Community Choir Improves Vocal Production Measures in Individuals Living with Parkinson's Disease

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Summary: Objectives. Parkinson's disease (PD) is a neurodegenerative disease leading to motor impairments and dystonia across diverse muscle groups including vocal muscles. The vocal production challenges associated with PD have received considerably less research attention than the primary gross motor symptoms of the disease despite having a substantial effect on quality of life. Increasingly, people living with PD are discovering group singing as an asset-based approach to community building that is purported to strengthen vocal muscles and improve vocal quality.

Study design/Methods. The present study investigated the impact of community choir on vocal production in people living with PD across two sites. Prior to and immediately following a 12-week community choir at each site, vocal testing included a range of vocal-acoustic measures, including lowest and highest achievable pitch, duration of phonation, loudness, jitter, and shimmer.

Results. Results showed that group singing significantly improved some, though not all, measures of vocal production. Group singing improved lowest pitch (both groups), duration (both groups), intensity (one group), jitter (one group), and shimmer (both groups).

Conclusions. These findings support community choir as a feasible and scalable complementary approach to managing vocal production challenges associated with PD.

Key Words: Parkinson's disease−Singing−Speech therapy−Vocal quality−Intervention.

INTRODUCTION

Vocal communication can be challenging for people living with Parkinson's Disease (PD), a neurodegenerative disorder that affects approximately 1% of individuals over the age of 60.[1] Approximately 90% of PD patients experience distinct vocal challenges[2] originating from dystonia in muscles required for speech production, articulation, and respiration.[3] Features of hypokinetic dysarthria, including reduced volume (hypophonia), a harsh and breathy voice, shorter phonation duration, and limited intonation are often present during early stages of the disease[4] and remain largely consistent throughout disease progression.[3,5] In intermediate stages, fluency issues such as initiation difficulties, syllable repetition, and pauses become apparent.[2] In later stages, salient hypokinetic dysarthria becomes more severe, leading to reduced pitch variation, reduced loudness, breathy voice, and variable speaking rate, with short rushes of speech.[5,6]

Other common measures of vocal quality that have been considered with respect to Parkinson's disease include jitter and shimmer, which are acoustic terms that refer to variations in fundamental frequency (pitch) and amplitude (loudness) measured during sustained vowel phonation.[7] Jitter specifically refers to the perturbations in fundamental frequency between sound wave cycles and is caused by irregularities in vocal fold vibrations.[8] Conversely, shimmer refers to perturbations in the amplitude between sound wave cycles and is associated with reduced resistance of the glottis.[8] Performance by PD patients on such tasks has revealed significantly higher levels of jitter and shimmer compared to healthy controls.[9] These higher levels of jitter and shimmer manifest perceptually as the cracked and hoarse voice qualities that characterizes PD. Importantly, some of these characteristics can already be heard in non-advanced stages of the disease.[4]

Deficits in vocal production can have a detrimental impact on interpersonal relationships. For example, lack of expressiveness can give a false impression of withdrawal, lack of interest, and coldness during interpersonal encounters.[10] This overall lack of emotional expressiveness in the voice can lead to frequent misunderstandings of how a person with PD is feeling.[11,12] Self-perceptions of quality of voice may also create barriers in how individuals relate to close others and may affect overall comfort in social discourse. Such challenges may lead to a self-fulfilling prophecy,[13] whereby a degradation in self-perception of voice quality leads to disengagement and social isolation,[14,15] with downstream consequences for depression and anxiety.[16-18]

Current research is pointing to group singing as an enjoyable, strength-based activity that may improve vocal quality in PD.[19-22] Although other non-pharmacological interventions have also demonstrated success in improving vocal quality (eg, Lee Silverman Voice Training, LSVT), researchers have pointed out the additional psychosocial benefits of a group singing format, including improvements in social wellbeing, mood, and overall quality of life.[19,21]

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Singing requires exquisite control over the lungs, larynx, head, and facial muscles[23,24] and preliminary evidence suggests that choral singing can improve the function of these muscles, resulting in improved phonic and prosodic quality of the voice.[25] Singing training focuses on improving coordination between the voice subsystems and strengthening muscles of the respiratory system, the abdomen, as well as muscles of the throat involved in phonation and articulation, all of which are central in the mechanism of speech production.[26] As such, we expect that singing interventions will support vocal production.

In a systematic review, Barnish et al,[27,28] reports that most studies find improvements in some aspects of vocal production, though the literature is sparse, and results appear to be mixed. Specifically, while some studies do not find improvements in aspects of vocal quality,[22] singing-related gains are predominantly found in phonation duration[25,29,30]and vocal intensity.[30-34]

Regarding jitter and shimmer, to date, there have only been two studies that have reported outcomes related to these particular acoustic measures. In the first study, Di Benedetto et al,[29] employed a 26-hour choral singing intervention led by a certified Speech Language Therapist (SLP) and did not find any improvements on jitter and shimmer. In the second study, Lewellen et al,[30] conducted an 8-week therapeutic singing protocol administered by a board-certified music therapist. They found significant improvements in various aspects of vocal quality, including jitter and shimmer. Although the reasons for these contradictory findings are not clear, it is important to note that there are a multitude of factors beyond the researchers control when group singing is employed, for example, the charisma and approach of the leader, the group dynamics, and even the venue. Additional research is thus needed to understand the impact of group singing on the quality of vocal production in PD. Ideally, the study would combine data from more than one site given the range of factors that escape control in this type of study. Finding an effect across different contexts would lend much needed support to the findings and speak to their scalability. The constructs of jitter and shimmer are important to understand in the context of a vocal intervention as they manifest perceptually in the cracked and hoarse voice qualities often associated with PD.

