



ORIGINAL ARTICLE

Individual Therapeutic Singing Program for Vocal Quality and Depression in Parkinson's Disease

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Objective Patients with Parkinson's disease (PD) frequently experience depression associated with voice problems. Singing involves the use of similar muscles and the neural networks associated with vocal function and emotional response. The purpose of this study is to enhance vocal quality and depressive symptoms of patients with PD using individual singing program.

Methods The Individual Therapeutic Singing Program for PD (ITSP-PD) was conducted by a certified music therapist. In total, nine PD patients with a subjective voice problem or depression participated in 6 sessions over 2 weeks. We measured the Maximum Phonation Time (MPT) via the Praat test, the Voice Handicap Index (VHI), the Voice-Related Quality of Life (V-RQOL) and the Geriatric Depression Scale (GDS).

Results In total, 8 out of 9 patients completed all the sessions; 6 out of 8 patients participated in the follow-up test after 6 months. A statistically significant change in MPT ($p = 0.011$) was observed between the pre- and post-tests. The VHI ($p = 0.035$) and the GDS ($p = 0.018$) were significantly lower in the post-test. In the pre-, post-, and follow-up tests, the MPT ($p = 0.030$), V-RQOL ($p = 0.008$), and GDS ($p = 0.009$) were significantly changed.

Conclusion The ITSP-PD based on neurological singing therapy for PD showed therapeutic possibility for vocal function and depression in patients with PD. Our findings suggest the need for a randomized study to examine the continuing positive effects of the ITSP-PD over a longer period of time.

Key Words Parkinson's disease; music therapy; singing; voice; depression.

Patients with Parkinson's disease (PD) usually have inaudible voices, rapid monotonous speech, and hypokinetic dysarthria.¹⁻⁴ Moreover, problems with phonetics, such as breathing, phonation, and articulation, also affect speech, leading to significant difficulties in communication.³⁻⁶ These communication difficulties can lead to social isolation and depression eventually,^{4,5} which together may impair quality of life.⁷⁻⁹

There has been ongoing research to enhance the speech and vocal attributes of PD patients using singing as a therapeutic medium in a group.⁹ The mechanisms of speech and singing share considerable similarities, as both involve breathing, phonation, articulation, vocal production, neural control, and emotion.¹⁰⁻¹² The primary differences between them are that singing uses more specific mechanisms, including breathing cycles, more

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activation of the organs related to phonation and articulation, and it more strongly affects emotion than speech.⁶⁻⁸ According to systematic reviews on the effects of singing, it appears that it may be of benefit in speech production for patients with PD, although the evidence is controversial.⁹⁻¹³ What this literature suggests is that singing can be used as a therapeutic intervention for voice therapy while also alleviating depressive symptoms.¹⁴

Depression is a common non-motor symptom in patients with PD.^{15,16} Other than psychotherapy programs, the main treatments for depression has been daily medication for them.⁴ There has been no research to date on reducing depression in PD patients through vocal function interventions to enhance individual phonetics and alleviate psychological symptoms.¹⁷

Non-pharmacologic treatments are suggested to improve the quality of life in patients with PD.^{4,17,18} In therapeutic settings for patients with PD, music therapy is applied as one of the non-pharmacologic treatments for music perception or vocal prosody.^{7,19,20} Singing programs have been applied to provide opportunities for socialization, mental stimulation, and emotional expression in psychosocial outcomes. However, the emotional effect of singing programs in PD has received little attention.

The use of structured singing as a therapeutic medium must be undertaken after considering severity of patient's functional state such as vocal condition, including respiration, voice range, dynamics, musical responses, expressions of emotions, and song-related memory.^{10,14-17,20,21} There are several therapeutic voice programs for PD, including the Lee Silverman Voice Treatment, the accent method, resonant voice therapy, and vocal function exercises. However, these programs focus on the modification of the voice production mechanism without appropriate emotional and psychosocial approaches.^{3,8,12,13,15}

Therefore, we sought to determine whether the Individual Therapeutic Singing Program for PD (ITSP-PD) is effective for enhancing vocal quality and alleviating symptoms of depression in PD patients.

