Música Hodie | ISSN: 2317-6776 DOI: 10.5216/mh.v25.81634

Neurologic Music Therapy for Inhibitory Control in Parkinson's disease: a feasibility study

Musicoterapia Neurológica para Controle Inibitório na doença de Parkinson: um estudo de viabilidade

Leonardo Francisco Citon
Universidade Federal do Paraná, Curitiba, Brasil
leonardo.citon@ufpr.br

Luísa Teixeira dos Santos
Universidade Federal do Paraná, Curitiba, Brasil
luisasantos@ufpr.br

Amer Cavalheiro Hamdan
Universidade Federal do Paraná, Curitiba, Brasil
achamdan@ufpr.br

Abstract: Parkinson's disease (PD) is characterized by motor deficits as cardinal symptoms, in addition to non-motor symptoms, including impairments in inhibitory control. Neurologic music therapy – a therapeutic intervention based on research on the effects of music on the central nervous system – can be considered a potential therapeutic approach for various impairments, including cognitive aspects. Methods: In this feasibility study, we randomly recruited five (n=5) participants with PD. We carried out an individualized intervention over four weeks, with three weekly sessions of 30 minutes each, totaling 12 sessions, held at each participant's home. We investigated recruitment and retention rates, as well as a qualitative assessment of assessment and intervention protocols. We also evaluated inhibitory control, quality of life, and motor/cognitive development. Results: The recruitment of the five participants took 40 days, with a dropout

rate of 20% and 85% approval of the protocols. Due to the small sample size, inferential statistical analysis for motor/cognitive outcomes was not performed. The results indicate positive aspects pointed out by participants and researchers, such as the evaluation and intervention protocols, and highlight the need for a longer intervention period and longer duration of sessions. Conclusion: This study provides preliminary data for the planning of future research with larger samples and randomized controlled designs.

Keywords: Parkinson's disease, Inhibitory control, Feasibility study, Neurologic music therapy.

Resumo: A doença de Parkinson (DP) é caracterizada por déficits motores como sintomas cardinais, além de manifestações não motoras, incluindo prejuízos no controle inibitório. A musicoterapia neurológica – uma intervenção terapêutica fundamentada em evidências sobre os efeitos da música no sistema nervoso central – configura-se como uma abordagem promissora para diversos comprometimentos, incluindo aspectos cognitivos. Métodos: Neste estudo de viabilidade, foram recrutados aleatoriamente cinco participantes com diagnóstico de DP (n=5). A intervenção foi realizada de forma individualizada ao longo de quatro semanas, com três sessões semanais de 30 minutos, totalizando 12 sessões, todas conduzidas no domicílio dos participantes. Foram analisadas as taxas de recrutamento e retenção, bem como aspectos qualitativos relacionados aos protocolos de avaliação e intervenção. Avaliaram-se também o controle inibitório, a qualidade de vida e o desempenho motor e cognitivo. Resultados: O recrutamento dos cinco participantes foi concluído em 40 dias, com uma taxa de evasão de 20% e um índice de aprovação dos protocolos de 85%. Devido ao tamanho reduzido da amostra, não foi realizada análise estatística inferencial dos desfechos motores e cognitivos. Os resultados apontam aspectos positivos

destacados pelos participantes e pesquisadores, como os próprios protocolos de avaliação e intervenção, além de indicarem a necessidade de um período de intervenção mais prolongado e sessões de maior duração. Conclusão: Este estudo oferece dados preliminares que podem subsidiar o planejamento de pesquisas futuras com amostras mais amplas e delineamentos controlados e randomizados.

Palavras-chave: Doença de Parkinson, Controle inibitório, Estudo de viabilidade, Musicoterapia neurológica.

Submetido em: 4 de fevereiro de 2025

Aceito em: 5 de julho de 2025

Publicado em: agosto de 2025

Introduction

Parkinson's Disease (PD) is a progressive neurodegenerative disorder, characterized primarily by the loss of dopamine-producing neurons in the substantia nigra area of the midbrain, but it also affects other brain regions involving non-dopaminergic neurons (Simon et al., 2020). PD is characterized by motor symptoms, such as tremors, muscle rigidity, slowness of movement (bradykinesia), difficulty initiating movements (akinesia), and balance problems (Balestrino & Schapira, 2020). Additionally, it includes non-motor symptoms, such as cognitive decline, neuropsychiatric changes, sensory changes, and autonomic dysfunctions (Duncan et al., 2014). Age is the main risk factor, along with specific genetic mutations and long-term exposure to certain environmental toxins (Lopes et al., 2017). PD is the second most common neurodegenerative disease in the world, after Alzheimer's, with estimates pointing to around 10 million cases in the largest Western European countries and the ten most populous nations by 2030, highlighting the critical need for more research (Asadpoordezaki et al., 2023).

The diagnosis of PD is primarily based on the identification of motor symptoms, although cognitive impairments, such as difficulties in inhibitory control (IC), may appear even before motor symptoms (Weintraub et al., 2022). Inhibitory control is a facet of executive functions involved in the management of attention, behavior, thoughts, and emotions, through the suppression of inappropriate responses for a given context (Diamond, 2013). The neurophysiological causes of inhibitory control disorders (ICDs) are not completely known, but it is suggested that long-term use of dopaminergic medications, common in the treatment of PD, may contribute to ICDs (Voon et al., 2017).

In a recent review, Mirabella et al. (2024) highlight that the relationship between dopaminergic treatment and inhibitory control may vary according to the stage of the disease, on the Hoehn & Yahr scale (Hoehn & Yahr, 1967), as can be seen in Table 1.

Table 1. Relationship between dopaminergic treatment and inhibitory control.

H&Y Internship	Type of inhibition affected	Effect of dopaminergic treatment
H&Y 1	Reactive inhibition	Weakened ability to respond to a stop signal
H&Y 2	Proactive inhibition	Weakened ability to modulate inhibition according to context
H&Y 3	Proactive inhibition	Mildly beneficial effects on modulating proactive inhibition

H&Y = Hoehn & Yahr Parkinson's Ladder Scale.
Source: Mirabella et al., 2024.