THE CURRENT STUDY

The goal of the current research was to investigate the impact of community choir on acoustical aspects of vocal quality, including a more in-depth investigation of jitter and shimmer, for individuals living with PD. Prior to and immediately following participation in 12 weeks of community choir, vocal testing detected a range of vocal features that are most consistently impaired throughout all stages of disease progression in PD, including lowest and highest achievable pitch, loudness, phonation duration, jitter, and shimmer. Given the inherent emphasis on breath control, loudness, and pitch modulation in choral singing, as well as the general strengthening of the vocal muscles, we expected that choir participation would result in: (1) a decrease in lowest achievable pitch; (2) an increase in highest achievable pitch; (3) an increase in maximum loudness; (4) an increase in phonation duration; (5) a reduction in jitter levels, and; (6) a reduction in shimmer levels.

Moreover, many of the singing interventions discussed in the literature are prescriptive in nature and require the professional training of a music therapist or speech language pathologist to administer. In the current study, we broaden the accessibility and scalability of such interventions by exploring vocal outcomes stemming from participation in community choir. We recruited participants from two community choirs that adopted an asset-based approach. The choirs were designed with the intention of emphasizing inclusion, community building, and vocal strengthening as part of the Parkinson's disease stream of a larger research initiative called SingWell (see www.singwell.org for more information). The two sites were comparable in that they were non-auditioned community choirs intended for anyone with PD wishing to sing; however, each choir developed naturally in response to the style of the choir leader and the needs of the community. As such, the inclusion of two sites with slightly differing situationally dependent features contributes to an assessment of generalizability of the effect in different contexts. The current study took the approach of trading tight control of variables for a more externally valid, applied, and accessible approach.[35]

METHOD

Participants

[1]In collaboration with local support organizations, we recruited 14 individuals living with PD in each of two communities (Group A = Toronto; Group B = Winnipeg). In total, six of 28 individuals (2 from Group A and 4 from Group B) chose to not participate in the research study (none were excluded). The 22 participants who were entered into the research study ranged in age from 50 to 80, were diagnosed with idiopathic PD at age 50 or later, had no other movement disorder, had not recently participated in singing-based programs, and were within a mild-to-moderate level of disease progression.[36] All participants were actively taking dopamine replacement medication for PD (eg, Levodopa), and were asked to schedule testing during an "on time," when the full effects of the medication could be expected. Medication types and dosages varied between patients; however, all participants reported remaining on a consistent dosage of medication throughout the study period. As may be observed in Table 1, participants across the two groups did not differ with respect to vocal quality, overall impairment or age. Although the groups did show a

[1]Participants were recruited with the support of Parkinson's Canada (Toronto), U-Turn Parkinson's (Winnipeg), and the Faculty of Arts, Toronto Metropolitan University (formerly, Ryerson). The cohort recruited with Parkinson's Canada has since become a registered Canadian non-profit corporation known as "Singing with Parkinson's."

TABLE 1.
Participant Characteristics

Variable	*Group A* N	*Group B* N	
Male	8	5	
Female	4	5	
Total	12	10	
Medicated	12	10	
Variable	M ± SD	M ± SD	*t* test
Age (years)	69.58 ± 9.002	73.10 ± 5.0	-1.099
MoCA	27.58 ± 1.311	25.20 ± 1.8	3.574*
Vocal Impairment	0.75 ± 0.45	0.50 ± 0.53	1.198
Overall Impairment	1.42 ± 0.67	1.17 ± 0.41	.834

* *t* test significant at $P < 0.05$.
Vocal impairment (SLP), where 0 (normal), 1 (slight), 2 (moderate), 3 (severe).
Overall impairment (self-report), where 1 (mild), 2 (moderate), 3+ (severe).
Abbreviations: M = Mean, SE = Standard Error; MoCA = Montreal Cognitive Assessment.

significant difference in cognition, none of the participants had scores that would indicate cognitive decline related to dementia.

Baseline testing

Cognitive ability

The Montreal Cognitive Assessment (MoCA)[37] was administered to rule out dementia (defined as a score of 21 or less) and to ensure adequate cognitive ability to complete all the required tasks. All participants were also required to have self-reported normal or corrected-to-normal hearing and vision.

Vocal impairment

Participants were asked to read a short passage, The Grandfather Passage,[38] that was used to assess baseline vocal quality used for further classification of the sample. Recordings of these readings were analyzed by an SLP using a general scale of vocal quality, the GRBAS (grade, roughness, breathiness, asthenia, strain) scale. In this scale, "G," refers to vocal impairment, from 0 (normal) to 3 (severe). This "G" measure is reported as vocal impairment in Table 1.

Overall impairment

Participants were asked to fill out a brief questionnaire assessing their overall disease impairment derived from the Unified Parkinson's Disease Rating Scale (UPDRS), with one (mild) - three (mid-severe) symptoms.

Community choir curriculum

Two, 12-week community choir sessions were tracked for this study. *Group A* was led by a professional choir director with a musical theater background and included a trained piano accompanist; *Group B* was led by a music therapist who served as her own instrumental (guitar) accompanist. Both groups consisted of a similar program emphasizing community inclusion and vocal strengthening. Each weekly session consisted of approximately 10 minutes of warm up exercises, such as breathing exercises, pitch range exercises, and sustained duration exercises, followed by 40 minutes of learning and practicing selected songs. The songs varied across sites. The choir leaders determined this on their own and in consultation with choir members. Participants were encouraged to practice the songs at home and were provided with audio tracks and lyric sheets.

Procedure

During the first choir session, choir members learned about the research component of the program via a brief talk and were informed that the purpose of the study was to investigate the effects of choir participation on vocal outcomes in PD. It was made clear that participation in the study would not affect individuals' choir membership. All choir members who consented to participate in the study were scheduled for their baseline and pre-testing session within the first 2 weeks of choir participation. Participants first completed all baseline measures to ensure eligibility, and then progressed to the pre-testing of the vocal outcomes tasks as per the following procedures, which were repeated as post-testing within two weeks of completion of the choir program. All 22 participants completed baseline, pre-test, and post-test sessions.