MATERIALS & METHODS

Participants

Patients with PD were recruited from a single

movement disorder center. The main inclusion criterion for the study was a diagnosis of PD based on the UK Parkinson's Disease Society Brain Bank Clinical Diagnostic Criteria for PD.^{21,22} Additional inclusion criteria for the ITSP-PD were as follows: a score of 24 points or higher on the Mini Mental State Examination (MMSE),³ no prior experience with speech therapy nor participation in music therapy, capable of independent sitting, and voluntary vocalization for longer than 5 seconds of an /ah/ phonation.¹³ Patients of the outpatient clinics with complaints of voice problems and depressive mood either by self-report or by their caregivers were invited to participate by a neurologist (JYY).

Patients with a medical history of other neurological diseases, pulmonary diseases, or acute cardiovascular events within the past six months were excluded. Patients taking antidepressants were also excluded. Written informed consent was obtained from all patients. Institutional Review Board (IRB no. 042-002) approval was processed and obtained prior to the study.

Design and data collection

A pre-interview was held with each patient to gather personal background details, including medical, musical, and social history, and subsequently, pre- (1st session), post- (8th session), and 6-month follow-up tests were administered. Based on previous studies, we designed the ITSP-PD to include six 50-minute music therapy sessions provided by a certified music therapist over a period of two weeks.¹⁰⁻¹⁴ All data collection and music therapy sessions were performed in the hospital or in the patients' homes. All tests and sessions were video recorded with the written consent of each patient.

The Hoehn and Yahr staging scale (H&Y),²³ Unified Parkinson's Disease Rating Scale (UPDRS) for speech (item 18), and the Levodopa Equivalent Daily Dosage (LEDD) were also assessed by a neurologist (JYY).

We evaluated three main aspects of the participants' vocal and emotional state: vocal attributes, depression, and patient responses during the sessions. To evaluate depression, we used the Geriatric Depression Scale (GDS). The total GDS score ranges from 0 to 30, where a score over 10 indicates depressive symptoms.¹⁵ The Maximum Phonation Time (MPT), the Voice Handicap Index (VHI), and the

Voice-Related Quality of Life (V-RQOL) were assessed during the pre-, post-, and follow-up tests.

The MPT was measured to examine respiratory and sound control, glottis efficiency, and duration using the computer software program of the Praat test.¹³ The same distance between the participant's mouth and the headset microphone was maintained during the three trials. The MPT is the maximum time in seconds for which a person can sustain a vowel sound, /ah/, produced from one deep breath at a relatively comfortable pitch and loudness.¹⁴ Kang et al.³ reported that the MPT for normal Korean adults between 63–75 years of age was 12.8 ± 5.5 (s), while in 15 patients with PD, it was found to be 12.2 ± 4.1 (s).

The VHI is a questionnaire that measures voice problems in daily life. It consists of 30 items divided into three subscales: emotional, functional, and physical. Summing the scores of the 30 items yields a total VHI score ranging from 0 to 120.² Higher scores represent higher degrees of patient-perceived vocal handicap. Previous VHI research in normal Korean adults between the ages of 65–82 reported an average score of 12.0 ± 16.3 for men and 11.7 ± 16.5 for women.^{2,24}

The V-RQOL is a questionnaire that discriminates between patients with voice problems and those without. It consists of 10 items divided into two subscales: social-emotional and physical. The total V-RQOL score ranges from 0 to 100. Higher scores represent lower degrees of patient-perceived vocal problems.² Previous V-RQOL research in patients with PD between 55–70 years of age reported an average score of 59.1 ± 20.2 .^{2,24}

Additionally, behavioral observations, use of voice, and interactions using physical, linguistic, emotional, and musical responses were reported by a researcher. The descriptive observations and subjective analysis of each session for each patient were recorded.

Statistical analysis

Demographic and clinical characteristics were analyzed using the Wilcoxon signed-rank test for continuous variables and the χ^2 test for categorical variables. Three statistical methods for nonparametric tests were used to analyze MPT, VHI, V-RQOL, and GDS during the pre-, post-, and follow-up tests. The Wilcoxon signed-rank test was used to

analyze the effect size of the pre- and post-tests. The Friedman test as the non-parametric alternative to one-way ANOVA with repeated measures was used to analyze the pre-, post-, and 6-month follow-up tests. Lastly, the Spearman rank-order correlation was used to measure the strength and direction of the association between voice and quality of life in the pre- and post-tests. All statistical analyses were performed using the R language (R 3.4.2 version)²⁵ for analysis to visualize the results.