Neuroimaging research indicates a link between DCIs and increased dopamine release in the ventral striatum during reward tasks (Sanchez-Luengos et al., 2021). ICDs affect about 13.6% of PD patients on dopaminergic medications (Weintraub et al., 2010) and can result in psychosocial, financial, and legal challenges due to increased impulsive behaviors (Phu et al., 2014).

Some nonpharmacologic interventions for cognitive deficits in PD found in the literature include physical therapy, occupational therapy, neuropsychology, dance, games, computerized programs, and brain and cranial stimulation (see Sanchez-Luengos et al., 2021; Lawrence et al., 2017; Leung et al., 2015). Music therapy is understood as a field of knowledge that studies the effects of music and the use of musical experiences, resulting from the encounter between the music therapist and the people assisted (Ubam, 2018). In the neurological context, it engages patients in diverse and complex cognitive experiences due to its ability to activate multiple sensory and motor systems (Herholz & Zatorre, 2012). In addition, it is an affordable approach for patients of different age groups and is generally low risk (Robb et al., 2011). However, there are potential iatrogenic risks, such as the induction of negative emotional responses (Murakami, 2021) or even the occurrence of epileptic seizures, if it is applied inappropriately (Maguire, 2015).

Some studies have explored the possible benefits of musical experiences in the therapeutic context in general. The study developed by Verghese et al. (2003), showed that lifelong musical practice is associated with a lower risk of dementia and mild cognitive impairment in the elderly. The study by Junemann et al., (2022), comparing the density of white matter nerve fibers in the fornix (a region with a fundamental role in episodic memory) of elderly people who listened to music and elderly people who performed piano training, showed that the group that trained piano maintained stability in the size of this region, while the group that listened to music had this structure reduced, normal process during aging. Studies of this nature demonstrate the potential of sound-musical experiences to induce functional and structural neuroplasticity (see Cheng et al. 2023; Liebscher et al. 2023; Guo et al. 2023; Zaatar et al. 2024; Colverson et al. 2024). Considering the view of music therapy from the neurological perspective as the responses of the central nervous system to the musical experience, neurologic music therapy emerges, which combines advances in neuroscience with music therapy techniques, and is designed to use music therapeutically in neurological disorders, and can offer substantial benefits in cognitive rehabilitation by taking advantage of neuroplasticity and compensatory processes stimulated by musical activities (Moreira et al., 2012).

In a literature review, several studies were found that examined cognitive improvements, including inhibitory control, in individuals with PD (Bugos et al., 2007; Pohl et al., 2020; Pohl et al., 2013; Kim & Park, 2021; Bugos et al., 2019). In the research of Moreno and Farzan (2015), a causal relationship was identified between musical training and improved inhibitory control, with results suggesting that inhibitory control may facilitate a transfer effect of musical training to verbal skills. Kim and Park (2021) also observed improvements in inhibitory control during cognitive tasks in a study utilizing rhythmic exercises. Bugos et al. (2019) reported that piano training significantly improved performance on inhibitory control

tests compared to a control group. However, a recent systematic review on music interventions aimed at cognitive outcomes in PD, carried out by Citon and Hamdan (2023), only the study by Pohl et al. (2013), showed significant improvements in inhibitory control.

The variability in results between studies indicates a lack of consensus on the efficacy of music therapy to improve inhibitory control in Parkinson's disease. In this context, we propose this study as preliminary research for the collection of data on the feasibility of a neurologic music therapy process, aiming at a broader study for the future.

Reasoning for Neurologic Music Therapy in Inhibitory Control

The primary clinical goal of a neurological intervention of any kind is to ensure that the skills learned during treatment are transferred to the patient's everyday activities (Kleim & Jones, 2008). In neurologic music therapy, inserted in the context of neurological intervention, it seeks to stimulate and develop specific skills through specific techniques of music therapy and neurological rehabilitation (Moreira et al., 2012), with the expectation that the skills developed in these musical contexts will be transferred to non-musical situations. However, understanding the mechanisms underlying this transfer process remains a significant challenge.

Miyake and Friedman (2013) propose that inhibitory control may be the main mediating factor in the transfer of general skills between different cognitive capacities, since it is a component of executive functions that is directly related to monitoring, flexibility, and inhibition. In the musical context, based on research on neuroplasticity induced by musical experience, Moreno and Farzan (2015) and Moreno and Bidelman (2014) proposed a multidimensional continuum model as a framework for understanding the transference of musical skills. This model

considers the interaction between the level of processing (sensory or cognitive), the nature of transfer (near or far), and the role of executive functions. In this way, neurologic music therapy can be applied to the development of musical skills, which intrinsically involves all aspects of executive functions, including working memory, selective attention, inhibitory control, cognitive flexibility, and monitoring. The authors suggest, therefore, that executive functions may mediate the process of transferring cognitive skills developed during music-making, such as executive processing, intelligence, and working memory (Moreno & Farzan, 2015; and Moreno & Bidelman, 2014).

Based on this reasoning, considering the potential of inhibitory control as a possible mediator in the transfer of cognitive skills from the musical to the non-musical context, the musical interventions proposed here were developed considering paradigms such as the Stroop test – whose psychological principle is the inhibition of automatic response through simultaneous conflicting stimuli (Stroop, 1992); the Go/No-Go task – which demands inhibition of an automatic response by signaling an inhibitory stimulus (Verbruggen & Logan, 2008), and neurological music therapy techniques for cognition, such as Musical Attention Control Training (MACT), Auditory Perception Training (APT) and Musical Executive Function Training (MEFT) (Thaut & Hoemberg, 2014).

Thus, the objective of this study was to evaluate the feasibility of a neurologic music therapy intervention for inhibitory control in PD, based on musical practices developed exclusively for this research based on the theoretical precepts previously presented.

Methods

This feasibility study was structured based on the Consolidated Standards for Trial Reporting (CONSORT) for pilot and feasibility

studies (Eldridge et al., 2016). Our theoretical-methodological basis follows an empirical-inductive-based pragmatic approach, focused on the practical application of knowledge and adopts mixed methods, combining quantitative and qualitative data, in order to understand both the objective and subjective aspects of the intervention (Creswell & Clark, 2017).