Vocal outcome tasks

For all vocal tasks, the microphone was placed in a uniform position at one end of the testing room. Participants were asked to stand so that their mouths were 88cm from the microphone, guided by a marking on the floor and verified by measuring the distance with a tape measure. Once these adjustments were made, recording began, and the following tasks were carried out.

Pitch range task

Participants were asked to vocalize the vowel "Ah" from the lowest possible note they were able to vocalize to the highest possible note, either in the form of a glissando (continuous upward slide of notes) or by repeating "Ah" in an ascending scale. Participants were asked to attempt this task a second time with greater effort. This task provided measures of lowest and highest achievable pitch.

Loudness task

Participants were asked to vocalize the vowel "Ah" as loudly as they could, followed by a second trial in which they were asked to attempt to be even louder. This task provided the measure of maximum loudness.

Phonation duration task

Participants were asked to take a deep breath and sustain the vowel "Ah" for as long as possible, followed by a second attempt. This task was used to measure the maximum duration of the sustained vowel, or phonation, as well as jitter and shimmer. Moreover, with this task, we obtained a measure of sustained intensity that was used as a covariate for the outcome measures. Importantly, this measure of sustained intensity is distinct from the primary outcome measure of loudness, measured by the Loudness task (see below), in that its primary function is as a covariate representing baseline measure vocal intensity to control for differences in voice sound pressure level recorded during pre-post intervention tasks.

Vocal acoustic analysis

Data were analyzed for each measure as described below. Since each participant was given two attempts for each task, the best of these attempts was selected for analysis (eg, the pitch range attempt with the highest/lowest pitch, the phonation duration attempt with the longest duration, etc). Acoustic features were extracted from vocal recordings with the use of version 5.3.55 of the acoustic analysis software PRAAT using the methods described below.

Pitch range task data

Since participants were asked to vocalize from the lowest possible pitch to the highest possible pitch, lowest achieved pitch was calculated (in Hz) within the first 3 seconds from vocalization onset while highest achievable pitch was calculated using the final 3 seconds prior to termination of the vocalization. This process is consistent with other studies using this measure.[5]

Loudness task data

Maximum amplitude values (in dB) were calculated for the entire vocalization, regardless of length.

Phonation duration task data

The period of time between vocalization onset and termination was calculated to determine vowel sustain duration (in seconds). Following Holmes et al[5] and Tanaka et al,[9] jitter and shimmer were calculated based on a 3-second window in the middle portion of the vocalizations produced in the phonation duration task. For the covariate measure of sustained intensity, the period of time between vocalization onset and termination was used to calculate a baseline average of vocal intensity (in dB).

Statistical analysis

Model parameters

To model changes in acoustic properties, a series of linear mixed-effect multiple regressions were performed. All models were estimated in R using the *lmer4* package[39] which used a log-likelihood function to estimate coefficients. Degrees of freedom were estimated using the Satterthwaite approximations and used for two-tailed *P*-values.[40] Goodness of fit for the reported models were measured with R^2 and estimated using the *MuMin* package.[41]

Due to the repeated measure design of the experiment, there is an intrinsic violation of the assumption of lack of independence of observations. To control for this, we used a random-intercept model with participants as the random-effect. All other variables were modeled as fixed effects. The main predictor variable for each model was treatment (Pre vs. Post). To control for demographic differences: sex (Male vs. Female) and groupID (*Group A* vs. *Group B*) were included as covariates in our models. We also included an interaction term between groupID and treatment to examine if treatment effects may vary between groups. Upon the discovery of a significant interaction term, simple slopes were decomposed.

In order to determine the best fit of the models, all models were subjected to a comparison between the intercept only model and one that contained all fixed-effects (predictor variables). For all six acoustic parameters, the models which contained fixed-effects explained a significantly greater amount of the variance than the intercept-only model (see Appendix A for all descriptions of model parameters). As the sound pressure associated with intensity may confound vocal acoustic measures,[42,43] we used a hierarchical modeling design to compare a model that controlled for sustained intensity with a model without it using a Chi-Square test. If a model that contained sustained intensity was shown to be a better fit, sustained intensity was included in the final model as a covariate.

The model that was a better fit to the data was reported in the results. Categorical variables, treatment and sex were coded using contrast codes (ie, 0 and 1) which provided a fixed reference. For the predictor variable of treatment, pre-measures were used as the reference and for the covariate of sex, female was used as the reference. Dummy codes were used to analyze differences between groups, such that Group A was coded as -1 and Group B was coded as 1. Based on the boxplot method, a single data point in the jitter measure was rejected. See Table 2 for a summary of mixed-effects models and parameters for each acoustic measure.

TABLE 2.
Summary of Mixed-Effects Models and Parameters (Slope and 95% Confidence Intervals)

Acoustic Measure	Goodness of Fit (R^2)	Fixed effect			Covariates	
		Treatment	Group	Treatment X Group	Gender	Sustained Intensity
Pitch Max.	0.88	-3.68 -27.25 19.88	-36.8 -78.45 4.84	-4.59 -28.16 18.98	-111.05* -192.49 -29.61	N/A
Pitch Min.	0.65	-15.6* -30.25 -0.09	11.56 -2.44 25.58	7.14 -10.76 18.51	-31.32* -56.1 -6.55	N/A
Loudness	0.97	1.13 -0.40 2.68	-36.18 -21.27 -14.91	1.52* 0.01 3.04	-0.74 -4.89 3.39	0.28 0.08 0.47
Duration	0.87	1.87* 0.41 3.32	2.12 -4.78 0.54	-0.07 -1.52 1.38	1.01 -4.22 6.22	N/A
Jitter	0.65	-0.13 -0.23 -0.04	0.11 -0.03 0.24	0.1* 0.01 0.19	-0.1 -0.25 0.04	-0.01* -0.2 -0.005
Shimmer	0.67	-4.31‡ -6.43 -2.19	3.85† 1.38 6.34	1.05 -0.86 3.35	1.15 -3.12 1.61	-0.54‡ -0.71 -0.38

* $P < 0.05$.
† $P < 0.01$.
‡ $P < 0.001$.