ITSP-PD

Six intensive 50-minute music therapy sessions were conducted over two weeks. Each session was structured using four steps based on the therapeutic content and duration of the session. The ITSP-PD consisted of three progressive levels of therapeutic musical approaches based on neurological and psychological mechanisms for the six sessions, taking into consideration the specific physical, phonetic, and psychological characteristics of the patients with PD as assessed by a music therapist. Six sessions of the ITSP-PD were developed that consisted of two aspects, i.e., voice and emotion, based on phonetics and song psychotherapy.^{7,9,10,26} During the ITSP-PD sessions, adjustments of antiparkinsonian medications were not permitted.

Exploration level (1st and 2nd sessions)

In this level, patients are invited to explore various aspects of their own voice. Vocal exploration includes making natural sounds, various vocal patterns, and exploring pitch ranges and dynamics of sound quality. Along with this vocal exploration, patients are asked to sing their preferred songs that have positive associations or meaning. The patients may verbally share their positive meanings and feelings related to the songs they choose.^{19,27}

Reinforcement level (3rd and 4th sessions)

At this level, patients are introduced to structured sequential vocal patterns that employ gradual dynamics and expanded ranges with intervals in order to strengthen vocal capacity. The patients are invited to model or improvise given the vocal range with different dynamics. At the same time, the patients are asked to select specific songs that may help them to cope with their negative emotions. These songs function as positive resources for any negative

feelings such as depression.^{14,28}

Integration level (5th and 6th sessions)

In this level, the patients are invited to create their own songs and singing patterns based on their vocal condition and capacity. Individual vocalizing patterns are designed to best meet the patients' vocal needs based on their personal meaning and musical preferences. These factors are important in prompting patients to sing more frequently and with enjoyment. At the same time, each patient's preferred songs are combined into a medley for their daily singing practice. These singing resources alleviate negative feelings or emotions, since the songs are associated with positive meanings and feelings for the patient.^{20,29}

In detail, each session of the ITSP-PD consisted of four progressive steps based on the voice and the emotional condition of the patient with PD, as follows.

Pre-interview & self-report (pre-session, 5 min)

This included the MPT test and a self-evaluation of the patient's voice and emotional status before each session and an interview with a certified music therapist.^{12,30}

Therapeutic vocalization (20 min)

Therapeutic vocalization consisted of facilitated breathing, phonation, larynx and vocal folds, and auditory feedback. These musical patterns were adjusted according to the phonetic characteristics of each patient with PD, including posture, pitch, tempo, scale, interval, and dynamics, as well as the physical symptoms of the patients with PD. The five patterns were designed to facilitate more interactive movement of the larynx and vocal folds based on comfortable breathing cycles and pitches with their own hand movements.^{3,6-8,31-33}

Vocal improvisation & song-making activities (20 min)

Therapeutic singing to emphasize personal approaches, including 'Finding the musical mind,' 'Expressing one's own emotions,' 'Remembering positive memories,' and 'Enhancing daily life.' These activities were adjusted according to the psychosocial state of each patient with PD using song selection, vocal im-

itation, vocal interaction, song conversation, song composition, and performance. A music therapist asked each patient to practice at home.^{9,10,19,29,31,34,35}

Post-interview & self-report (post-session, 5 min)

The MPT test and the self-evaluation of voice and emotion were conducted after each session and an interview with a certified music therapist.^{28,31}

Several therapeutic instruments were used in each session depending on the therapeutic objective of the session, including the Q-chord for supportive accompaniment of voice and emotion, a kazoo to enhance vocal initiation, touch bells to provide pitch and musical structure, and a Korean traditional drum, a guitar, and egg shakers to facilitate participation in singing.^{10,30,35} After all the sessions, we asked the patients not to practice therapeutic singing at home.

RESULTS

Participants

Nine patients with PD initially enrolled, and eight patients completed all of the sessions. The individual voice and emotional states of the patients were recorded by a music therapist (EYH) through interviews before the pre-test (Table 1).