To assess feasibility, a single-arm study with pre- and post-intervention assessments was conducted, involving five participants. The sample size is consistent with the objectives of a phase I feasibility study, which aims to focus on outcomes related to the ability to execute the study (Bowen et al., 2009). The sessions were individualized, held three times a week, lasting 30 minutes each, over four weeks, in the participants' homes.

Participants with a confirmed diagnosis of Parkinson's disease, between 50 and 80 years of age, were included. In the pre-intervention evaluation phase, data were collected regarding the staging on the Hoehn and Yahr scale (Hoehn & Yahr, 1967) from I to III (indicating mild to moderate impairment and independent living), and the Montreal Cognitive Assessment (MoCA) score ≥ 24 (Nasreddine et al., 2005). Participants diagnosed with other neurological disorders, visual and/or hearing impairments that affected comprehension and task performance, or who were undergoing treatment for cognitive disorders were excluded. The participants were recruited from the Parkinson's Association of Paraná, a non-profit organization located in the city of Curitiba, PR, Brazil. The practical team consisted of an evaluative researcher, graduated in Psychology – who carried out the pre and post-intervention evaluations; and an interventional researcher specialized in music therapy with certification in neurological music therapy by the *Academy of Neurologic Music Therapy*® – who developed the evaluation protocols and applied the neurologic music therapy intervention.

The randomization of the participants was performed by an employee of the institution where the recruitment took place, who was instructed by the researcher responsible for the intervention on how to conduct the process. A randomization procedure was conducted to select five participants for the study: from a list of active members of the partner institution, each member was numbered sequentially, and the random.org site was used to generate five random numbers. The reason for randomization in the selection process was in order to mitigate the risk of bias in the selection of participants, striving for a procedure with more methodological rigor.

The intervening researcher received the names and forwarded them to the evaluating researcher. The selected members were contacted by telephone and invited to participate in the study. Those who accepted received detailed information and were referred for the initial evaluation. This procedure occurred until the number of five participants was confirmed.

Neurologic Music Therapy Evaluation Protocol

The neurologic music therapy assessment protocol (Citon & Hamdan, 2025) – with descriptions of each instrument and its functions, can be seen in Table 2.

Table 2. Neurologic Music Therapy Evaluation Protocol

Evaluation instrument	Description	Time of application
Sociodemographic/clinical questionnaire - supplementary material 1 - (protocol function/ inclusion criteria)	Developed by the interventionist researcher for this study, it collected data including age, gender, time since diagnosis, education, levodopa use, use of deep brain stimulation, visual or hearing problems, neurological diagnosis, and participation in other therapies for cognitive improvement.	5-10 minutes
Hohen & Yahr scale (inclusion criteria)	It considers four stages in PD: stage I – Unilateral involvement, usually with minimal or no functional impairment; stage II – Bilateral or midline involvement, without compromising balance; stage III – First sign of impairment of postural reflexes; stage IV – fully developed and severely disabling disease (Hoehn & Yahr, 1967)	10-15 minutes
Montreal Cognitive Assessment (MoCA) (inclusion criteria)	It facilitates the screening of cognitive function in primary care by examining the following cognitive skills: visuospatial/executive function, naming, episodic memory, attention, language, abstraction, and orientation. Its score is 30 points, with higher scores reflecting better performance. The cut-off score is 24, and those with a score of 24 or less are suspected of having Mild Cognitive Impairment (MCI). (Nasreddine et al., 2005)	10-15 minutes
Recruitment rate (primary outcome)	Determined by dividing the number of individuals who accepted the invitation by the number of individuals who were contacted.	-
Retention rate (primary outcome)	Calculated by dividing the number of participants who completed the study by the total number of participants recruited.	-
Dropout rate (primary outcome)	Defined as the percentage of participants who did not complete the study, calculated by dividing the number of participants who dropped out by the total number of recruited.	-
Questionnaire Acceptance of the protocol – supplementary material 2 (primary outcome)	Developed by the intervening researcher, it evaluates through a questionnaire filled out by the participants at the end of the post-intervention evaluation, using a Likert scale with a maximum score of 44 (excellent) and a minimum score of 0 (very bad).	5-7 minutes

Researchers' report (primary outcome)	Qualitative analysis based on observations and subjective perceptions. Researchers' report of the evaluation and intervention on relevant aspects perceived during the study.	-
Stroop Color-Word Test (secondary outcome)	Measure of the ability to inhibit cognitive interference. The test consists of three cards containing stimuli (rectangles or words) printed in different colors. Participants should name the color of the printed stimulus as soon as possible. Performance is evaluated based on the time taken to read each card (Stroop, 1992).	5-10 minutes
Go/No-Go task (secondary outcome)	It allows the assessment of response inhibition under conditions in which other cognitive and behavioral processes are minimized. In this task, the letter A serves as the Go stimulus, while the letter B acts as the No-Go stimulus. The stimuli are presented in white on a black screen. Participants must respond quickly by pressing a key when the letter A appears and refrain from responding when the letter B is displayed (Sánchez-Khun et al., 2017).	5-10 minutes
Hayling test (secondary outcome)	Instrument in which the respondent must complete sentences by providing a word. It consists of two parts: Part A evaluates processes such as pre-programmed organization, focused attention, verbal initiation, processing speed, and effective automated word search strategies associated with semantic network pre-activation. Part B evaluates more complex components of executive functions (Burgess & Shallice, 1997).	5-7 minutes
Unified Parkinson's Disease Rating Scale (MDS-UPDRS) (secondary outcome)	Widely used for Parkinson's disease. It is divided into 4 domains: non-motor aspects of daily living, motor aspects of daily living, motor assessment, and motor complications. In this study, only the first two domains were evaluated (Goetz et al., 2008).	5-7 minutes
Quality of Life in Parkinson's Disease Questionnaire (PDQ-39) (secondary outcome)	Self-administered with 39 questions that are divided into 8 domains: Mobility; Body Discomfort; Activity of Daily Living; Emotional Well-Being; Communication; Stigma; Social Support; and Cognition. To answer the questionnaire, the participant must choose, subjectively, the option that answers the question most appropriately, among the answers: never, once in a while, often, always. The score ranges from 0 to 100, where 0 corresponds to the best quality of life and 100 corresponds to the worst quality of life (Jenkinson et al., 1997).	5-7 minutes

Note: the entire evaluation protocol was conducted by the evaluating researcher.

