doi: 10.48095/cccsnn2026123

Music therapy as a communication-focused intervention in Parkinson's disease – quantitative outcomes and clinical implication

Muzikoterapeutická intervencia zameraná na komunikáciu pri Parkinsonovej chorobe – kvantitatívne výsledky a klinické implikácie

The Editorial Board declares that the manuscript met the ICMJE "uniform requirements" for biomedical papers.
Redakční rada potvrzuje, že rukopis práce splnil ICMJE kritéria pro publikace zasílané do biomedicínských časopisů.

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Accepted for review: 10. 11. 2025
Accepted for print: 17. 2. 2026

Abstract

Background: Parkinson's disease is a neurodegenerative disorder that not only affects motor functions, but also speech and voice production. Music therapy represents a promising non-pharmacological approach to support communication in this population. *Objectives:* This interventional study aimed to evaluate the impact of an original structured music therapy program on speech intelligibility, voice quality, and spontaneous speech production in individuals with Parkinson's disease. *Methods:* Study participants (N = 17) participated in an eight-week structured group program focused on voice, breathing, articulation, and singing. Pre- and post-intervention assessments included the GRBAS scale, a speech intelligibility test, and the Analysis of Spontaneous Speech (ASpoR) tool to evaluate spontaneous speech. Data were analyzed statistically using descriptive and inferential methods with effect size calculation. *Results:* Participants demonstrated consistent improvement in overall speech intelligibility, with a significant gain in the combined score ($P = 0.0099$, $d = 0.71$). GRBAS scores improved descriptively, though not significantly, with large effect sizes for breathiness ($r = 0.83$) and strain ($r = 0.67$). While fluency and error rates in spontaneous speech showed no significant change, the intervention significantly enhanced self-monitoring, as evidenced by a higher percentage of corrected errors relative to total errors ($P = 0.00097$, $r = 0.87$), and a reduced ratio of uncorrected to corrected errors ($P = 0.00049$, $r = 0.87$). *Conclusion:* The program improved several aspects of communication, suggesting the therapeutic potential of music therapy for this population.

Súhrn

Úvod: Parkinsonova choroba je neurodegeneratívne ochorenie, ktoré ovplyvňuje nielen motorické funkcie, ale aj oblasť reči a hlasu. Muzikoterapia predstavuje sľubný nefarmakologický prístup na podporu komunikácie u tejto populácie. *Ciele:* Cieľom intervenčnej štúdie bolo zhodnotiť prínos originálneho muzikoterapeutického intervenčného programu na zrozumiteľnosť reči, kvalitu hlasu a spontánnu rečovú produkciu u osôb s Parkinsonovou chorobou. *Metódy:* Participanti ($n = 17$) absolvovali osemtýždňový skupinový program zameraný na precvičovanie hlasu, dýchania, artikulácie a spevu. Pred a po intervencii boli realizované hodnotenia pomocou škály GRBAS, testu zrozumiteľnosti reči a testu spontánnej rečovej produkcie (Analysis of Spontaneous Speech; ASpoR) na vyhodnotenie spontánnej reči. Dáta boli analyzované prostredníctvom deskriptívnej a inferenčnej štatistiky vrátane výpočtu veľkosti efektu. *Výsledky:* U participantov sa preukázalo zlepšenie celkovej zrozumiteľnosti reči so signifikantným nárastom kombinovaného skóre ($p = 0{,}0099$, $d = 0{,}71$). Skóre GRBAS sa deskriptívne zlepšilo bez štatistickej signifikancie, s veľkými efektmi pri parametroch dyšnosť ($r = 0{,}83$) a napätie ($r = 0{,}67$). Plynulosť a počet chýb v spontánnej reči zostali stabilné, avšak intervencia významne zlepšila sebamonitorovanie, čo potvrdzuje vyšší podiel opravených chýb ($p = 0{,}00097$, $r = 0{,}87$) a nižší pomer neopravených chýb k opraveným chybám ($p = 0{,}00049$, $r = 0{,}87$). *Záver:* Program zlepšil viaceré aspekty komunikácie, čo poukazuje na terapeutický potenciál muzikoterapie pre túto populáciu.