Patient 'A' had daily communication problems due to unclear articulation, delayed phonation, and weak voice with tremor, as well as a less severe depressive mood. Patient 'B' had short breathing cycles during conversation, delayed speech, and low motivation to maintain daily life. Patient 'C' had dry mouth, a soft voice, and feelings of boredom in life. Patient 'D' had subtle voice problems daily. However, caregivers said she had difficulties expressing her own emotions and tried to hide her depressive mood from her family and friends. Patient 'E' had a soft and weak voice as well as a short breathing cycle. She complained of chronic fatigue and a depressive mood. Patient 'F' had lowered pitch phonation, problems with communication, and felt isolated and depressed. Patient 'G' had a weak and unstable voice with a short breathing cycle. She had anxiety about her illness and severe separation anxiety from her family. Patient 'H' had delayed phonation and lack of volume control, and he has flat affect which he could maintain in his work place when interacting

with others. Patient 'T' had a soft and weak voice with tremor, and she had positive mindset due to which she had fewer problems communicating with others. The vocal and emotional problems of the patients are described in detail in the Supplementary Material 1 (in the online-only Data Supplement).

The mean age of the eight patients was 65.7 ± 7.7 years, and the mean duration of PD was 4.8 ± 3.0 years. Eight patients participated in the pre- and post-tests, and six patients participated in the 6-month follow-up tests. One patient was not able to participate after the second music therapy session due to an influenza infection. Two patients were not included in the 6-month follow-up test due to being lost to follow-up.

We maintained all the antiparkinsonian medications during the sessions. The LEDD was identical between the pre- and post-sessions. There were no

statistically significant changes in the LEDD during the sessions (663.0 ± 276.3 mg/day) through the 6-month follow-up tests (704.17 ± 350.24 mg/day, $p = 0.317$). There was no statistical change in the H&Y ($p = 1.000$) and UPDRS-speech ($p = 1.000$) scores during the pre-test through the 6-month follow-up test (Table 1).

Vocal attributes and depression

There were two primary aspects to this study, including the statistically significant changes in vocal attributes (MPT, VHI, and V-RQOL) and in depression (Table 2). Additionally, we recorded the individual responses of the patients during the sessions (Supplementary Material 1 in the online-only Data Supplement). We describe the change process experienced by patient 'A' in detail, as this patient demonstrated the most statistically significant results

Table 1. Baseline characteristics of participants

Patients (n = 9)	Sex/age (years)	Disease duration (years)	LEDD (mg/day)	H&Y (on)	UPDRS_speech	MMSE (score)	MPT (sec)	VHI (0–120)	V-RQOL (0–100)	GDS (0–30)
A	F/62	8	1,050.0	2.5	2	24	10.8	87	27.5	26
B	M/53	2	750.0	2.0	1	30	5.8	31	85.0	26
C	M/74	10	400.0	2.0	1	25	16.5	20	97.5	18
D	F/61	3	487.5	1.5	1	30	20.8	10	97.5	1
E	F/74	3	450.0	2.0	0	29	7.9	77	47.5	24
F	F/63	3	750.0	2.0	2	27	14.1	55	72.5	15
G*	F/78	3	525.0	1.5	1	25	17.9	69	75.0	21
H	M/59	2	375.0	1.5	0	30	9.1	25	87.5	10
I	F/67	9	1,187.5	3.0	2	25	9.6	27	95.0	5
Mean	65.7 ± 7.7	4.8 ± 3.0	663.0 ± 276.3	2 ± 0.5	1.1 ± 0.8	27.2 ± 2.4	12.5 ± 5.1	44.6 ± 27.9	76.1 ± 24.2	16.2 ± 9.2

*patient G withdrew ITSP-PD after the 2nd session due to a personal health condition. LEDD: Levodopa Equivalent Daily Dosage, H&Y: Hoehn and Yahr stage, UPDRS_speech: Speech score of Unified Parkinson's Disease Rating Scale, MMSE: Mini Mental State Examination.

