain’s plasticity [28]. Music is a potent stimulus for the rewiring process due to its rhythmic patterns which drive priming and timing of the motor system and the rich connections between the auditory and motor systems. NMT offers some advantages over other types of therapy for motor control [28]. Two important findings regarding the application of NMT standout [28]. First, music activates brain networks and areas which are not unique to music processing and second, music based learning increases brain volume and efficiency [28]. Active learning and training optimize rewiring in the injured brain and the recovery of its function [29].

Music can facilitate rehabilitation in congenital or acquired neurological dysfunctions through the induction of emotions and the reward system in the brain [27]. Exposure to music is one of the richest human emotional, sensorimotor and cognitive experiences and is commonly associated with strong emotions such as happiness or sadness (known as Apollo’s gift) [27]. Neurohormonal status modulations induced by music provide a pleasurable experience but also play a role in NMT [27]. Dopamine has a dominant role in the neurobiology of reward based learning and curiosity, and facilitates plastic adaptations in the brain [27].

Dopamine is secreted when a new pleasure is experienced. Serotonin is associated with feelings of Satisfaction [27]. It has also been shown that more aggressive environmental sensory stimuli the more the chance to have Peripheral and central nervous system disorders [30]. Lifestyle factors such as regular good quality of sleep and Physical activities, during the whole life, have tremendous effect On the prevention of neurodegenerative diseases [30]. The frontal lobe is involved in integrating auditory and motor information, imitation and empathy. It has an important role in learning musical skills and emotional expression [27]. The cerebellum is active during a musical experience and involved in timing, rhythm processing, and motor coordination [27].

Finally, the emotive network of the cingulate gyrus, amygdala, hippocampus, and midbrain plays an important role in any musical activity and underlies the motivation to listen to music [27]. Skilled musicians have a larger corpus callosum in response to high demands for bimanual coordination and the rapid exchange of information between hemispheres [31]. Children learning to play a musical instrument [31] show a similar change with greater brain plasticity than adult amateur musicians [32]. Bengtsson et al. [33] and Rueber et al. [34] have found structural differences in the corticospinal tract between musicians and non musicians. These are most striking in the posterior limb of the internal capsule. They have also identified differences between musician groups, with a difference seen between keyboard players and string instrumentalists [34]. Between-group differences were related to measures of training intensity as well as to the specific demands of the instruments played [34].

Professional musicians tend to have a larger cerebellar gray matter volume than non-musicians. This results from increased and repetitive demands for precise timing, coordination of motor functions, and accuracy when playing a musical instrument [35,36]. Skilled musicians have an enlarged homuncular hand representation in the motor cortex that results from repeated music practice [37]. Music also has a wide variety of other physiological effects on the human body. It can affect the autonomic system. Music can modulate heart rate, respiration, blood pressure, skin conductivity, skin temperature, muscle tension, and multiple biochemical responses [38,39].

Music-supported therapy (MST), in contrast to NMT, is the addition of music to a standard therapy modality in order to reduce the disability burden of coordinative, emotional, or sensory-motor impairment [27]. Music-supported training is more efficient and effective than functional motor training without auditory feedback [27]. Playing music can make rehabilitation therapies more enjoyable and, similar to NMT, help to remediate impaired neural processes or neural connections by engaging and linking brain regions with each other that might otherwise not be linked [27]. Aphasia is the loss of language comprehension (Wernicke aphasia) and/or loss of the ability to produce language (Broca's aphasia) [27].

Aphasia can be classified broadly as fluent (Wernicke's) or nonfluent (Broca's). These types of aphasia result from lesions of the left posterior superior temporal lobe and left posterior inferior frontal lobe respectively [27]. Patients with Wernicke's aphasia have normal articulation with speech comprehension deficits while those with Broca's aphasia have relatively intact comprehension for conversational speech but have marked impairments in articulation and speech production [27].