Key words
Parkinson's disease – music therapy – communication – speech intelligibility – voice quality

Kľúčová slova
Parkinsonova choroba – muzikoterapia – komunikácia – zrozumiteľnosť reči – kvalita hlasu

Introduction

Parkinson's disease (PD) is a progressive multisystem neurodegenerative disorder affecting the central nervous system, primarily due to the loss of dopaminergic neurons in the substantia nigra, as well as changes in other brain regions and neurotransmitter systems. It leads to motor symptoms such as tremors, rigidity, bradykinesia, and postural instability [1]. However, communication difficulties are also highly prevalent, affecting up to 89% of individuals [2]. The most common is hypokinetic dysarthria, characterized by hypophonia, monopitch, irregular speech rate, imprecise articulation, and disrupted prosody [3–6]. Speech characteristics include a breathy, hoarse voice, monotonous intonation, and alterations in speech rate (often accelerated), reflecting impaired motor control of speech musculature [4,7,8]. Individuals with PD also experience language deficits such as reduced fluency, syntactic disturbances, and weakened discourse coherence [9–11].

Treatment of communication disorders has traditionally focused on speech and voice interventions targeting hypophonia, dysprosody, and articulatory imprecision [5,12]. The most extensively validated method is the Lee Silverman Voice Treatment (LSVT LOUD), emphasizing vocal loudness, articulatory precision, and voice quality [2,13]. Newer approaches increasingly use acoustic and phonetic analysis to detect early speech changes [14].

Among complementary rehabilitation methods, music therapy has emerged as a promising intervention combining respiratory, vocal, and articulatory exercises with singing [15–22].

Building on this foundation, recent studies reinforce the positive effects of music therapy on speech and voice functions in PD. Specifically, improvements have been reported in speech loudness [23], vocal intensity and maximum frequency range [24], as well as in overall voice quality [25]. However, further studies are needed to clarify its mechanisms and functional outcomes in everyday communication.

Methods

Study design and setting

The study evaluated the impact of a group-based music therapy intervention on voice and speech impairments in individuals with PD. It followed a quasi-experimental A–B–A design without a control group, employing validated speech-language assessment tools.

Participants and recruitment

A total of 17 participants receiving dopaminergic treatment took part in the study. All met the inclusion criteria: idiopathic PD diagnosis (according to Postuma et al. [26]), stable mental health, no significant cognitive impairment, and ability to complete the 8-week intervention program.

The sample included 11 men and 6 women aged 61–80 years (mean 69.8 years). Eight participants completed high school, while nine held a university degree. The mean time since diagnosis was 7.5 years. The mean Hoehn and Yahr stage was 2.59 (median = 2, interquartile range = 1). All participants were assessed during their ON medication state. Pre- and post-intervention assessments were scheduled at a consistent time following dopaminergic medication intake to reduce variability associated with motor fluctuations.

Intervention timeline

Intervention comprised of eight 90-min weekly group sessions supplemented by home-based video practice.

Three small group cycles (4, 5 and 8 participants) were implemented in 2024, each following the same sequence:

1. a pretest diagnostic session approximately one week before intervention,
2. an 8-week intervention phase, and
3. a post-test diagnostic session within one week after completion.

Assessment methods

To assess the impact of therapy on selected aspects of communication, three assessment methods were administered prior to the onset of therapy (pretest) and after its completion (post-test).

- **GRBAS scale** is used for the perceptual analysis of voice quality. It evaluates five parameters of dysphonia: the overall grade (G), roughness (R), breathiness (B), asthenia (A), and strain (S) on a four-point scale: 0 = normal; 1 = mild impairment; 2 = moderate impairment; and 3 = severe impairment [27]. An experienced speech-language therapist (SLT) listened to audio recordings of participants reading a standardized text aloud and rated each parameter using the established rating scale.
- **Speech intelligibility test** – speech intelligibility was assessed using a conventional approach. For analytical purposes, audio recordings were made of participants reading a list of words aloud, pseudowords, and sentences derived from a pre-generated and linguistically controlled stimulus set [28]. Audio recordings were anonymized, transcribed verbatim by blinded assistants, and evaluated for accuracy by an experienced SLT.
- **ASpoR** – Analysis of Spontaneous Speech evaluates spontaneous speech at the discourse level, focusing on three core aspects: productivity, errors and repairs, and cohesion. It provides normative data stratified by age and education for adults with neurogenic communication disorders [29].

