

A Mini Review of Music Therapy as a Non-Pharmacological Treatment Approach for Parkinson's Disease

ABSTRACT

Music offers significant benefits to the human body, especially in treating neurodegenerative diseases like Parkinson's disease. Pharmacological approaches often fall short, leading to increased interest in complementary therapies. Music therapy, in particular, has shown great potential in managing neurological disorders by influencing brain connections, thereby improving the quality of life for Parkinson's patients. Given that Parkinson's has no cure and drug therapies are costly and insufficient, non-pharmacological interventions are essential. This paper explores recent literature on the relationship between the brain and music therapy, focusing on its impact on Parkinson's disease. It specifically examines how music-based practices can be used to repair functions that have been neurologically damaged by the disease while also fostering meaningful relationships with therapists or among patients. The aim is to enhance understanding of music education and its vital role in promoting human well-being.

Keywords: Music Therapy, Parkinson's disease, Intervention, Well-being

1. INTRODUCTION

In the face of significant challenges in the treatment of Parkinson's disease, pharmaceutical approaches are highly utilized but the outcomes in addressing the symptoms have often been underwhelming. Research indicates that patients with this neurodegenerative disorder rely on dopaminergic medications which pose the risk of drug resistance and levodopa-induced dyskinesias [1]. With no cure, Parkinson's patients are heavily reliant on drug therapy which poses adverse side effects after long-term use hence proving insufficient for disease management [2]. A study analyzing the effectiveness of a medication like Levodopa used to treat Parkinson's disease shows that it is associated with challenges such as fluctuations in motor response due to poor bioavailability, short half-life, and discontinuous drug delivery.

Recent research by Fan et al. [3], shows that 10 million of the global population will have Parkinson's disease by 2030. It further demonstrated that the older population has a high prevalence rate for Parkinson's disease. With the increased global population of older adults, the healthcare system can anticipate an increased patient population with Parkinson's disease. Therefore, there is a critical need to seek alternative interventions to lower dependence on drug therapy. This turns the attention towards non-pharmacological avenues that can aid greater disease management for patients experiencing neurological disorders. Bega and Zadikoff [4] found out that in Asian countries where treatment for Parkinson's incorporates complementary medicine, the prevalence particularly among older adults is as low as 0.6% whereas countries that solely practice conventional Western treatments have a significant prevalence of at least 1%.

1.1 Parkinson's Disease

According to Bashir et al. [5] Parkinson's disease is the disease of basal ganglia. Parkinson's can be characterized by varying levels of motor impairments in addition to constellations of non-motor symptoms [4]. A different study by Raglio [6], characterizes the disorder with progressive degeneration of dopaminergic

systems that are imperative for the dysfunctions in movement and symptoms affecting the psychological and cognitive aspects. Previously, Parkinson's disease was only recognized as a disease that caused motor-related symptoms [2]. Now, the disease is characterized by both motor and non-motor symptoms. The condition is also associated with a relative preservation of intellectual abilities [7]. Symptoms caused by motor dysfunction include tremors, posture and muscle tone changes, and slow movements [5]. On the other hand, Fan et al. [3] noted that patients with Parkinson's disease are susceptible to non-motor symptoms such as depression and anxiety which negatively influence their quality of life. They further highlight that the most common manifestation of Parkinson's disease although it occurs in the last stages is the gait disturbance.

In their study, Machado Sotomayor et al. [7] clarified that this disease disrupts the timing and size of repetitive sequences that are automatically generated by the brain. Therefore, the deficit is the cause of disruption of gait patterns leading to the instability of the trunk, short steps, loss of rhythm, and slower gait. More studies show that the non-motor symptoms experienced by patients with Parkinson's disease are autonomic dysfunction, cognitive impairment, apathy, depression, and sleep disturbances [4]. Machado Sotomayor et al. [7] also highlight other non-motor symptoms including autonomic, gastrointestinal dysfunctions, and sensory disorders. Further research indicates that Parkinson's disease treatment has historically been pharmacologically based by targeting dopamine replacement [4]. In some cases, this method of treatment has failed or worsened the non-motor symptoms. As Panebianco and Lotter [8] illustrate, even with surgical and medical treatments, the motor symptoms associated with this disease often require rehabilitation for effective management, especially because most advance into dyskinesia or more adverse side effects.