Singing mainly relies on right hemispheric function and can help people with left hemispheric lesions produce speech by bypassing the injured hemisphere [40]. Learning a list of words in a song activates frontal and temporal brain areas on both sides of the brain while spoken-word learning activates only areas in the left hemisphere [41]. Melodic Intonation Therapy (MIT) engages a sensorimotor network of articulation in the unaffected hemisphere through rhythmic tapping. It was developed [42,43] based upon the clinical observation that patients with severe Broca's aphasia can sing lyrics better than they can speak the identical words [43,44].

MIT increases right-hemisphere network activation [45] and produces volume gains in the right hemisphere arcuate Fasciculus [46,47]. Persistent and continuous use of therapies such as MIT in chronic stroke patients leads to speech output improvements [47]. Stroke ranks fourth among all causes of death in the United States [48]. It is a leading cause of serious physical and cognitive long-term disability in adults [49]. The annual incidence of stroke approaches 800,000 US residents, of which 600, 000 are first events [50]. The USA prevalence (stroke survivors) exceeds 5.7 million but only five percent of these regain full upper extremity function despite intensive rehabilitation [51].

Approximately eighty percent of new stroke survivors each year need hand therapy [52-54].

Few technologies exist to supplement upper extremity exercise and functional retraining-the typical standard rehabilitation program-or the home exercise program for the chronic stroke patient [55].

Rehabilitation can be expensive due to the one by one delivery of care by trained physical or occupational therapists. Access can be limited by service availability, financial problems or other health care issues [55]. Also, home hand therapy devices can be expensive, patients may not be sufficiently motivated and community gyms generally lack suitable equipment to improve hand dexterity [55]. The home program may not be focused on training hand movement for activities of daily living. The addition of music, along with positive feedback on motor performance, can help to motivate patients [55]. Motivation for training hand motor performance significantly improves by adding music to training session [55]. Adamovich developed a virtual piano trainer to use for regaining finger dexterity. The trainer uses a haptic device (CyberGrasp) worn over a data glove (Cyber Glove) [56]. The system supports the use of a pair of CyberGloves (220 grams) for hand tracking combined with a CyberGrasp (450 grams) to apply variable forces for haptic effects [56]. They designed the game architecture to use various tracking mechanisms to retrieve arm, hand, and finger movement data simultaneously [56]. The system presents the virtual hands in a first person perspective because visual information processing is much easier when one looks at one's own hand rather than someone else's (similar to mirror therapy) [56].

Adamovich et al. trained subjects to move their fingers effectively and to combine hand movements with arm tracking by providing the realistic visual and auditory feedback of a piano keyboard during use of the Virtual Piano Trainer [56]. Subjects ranged from eleven months to seven years post stroke. They were trained ninety minutes per day for eight to nine sessions using the virtual piano trainer. Subjects had mild to moderate impairments and minimal to moderate spasticity and had at least ten degrees of active finger extension. All subjects improved in key press duration, key press time once the note was cued, and accuracy as measured by comparing the number of correctly pressed keys the first time to the total number of keys pressed. In order to manipulate small objects during daily activities, fractionation, or the ability to move each finger independently, is necessary. Use of the virtual piano trainer improved fractionation in all subjects [56].

Rehabilitation progress can be monitored by the objective measurement of hand use during therapy sessions. Motor function can be improved through feedback about movement performance [57]. Nizan and Friedman et al. developed the MusicGlove for such purpose. This is a music based rehabilitation device to help people regain hand function in both clinic and home settings [58].

In a study of 10 chronic stroke patients, the MusicGlove was used with subjects who had severe hand impairment quantified by a Box and Block score of 7 out of 60 [58]. Most participants in the MusicGlove trial found the device to be a motivating tool and preferred to continue its use for rehabilitation. The MusicGlove based therapy significantly improved hand motor control in post-stroke patients after multiple training sessions compared to a conventional tabletop exercise and isometric movement rehabilitation group [58].