Intervention protocol

The music therapy program was implemented as follows. Each 8-week cycle consisted of in-person 90-min sessions once per week and home-based practice at least three times weekly with video guidance. Online supervision was offered but not utilized.

The in-person group protocol consisted of the following components (Tab. 1).

To enhance participant motivation and engagement, certain parts of the program were partially adapted to individual groups. For example, individual preferences were considered in the selection of songs, the choice of texts for reading out loud, and in the socialization component through the selection of topics and tasks completed collaboratively by the participants.

Statistical analysis

Descriptive and inferential statistics were used to analyze the GRBAS scale, ASpoR, and Speech Intelligibility Assessment results.

Analyses were performed in Microsoft Excel (Microsoft, Redmond, WA, USA) with the Real Statistics Resource Pack add-in. Data normality was tested using the Shapiro-Wilk test. For normally distributed data ($P > 0.05$), a paired t-test was applied; otherwise ($P \leq 0.05$), the Wilcoxon signed-rank test was used. Effect sizes were calculated to assess practical significance: Cohen's d for the t-test (0.2 = small, 0.5 = medium, 0.8 = large) and r for the Wilcoxon test (0.1 = small, 0.3 = medium, 0.5 = large) [30]. The significance level was set at $\alpha = 0.05$.

Results

Evaluation of the impact of music therapy intervention on voice quality according to the GRBAS scale

In the study sample (N = 17), voice quality assessed by the GRBAS scale showed de-

Tab. 1. Protocol for in-person group sessions.

Session Outline	Content	Target Areas	Assessment Methods
introductory activities	session opening, motor and respiratory exercises	• welcome and session introduction • reflection on home-based practice and implementation of strategies for practicing loud and intentional speech throughout the week • preparatory motor exercises to release tension in the orofacial, neck, and shoulder regions in preparation for vocal tasks • respiratory exercises to increase lung capacity, activate abdominal musculature, and improve diaphragmatic breathing, breath support, and breath control	ASpoR (self-monitoring)
vocal warm-up and exercises	vocal and intonation tasks within the natural vocal range	• activation of laryngeal musculature • breath control during singing, including the regulation of subglottal pressure and coordination with phonation • vocal control in singing – tone onset, maintenance of stable phonation, extension of functional vocal range, and enhancement of vocal resonance • support of prosodic features through glissando singing, facilitating melodic intonation and pitch range expansion via interval training • articulatory exercises – wide movements of lips, tongue, and jaw during vocalization, and training of articulatory precision for speech sound production	GRBAS (perceptual voice evaluation)
singing songs	singing songs – with a preference for familiar melodies featuring a stable rhythmic structure within the natural vocal range	• integration of vocal techniques within musical activity • respiratory control – regulation of breath support during singing • vocal control – extension of maximum phonation time during singing of song phrases, strengthening of vocal output • articulatory control – clear and precise articulation during vocal performance • targeted and conscious support of prosodic features of vocal expression – intentional modulation of dynamics, support of loud and expressive vocalization • rhythmic structuring – use of rhythm to enhance timing and fluency of vocal output • emotional engagement – consideration of individual musical preferences and reinforcement of social and emotional connection through group singing	GRBAS, Speech Intelligibility Test, ASpoR
break	scheduled rest	• recovery phase for physical and vocal rest • socialization – informal peer interaction	–
voice and speech exercises	exercises targeting vocal intensity, prolongation of maximum phonation time, group loud reading, articulatory drills, and tongue twisters	• transfer of vocal habits from singing to speech, with emphasis on intentionally regulated verbal output • focus on respiratory coordination during speech, vocal control (loudness and modulation) while articulating words, sentences, phrases, and tongue twisters • prolongation of phonation time during speech and enhancement of prosodic features (intonation, stress, rhythm, and speech melody) • rhythmic structuring of words, phrases, and tongue twisters to support temporal organization and speech fluency	Speech Intelligibility Test, ASpoR
socialization	discussions on various actual or participant-requested topics and collaborative task completion	• promotion of social bonding • reinforcement of group cohesion and peer interaction • transfer of newly acquired speech behaviours into spontaneous, real-life communication	ASpoR
session closure	task summary and motivation for continued engagement	• advice on safe vocal use and vocal care • transfer of acquired skills into daily communication, including strategies for self-monitoring and enhancing speech clarity • reflection and feedback	ASpoR (self-monitoring)

ASpoR – Analysis of Spontaneous Speech; GRBAS – G – grade, R – roughness, B – breathiness, A – aesthenicity, S – strain

Tab. 2. Results of GRBAS Scale Scores (pretest vs. posttest) – descriptive statistics, Wilcoxon signed-rank test.