1.2 Music Therapy

Music therapy is renowned for its cognitive, psychosocial, motor, and behavioral benefits to individuals experiencing different neurological disorders [7]. Across centuries, music has been highly utilized to serve therapeutic purposes. Although highly regarded for entertainment purposes, music is now an invaluable tool due to its influence on brain and cognitive development. Fodor et al. [9] highlighted that music has therapeutic effects because the use of rhythmic auditory cueing techniques can partially replace the loss of rhythm and automaticity in patients. Music therapy entails the use of sounds of music to foster patients' mental, physical, and social well-being [7]. As Zhang [10] noted, it incorporates medicine, psychology, and music to enhance the physical and mental health of the patients. The paper further indicated that through a physiological lens, music therapy occurs as an outcome of the stimulation of the central nervous system by an objective stimulus. According to Bashir et al. [5], music therapy is categorized into the active form which demands participation, and the passive form which involves listening. The paper acknowledges that there haven't been significant and objective reports on the efficacy of passive music therapy on patients with Parkinson's. However, this form of music therapy can be utilized in enhancing memory, and concentration, reducing stress, and promoting coping for patients with heart issues [5]. In a different research, Zhang [10] differs and argues that most music therapy sessions involve patients who are passively listening.

Music can stimulate different areas of the brain and lead to physiological effects [10]. These effects can be attributed to its unique ability to stimulate brain regions that are used to facilitate cognition, motor functions, language, motivation, and emotions simultaneously [30]. Recent research on the brain shows that due to its plasticity, its structure and function can be uniquely shaped when under the influence of the environment or experiences [10]. The auditory cortex found in the brain is particularly vital in facilitating the recognition and monitoring thus influencing complex brain roles. Zhang [10] further found that music has the potential to enhance signals and establish a network for brain functions which are crucial for brain activities. In their findings, Panebianco and Lotter [8] illustrated that the areas within the brain used for music are also fundamental in regulating sensory, cognitive, and emotional functioning. Music activates areas within the brain necessary for language and speech production. Therefore, the correlation between music and the brain can compensate the neurological damage by stimulating and activating different functions in the body. That explains why Machado Sotomayor et al. [7] strongly recommended the use of music as a formidable

alternative for Parkinson's treatment due to its ability to engage both the multisensory and motor network by inducing change and linking brain regions.

Recent research justifies this correlation by revealing that music works in Parkinson's treatment due to its direct effect on the limbic system and the brainstem structure [10]. It further shows that the melody produced during therapy stimulates the patients' thinking, behavior, and ability to launch emergency responses. Raglio [6] highlighted that rhythm is particularly instrumental in rehabilitation since it enhances the connection between the auditory and motor systems. The auditory cues from music act as time reference to regulate the patient's walking pace hence compensating for the affected temporal and spatial mechanisms affected by the disease [1]. In their research, Leuk et al. [1] further demystify the compensation mechanism that when the basal ganglia network is adversely affected by the disease, the acoustic rhythms released in music empowered alternative cortical structures such as the cerebello-thalamocortical circuitry to foster neural entrainment and boost motor functioning. It further clarifies that the efficiency of external cues is centered on their activation of the lateral premotor cortex and cerebellar connections to the designated motor cortices.

Music therapy stands as a unique tool primarily for its therapeutic effects and the brain's plasticity that supports the reorganization of its connections when under the influence of stimulation. Its use in treatment is founded on the principle that music can elicit behavior changes and the brain's reward pathways. According to Hegde [11], music causes neurochemical changes that influence psychophysiological parameters such as blood pressure, perception of pain, heart rate, and respiration control among others. In the same research, Hegde [11] noted that these changes to the brain influence aspects such as dopamine and opioids to mediate pleasure and reward, oxytocin mediates the patients' socializations, cortisol and adrenocorticotrophic mediate stress and arousal, while others like serotonin work to mediate immunity. As Leubner and Hinterberger [12] insisted in their research, due to the delicate nature of areas affected by Parkinson's disease, interventions such as music therapy must be administered by a board-certified music therapist who uses carefully selected music to uniquely benefit a particular patient based on their health condition.

2. THE IMPACT OF MUSIC THERAPY

A systematic review focusing on scientific evidence between 2015 and 2020 indicated that music therapy can achieve tremendous improvements in the quality of life for patients with Parkinson's disease [7]. A different study noted that music-based therapeutic activities ease behavioral and psychological symptoms among these patients without posing any side effects [30]. From a rehabilitative aspect, the benefits accrued from music therapy spearhead patients toward a functional recovery. As research shows, music-based practices can be used to repair functions that have been neurologically damaged by the disease while also being used to establish meaningful relationships with the therapist or among patients [6]. This form of intervention poses greater benefits that make the disease manageable. Below is an in-depth elaboration showing music therapy's impact on particular aspects affected by symptoms of Parkinson's disease.