Velocity and walking distance improve in both the laboratory and the community by combining robotic and virtual environment strategies for gait training [59]. Music enhanced this effect in a study focusing on restoration of ability rather than compensatin for a deficit in the acute and sub-acute stages of recovery. Retention of gains was also improved when combining music with multiple tasks in one therapy session [60,61].

Teppo and Sarkamo et al. recruited sixty stroke subjects to test whether coupling VR games, robotic training and music enhances speed, precision, force, attention, and timing during the recovery of arm use [62]. They provided self-selected music CDs and portable CD players to subjects in a music group and portable cassette players with narrated audio books to subjects in a non-music group [63]. Both groups were compared to a control group. Individually, subjects listened to the provided material for a minimum of one hour daily for two months and documented their time in a listening diary [63]. Subjects were assessed at 2 and 6 months. Verbal memory, working and short term memory, visuospatial cognition, language, music cognition, executive functions, sustained attention and focused attention were evaluated by clinical neuropsychological assessment [63].

There were no statistically significant differences between the groups in the baseline demographic, cognitive performance, or Mood. Subjects who listened to their favourite music showed significant improvement in verbal memory and focused attention when compared to those who listened to audio books or received no listening material at 2-months. Subjects who listened to music tended to be less confused and less depressed [63].

A music enriched environment, electrical cortical and peripheral stimulation, and virtual environments will improve post -stroke motor recovery [63]. Music increases not only well-being, attention span and neuropsychological performance but also promotes plastic changes in the motor cortex [64-68]. Mozart's music (K.448) has an anti-epileptic effect in comatose patients [69].

A meta-analysis of 12 studies showed that idiopathic epileptic subjects and those with generalized central discharges associated with a high IQ had significantly decreased epileptic activity, 31.24% during, and 23.74% after exposure to Mozart's music [69].

Interestingly, relaxation without music does not reduce the number of epileptic discharges [70]. Mozart's music has antiepileptic effects in children as well [71]. Intriguingly, in contrast to the classic piano piece the string version of K. 448 has no effect on epileptiform discharges [72]. The anti-epileptogenic effect of music may result from modulation of dopaminergic pathways or enhancement of parasympathetic tone, both of which can be involved in intractable epilepsy and its treatment [73,74].

Combining acupuncture with an of hour music therapy might be more effective than acupuncture alone in helping children with cerebral palsy acquire gross motor skills (kneeling, walking, standing and crawling) and can reduce anxiety during therapy [75]. Using background music during pediatric physical therapy sessions reduces the amount of crying and increases parent's satisfaction [76].

Several virtual reality models have been developed for the assessment and training of neglect, which occurs in 50% of right hemispheric stroke patients [77]. These include the virtual supermarket [78-80], virtual wheelchair navigation [81] and a three-dimensional virtual street [82]. Listening to preferred music while engaged in a virtual reality task increases visual awareness versus adding non-preferred music or omitting music altogether [83].

Combining rhythmic music listening with a specialized rehabilitation program improves gait velocity, stride length, symmetry, interpersonal relationships and mood in post stroke patients in comparison to the rehabilitation program alone [84]. Environmental stimulation enhances the plastic changes happening in the brain during the first months of recovery after stroke [85,86]. Adding auditory, visual and olfactory stimuli to an enriched motor environment enhances motor and cognitive recovery more than an enriched motor environment alone [87].

In a randomized mixed-methods study involving 30 adults with post-stroke hemiparesis, Palumbo et al. demonstrated a reduction in depression among participants engaged in Music Upper Limb Therapy-Integrated (MULT-I) compared to those following a home exercise program (HEP). Notably, Brain-derived neurotrophic factor (BDNF) levels significantly increased in the MULT-I group but decreased in the HEP group, with a notable difference between the two groups, particularly after excluding individuals with post-stroke depression. Participants in the MULT-I group experienced improvements in quality of life, as well as self-perceived physical strength, mobility, activity, participation, and recovery from pre-intervention to post-intervention. Conversely, HEP participants showed improvement in upper limb function. From a qualitative standpoint, MULT-I provided psychosocial support and enjoyment, while HEP supported self-management of rehabilitation. The study's authors concluded that implementing a music-enriched environment is not only feasible but also effective in reducing post-stroke depression and may enhance the neural environment for recovery through increased BDNF levels. Additionally, self-management of rehabilitation through an HEP was found to potentially improve upper limb function [88].