RESULTS

Pitch maximum

This model revealed no significant effect of treatment, *b* = -3.68, 95% CI = [-27.25 19.88], *t*(22) = -0.32, *P* = 0.75, indicating that choir practice did not significantly improve maxim pitch of the voice. There was however a significant difference between males and females, *b* = -111.05, 95% CI = [-192.49 -29.61], *t*(22) = -2.79, *P* < 0.05, with females showing higher pitch threshold compared to males when controlling for all other variables. There was no significant differences between groups, *b* = .45, 95% CI = [-4.84 78.45], *t*(25) = 1.79, *P* = 0.08, and no interaction between treatment and groups, *b* = 4.59, 95% CI = [-28.16 18.98], *t*(22) = 0.39, *P* = 0.69. Figure 1A

Pitch minimum

This model revealed a significant effect of treatment, *b* = -15.6, 95% CI = [-30.25 -0.096], *t*(22) = -2.18, *P* < 0.05, with lower pitch minimum thresholds being achieved in the post compared to pre measurement when controlling for all other variables. There was also a significant difference between males and females, *b* = -31.32, 95% CI = [-56.1 -6.55], *t*(22) = -2.59, *P* < 0.05, with males showing lower pitch minimum threshold than females when controlling for all other variables. No significant differences between groups, *b* = 11.56, 95% CI = [-2.44 25.58], *t*(35) = 1.66, *P* = 0.1, and no interaction between treatment and groups, *b* = 7.14, 95% CI = [-10.76 18.51], *t*(22) = 0.54, *P* = 0.59 was revealed in the model. Figure 1B

Loudness

This model revealed no difference between males and females, *b* = -0.74, 95% CI = [-4.89 3.39], *t*(23) = -0.36, *P* =0.71. However, there was a significant difference in loudness between groups, *b* = -36.18, 95% CI = [-42.55 -29.83], *t*(42) = -11.41, *P* < 0.001, which was qualified by a significant interaction between treatment and groups, *b* = 3.05, 95% CI = [0.03 6.09], *t*(22) = -2.07, *P* < 0.05. Decomposition of the simple slopes revealed a significant effect of treatment for Group B, *b* = 2.66, 95% CI = [0.42 4.9], *t*(22) = 2.43, *P* < 0.05, with loudness significantly increased in post measures, but no significant effect of treatment for Group A, *b* = -0.39, 95% CI = [-2.47 1.68], *t*(22) = -0.38, *P* = 0.70.

Duration

This model revealed a significant effect of treatment, *b* = 1.87, 95% CI = [0.41 3.32], *t*(22) = 2.63, *P* < 0.05, with duration increasing in post compared to pre measures when controlling for all other variables. No significant difference was found between groups, *b* = 2.12, 95% CI = [-0.54 4.78], *t*(25) = 1.62, *P* = 0.12, or males and females, *b* = 1.01, 95% CI = [-4.22 6.22], *t*(22) = 0.39, *P* = 0.69. No interaction between group and treatment, *b* = -0.07, 95% CI = [-1.52 1.38], *t*(22) = -0.1, *P* = 0.92 was found either. Figure 3.

Jitter

This model revealed no difference between males and females, *b* = -0.1, 95% CI = [-0.25 0.04], *t*(23) = -1.41, *P* = 0.17, or groups, *b* = 0.11, 95% CI = [-0.03 0.24], *t*(36) = -1.6, *P* = 0.12. However, there was a significant effect of treatment, *b* = -0.13, 95% CI = [-0.23 -0.04], *t*(19) = -2.88, *P* < 0.01, with jitter showing a reduction in post compared to pre measures when controlling for all other variables. This was qualified by a significant interaction between treatment and groups, *b* = 0.1, 95% CI = [0.01 0.19], *t*(19) = 2.22, *P* < 0.05. Decomposition of simple slopes revealed no effect of treatment in Group B, *b* = -0.03, 95% CI = [-0.15 0.09], *t*(17) = -0.52, *P* = 0.6, but a significant effect in Group A, *b* = -0.23, 95% CI = [-0.37 -0.09], *t*(21) = -3.41, *P* < 0.01.Figure 4A