Table 2. The individual data for vocal attributes and depression

Patients (n = 9)	MPT (sec)			VHI (0–120)			V-RQOL (0–100)			GDS (0–30)		
	Pre	Post	F/U	Pre	Post	F/U	Pre	Post	F/U	Pre	Post	F/U
A	10.8	13.8	14.6	87	71	41	27.5	45.0	87.5	26	11	10
B	5.8	6.6	5.7	31	32	34	85.0	80.0	92.5	26	24	25
C	16.5	27.9	19.8	20	11	9	97.5	99.0	99.0	18	16	15
D‡	20.8	23.8	NA	10	11	NA	97.5	97.5	NA	1	1	NA
E	7.9	10.9	11.2	77	57	55	47.5	55.0	75.0	24	17	22
F‡	14.1	20.5	NA	55	52	NA	72.5	80.0	NA	15	12	NA
G†	17.9	NA	NA	69	NA	NA	75.0	NA	NA	21	NA	NA
H	9.1	10.8	10.0	25	19	27	87.5	92.5	100.0	10	0	1
I	9.6	15.7	14.2	27	16	15	95.0	99.0	10.0	5	1	3
Mean	12.5 ± 5.1	16.3 ± 7.3	12.6 ± 4.8	44.6 ± 27.9	33.6 ± 23.4	30.2 ± 17.0	76.1 ± 24.2	81.0 ± 20.8	77.3 ± 34.2	16.2 ± 9.2	10.3 ± 8.8	12.7 ± 9.8
Pre vs. post	0.011*			0.035*			0.075			0.018*		
Pre vs. post vs. F/U	0.030*			0.311			0.008*			0.009*		

* $p < 0.05$, †the data of Patient G were not included due to withdrawal from the ITSP-PD after the 2nd session due to a personal health condition, ‡the data of Patients D & F were not included in the 6-month follow-up tests as they were lost to follow-up. MPT: Maximum Phonation Time, VHI: Voice Handicap Index, V-RQOL: Voice-Related Quality of Life, GDS: Geriatric Depression Scale, F/U: Follow-up test 6 months later, NA: not available.

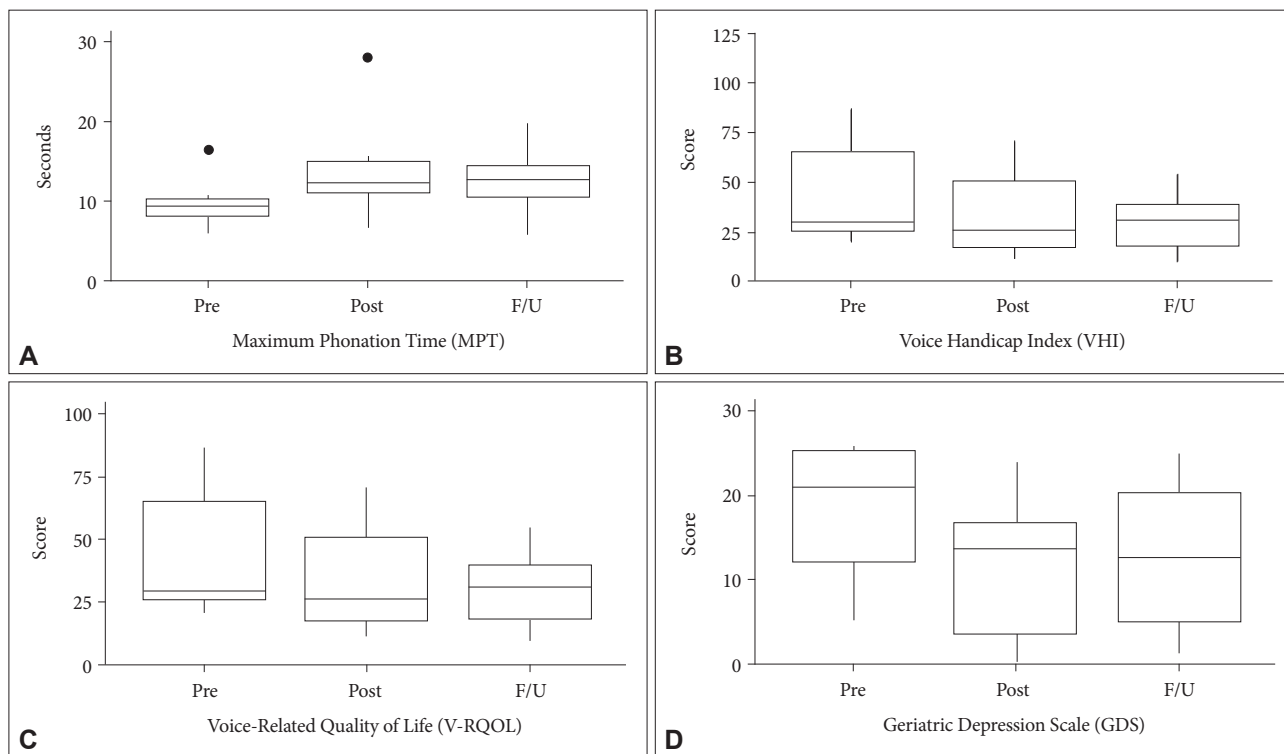


Figure 1. A box plot showing the distribution of measured mean values for each pre-, post-, and 6-month follow-up test (F/U).