In a cross-over randomized controlled trial conducted by Siponkoski et al., 40 individuals with moderate-severe traumatic brain injury (TBI) underwent a 3-month neurological music therapy intervention (2 times/week, 60 min/session). This intervention was administered either during the first half (AB, n = 20) or the second half (BA, n = 20) of a 6-month follow-up period. The study assessed self-report and caregiver-report questionnaires at baseline, 3-month, 6-month, and 18-month stages. The findings revealed that the self-reported Behavioural Regulation Index of the Behaviour Rating Inventory of Executive Function (BRIEF-A) exhibited greater improvement in the AB group compared to the BA group from baseline to the 3-month stage, with this effect sustained in the 6-month follow-up. Notably, no significant changes were observed in mood or quality of life questionnaires. However, a qualitative content analysis of participant feedback indicated that many individuals perceived the intervention as beneficial for emotional well-being and daily activities. These results suggest that music therapy may have a positive impact on everyday behavioral regulation skills following TBI [89].

In an analysis conducted by Sihvonen et al., drawing data from two single-blind randomized controlled trials involving stroke patients (N = 83), the researchers compared the impact of daily listening to self-selected vocal music, instrumental music, and audiobooks within the initial three months post-stroke. The study assessed neuropsychological tests, focusing on verbal memory as the primary outcome, along with language and attention. Additionally, a mood questionnaire was administered at acute, 3-month, and 6-month stages, complemented by structural and functional MRI assessments at acute and 6-month stages.

Results indicated that listening to vocal music contributed to more significant improvements in verbal memory recovery compared to instrumental music or audiobooks. Furthermore, vocal music listening was found to enhance language recovery, particularly in patients with aphasia, surpassing the effects observed with audiobooks. Voxel-based morphometry and resting-state and task-based fMRI analyses revealed that vocal music listening specifically increased gray matter volume in left temporal areas and improved functional connectivity in the default mode network.

The researchers concluded that listening to vocal music represents an effective and easily applicable tool to support cognitive recovery after a stroke, particularly in enhancing early language recovery in individuals with aphasia. The rehabilitative effects of vocal music were attributed to both structural and functional plasticity changes in temporoparietal networks crucial for emotional processing, language, and memory [90].

In a single-blinded randomized trial with a placebo control, Paprad, Veeravigrom, and Desudchit investigated the impact of Mozart K.448 for two pianos on interictal epileptiform discharges (IEDs), quantitative electroencephalogram (qEEG), and heart rate variability (HRV) among patients with epilepsy. The treatment group listened to the initial 8 minutes of Mozart K.448 for two pianos during EEG recording, while the control group underwent a similar EEG recording duration in a quiet environment. IEDs were manually counted before, during, and after the music was played. Quantitative electroencephalogram and HRV were analyzed across each period. Thirty-two patients aged 0-18 years participated, with 12 in the music group and 14 in the control group.

Results indicated that 67% of patients in the music group experienced a significant decrease in IEDs compared to 42% in the quiet group (RR [Relative Risk Reduction]: 0.72, p-value: <0.001, 95% confidence interval [CI]: 0.69-0.74). During music exposure, qEEG demonstrated an increase in the delta/theta to alpha/beta ratio relative to controls (median in music: +3% and control: -6%, p-value: 0.520). Heart rate variability analyses revealed a decrease in the ratio of low frequency to high frequency (LF/HF), indicative of parasympathetic activity during music exposure (34% decrease, p-value: 0.382).