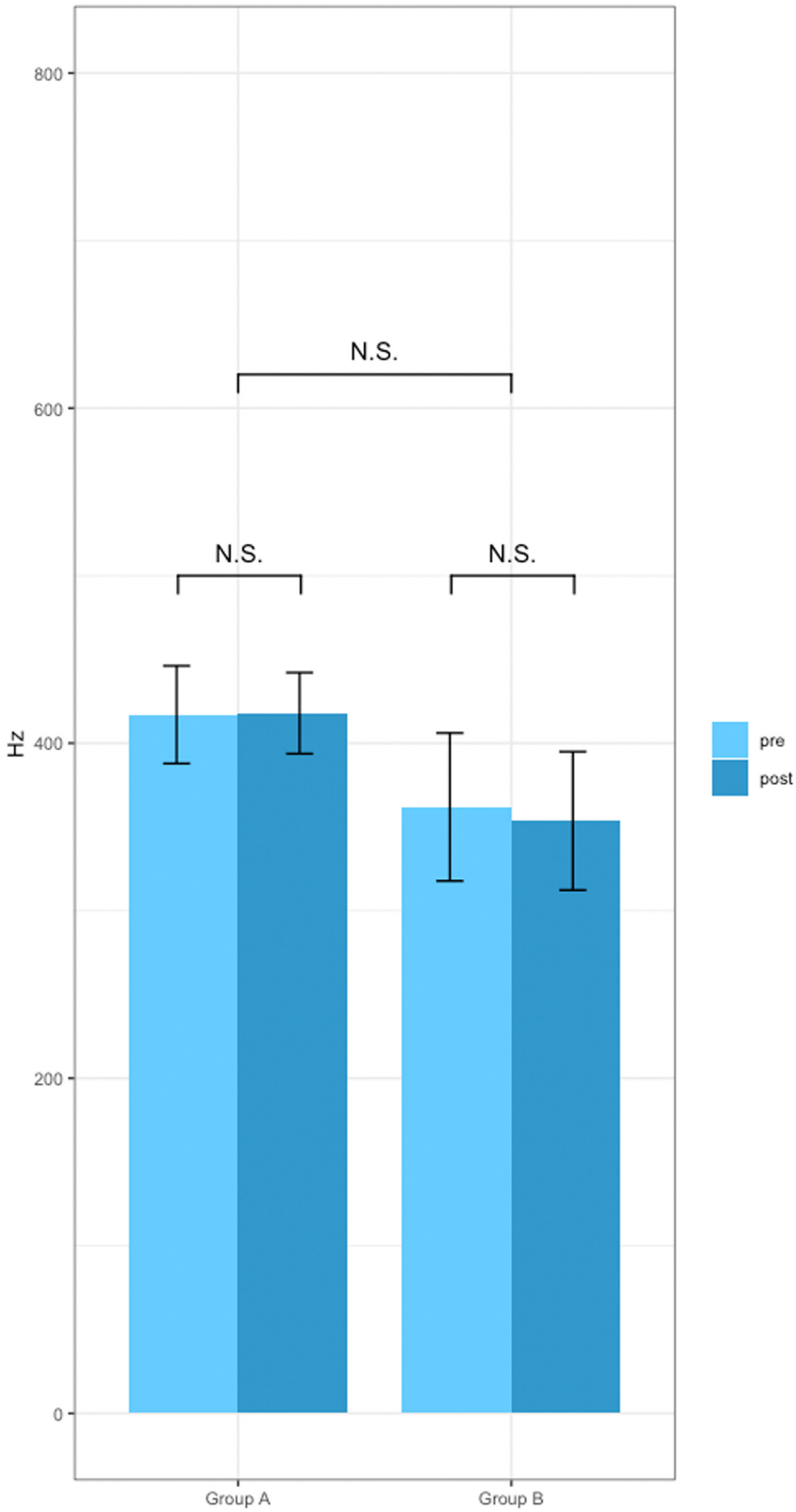

FIGURE 1. A,B: Differences between pre and post measures of highest achievable pitch (Plot 1A. pitch max.) and lowest available pitch (Plot 1B. pitch min). Figure A1 shows that there was no significant difference between pre and post measurements. Figure A2 also shows a significant difference ($P > 0.05$) between the pre and post measures when collapsing across groups and sex. Error bars reflect standard error.