2.1 Gait Impairment

Gait-related issues are highly common among patients diagnosed with Parkinson's disease. A study by Harrison and Earhart [13], closely associated gait impairment to fall risks among patients experiencing Parkinson's symptoms. Gait impairment is linked to cases of freezing and balance difficulties among Parkinson's patients. According to Fan et al. [3], freezing of the gait occurs due to motor disturbance affecting the patient's ability to maintain or initiate locomotion even when they intend to walk. Research by Machado Sotomayor et al. [7] shows that gait training involves using music to foster rehabilitation by inducing the modification of spatiotemporal parameters and trunk oscillations. Patients engage in singing at different tempos formulating internal cues that are instrumental in promoting their motor performance because the rhythmic auditory stimulation compensates for the effects on their rhythmic movements caused by the illness [7]. In a related study by Buard et al. [14] investigating the efficacy of auditory stimulation as a neurological music therapy technique on three patients with Parkinson's disease, the team discovered that metronomes helped participants improve their fine motor function. Although it notes that the

improvements in task performance were not consistent in all patients, it acknowledges that each patient experienced an improvement in a single or more motor function.

A different study by [6] claimed that training patients on rhythm auditory cues releases compensation for the cerebello-thalamo-cortical network to help enhance the length of their strides, speed, and motor timing. In addition, music therapy corrects their impaired timing system by using external cues to stimulate the putamen activity that helps patients to sequence, synchronize, and automate their movements. A randomized controlled trial seeking to investigate the impact of rhythmic auditory stimulation on patients with idiopathic Parkinson's disease discovered that the patients experienced significant improvement in their balance, gait quality, and the length of their strides [15]. In essence, music therapy corrects the absence of stimuli using rhythm. Similarly, Harrison and Earhart [13] discovered that rehabilitation techniques that adopt rhythmic auditory simulation help these patients to walk on musical cues and tones hence improving the length of their strides and gait speed. Leuk et al. [1] add that these external cues are applied by presenting a beat of a metronome that matches an individual's baseline cadence after which they are adjusted to suit an optimal pace while patients practice to synchronize their steps with the beats. External cues assist patients in overcoming freezing and walking in time. However, in a different study, Harrison et al. [16] compared the effects of internal and external cueing techniques when treating gait impairments and discovered that internal cues through singing aloud elicited more benefits to gait recovery compared to external cueing which primarily involves listening to music playing.

In their study, Machado Sotomayor et al. [7] affirm that the inclusion of music-centered physical therapy helped patients with Parkinson's disease to improve their functional mobility and balance. Most importantly, the music can be professionally structured and selected to meet the patient's needs. In support, Ashoori et al. [17] indicated that rhythmic auditory stimulation can be tailored to adapt to the patient's movements and is more effective compared to fixed-tempo rhythmic acoustic stimulations. Studies also demonstrate that different music genres are feasible in providing rhythmic auditory cues which are crucial for enhanced gait and motor behaviors in Parkinson's patients [7]. In their research, Fan et al. [3] discovered that music rhythm activates motor neurons causing contraction of muscles and the synchronization of body movements using beats. That demystifies the findings by Raglio [6] on the application of rhythmic auditory stimulation and its utilization of rhythm to improve the gait, balance, limb coordination, and postural control through enhancing the sensory, motor, and cognitive function in the patient's brain using music. As a result of gait impairment, the reduction of the arm swing is among the primary symptoms experienced by patients with Parkinson's disease. Therefore, to test the impact of musification, Mainka et al. [18] used mobile technology specifically the CuraSwing application to generate music that would act as the rhythmic auditory cue and stimulate the patients' gait kinematics. The research shows that the music from the application led to an increase in the arm swing amplitudes beyond the normal range among these patients.

A different study conducted by Cochen De Cock et al. [19] used a personalized music-based gait rehabilitation protocol (BeatWalk) embedded in a smartphone to stimulate patients to walk outdoors while listening to music. BeatWalk works by modifying the music tempo to induce spontaneous synchronization of the gait. The participants found that the application was tolerable, enjoyable, and safe to use. Moreover, it revealed that BeatWalk fostered physical activity which is crucial in improving gait parameters. In a related study, Fan et al. [3] appreciated the recent inclusion of music in clinical therapy as clinicians seek to find alternative solutions to gait and speech disorders among patients with Parkinson's. Although the study recognizes the role of music therapy, it still highlights the contribution of FDA-approved interventions such as deep brain stimulation, rehabilitation, and dopaminergic pharmacotherapy in addressing gait impairment and further highlights risks associated with these treatments including disability and social isolation. Essentially, these studies posit that music therapy is a formidable tool that clinicians can utilize to restore gait abilities in patients without putting them at significant risk.