Blinding

Blinding both the intervening researcher and the participants in the intervention stage was not feasible due to the nature of the study. To minimize biases in the conduct of the research, blinding was performed in the selection process – through the randomization of participants; and evaluation – in which the intervening researcher had access to the results of the evaluations after all the practical part (evaluations and intervention) was completed.

Neurologic Music Therapy Intervention Protocol

The intervention protocol was divided into: Structure of the Sessions (Flowchart 1) and neurologic music therapy Practices (Table 3), and was implemented individually, carried out three times a week, lasting 30 minutes each, over four weeks, in the participants' homes (Citon & Hamdan, 2025). The media developed and used in the study can be found at the link: https://osf.io/r9vue/.

Flowchart 1. Structure of the sessions.

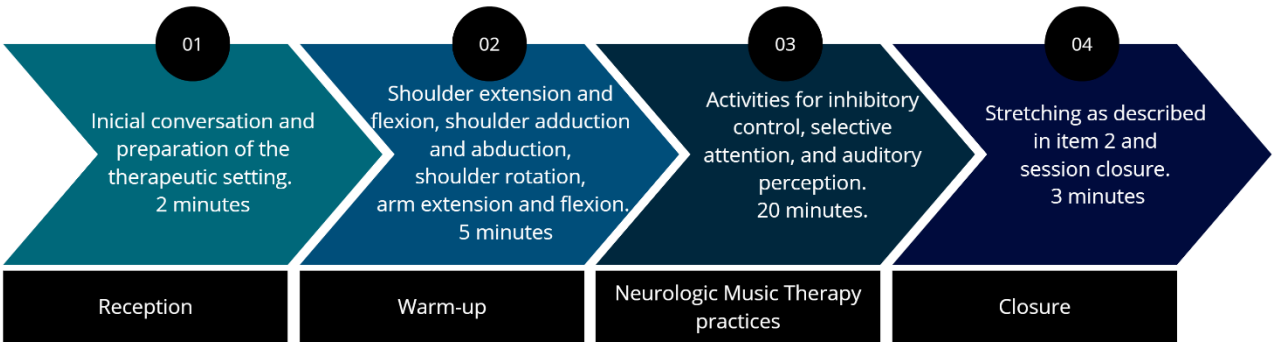

Table 3 describes the Neurologic Music Therapy Practices.

Table 3. Neurologic Music Therapy Practices

Function/Technique of neurological music therapy	Resources	Practice
Perception and temporal organization/APT	Laptop, metronome, MIDI controller, and headset	A metronome plays 48 stimuli at 60 bpm (beats per minute). The participant must respond by touching a key on the MIDI controller, trying to synchronize with the stimulus heard. The procedure is repeated at 80 and 100 bpm.
Perception and temporal organization/APT	Boomwhacker and metronome	Play the Boomwhacker with 2 hands alternately, accompanying a metronome at 60 bpm. For every 4 quaternary bars played, there will be a 1-bar pause. During this pause, the respondent will not be able to play. Variations are made by considering the tempo and defining specific tempos that can be played during the rest measure.
Selective attention/MACT	Laptop, recorded track, MIDI controller, and headphone jack	In a pre-recorded music track, there is a target stimulus (C6 played on the piano). During the execution of the track, the target stimulus is played randomly and the participant must respond to the stimuli as quickly as possible by touching the corresponding key on the MIDI controller. *(Media available at the supplementary link).*
Go/No-go paradigm – auto-response inhibition/MEFT	Laptop, recorded track, MIDI controller, and headphone jack	Respond to target stimuli as quickly as possible, considering the laterality heard. In the congruent condition: when hearing the stimulus on the right side (R), touch with the right hand; when listening to the stimulus on the left side (L), touch with the left hand; When you hear the stimulus on both sides, play with both hands simultaneously. In the incongruent condition: respond in the opposite way to the side heard. *(Media available at the supplementary link).*
Stroop Paradigm – Conflicting Simultaneous Information/ MEFT	Laptop, recorded track, microphone, and headset	Respond verbally to the stimuli heard. In the congruent condition, the tone of voice and the spoken word are congruent (deep voice speaking "baixo" and high voice speaking "alto"). In the condition of random tone and words, the tones "baixo" and "alto" are used in words such as house, plane, wolf, ball, today, each, never. In the congruent/incongruent condition, the words "alto" and "baixo" are spoken in congruent and opposite tones. In the mixed condition, all elements are displayed in the same interval. *(Media available at the supplementary link). Note: The words 'Baixo' and 'Alto' correspond to the English terms 'Low' and 'High', respectively.*

Stroop Paradigm – Conflicting Simultaneous Information/ MEFT	Auditory metronome, visual metronome, boomwacker and headset	Striking with a boomwhacker on a surface with simultaneous or separate hands following a metronome on the headset at 60 bpm, while viewing a second metronome with a visual signal at 80 bpm. The participant must maintain the rhythm trying to synchronize with one of the two metronomes. Variations are made by inverting the stimulus that must be followed and/or the chosen gaits.
Go/no-go paradigm – auto-response inhibition/MEFT	Tablet, BandLab, recorded track	A musical note is set as a target in a pre-recorded melody. Bandlab is used with the piano function on the screen. Every time the target note is played, a light on the target note key turns on. When this happens, the participant must strike the table with their hand. When the key light comes on, but the sound is not played, the participant must not strike. One possible variation is to reverse the order and ask the participant to respond only when the target note does not produce a sound. *(Media available at the supplementary link).*
Go/no-go paradigm – automatic response inhibition (MEFT)	Tambourine and metronome	With a metronome at 60 bpm, quaternary measure, the participant is instructed to play the tambourine, alternating hands, while verbalizing the pulses through numbers. This practice is carried out long enough to establish an association between movement and verbalization. In the second stage, the participant must inhibit the verbalization of some pre-defined pulses while continuing to play the tambourine.
Go/no-go paradigm – automatic response inhibition (MEFT)	Laptop, recorded track, controller and headset	Respond to stimuli as quickly as possible, according to the tone heard. In the congruent condition: listen to the stimulus C2 and respond by touching the corresponding key on the controller; the same procedure for C6. In the incongruent condition: Respond in the opposite way to the tone heard. *(Media available at the supplementary link).*
Go/no-go paradigm – automatic response inhibition (MEFT)	Tambourine and metronome	With a metronome at 60 bpm, quaternary time, the participant is instructed to play the tambourine, alternating hands, while verbalizing the pulses through numbers. This practice is carried out long enough to establish an association between movement and verbalization. In the second stage, the participant must maintain the verbalization of each pulse while doubling the number of beats on the tambourine (voice in quarter note, percussion in eighth note).