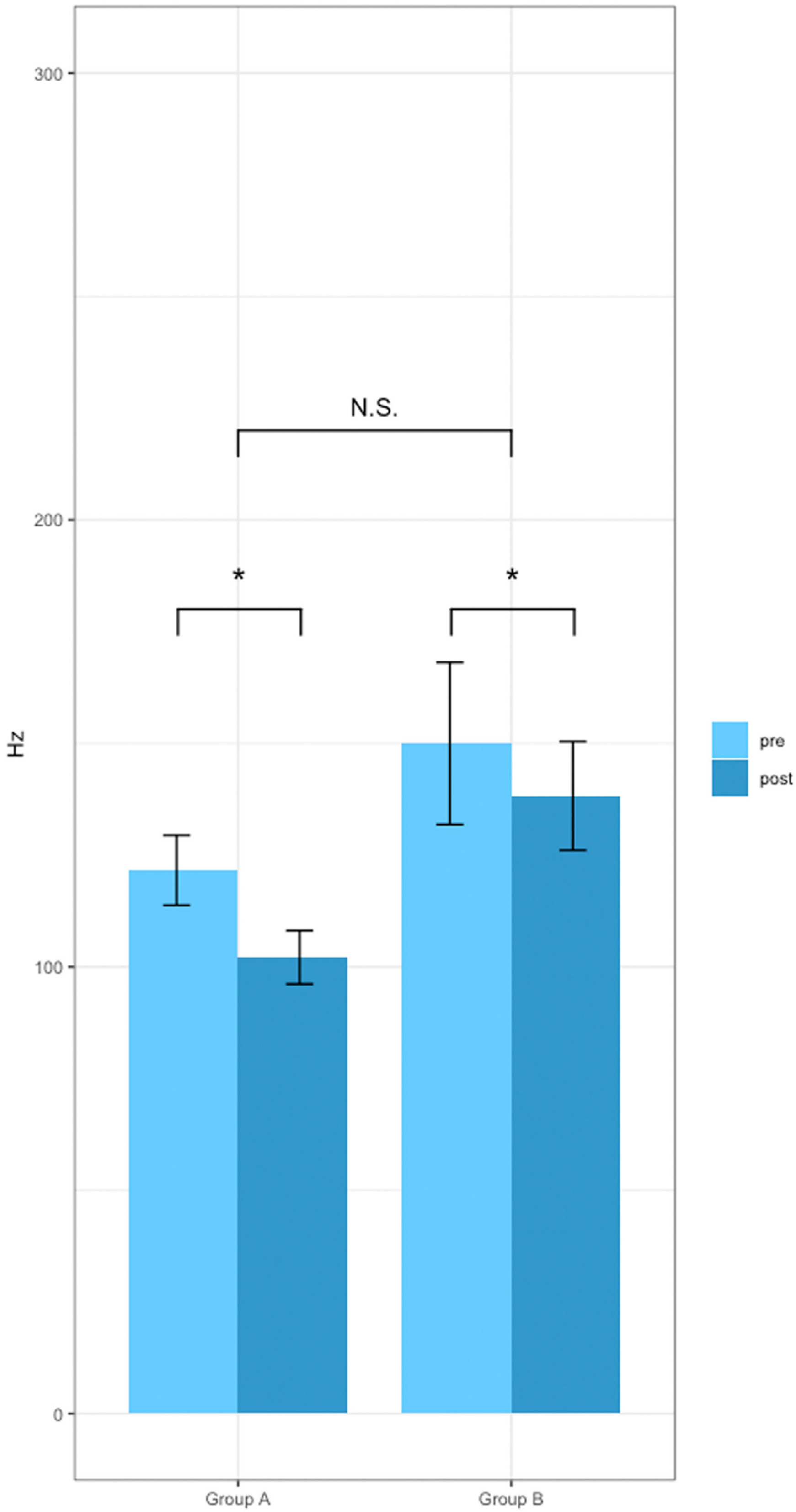

FIGURE 1. Continued

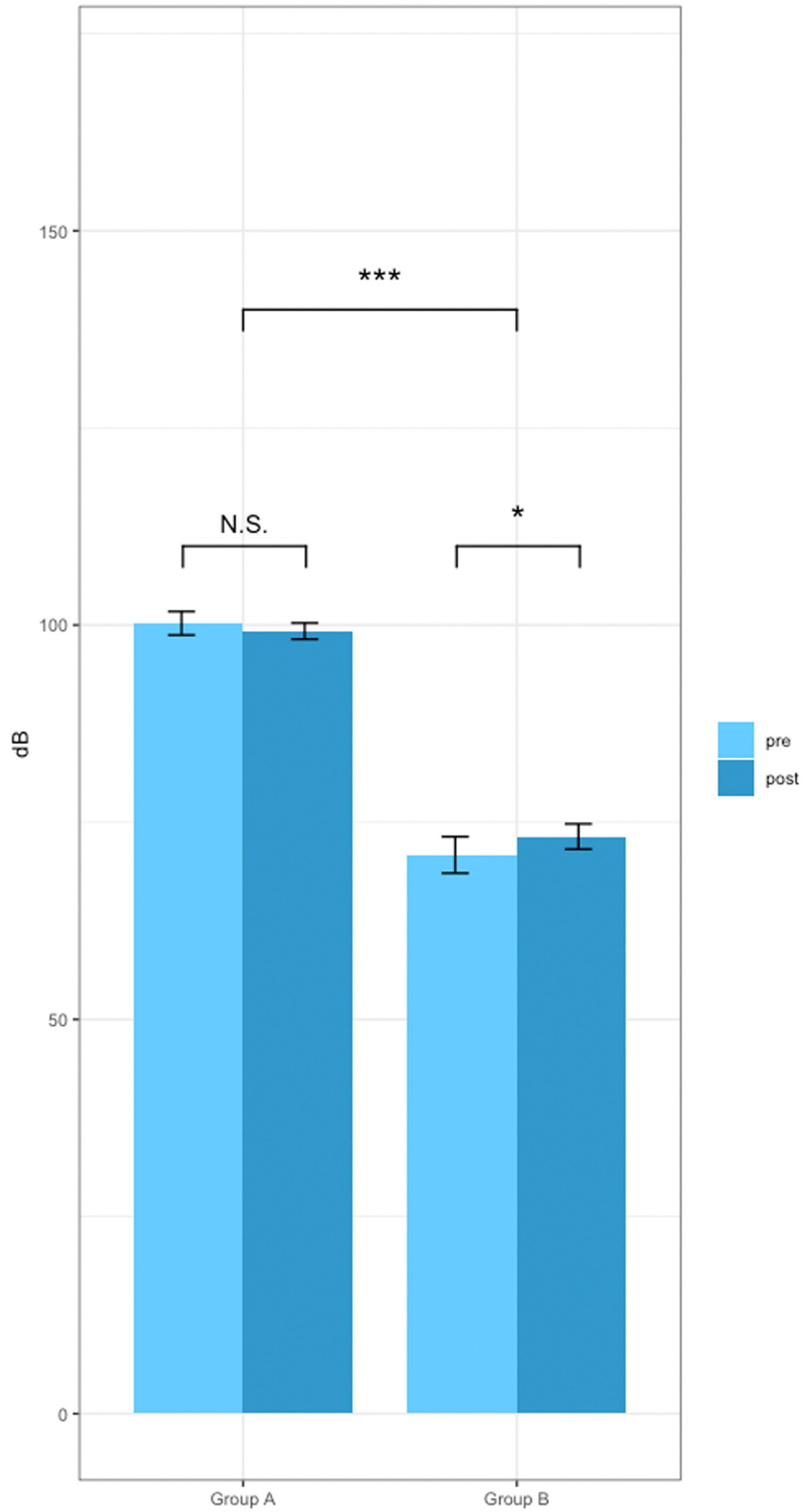

FIGURE 2. It shows that there was a significant effect of treatment in Group B ($P < 0.05$), with an increase in sound intensity, but no significant effect in Group A. Error bars reflect standard error.