Parameter	Pretest (SD)	Posttest (SD)	W	P-exact	Effect size (r)	Interpretation
grade	1.00 (0.79)	0.94 (0.90)	2.0	0.75	0.17	not significant, small effect size
roughness	0.47 (0.51)	0.47 (0.62)	5.0	1	0.1	not statistically significant, very small effect size
breathiness	0.88 (0.78)	0.71 (0.85)	0.0	0.25	0.83	not statistically significant, large effect size
asthenia	0.29 (0.59)	0.24 (0.56)	0.0	1	0.00	not statistically significant, no effect
strain	0.41 (0.62)	0.29 (0.59)	0.0	0.5	0.67	not statistically significant, large effect size

Evaluation based on the 4-point GRBAS scale: 0 = normal, 1 = mild impairment, 2 = moderate impairment, and 3 = severe impairment.
GRBAS – G – grade, R – roughness, B – breathiness, A – aesthenicity, S – strain; SD – standard deviation

Tab. 3. Results of Speech Intelligibility Test Scores (pretest vs. posttest) – descriptive statistics, paired t-test.

Parameter	Pretest (SD)	Posttest (SD)	Paired t-test	P-value	Cohen´s d	Interpretation
words	19.59 (4.49)	20.18 (4.61)	−1.3704	0.1895	0.33	not statistically significant, small effect size
pseudowords	25.59 (9.12)	27.29 (9.04)	−1.9721	0.0661	0.48	not statistically significant, small to medium effect size
total	54.53 (15.60)	57.53 (16.09)	−2.9257	0.0099	0.71	statistically significant, medium to large effect size

Each intelligibly read word, pseudoword, or sentence was awarded one point (words: max. = 24; pseudowords: max. = 36; sentences: max. = 12; total: max. = 72).
SD – standard deviation

Tab. 4. Results of Speech Intelligibility Test Scores (pretest vs. posttest) – descriptive statistics, Wilcoxon signed-rank test.

Parameter	Pretest (SD)	Posttest (SD)	W	P-exact	Effect size (r)	Interpretation
sentences	9.35 (3.37)	10.06 (3.01)	6.0	0.1094	0.58	not statistically significant, large effect size

SD – standard deviation

creased mean values in most parameters, indicating improved voice quality, although the Wilcoxon test revealed no significant pre–post differences (all $P > 0.05$). Notably, breathiness ($r = 0.83$) and strain ($r = 0.67$) showed large effect sizes, suggesting clinically meaningful improvements despite the lack of statistical significance (Tab. 2).

Impact of music therapy intervention on speech intelligibility

Speech intelligibility ($N = 17$), assessed using the Intelligibility Test, was analysed across four categories (words, pseudowords, sentences, and total score; Tab. 3 and 4).

A small, nonsignificant improvement was observed in the Words category ($t = -1.37$; $P = 0.19$, Cohen's $d = 0.33$). Pseudowords showed a trend toward significance ($t = -1.97$; $P = 0.066$) accompanied by a small-to-medium effect ($d = 0.48$). Sentence reading also did not reach statistical significance ($W = 6$; $P = 0.11$), yet a large effect size ($r = 0.58$) indicated a meaningful magnitude of change. The Total score demonstrated a statistically significant improvement ($t = -2.93$; $P = 0.0099$*, $d = 0.71$), representing a large effect and confirming a positive impact of music therapy on overall speech intelligibility.

Impact of music therapy intervention on spontaneous speech production

In the test targeting spontaneous speech analysis, participants were asked to narrate the well-known story of Cinderella in their own words.

Speech productivity was assessed using three parameters: total number of elementary text units, number of words, and total speech time (in seconds). Comparison of pretest and post-test data showed no consistent trend, with productivity increasing in some participants and decreasing in others. To control for variability in utterance length, disfluencies and discourse errors were normalized to total word count, yielding percentage values comparable across participants.

In the assessment of spontaneous speech, disfluencies in discourse were analyzed as an indicator of fluency. Mean and median disfluency rates remained stable at approximately 5–6% across both testing phases (Fig. 1).