(Supplementary Material 2 in the online-only Data Supplement). Figure 1 shows a box plot of the distribution of the measured values for each pre-, post-, and 6-month follow-up test.

With regard to vocal attributes, i.e., the acoustic measurement of voice, the MPT was statistically different ($p = 0.011$). In the follow-up test, the MPT was still significantly different from baseline ($p = 0.030$). With regard to the subjective measurement of voice impediments, the VHI showed statistically significant lower scores ($p = 0.035$). In the follow-up test, however, VHI did not show significant changes ($p = 0.311$). With regard to the subjective measurement of voice-related quality of life, the V-RQOL scores did not show statistically significant changes ($p = 0.075$). However, there was a statistically significant difference in the V-RQOL in the follow-up test ($p = 0.008$). Lastly, with regard to the measurement of depression, the GDS was statistically significantly lower in the post-tests ($p = 0.018$). Moreover, in the follow-up test, the GDS showed statistically significant changes ($p = 0.009$) (Table 2). There was a strong negative correlation between post-VHI and post-V-RQOL scores that was statistically significant ($p = 0.01$).

DISCUSSION

ITSP-PD is a multidisciplinary program designed to improve both vocal quality and depression in PD patients. To evaluate the applicability of ITSP-PD for both vocal quality and depression, we conducted the program in a small group of patients.

According to previous studies, singing, which includes physical, emotional, social, and cognitive engagement, might be useful as a therapeutic intervention.^{9,10,19,26} Moreover, a high prevalence of voice handicap in patients with PD may be associated with the high incidence of depression that occurs in these patients.¹ However, previous studies using singing programs typically utilized group singing activities that focused on phonation, speech, or the mood of the patients with PD separately.^{9-11,14} In group singing activities, it is difficult to consider the specific characteristics of the individual PD patients, such as breathing pattern, posture, vocal folds, the state of the larynx, or their psychological state.^{10,11,16,20}

The ITSP-PD provided individual therapeutic vocalization exercises based on the therapeutic rationale on neural mechanisms, which allowed the facilitation of abdominal breathing, extended vocal range, flexible tempo, wide pitch process, and a spe-

cific order of vowels ('i-e-a-o-u') for voice production that are related to respiratory and phonation muscles.^{6,12,31} Therefore, an optimized therapeutic program based on personal characteristics can be applied individually to each patient.^{13,30,33}

The 6-month follow-up tests might imply continuing positive effects of the ITSP-PD relative to the baseline scores. In group singing activities, it is difficult to consider the specific characteristics of the individual PD patients.^{10,20} The ITSP-PD is based on neurological singing therapy activities so that it is possible to adjust activities based on the individual's voice and emotional state.^{6,7} Although we did not provide the individual therapeutic singing practices to patients after all the sessions were over, PD patients who experienced changes in their voice and emotion through therapeutic interventions and were able to transfer the learned skills onto their everyday living. This may have contributed to the prolonged therapeutic effects. Additionally, this was not a blinded study, although PD patients are known to be vulnerable to placebo effects.^{34,35} Accordingly, we cannot exclude the possibilities of voluntary responses in PD patients.³⁶ These findings suggest the necessities to study continuing positive effects of the ITSP-PD in the long-term period with more controlled design.

To the best of our knowledge, previous studies of non-pharmacological treatment using singing in PD evaluated the effects of the voice handicap and depression separately.^{7,26,29} A few studies have reported that singing induces changes in mood states,^{10,11,14} although these studies did not include statistically significant changes in patients with PD.^{10,11,14,36} We assessed not only the subjective perceptions of their voice but also quantified measures on their vocal acoustics using the Praat test, the VHI, and the V-RQOL. We also examined the potential utility of ITSP-PD for treating depression in patients with PD.