2.2 Tremors and Rigidity

Tremors affecting the hands, limbs, and mouth are among the most noticeable symptoms of Parkinson's disease. According to Abusrair et al. [20] the management of tremors is complex due to their progression and the fact that their response to dopaminergic agents is relatively poor. The study further notes that the

tremor pathophysiology has remained difficult to understand while the symptoms are the most troublesome among patients with Parkinson's disease. 75% of patients with Parkinson's experience tremors and exhibit poor response to dopaminergic agents [21]. Despite extensive research, it is clear that not many studies have focused on the impact of music therapy on tremors. Leuk et al. [1] attempted to grasp the impact of music therapy on tremors among patients with Parkinson's and discovered that, unlike rhythmic acoustic stimulation, vibroacoustic therapy includes sound vibrations which manipulate sensory feedback to the muscles and hence are vital in the improvement of movements and reduction of tremor frequency. On the other hand, Zach et al. [22] found that cognitive stress in patients with Parkinson's disease impairs the efficiency of medication targeting the treatment of tremors. As a result, the study recommends the use of music to foster relaxation based on its therapeutic effect. According to Buhmann et al. [23], tremors among these patients can also be elevated by emotional and mental distress. However, the use of music during therapy promotes mental relaxation and eliminates tremors. Leuk et al. [1] suggest that based on music's power to modulate neural activities that are affected by Parkinson's, the acoustic-based intervention presents an affordable and effective treatment pathway for these patients. Consequently, the ability of music to induce adaptable changes to the auditory-motor network makes it instrumental in facilitating the functional recovery of movements. Although limited studies shine a light on music therapy as an intervention for tremors among these patients, a study by Fujikawa et al. [24] recommends mechanical interventions such as deep brain stimulation, orthosis, and electrical muscle stimulation as the current and most effective in diagnosing and evaluating tremors.

2.3 Mood Disorders and Cognitive Function

Most patients with Parkinson's lead a life of isolation due to limited social participation. Therefore, they are highly susceptible to depression and anxiety. According to Panebianco and Lotter [8], the immobility brought about by motor symptoms leads to mental fatigue that causes patients to experience frustrations, loss, and sadness. Moreover, the loss of vocal abilities in most patients directly leads to social withdrawal. As a result, this negatively affects their moods and cognitive function. Research by Raglio [6], shows that mood disorders leading to depression and anxiety often prevail even before the motor-related symptoms manifest. It further shows that among patients with Parkinson's, 35% display symptoms of depression while 40% have anxiety issues. Depression is particularly a significant burden for patients with Parkinson's disease. Currently, antidepressants are the most reliable and commonly used intervention among these patients. However, a study by Bashir et al. [5] denoted that a combination of physical and music therapy has a significant effect on depression. Similarly, an exploration of patient experiences shows that enrolling Parkinson's patients in choral singing therapy has a therapeutic implication by promoting their morale and preventing social isolation [25]. As these patients enjoy these activities, they attain better control of symptoms affecting their moods and language. In a case of eleven Parkinson's patients enrolled for group singing, Machado Sotomayor et al. [7] note that these patients displayed social connectedness which positively impacted their quality of life. In a different study, the effects of music such as acoustic cues seemed to pose a rhythmic and arousal impact that fostered greater motivational and emotional processing among patients [26]. Music therapy is patient-centered and highly dependent on individual participation. For instance, Raglio [6] discovered that music therapy is less performance-based but instead accounts for the patient's expression to allow the calibration of the stimulus for the integration and regulation of both physical and psychological functions. As Raglio [6] further elaborated, sound from music invigorates non-verbal communication hence stimulating the patient's emotional expression and regulation. Further, it creates an avenue for emotional connection and the forging of empathetic relationships among patients.

Recent evidence suggests that the most impactful benefit of music therapy is the socialization among patients as they sing, listen, or make music together. Fan et al. [3] found that music is widely approved for boosting motivation and making experiences enjoyable for Parkinson's patients with speech disorders. As a result, it positively impacts their mood and reduces their stress levels. Although it is important to protect Parkinson's patients from sadness, research by Hegde [11] reveals that listening to sad music helps patients with their emotional regulation, empathy, and imagination. A study using classical Indian music to investigate the impact of music therapy on mental disorders found that when the participants listened to music for 30 minutes every day for 20 days, they had a significant reduction in their blood pressure, stress levels, depression, and anxiety levels [11]. Additionally, these participants experience a greater sense of

hope, optimism, and life satisfaction. In their study, Fodor et al. [9] found that including rhythmic music in the multimodal rehabilitation program posted greater improvements in the participants' social support, emotional well-being, communication, and bodily discomfort. As a result, their quality of life was positively impacted especially because their social support increased when they were exposed to music as a group.