While the study demonstrated the potential of Mozart K.448 to reduce IEDs and enhance parasympathetic activity in pediatric epilepsy, statistical significance was not reached, possibly due to the small study population. Nonetheless, the findings underscore the significant potential of music in the treatment of pediatric epilepsy [91].

In a randomized controlled trial, Feng et al. investigated the impact of choral singing on cognitive decline in aging individuals. The study involved recruiting older Singaporeans at a high risk of future dementia, with 47 assigned to the choral singing intervention (CSI) group and 46 to the health education program (HEP) group. Over a two-year period, participants attended weekly one-hour sessions of either choral singing or health education. Cognitive function changes were assessed using a composite cognitive test score (CCTS) derived from raw scores of neuropsychological tests. Biomarkers, including brain magnetic resonance imaging, oxidative damage, and immunosenescence, were also analyzed.

The average age of the participants was 70 years, with 73 out of 93 (78.5%) being female. The change in CCTS from baseline to 24 months was 0.05 in the CSI group and -0.1 in the HEP group. The between-group difference (0.15, p=0.042) slightly decreased (0.12, p=0.09) after adjusting for baseline CCTS. No significant between-group differences in biomarkers were observed. The data support the role of choral singing in enhancing cognitive health during aging, with the beneficial effect being at least comparable to that of health education in preventing cognitive decline in a community of elderly individuals. Further studies should explore the biological mechanisms underlying the observed efficacy [92].

Froutan et al. explored the impact of integrating music therapy with family recollection on the physiological parameters of 60 patients with traumatic brain injury (TBI) admitted to Intensive Care Units, randomly assigned to intervention and control groups. In the intervention group, patients received a combined session of music and auditory stimulation twice daily for 15 minutes over six consecutive days. Physiological parameters were assessed before the intervention, as well as 10 and 30 minutes afterward.

The results, obtained through two-level multiple linear models over the six days, revealed a significant reduction in systolic blood pressure, diastolic blood pressure, respiratory rate, and heart rate among patients in the intervention group compared to the control group ($P < 0.0001$). However, no significant difference was noted in temperature and oxygen saturation ($P > 0.05$). The study suggests that the integration of music therapy with family recollection can effectively moderate physiological parameters. Consequently, the authors recommend incorporating this cost-effective treatment alongside routine therapies, particularly for patients dealing with traumatic brain injury [93].

Dimitriou et al. conducted a cross-over randomized controlled trial involving 60 participants with various types and stages of dementia. The participants were randomly assigned to six different groups, each consisting of 10 participants, and were subjected to three non-pharmacological interventions: a) Music Therapy, b) Exercise, and c) Aromatherapy & Massage. The study measured cognitive function using MMSE, ACE-R, GDS, FRSSD, and NPI questionnaires, with each intervention lasting 5 days and a two-day wash-out period between sessions. Notably, there was no drop-out rate recorded.

The findings revealed that Music Therapy was the most effective intervention, followed by Exercise and Aromatherapy & Massage, respectively. The p-values indicated that Music Therapy's effectiveness was significantly superior ($p < 0.05$) compared to Exercise and Aromatherapy & Massage, with no interference from the sequence of interventions ($p = <0.05$, $p = 0.55$, respectively). Caregivers' burden also diminished notably with Music Therapy, and the p-values supported its superiority over the other interventions ($p < 0.05$, $p = 0.19$), unaffected by the sequence.

The study's outcomes aligned with existing literature, positioning Music Therapy as a promising alternative for managing anxiety in patients with dementia (PwD). Additionally, Music Therapy emerged as an effective non-pharmacological approach for reducing caregivers' burden associated with anxiety symptoms in PwD, including sleep disturbances, lack of personal time, an unhealthy lifestyle, and uncertainty about managing patients. However, the optimal music type, intervention duration, and long-term benefits remain unclear, underscoring the need for further research with robust evaluation methods [94].

Pohl et al. randomly assigned forty-six individuals diagnosed with Parkinson's disease to either the intervention group (n = 26), which underwent training with a music-based intervention, or the control group (n = 20) without any training.