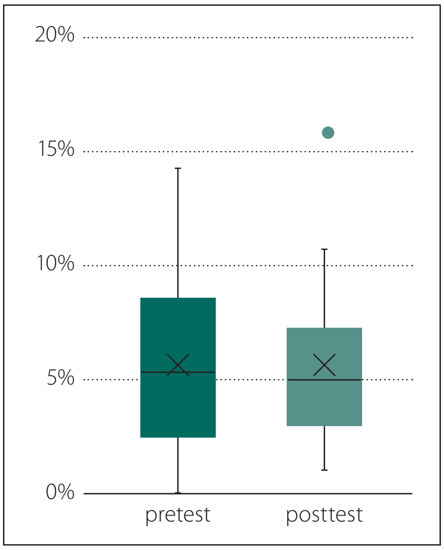

Fig. 1. Descriptive statistics of Analysis of Spontaneous Speech – percentage of disfluencies in spontaneous speech – pretest vs. posttest (not statistically significant).
Obr. 1. Deskriptívna štatistika Analýzy spontánnej reči – percentuálna miera dysfluencií v spontánnej reči: pretest vs. posttest (štatisticky nevýznamné).

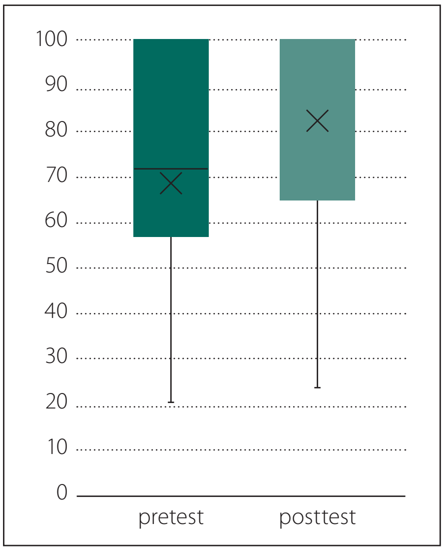

Fig. 3. Descriptive statistics of Analysis of Spontaneous Speech – self-monitoring accuracy (%) in spontaneous speech – pretest vs. posttest.
Percentage of corrected errors, with 100% representing either error-free discourse or full success in real-time error correction.
Obr. 3. Deskriptívna štatistika Analysis of Spontaneous Speech – presnosť sebamonitorovania (%) v spontánnej reči – pretest vs. posttest.
Percento opravených chýb, pričom 100 % predstavuje buď bezchybný prejav, alebo úplnú úspešnosť korekcie chýb v reálnom čase.

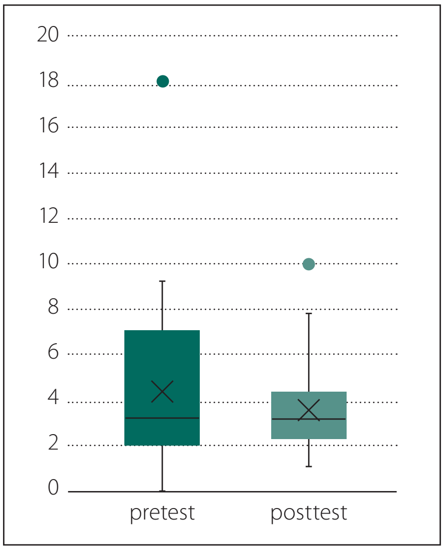

Fig. 2. Descriptive statistics of Analysis of Spontaneous Speech – percentage of speech errors in spontaneous speech – pretest vs. posttest (not statistically significant).
Obr. 2. Deskriptívna štatistika Analýzy spontánnej reči – percentuálna miera chybovosti v spontánnej reči – pretest vs. posttest (štatisticky nevýznamné).