Antidepressants are required to treat depressive mood in PD patients. Considering their adverse effects, including dry mouth, dizziness, insomnia, and constipation,³⁷ however, non-pharmacologic therapeutic options can be considered as complementary therapies in order to limit the dose of antidepressants necessary.^{4,16} Holistic outcomes of singing intervention led to alleviation of depressive mood and the amelioration of voice-related difficulties to improve the quality of life of patients with PD.^{7,15,19,20}

This study was conducted with only eight participants. Therefore, the statistical results have limited value, and there is a limit to the interpretation of the results according to the three measuring points. We attempted to explore the potential benefits of the therapeutic singing program for the integration of vocal function and emotional changes for PD patients in this small group prior to the design of a randomized controlled study in a larger population. Further randomized and well-designed studies using the ITSP-PD will be required to better demonstrate its potential therapeutic effects.^{7,27,29}

This study suggests that the ITSP-PD might be effective in enhancing vocal quality and alleviating depression in patients with PD. As such, the ITSP-PD has shown applicability in the improvement of voice integration and depression. In non-pharmacological interventions, both functional and emotional approaches must be considered. In this respect, ITSP-PD may be a useful therapeutic intervention to help improve vocal functioning and the depressive state of PD patients.

Supplementary Materials

The online-only Data Supplement is available with this article at <https://doi.org/10.14802/jmd.17078>.

Conflicts of Interest

The authors have no financial conflicts of interest.

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REFERENCES

1. Sunwoo MK, Hong JY, Lee JE, Lee HS, Lee PH, Sohn YH. Depression and voice handicap in Parkinson disease. *J Neurol Sci* 2014;346:112-115.
2. Yu G, Jang I, Kim L. Voice handicap index and voice-related quality of life in idiopathic Parkinson's disease. *J Oriental Neuropsychiatr* 2013;24:155-162
3. Kang YA, Kim YD, Ban JC, Seong CJ. A comparison of the voice differences of patients with idiopathic Parkinson's disease and a normal-aging group. *Phon Speech Sci* 2009; 1:99-107.
4. Ghazi-Noori S, Chung TH, Deane K, Rickards HE, Clarke CE. Therapies for depression in Parkinson's disease. *Cochrane Database Syst Rev* 2003;2:CD003465.
5. Shiba M, Bower JH, Maraganore DM, McDonnell SK, Peterson BJ, Ahlskog JE, et al. Anxiety disorders and depres-