The intervention, delivered twice weekly, spanned over 12 weeks. The primary outcome assessed was Timed-Up-and-Go subtracting serial 7's (dual-task ability), while secondary outcomes included cognition, balance, concerns about falling, freezing of gait, and quality of life. Evaluations were conducted at baseline, post-intervention, and three months post-intervention. Focus groups and individual interviews were carried out with the intervention group participants and the delivering physiotherapists.

Results revealed no significant between-group differences in dual-task ability. However, significant between-group differences were observed post-intervention for Falls Efficacy Scale (mean difference (MD) = 6.5 points; 95% confidence interval (CI) = 3.0 to 10.0, P = 0.001) and Parkinson Disease Questionnaire-39 items (MD = 8.3; 95% CI = 2.7 to 13.8, P = 0.005) compared to the control group, although these differences were not sustained at three months post-intervention. Thematic analysis of interviews yielded three themes: Expectations versus Results, Perspectives on Treatment Contents, and Key Factors for Success.

In conclusion, patient-reported outcomes and interviews suggest that the group-based music intervention positively impacts mood, alertness, and quality of life in individuals with Parkinson's disease. However, the study does not provide support for the efficacy of the intervention in producing immediate or lasting improvements in dual-tasking, cognition, balance, or freezing of gait [95].

Siponkoski et al. in this crossover randomized controlled trial assessed the clinical effectiveness of music therapy on cognitive functioning in traumatic brain injury (TBI) patients and explore its neural basis. The trial included 40 participants with moderate or severe TBI, randomized to receive a 3-month music therapy intervention either during the first (AB) or second (BA) half of a 6-month follow-up period. Neuropsychological and motor testing, along with magnetic resonance imaging (MRI), were conducted at baseline, 3-month, and 6-month stages.

Results from the intention-to-treat analysis showed that general executive function (Frontal Assessment Battery [FAB]) and set shifting improved more in the AB group during the first 3-month period, and this improvement in general executive function was sustained at the 6-month follow-up. Voxel-based morphometry analysis of structural MRI data revealed a significant increase in gray matter volume (GMV) in the right inferior frontal gyrus (IFG) in both groups during the intervention versus control period. This increase correlated with cognitive improvement in set shifting. The findings suggest that neurological music therapy enhances executive function and induces specific neuroanatomical changes in prefrontal areas [96].

Seebacher et al. in a randomized controlled trial involving individuals with Multiple Sclerosis (MS) and Expanded Disability Status Scale scores of 1.5-4.5, participants were assigned to one of three groups: motor imagery with music cues, motor imagery with metronome cues, and controls. The interventions consisted of 17 minutes of motor imagery, six times per week, for 4 weeks.

Primary outcomes measured were walking speed (Timed 25-Foot Walk) and distance (6-Minute Walk Test), while secondary outcomes included walking perception, fatigue, and quality of life (QoL).

Results from 101 participants completing the study showed that both interventions significantly improved walking speed, distance, and perception compared to controls. Cognitive fatigue saw significant improvements in the intervention groups, while physical fatigue improved only in the music-based group. Both interventions positively impacted QoL, with music-cued motor imagery demonstrating superior effectiveness in enhancing health-related QoL.

In conclusion, rhythmic-cued motor imagery, particularly with music, proves beneficial in improving walking, reducing fatigue, and enhancing the overall quality of life for individuals with MS [97].

Van Bruggen-Rufi et al. randomized 63 Huntington's disease (HD) patients with a Total Functional Capacity (TFC) score of ≤7, to receive either group music therapy or group recreational therapy in 16 weekly sessions. The assessments were conducted at baseline, after 8, 16, and 28 weeks using the Behaviour Observation Scale for Huntington (BOSH) and the Problem Behaviour Assessment-short version (PBA-s).