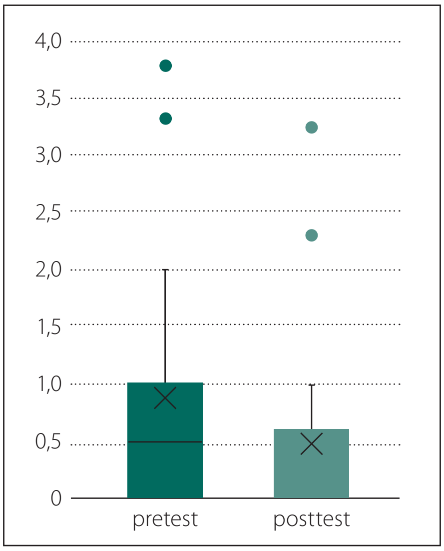

Fig. 4. Descriptive statistics of Analysis of Spontaneous Speech – ratio of uncorrected to corrected errors – pretest vs. posttest.
Obr. 4. Deskriptívna štatistika Analysis of Spontaneous Speech – pomer nekorigovaných ku korigovaným chybám – pretest vs. posttest.

Descriptive statistics showed reduced variance in disfluency rates, while one posttest outlier (21%) affected the overall results. Inferential analysis revealed no significant difference between phases ($t = -0.19$; $P = 0.85$, Cohen's $d = 0.05$).

Within the analysis of spontaneous speech production, the presence of discourse-level errors (phonological, grammatical, and lexical-semantic) was assessed. Following the same procedure as for disfluencies, the number of discourse errors in each phase was normalized to the total word count. The resulting percentage of errors is shown in Fig. 2.

A reduction in the average error rate was observed after intervention, suggesting a trend toward improvement. However, the paired t-test showed no significant difference ($t = 1.46$; $P = 0.16$, Cohen's $d = 0.35$), indicating only a minimal impact on speech errors in spontaneous discourse.

Although no significant effects were observed for fluency or error rates, intervention yielded promising results in enhancing monitoring ability – i.e., participants' capacity to detect and immediately correct their speech in cases of error occurrence. Monitoring accuracy was calculated as the percentage of corrected errors relative to total errors (Fig. 3).

Median monitoring accuracy increased from approximately 70% (range 20–100%) in the pretest to higher values post-intervention, indicating enhanced ability to detect and correct speech errors. Inferential analysis confirmed a statistically significant improvement ($W = 0$; $P = 0.00097^*$, $r = 0.87$), demonstrating a substantial and practically significant enhancement in self-monitoring of verbal output.

The following results complement the previous findings regarding speech self-monitoring by providing the ratio of uncorrected to corrected errors. This ratio offers an inverse perspective on monitoring efficiency – lower values indicate a higher proportion of errors that were successfully corrected relative to those left uncorrected (Fig. 4).

In the pretest, the mean ratio was 1.0, with two outliers exceeding 3.0, suggesting pronounced monitoring difficulties in some participants. After intervention, the ratio decreased to below 0.5 with reduced variance, indicating improvement. Inferential analysis confirmed a significant difference between phases ($W = 0$; $P = 0.00049$, $r = 0.87$), representing a large effect and a substantial enhancement in self-monitoring accuracy.

Discussion

The findings of this study underscore the potential of music therapy as an adjunctive intervention for improving vocal and speech functions in individuals with PD. It should be emphasized that hypokinetic dysarthria is a multidimensional motor speech disorder affecting respiration, resonance, phonation, articulation, and prosody. In the present study, the assessment primarily targeted phonatory aspects and overall intelligibility. A more comprehensive evaluation using instruments such as the Frenchay Dysarthria Assessment would provide a broader characterization of dysarthric manifestations. However, a validated Slovak version of this instrument is currently unavailable.

Singing activates many of the same anatomical and physiological structures as speech production [31]. It stimulates vocal and respiratory musculature and can alleviate speech and voice deficits [32]. Effective vocal production requires breathing and motor control of the vocal folds and articulators regulated by the central nervous system [33].

Post-intervention analysis showed improvement in most vocal parameters (dysphonia, breathiness, asthenia, and strain), except roughness. Although differences were not statistically significant ($P > 0.05$), large effect sizes for breathiness and strain suggest practical benefits.

Improved breathiness likely resulted from regular respiratory and phonatory exercises and training in proper breathing during singing and speech. Singing enhances breath support through rapid inhalation and controlled exhalation against partially adducted vocal folds [31], which improves vocal range, intonation, and loudness [34]. Similar respiratory benefits were reported by Di Benedetto et al. [16] and Stegemöller et al. [20]. The pronounced effect for strain likely reflects targeted relaxation and vocal flexibility training combined with vocal hygiene education [35].