- sive disorders preceding Parkinson's disease: a case-control study. *Mov Disord* 2000;15:669-677.
6. Sundberg J, Thomas DR. The science of singing voice. *J Acous Soc Am* 1990;87:462-463.
 7. Wan CY, Rüber T, Hohmann A, Schlaug G. The therapeutic effects of singing in neurological disorders. *Music Percept* 2010;27:287-295.
 8. Howard DM. Acoustics of the trained versus untrained singing voice. *Curr Opin Otolaryngol Head Neck Surg* 2009;17:155-159.
 9. Lima CF, Garrett C, Castro SL. Not all sounds sound the same: Parkinson's disease affects differently emotion processing in music and in speech prosody. *J Clin Exp Neuropsychol* 2013;35:373-392.
 10. Elefant C, Baker FA, Lotan M, Lagesen SK, Skeie GO. The effect of group music therapy on mood, speech, and singing in individuals with Parkinson's disease--a feasibility study. *J Music Ther* 2012;49:278-302.
 11. Pacchetti C, Mancini F, Aglieri R, Fundarò C, Martignoni E, Nappi G. Active music therapy in Parkinson's disease: an integrative method for motor and emotional rehabilitation. *Psychosom Med* 2000;62:386-393.
 12. Tamplin J. A pilot study into the effect of vocal exercises and singing on dysarthric speech. *NeuroRehabilitation* 2008;23:207-216.
 13. Kim SJ, Jo U. Study of accent-based music speech protocol development for improving voice problems in stroke patients with mixed dysarthria. *NeuroRehabilitation* 2013;32:185-190.
 14. Haneishi E. Effects of a music therapy voice protocol on speech intelligibility, vocal acoustic measures, and mood of individuals with Parkinson's disease. *J Music Ther* 2001;38:273-290.
 15. Brink TL, Yesavage JA, Lum O, Heersema PH, Adey M, Rose TL. Screening tests for geriatric depression. *J Clin Gerontol* 1982;1:37-43.
 16. Sagna A, Gallo JJ, Pontone GM. Systematic review of factors associated with depression and anxiety disorders among older adults with Parkinson's disease. *Parkinsonism Relat Disord* 2014;20:708-715.
 17. Reijnders JS, Ehrt U, Weber WE, Aarsland D, Leentjens AF. A systematic review of prevalence studies of depression in Parkinson's disease. *Mov Disord* 2008;23:183-189.
 18. Kadastik-Eerme L, Muldmaa M, Lilles S, Rosenthal M, Taba N, Taba P. Nonmotor features in Parkinson's disease: what are the most important associated factors? *Parkinsons Dis* 2016;2016:4370674.
 19. Clark I, Harding K. Psychosocial outcomes of active singing interventions for therapeutic purposes: a systematic review of the literature. *Nord J Music Ther* 2012;21:80-98.
 20. Buetow SA, Talmage A, McCann C, Fogg L, Purdy S. Conceptualizing how group singing may enhance quality of life with Parkinson's disease. *Disabil Rehabil* 2014;36:430-433.
 21. Kalia LV, Lang AE. Parkinson disease in 2015: evolving basic, pathological and clinical concepts in PD. *Nat Rev Neurol* 2016;12:65-66.
 22. Lorenz D, Deuschl G. Movement disorders and their impact on quality of life. In: Tröster AI, editor. *Clinical Neuropsychology and Cognitive Neurology of Parkinson's Disease and Other Movement Disorders*. New York: Oxford University Press, 2014;79-126.
 23. Hoehn MM, Yahr MD. Parkinsonism: onset, progression and mortality. *Neurology* 1967;17:427-442.
 24. Song YK. Prevalence of voice disorders and characteristics of Korean voice handicap index in the elderly. *Phon Speech Sci* 2012;4:151-159.
 25. Team RC. R: A Language and Environment for Statistical Computing. Vienna: R Foundation for Statistical Computing; 2016.
 26. Barnish J, Atkinson RA, Barran SM, Barnish MS. Potential benefit of singing for people with Parkinson's disease: a systematic review. *J Parkinsons Dis* 2016;6:473-484.
 27. de l'Etoile SK. Neurologic music therapy: a scientific paradigm for clinical practice. *Music Med* 2010;2:78-84.
 28. Chong HJ. Sori Therapy for a woman with trauma to empower inner safety. In: Baker F, Uhlig S, editors. *Voicework in Music Therapy: Research and Practice*. London: Jessica Kingsley Publishers, 2011;100-130.
 29. Maratos AS, Gold C, Wang X, Crawford MJ. Music therapy for depression. *Cochrane Database Syst Rev* 2008;1:CD004517.
 30. Tamplin J, Baker F. Interventions for communication Rehabilitation. In: Tamplin J, Baker F, editors. *Music Therapy Methods in Neurorehabilitation: A Clinician's Manual*. London: Jessica Kingsley Publishers, 2006;138-192.
 31. Zarate JM. The neural control of singing. *Front Hum Neurosci* 2013;7:237.
 32. Binazzi B, Lanini B, Bianchi R, Romagnoli I, Nerini M, Gigliotti F, et al. Breathing pattern and kinematics in normal subjects during speech, singing and loud whispering. *Acta Physiol (Oxf)* 2006;186:233-246.
 33. Henrich N, D'Alessandro C, Doval B, Castellengo M. Glottal open quotient in singing: measurements and correlation with laryngeal mechanisms, vocal intensity, and fundamental frequency. *J Acoust Soc Am* 2005;117(3 Pt 1):1417-1430.
 34. Shin CW, Hahn S, Park BJ, Kim JM, Park EO, Jeon B. Predictors of the placebo response in clinical trials on Parkinson's disease: a meta-analysis. *Parkinsonism Relat Disord* 2016;29:83-89.
 35. de la Fuente-Fernández R, Schulzer M, Stoessl AJ. The placebo effect in neurological disorders. *Lancet Neurol* 2002;1:85-91.
 36. Baker F, Uhlig S. Diversity in approaches to therapeutic voicework. In: Baker F, Uhlig S, editors. *Voicework in Music Therapy: Research and Practice*. London: Jessica Kingsley Publishers, 2011;333-349.
 37. Garlovsky JK, Overton PG, Simpson J. Psychological predictors of anxiety and depression in Parkinson's disease: a systematic review. *J Clin Psychol* 2016;72:979-998.