Numerous studies have demonstrated that different forms of music therapy have an impact on patients' cognitive function. A study on patients with Parkinson's disease showed that piano training was effective in activating the brain cerebellum due to fine finger movements during practice [7]. By awakening the executive functions, the training helps patients to enhance their cognitive control. A different study focusing on intensive piano training among older adults with Parkinson's disease discovered that it acted as an effective intervention for the participants' cognitive and psychosocial well-being [27]. In a randomized study, Spina et al. (2016) found out that music therapy helped to boost frontal lobe function due to music's ability to stimulate attention and executive functions. As a result, the exercise helps patients to experience increased cognitive skills and flexibility. Unfortunately, the study also recognizes the fluctuation and deterioration of this progress whenever music therapy is halted.

2.4 Quality of Life

The quality of life for patients with Parkinson's is highlighted as compromised due to their impaired ability to effectively communicate. The motor and neuropsychological dysfunctions are detrimental to a quality of life [28]. The disease manifestation and the rate of progression extensively influence the quality of life that patients experience. Fan et al. [31] elucidated that the quality of life for these patients is highly dependent on the success of their disease management. For instance, the study highlights that due to the negative impact of the illness Parkinson's patients have a double risk of developing Parkinson's compared to those that are free of Parkinson's. Research by Fan et al. [3] revealed that 89% of patients with Parkinson's experience speech disorders that adversely affect their articulation, prosody, phonation, and respiration. They further note that most FDA-approved treatments are incapable of addressing symptoms associated with speech impairment. The inability to communicate is detrimental to the patient's quality of life because it often leaves them feeling frustrated and angry. A study by Machado Sotomayor et al. [7] argued that enrolling such patients in group singing can be comforting and impede vocal deterioration as an eventual effect of the disease. Due to the correlation between singing and speech, this study suggests interventions such as ParkinSong and group singing as beneficial alternatives that can aid in maintaining vocal function and respiratory pressure. A comparable systematic review on the impact of music on patients with Parkinson's disease showed that voice development through enrolling patients in group singing activities was instrumental in promoting memory, speech information processing, and respiratory muscle function among others [29]. Further exploration has made it evident that respiratory control is a vital consequence of group singing and it plays an essential role in promoting swallowing.

3. CONCLUSION

The influence of music on the human brain is quite extensive. Research has demonstrated that medicine and music are closely intertwined. It has elaborated that symptoms associated with Parkinson's cannot be solely resolved with Western medication. The incorporation of alternative rehabilitative interventions is imperative for better disease management. As previously noted, most of the literature reviewed admits that there is exponential potential in the use of music therapy for the treatment of Parkinson's symptoms. Even then, there is a need for further inquiries to determine the outstanding value of music therapy in the rehabilitation of Parkinson's patients. So far, music provides a promising alternative to dealing with the complexities associated with Parkinson's disease. Therefore, the efficacious role of music therapy in the management of Parkinson's disease remains implicitly vital.

4. RECOMMENDATIONS

The previous section elaborates on music therapy's impact on aspects affected by symptoms of Parkinson's disease. Although most studies approve the use of music in dealing with Parkinson's disease symptoms,

others urge that the music must be carefully appraised and selected to be beneficial and effective. In their findings, Raglio et al. [30] noted that although Parkinson's patients seem to enjoy music, they also require encouragement to participate and settle for beneficial music selections. In a different paper, Zhang [10] cautions that music therapy must be planned, purposeful, and guided by medical psychology. Additionally, further research must be conducted to deeply explore procedures and the extent of practice in patients with neurological illnesses. There is a need for extensive research investigating the access and cost of music therapy among the Parkinson's patient community. The adoption of modern technologies also presents room for further exploration and study. In their study, Machado Sotomayor et al. [7] elucidates that mobile technologies such as applications ought to be optimized to create rhythmic auditory signals that can administer cues to patients with Parkinson's during walking. Even with a significantly large body of research indicating the valuable role of music therapy in treating patients with neurological diseases, it has not been adopted as standard medical practice. That limits its application and prevents reimbursement of such rehabilitative services through medical insurance.

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Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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