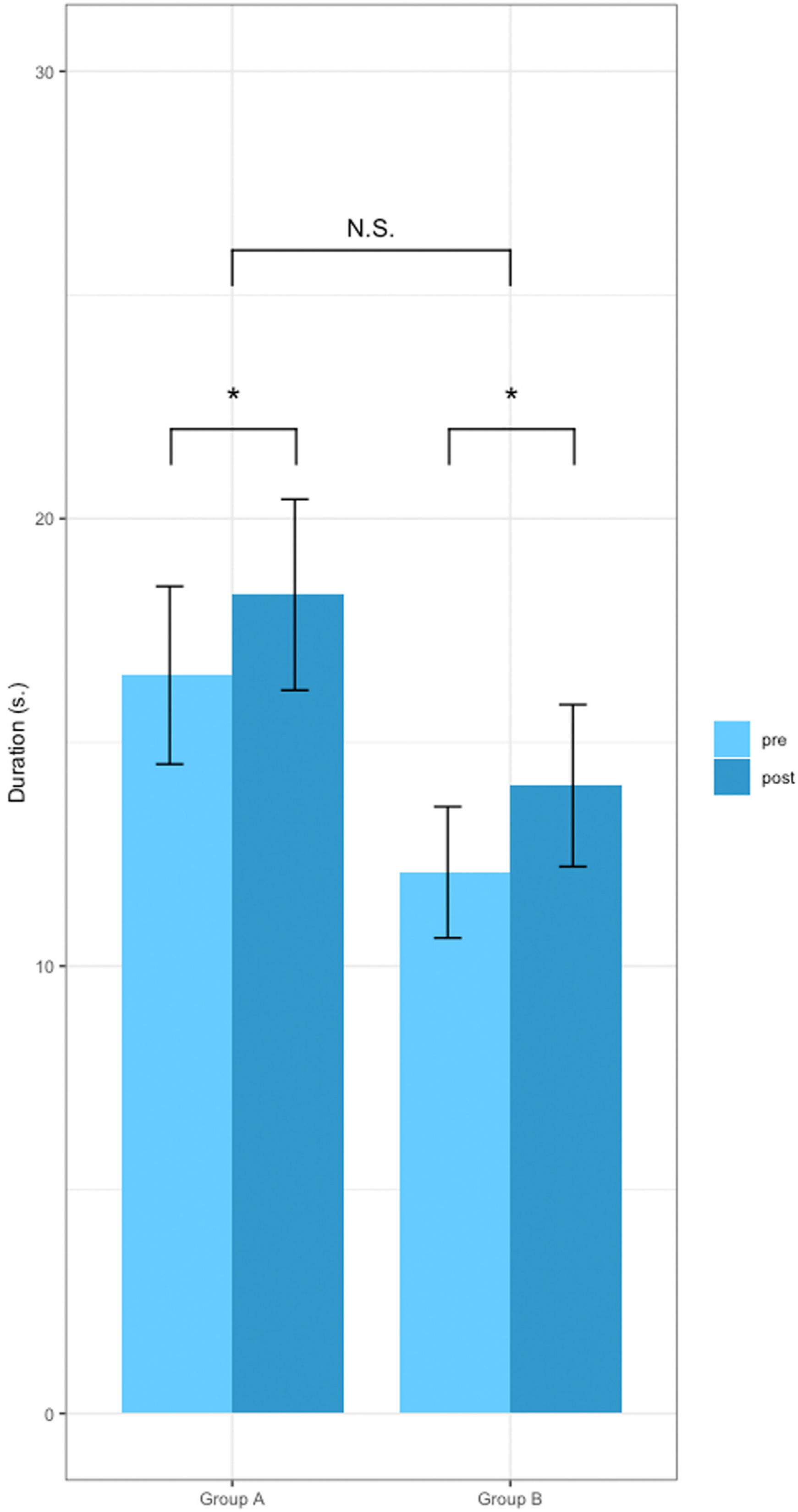

FIGURE 3. Differences between pre and post duration in each group. This plot shows no significant difference between groups and no interaction between pre and post measures and groups. However, this model did reveal a significant effect of treatment ($P < 0.05$). Error bars reflect standard error.

Shimmer

This model revealed a significant effect of treatment, b = -4.31, 95% CI = [-6.43 -2.19], $t(22)$ = -4.1, $P < 0.001$ (Figure 4), with shimmer showing a reduction in post compared to pre measures when controlling for all other variables. There was also a significant difference between groups, b = 3.85, 95% CI = [1.38 6.34], $t(38)$ = 3.13, $P < 0.01$, with Group B showing lower shimmer overall. No difference between males and females was revealed, b = 1.15, 95% CI = [-3.12 1.61], $t(23)$ = -0.66, P = 0.51. There was also no interaction between groups and treatment, b = 1.05, 95% CI = [-0.86 3.35], $t(22)$ = 1.18, P = 0.25. Figure 4B

DISCUSSION

The current study investigated the rehabilitative potential of a 12-week community choir program for a range of vocal deficits in people with PD. We found improvements in some, but not all, vocal parameters. Findings from each parameter will be discussed in turn below.

Pitch range (max and min)

Although the lower boundary of pitch improved significantly, the highest boundary of pitch did not. One explanation may lie in the comfort range within which most individuals choose to sing. Moore[44] and Killian and Buckner[45] showed that both musically trained and untrained adults are most comfortable singing closer to the lower quartile of their pitch range. Since choir participants were free to make octave adjustments as needed for comfort, it is possible that most singers spent most of their singing time at the lower end of their natural pitch range, thus resulting in the likelihood of greater strengthening of the vocal apparatus in ways that help execute lower pitch.

Loudness

Problems with loudness in PD are often targeted by speech therapies, since a soft speaking voice leads to considerable communication difficulties.[46] However, while speech therapies are shown to have positive effects, studies investigating the effects of singing-based interventions have produced equivocal findings.[20,22,25,34] For example, both Evans and colleagues[20] and Yinger and Lapointe[34] found improvements in loudness, while Stegemöller et al[25] and Shih et al[22] failed to find any improvements in loudness as a result of choir. While all the choirs in these studies included a range of vocal exercises, Yinger and Lapointe's[34] focused specifically on loudness, with participants repeatedly cued to pay attention to and maximize their loudness while singing songs, which could in part explain discrepant findings.

In the current study, we too found inconsistent results for the impact of choir singing on loudness, namely, Group B showed a significant increase in loudness following choir participation, while Group A did not. This could be due to myriad uncontrolled factors, including social dynamics and/or severity of disease. It is also possible that improvements in loudness are contingent on the approach adopted by the choir director. Based on our informal observation, the choir director for Group B placed more emphasis on loudness. Doing so, may have increased the likelihood of obtaining loudness gains.

Duration

Since singing often requires extending vowels beyond what is normal in speech, it is reasonable to expect improvements in phonation duration due to choir participation. Our study, like most studies in the literature,[25,29,30] found significant improvements in phonetic duration. Participants were better able to hold a note for a longer period following participation in community choir.