The results indicated that group music therapy, administered once weekly for 16 weeks to advanced-stage HD patients, did not demonstrate additional beneficial effects on communication or behavior when compared to group recreational therapy.

In conclusion, this study, the first of its kind to assess the impact of group music therapy on advanced-stage HD patients, did not confirm the previously reported beneficial effects of music therapy observed in qualitative case reports and studies. The study suggests the need for a comprehensive process evaluation alongside the effect evaluation to further explore the potential benefits of music therapy in this context [98].

Satoh et al. randomized 85 patients with mild to moderate dementia into two different groups, 43 subjects participated in the Yamaha Music Foundation's Expressive Music (ExM) program, while 42 subjects engaged in cognitive stimulation using portable game consoles. The interventions occurred once a week for 40 minutes over six months. Neuropsychological assessments, functional independence measures (FIM) reported by caregivers, and medial temporal lobe atrophy assessments using Voxel-based Specific Regional Analysis System for Alzheimer's Disease (VSRAD) were conducted before and after the intervention.

Results showed that both groups exhibited significantly improved visuospatial function post-intervention. The ExM group demonstrated significant benefits in psychomotor speed and ADL preservation, while the cognitive stimulation (CS) group showed benefits in memory. However, FIM scores and VSRAD scores significantly worsened in the CS group.

In conclusion, Expressive Music produced greater positive effects on cognitive function and activities of daily living (ADLs) in patients with mild to moderate dementia compared to cognitive stimulation, excluding memory. The study suggests that optimal interventions for dementia may involve a combination of Expressive Music and cognitive stimulation [99].

Martínez-Molina et al. demonstrated that a 3-month neurological music therapy in moderate-to-severe traumatic brain injury (TBI) patients enhanced executive function (EF) and increased grey matter volume in the right inferior frontal gyrus (IFG). The study expanded its investigation to include longitudinal resting-state functional connectivity (rsFC) analyses, focusing on cognitive networks associated with TBI. The frontoparietal (FPN), dorsal attention (DAN), default mode (DMN), and salience (SAL) networks were assessed through a region-of-interest (ROI)-to-ROI approach.

The results revealed that neurological music therapy increased coupling between the FPN and DAN, as well as between these networks and primary sensory networks. Conversely, the DMN exhibited reduced connectivity with sensory networks post-intervention. Additionally, there was a shift towards a less connected state within the FPN and SAL networks, commonly hyperconnected in TBI. Improved EF was correlated with rsFC within the FPN and between the DMN and sensorimotor networks. Seed-based connectivity analysis showed increased rsFC between the right IFG and the right inferior parietal and left frontoparietal (Rolandic operculum) regions.

In summary, the rehabilitative effects of neurological music therapy after TBI involve changes in within- and between-network connectivity in cognitive networks, as well as increased connectivity between frontal and parietal regions associated with music processing [100].

Discussion and Conclusion

Music serves as a universal language with valuable therapeutic applications for individuals with neurological-based disabilities. Its influence is channeled through neuromodulation, impacting mood, bodily functions, interpersonal communication, learning, and memory. Music proves beneficial in facilitating recovery from both hereditary and acquired neurologic conditions. Both listening to and creating music offer effective approaches to address disabilities associated with motor weakness, language deficits, impaired memory, cognitive dysfunction, and epilepsy.

Neurologic Music Therapy (NMT), Melodic Intonation Therapy (MIT), and Musical Sensory Training (MST) emerge as cost-effective methods to aid patients during the initial months post-stroke. Recognized by the World Federation of Neurorehabilitation, NMT is positioned to become a standard tool in rehabilitation care [101].

Neurologic Music Therapy has evolved into a distinct science, now taught globally. Music therapists have become integral members of rehabilitation teams in numerous hospitals. As this scientific discipline matures, it is expected to develop greater focus, offering clearer applications and protocols for effecting neurological repair and promoting functional recovery through the strategic use of specific types of music and musical instruments.

Conflict of Interest

The author declare no conflict of interest.

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N/A

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