Data analysis

The data were analyzed using the Jamovi software (The jamovi project, 2021, v. 2.2). A descriptive analysis was performed to characterize the sample. For quantitative variables, the mean and standard deviation were calculated. For the qualitative variables, absolute and relative frequencies were calculated. Due to the small sample size, inferential statistics were not conducted for secondary outcomes.

Sample Size and Test Power

This feasibility study did not aim to understand a sufficiently large sample size to draw definitive conclusions about cognitive outcomes. The sample size was limited by the ability of the researcher responsible for the intervention to provide individualized care.

Ethical Considerations

The study was approved by the Research Ethics Committee – Human and Social Sciences through the Plataforma Brasil system (6.287.086), with Universal Clinical Trial Registration Number (U1111-1295-6574) and registration in the ensaiosclinicos.gov.br (RBR-2h7szdg). Consent was obtained by means of signature after careful reading of the Informed Consent Form (ICF).

The data in this study were collected using printed forms. The information collected was protected by confidentiality by the principal investigator for a period of five years. The participants were informed about this confidentiality through the Informed Consent Form (ICF).

Results

In the total recruitment period, 15 people were contacted, of which five were included, according to the inclusion criteria, representing 33.3% (recruitment rate) of the total contacted. Of the ten people not included, one did not meet the MoCA score

criterion, three people refused to participate for various reasons such as lack of time and interest, and six people did not respond to the contacts made. The participant who was not included by the scoring criterion in the MoCA received music therapy sessions voluntarily by the interventionist researcher for 12 weeks.

The study was carried out between October 2023 and March 2024. Recruitment took place between October and November 2023. The total time to completion of recruitment was 40 days, with an average of one participant recruited every eight days. In the end, five participants were included. One of the participants, for personal reasons, chose not to receive treatment at home. In this way, we decided to carry out his intervention in the building of the Federal University of Paraná, Santos Andrade square, since this place was easily accessible to the participant by public transport. However, after the first two sessions, the participant presented extreme situations of fatigue and mobility difficulties. As provided for in the ethical agreements, he was offered the possibility of withdrawal in order to preserve his health. The participant agreed to the possibility and opted to withdraw from his participation. Thus, the study was completed with four participants (retention rate = 80%).

The sociodemographic characteristics of the participants are shown in Table 4.

Table 4. Characterization of the sample according to the results obtained in the Sociodemographic Questionnaire

Characteristics	**Single group (n=4)**
Age, years, mean (SD)	66.7 (7.22)
Education, years, average (SD)	15.1 (2.07)
Gender, count, female, n (%)	2 (50)
Time of diagnosis, years, mean (SD)	6 (5.33)
Levodopa user, n (%)	4 (100)
ECP User	-

MoCA scores, mean (SD)	24.7 (1.63)
H&Y stage I	1 (25)
H&Y Stage II	1 (25)
H&Y Stage III	2 (50)

SD = Standard Deviation; DBS = Deep Brain Stimulation; MoCA = Montreal Cognitive Assessment; H&Y = Hoehn & Yahr scale

Qualitative feasibility outcomes

Regarding the overall quality of the intervention, the score obtained in the protocol acceptance questionnaire was 151 points (85%) out of the maximum score of 176 points (100%). Happened 21 responses rated "Good" (47.7%), 21 rated "Excellent" (47.7%) and 2 as "Fair" (4.6%). None of the participants selected the items "Bad" or "Very Bad".

In Table 5, it is possible to see the summary of the participants' answers on the Likert scale.

Table 5. Summary of participants' responses to the protocol acceptance questionnaire.

Participant	Total score	Summary of answers	Final comment
A	33	Qualified "Good" for all questions.	Everything was fine. I would like more sessions and with a longer duration.
B	42	He qualified as "Good" the questions about the total number of sessions and duration of each session. The other qualifications were "Excellent".	"Duration of the longest intervention, e.g., 2 months."
C	39	Five answers as "Good": three related to the frequency, total number and duration of the sessions; two related to questionnaires and evaluations. The other answers were "Excellent".	"I liked the activity of trying to follow the music played, as if I were part of the band."
D	37	Six answers were "Excellent", three "Good" and two were "Regular" (related to the total number and duration of the sessions).	"I think there could be more sessions and with longer durations."

Researchers' report

Interventionist researcher

The home care required 120 minutes of travel, totaling 4 hours with sessions per day of care. The frequency of sessions was considered feasible, but the duration of the sessions was considered low, suggesting extending the duration to 45-50 minutes in future research. The four-week period was considered feasible within the study proposal. During the sessions, environmental factors, such as noise and inadequate furniture, impacted the practices, requiring adjustments such as changing chairs and footrests.

Evaluator Researcher

The participants were cooperative and showed interest in the pre- and post-intervention evaluation processes. Based on the evaluator's subjective perception, difficulty in initiating actions and inhibitory control was observed, as well as challenges in self-reporting symptoms, requiring adjustments in the application of the Hoehn & Yahr scale. The initial questionnaires helped to establish *Rapport* and to collect information on the impact of Parkinson's disease, but there were difficulties in understanding the Likert scales in the final questionnaires. Participants understood the test instructions well, although familiarity with some instruments may have influenced the results. The Go/No-go task proved to be useful to evaluate inhibitory control, and in the Hayling test, errors may be a more accurate parameter due to the slow response.