Results of the Speech Intelligibility Test suggest a positive effect of music therapy on speech intelligibility. Descriptive analysis revealed increased mean performance across all assessed categories (words, pseudowords, sentences, and total score), with statistically and practically significant improvement in the total score.

These results may be attributed to educational, musical, and speech-based exercises targeting articulator mobility, orofacial motor skills, and the conscious and precise pronunciation of syllables, sentences, phrases, and song lyrics. The findings support the hypothesis that music-based interventions can improve speech intelligibility by engaging multiple levels of language processing, from articulatory precision to prosodic integration. Furthermore, baseline assessment indicated predominantly mild dysarthria in the study sample. This may have resulted in a ceiling effect, limiting the magnitude of observable therapeutic change.

Analysis of ASpoR data provided insight into changes in spontaneous speech following music therapy intervention. Disfluencies were among the parameters assessed. Although singing and speech-based exercises can provide structure supporting the initiation and fluency of verbal expression by facilitating rhythmic sequencing of articulatory movements through various external sensory stimuli (visual, auditory, and tactile) [36], this effect did not generalize to spontaneous speech, where disfluency rates remained virtually unchanged.

This limited transfer may seem surprising given that music exerts a rhythmic-stabilizing influence on speech by facilitating synchronization and enhancing the processing of the sound envelope, that is dynamic changes in sound, such as alterations in volume and rhythmic patterns over time [37]. Moreover, in singing, the ability to maintain a stable tempo plays a crucial role [21,22]. However, the issue of generalization in this area has also been highlighted by Thaut [38], who notes that even individuals who benefit from rhythmically supported singing exercises may not exhibit generalization to speech.

Similarly, the intervention did not significantly affect the overall speech error rate. In contrast, a statistically significant and clinically relevant improvement was observed in speech self-monitoring – the ability to detect and correct errors in real time during spontaneous speech. Monitoring accuracy, expressed as the percentage of corrected errors supported by the ratio of uncorrected to corrected errors, showed consistent gains.

While speech error rates did not significantly change, self-monitoring improved substantially, indicating stronger feedback and regulation during speech. Enhanced self-monitoring, expressed through more corrected errors and lower uncorrected/corrected ratios, proved the most sensitive indicator of intervention efficacy. This finding suggests that music therapy can reinforce higher-order cognitive processes related to planning and self-regulation, possibly via neuroplastic changes in prefrontal regions [39].

Programs combining rhythmic, articulatory, and respiratory training with singing are most effective when integrated with conscious speech control and varied communicative contexts [20,22]. Group delivery likely enhances outcomes through social support and motivation [40]. An integrated model combining speech-language and music therapy may yield even stronger results [24].

Limitations

Several methodological limitations should be considered. The small sample size ($N = 17$) and lack of a control group restrict generalizability. Excluding zero values may have further reduced statistical power.

Heterogeneity in the disease stage, symptom severity, and communicative abilities may also have influenced outcomes. Although attendance at group sessions was high, home-based practice varied, possibly reducing the overall effect.

Despite standardized materials and expert SLT assessments, results remain partly subjective. The GRBAS scale was sensitive to voice changes, but highlights the need for objective measures such as acoustic or aerodynamic analyses and self-assessment tools (e.g., Voice Handicap Index [VHI]).

Future research should include larger samples, control groups, and objective evaluations to strengthen evidence on music therapy effects.

Conclusion

This study demonstrates the potential of structured music therapy to support vocal and speech functions in individuals with PD, with improvements in voice quality, speech intelligibility, and self-monitoring. Emphasis should be placed on generalization of gains to spontaneous communication. A multimodal approach combining music and speech-language therapy, supported by follow-up maintenance, may enhance and sustain benefits. Future controlled studies are needed to confirm and expand these findings.

Ethical principles

The entire study was conducted in accordance with the Helsinki Declaration of 1975 (as revised in 2004 and 2008). All participants provided written informed consent approved by the relevant Ethics Committees of the University Hospital Bratislava (EK 10/2024), 19. 3. 2024 and Comenius University in Bratislava (3/2024), 2. 7. 2024.

Acknowledgements

This study is a partial output of the VEGA project no. 1/0433/23 Therapeutic-educational intervention through music therapy to support speech in people with Parkinson's disease.

Conflict of interest

The authors declare they have no potential conflicts of interest concerning drugs, products, or services used in the study.

Resources

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