Secondary outcomes

Given the non-significant statistical representativeness, we chose not to analyze the data regarding secondary outcomes.

Discussion

The aim of this study was to evaluate the feasibility of neurologic music therapy for inhibitory control in individuals with Parkinson's disease. The results suggest that neurologic music therapy

protocols, both evaluation and intervention, are feasible for use in future studies. Regarding the effectiveness of the intervention for cognitive and motor outcomes, no statistical analysis was performed due to the small sample size.

The findings suggest, based on the protocol acceptance questionnaire, that the total intervention time and the duration of the sessions were considered low, and that sessions lasting 45-50 minutes and total intervention time of 12 weeks may be considered for future studies, as suggested by the researchers.

In a literature review focused on pilot or feasibility studies with cognition as the main outcome and musical intervention in music therapy in Parkinson's disease (PD), no study was found that directly corroborated the findings of this research. However, other pilot or feasibility studies involving different interventions were considered. For example, Golińska et al. (2021) conducted a comparative study on cognitive performance among groups with PD. They recruited 45 participants over approximately 290 days (an average of one participant every 6.4 days). After the evaluation, 26 participants (57% of the initial number) were included, with a retention rate of 100%. Notably, their recruitment and retention rates exceeded those observed in our study. Pohl et al. (2013) implemented a rhythmic practice intervention for PD over the course of 6 weeks. They invited 193 candidates and included 18, resulting in a recruitment rate of 9.3%. The authors did not specify the recruitment period, and there were no dropouts of participants. In the study by Bastepe-Gray et al. (2022), a pilot intervention They evaluated 110 candidates to recruit 26 participants, achieving a recruitment rate of 23.6%. Two participants (8%) dropped out of the study, although the recruitment period was not specified. These findings highlight the need for further investigation and optimization of PD intervention protocols, particularly considering recruitment and retention challenges.

The limitations of this study include the insufficient sample size to statistically analyze cognitive/motor outcomes and quality of life, preventing a comprehensive evaluation of the effectiveness

of the intervention, and the absence of a control group to reduce biases in the analysis of health-related outcomes.

Conclusion

This study aimed to evaluate the feasibility of implementing neurologic music therapy in a home setting for individuals with PD. The study revealed a protocol pass rate of 85%. However, he also highlighted the need to extend the duration of the intervention and the time of the sessions. Regarding the possibility of future research with a representative sample (40 or more participants), considering the study design, we conclude that the feasibility of execution is limited, except for alternative designs, such as group interventions, multicenter studies, or longitudinal approaches.

References

ASADPOORDEZAKI, Z.; COOGAN, A. N.; HENLEY, B. M**. Chronobiology of Parkinson's disease: Past, present and future**. European Journal of Neuroscience, v. 57, n. 1, p. 178-200, jul. 2023. Disponível em: https://doi.org/10.1111/ejn.15859.

BALESTRINO, R.; SCHAPIRA, A. H. V. **Parkinson disease**. European Journal of Neurology, v. 27, n. 1, p. 27-42, 2020. Available at: https://doi.org/10.1111/ene.14108.

BASTEPE-GRAY, S. et al. **GuitarPD: A Randomized Pilot Study on the Impact of Nontraditional Guitar Instruction on Functional Movement and Well-Being in Parkinson's Disease**. Parkinson's Disease, v. 2022, 2022. Disponível em: https://doi.org/10.1155/2022/1061045.

BIALYSTOK, E.; DEPAPE, A. M. **Musical Expertise, Bilingualism, and Executive Functioning**. Journal of Experimental Psychology: Human Perception and Performance, v. 35, n. 2, p. 565-574, 2009. Disponível em: https://doi.org/10.1037/a0012735.

BOWEN, D. J. et al. **How We Design Feasibility Studies**. American Journal of Preventive Medicine, [s. l.], v. 36, n. 5, p. 452-457, 2009. Available at: https://doi.org/10.1016/j.amepre.2009.02.002.

BUGOS, J. A. et al. **Individualized Piano Instruction enhances executive functioning and working memory in older adults**. Aging and Mental Health, v. 11, n. 4, p. 464-471, 2007. Disponível em: https://doi.org/10.1080/13607860601086504.

BUGOS, J.; LESIUK, T.; NATHANI, S. **Piano training enhances Stroop performance and musical self-efficacy in older adults with Parkinson's disease**. Psychology of Music, v. 49, n. 3, p. 615-630, 2019. Disponível em: https://doi.org/10.1177/0305735619888571.

BURGESS, P. W.; SHALLICE, T. **The Hayling and Brixton Tests**. Thames Valley Test Company, 1997.

CITON, L. F.; HAMDAN, A. C. **Effectiveness of music-based interventions for cognitive rehabilitation in Parkinson's disease: a systematic review of randomized controlled clinical trials**. Psychology: Research and Review, v. 36, n. 1, 2023. Disponível em: https://doi.org/10.1186/s41155-023-00259-x.

CITON, L. F.; HAMDAN, A. C. **Neurologic music therapy for inhibitory control in parkinson's disease: Intervention protocol for a feasibility study**. Applied Neuropsychology: Adult, [s. l.], p. 1-8, 2025. Disponível em: https://doi.org/10.1080/23279095.2025.2499856.

COLOMBO, P. J.; HABIBI, A.; ALAIN, C. Editorial: **Music Training, Neural Plasticity, and Executive Function**. Frontiers in Integrative Neuroscience, v. 14, p. 1-3, ago. 2020. Disponível em: https://doi.org/10.3389/fnint.2020.00041.

DIAMOND, A. **Executive functions**. Annual Review of Psychology, v. 64, p. 135-168, 2013. Available at: https://doi.org/10.1146/annurev-psych-113011-143750.

DUNCAN, G. W. et al. **Health-related quality of life in early Parkinson's disease: The impact of nonmotor symptoms**. Movement Disorders, v. 29, n. 2, p. 195-202, 2014. Disponível em: https://doi.org/10.1002/mds.25664.

ELDRIDGE, S. M. et al. **CONSORT 2010 statement: Extension to randomised pilot and feasibility trials**. Pilot and Feasibility Studies, v. 2, n. 1, p. 1-32, 2016. Disponível em: https://doi.org/10.1186/s40814-016-0105-8.

FANG, C. et al. **Cognition Deficits in Parkinson's Disease: Mechanisms and Treatment**. Parkinson's Disease, v. 2020, 2020. Disponível em: https://doi.org/10.1155/2020/2076942.

GOETZ, C. G. et al. **Movement disorder society-sponsored revision of the unified Parkinson's disease rating scale (MDS-UPDRS): Process, format, and clinimetric testing plan**. Movement Disorders, v. 22, n. 1, p. 41-47, 2007. Disponível em: https://doi.org/10.1002/mds.21198.

GOLIŃSKA, P. B. et al. **The anterior attentional–intentional system in patients with Parkinson's Disease** — A pilot and feasibility study. Brain Sciences, v. 11, n. 8, 2021. Disponível em: https://doi.org/10.3390/brainsci11081013.

HANNON, E. E.; TRAINOR, L. J. **Music acquisition: effects of enculturation and formal training on development**. Trends in Cognitive Sciences, v. 11, n. 11, p. 466-472, 2007. Disponível em: https://doi.org/10.1016/j.tics.2007.08.008.

HERHOLZ, S. C.; ZATORRE, R. J. **Musical Training as a Framework for Brain Plasticity: Behavior, Function, and Structure**. Neuron, v. 76, n. 3, p. 486-502, 2012. Disponível em: https://doi.org/10.1016/j.neuron.2012.10.011.

HOEHN, M. M.; YAHR, M. D**. Parkinsonism: onset, progression, and mortality**. Neurology, v. 17, n. 5, p. 427-442, 1967.

JENKINSON, C. et al. **The Parkinson's disease questionnaire (PDQ-39): Development and validation of a Parkinson's disease summary index score**. Age and Ageing, v. 26, n. 5, p. 353-357, 1997. Disponível em: https://doi.org/10.1093/ageing/26.5.353.

KANG, W.; WANG, J.; MALVASO, A. **Inhibitory Control in Aging: The Compensation-Related Utilization of Neural Circuits Hypothesis**. Frontiers in Aging Neuroscience, v. 13, p. 1-8, jul. 2022. Disponível em: https://doi.org/10.3389/fnagi.2021.771885.

KIM, S. J.; PARK, J. K. **Dual-task-based drum playing with rhythmic cueing on motor and attention control in patients with Parkinson's disease**: A preliminary randomized study. International Journal of Environmental Research and Public Health, v. 18, n. 19, 2021. Disponível em: https://doi.org/10.3390/ijerph181910095.

KLEIM, J. A.; JONES, T. A. **Principles of experience-dependent neural plasticity**: implications for rehabilitation after brain damage. Journal of Speech, Language, and Hearing Research, [S. l.], v. 51, n. 1, p. S225-S239, fev. 2008. DOI: 10.1044/1092-4388(2008/018). PMID: 18230848.

LEE, Y. S.; LU, M. J.; KO, H. P. **Effects of skill training on working memory capacity**. Learning and Instruction, v. 17, n. 3, p. 336-344, 2007. Disponível em: https://doi.org/10.1016/j.learninstruc.2007.02.010.

LI, K.; WENG, L.; WANG, X. **The State of Music Therapy Studies in the Past 20 Years: A Bibliometric Analysis**. Frontiers in Psychology, v. 12, p. 1-14, jun. 2021. Disponível em: https://doi.org/10.3389/fpsyg.2021.697726.

LOPES, R. et al. **Cognitive phenotypes in parkinson's disease differ in terms of brain-network organization and connectivity**. Human Brain Mapping, v. 38, n. 3, p. 1604-1621, 2017. Disponível em: https://doi.org/10.1002/hbm.23474.

MAGUIRE, M. **Music and its association with epileptic disorders**. Progress in Brain Research, v. 217, p. 107-127, 2015. Disponível em: https://doi.org/10.1016/bs.pbr.2014.11.023.

MIYAKE, A.; FRIEDMAN, N. P. **The Nature and Organization of Individual Differences in Executive Functions: Four General Conclusions**. Current Directions in Psychological Science, v. 21, n. 1, p. 8-14, 2013. Disponível em: https://doi.org/10.1177/0963721411429458.

MIRABELLA, G. et al. **Effects of dopaminergic treatment on inhibitory control differ across Hoehn and Yahr stages of Parkinson's disease**. Brain Communications, v. 6, n. 1, p. 1-17, 2024. Disponível em: https://doi.org/10.1093/braincomms/fcad350.

MOREIRA, S. V. et al. **Neuromusicoterapia no Brasil: aspectos terapêuticos na reabilitação neurológica**. Brazilian Journal of Music Therapy, v. 14, n. 12, p. 18-26, 2012.

MORENO, S. et al. **Short-Term Music Training Enhances Verbal Intelligence and Executive Function**. Psychological Science, v. 22, n. 11, p. 53, 2012. Disponível em: https://doi.org/10.1177/0956797611416999.

MORENO, S.; BIDELMAN, G. M. **Examining neural plasticity and cognitive benefit through the unique lens of musical training**. Hearing Research, v. 308, p. 84-97, 2014. Disponível em: https://doi.org/10.1016/j.heares.2013.09.012.

MORENO, S.; FARZAN, F. **Music training and inhibitory control: A multidimensional model**. Annals of the New York Academy of Sciences, v. 1337, n. 1, p. 147-152, 2015. Disponível em: https://doi.org/10.1111/nyas.12674.

MORENO, S.; LEE, Y. **Short-term Second Language and Music Training Induces Lasting Functional Brain Changes in Early Childhood**. Child Development, v. 86, n. 2, p. 1-17, 2015. Disponível em: https://doi.org/10.1111/cdev.12297.

MORENO, S. et al. **Inhibitory control in bilinguals and musicians**: Event related potential (ERP) evidence for experience-specific effects. PLoS ONE, v. 9, n. 4, p. 1-8, 2014. Disponível em: https://doi.org/10.1371/journal.pone.0094169.

MURAKAMI, B. The music therapy and harm model (MTHM). **Conceptualizing harm within music therapy practice**. ECOS - Scientific Journal of Music Therapy and Disciplines Afines, v. 6, n. 1, p. 003, 2021. Available at: http://portal.amelica.org/ameli/jatsRepo/459/4592020002/index.html.

NASREDDINE, Z. S. et al. **The Montreal Cognitive Assessment, MoCA**: A Brief Screening Tool For Mild Cognitive Impairment. Journal of the American Geriatrics Society, v. 53, n. 4, p. 695-699, 2005.

PHU, A. L. et al. **Effect of impulse control disorders on disability and quality of life in Parkinson's disease patients**. Journal of Clinical Neuroscience, v. 21, n. 1, p. 63-66, 2014. Disponível em: https://doi.org/10.1016/j.jocn.2013.02.032.

POHL, P.; DIZDAR, N.; HALLERT, E. **The Ronnie Gardiner rhythm and music method**-A feasibility study in parkinson's disease. Disability and Rehabilitation, v. 35, n. 26, p. 2197-2204, 2013. Disponível em: https://doi.org/10.3109/09638288.2013.774060.

POHL, P. et al. **Group-based music intervention in Parkinson's disease – findings from a mixed-methods study**. Clinical Rehabilitation, v. 34, n. 4, p. 533-544, 2020. Disponível em: https://doi.org/10.1177/0269215520907669.

RAY DORSEY, E.; BLOEM, B. R. **Parkinson's Disease Is Predominantly an Environmental Disease**. Journal of Parkinson's Disease, v. 14, n. 3, p. 451-465, 2024. Disponível em: https://doi.org/10.3233/JPD-230357.

ROBB, S. L.; CARPENTER, J. S.; BURNS, D. S. **Reporting guidelines for music-based interventions**. Journal of Health Psychology, v. 16, n. 2, p. 342-352, 2011. Disponível em: https://doi.org/10.1177/1359105310374781.

SÁNCHEZ-KUHN, A. et al. **Go/No-Go task performance predicts differences in compulsivity but not in impulsivity personality traits**. Psychiatry Research, v. 257, p. 270-275, 2017. Disponível em: https://doi.org/10.1016/j.psychres.2017.07.064.

SANCHEZ-LUENGOS, I. et al. **Effectiveness of cognitive rehabilitation in Parkinson's disease**: A systematic review and meta-analysis. Journal of Personalized Medicine, v. 11, n. 5, 2021. Disponível em: https://doi.org/10.3390/jpm11050429.

SCHELLENBERG, E. G.; PERETZ, I. **Music, language and cognition: unresolved issues**. Trends in Cognitive Sciences, v. 12, n. 2, p. 44-45, 2008. Disponível em: https://doi.org/10.1016/j.tics.2007.11.002.

SIMON, D. K.; TANNER, C. M.; BRUNDIN, P. **Parkinson Disease Epidemiology, Pathology, Genetics and Pathophysiology**. Clinics in Geriatric Medicine, v. 36, n. 1, p. 1-12, 2020. Disponível em: https://doi.org/10.1016/j.cger.2019.08.002.

STROOP, J. R. **Studies of interference in serial verbal reactions**. Journal of Experimental Psychology, v. 18, n. 6, p. 643-662, 1935. Available at: https://doi.org/10.1037/h0054651.

STROOP, J. R. **Studies of interference in serial verbal reactions**. Journal of Experimental Psychology: General, v. 121, n. 1, p. 15-23, 1992. Available at: https://doi.org/10.1037/0096-3445.121.1.15.

THAUT, M. H.; HOEMBERG, V. **Handbook of Neurologic Music Therapy**. Oxford University Press, 2014.

THE JAMOVI PROJECT. **jamovi. (Version 2.2)** [Computer Software]. 2021. Available at: https://www.jamovi.org.

UBAM. Brazilian Union of Music Therapy Associations. **Definition of Music Therapy [2018]**. Accessed on 05/23/2025. Available in https://ubammusicoterapia.com.br/institucional/musicoterapia/definicao/

VERGHESE, J. et al. **Leisure Activities and the Risk of Dementia in the Elderly**. New England Journal of Medicine, v. 348, n. 25, p. 2508-2516, 2003.

VOON, V. et al. **Impulse control disorders and levodopa-induced dyskinesias in Parkinson's disease: an update**. The Lancet Neurology, v. 16, n. 3, p. 238-250, 2017. Disponível em: https://doi.org/10.1016/S1474-4422(17)30004-2.

WEINTRAUB, D. et al. **The neuropsychiatry of Parkinson's disease: advances and challenges**. The Lancet Neurology, v. 21, n. 1, p. 89-102, 2022. Disponível em: https://doi.org/10.1016/S1474-4422(21)00330-6.

WEINTRAUB, D. et al**. Impulse Control Disorders in Parkinson Disease**. Archives of Neurology, v. 67, n. 5, p. 589-595, 2010.

Authorship contribution

Leonardo Francisco Citon – Development of the research and intervention protocol, implementation, and writing and revision of the text.

Luísa Teixeira dos Santos – Administrator of the assessment protocol, writing and revision of the text.

Amer Cavalheiro Hamdan – Project coordinator, writing and revision of the text.

Financing

This study was funded in part by the Coordination for the Improvement of Higher Education Personnel – Brazil (CAPES) – Financing Code 001.

Research ethics committee approval

The study was approved by the Research Ethics Committee – Human and Social Sciences through the Plataforma Brasil system (6.287.086), with Universal Clinical Trial Registration Number

(U1111-1295-6574) and registration in the ensaiosclinicos.gov.br (RBR-2h7szdg). Consent was obtained by means of signature after careful reading of the Informed Consent Form (ICF).

Data Availability Statement

All data relevant to the study are included in this article and/or in the supplementary material files, available at the link: https://osf.io/r9vue/

Publisher

Federal University of Goiás. School of Music and Performing Arts. Graduate Program in Music. Publication in the Portal of Periodicals UFG.

The ideas expressed in this article are the responsibility of their authors, and do not necessarily represent the opinion of the editors or the university.