Jitter and shimmer

In the current study, jitter and shimmer levels significantly decreased following choir participation. In perceptual terms, this change translates to a clearer, less harsh or coarse speaking voice. It is notable that mean jitter levels in Group A were similar in elevation at pre-test as Tanaka et al's[9] PD sample and decreased to just below the levels of their age-matched healthy control group following the intervention, suggesting restoration to normal levels.

Limitations and future directions

The most significant limitation of this study is the absence of a control group. Including an inactive control group of PD patients would have helped control for any effects of natural disease progression on our measures across the 3-month study period, which may otherwise reduce the apparent magnitude of findings despite being clinically meaningful. Also, while we observed improvements on some of our measures, we are unable to determine how long-lasting these effects may be in the absence of follow-up testing. For example, it is possible that maintenance of any improvements is dependent on continued engagement in a choral singing program, without which, the positive effects may quickly diminish.

There are many opportunities to gain further knowledge in the various areas of interest through follow-up research. For example, a more thorough investigation of individual differences - age, disease progression, baseline vocal quality, and cognitive ability - would help identify who benefits most from a group singing intervention and how to tailor an intervention to individual needs. Moreover, outcomes may be influenced by differences in program duration and content, choral director characteristics, instrument accompaniment (eg, guitar or piano), or other program-related factors. Notably, although we saw improvements in most of our target vocal outcomes, it appears that effectiveness may be dependent on more intentional and deliberate focus on each aspect of vocal production It would be valuable for future researchers to unpack the role of the choral director and the kinds of skills that are emphasized during a

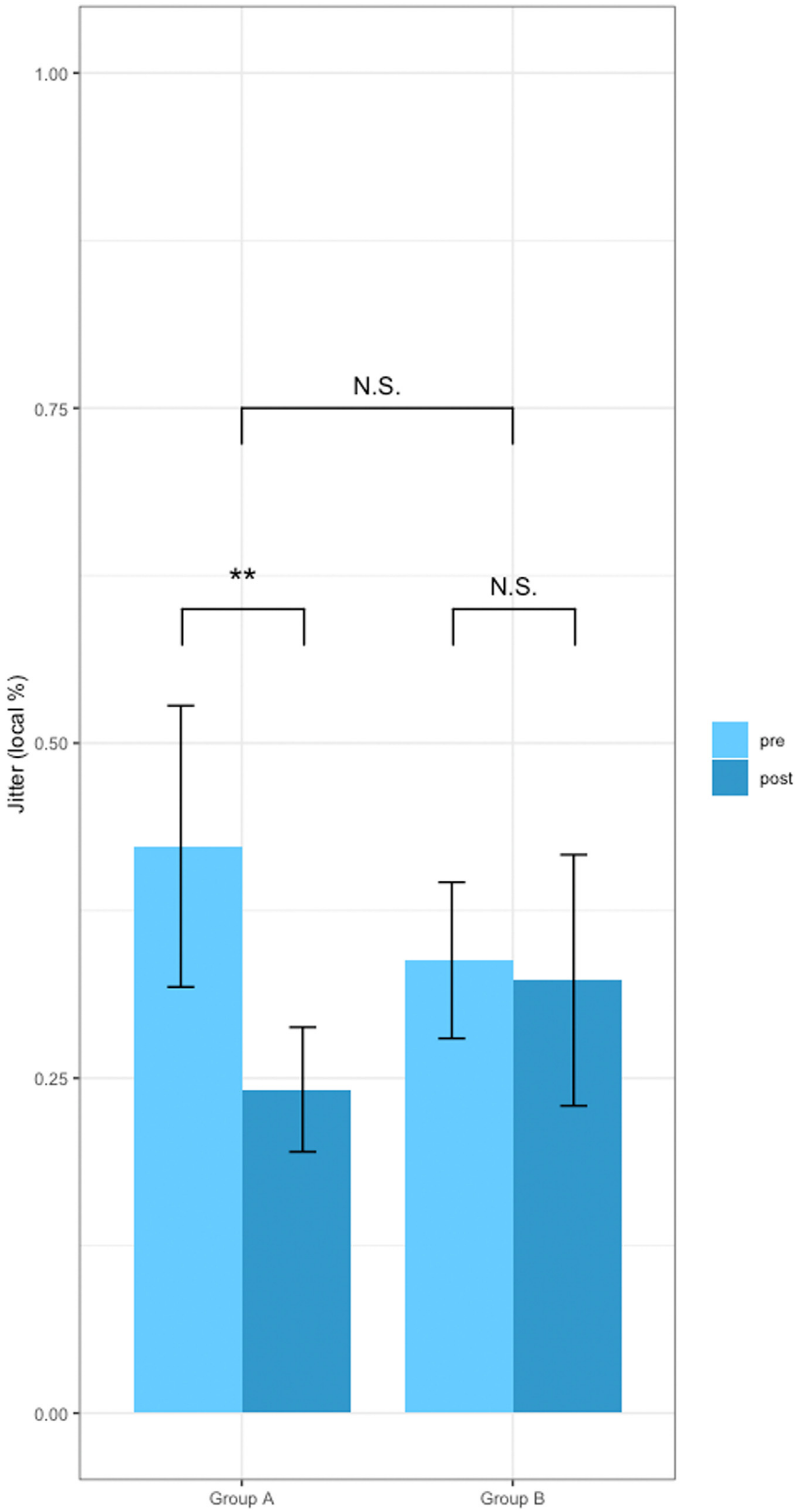

FIGURE 4. A,B: Differences between pre and post jitter and shimmer in each group. Figure 4A shows a significant interaction between groups and pre and post measures ($P < 0.05$) with no significant difference between pre and post measures in Group B, but a significant difference for Group A ($P < 0.01$). Figure 4B shows a significant difference in shimmer ($P < 0.01$) between Group A and Group B, with shimmer being lower in Group B when collapsing across pre and post measures. No interaction was revealed between groups and pre and post measures, but overall, a difference between pre and post measures was significant ($P < 0.001$) with shimmer being reduced in post measures when collapsing across groups. Error bars reflect standard error.

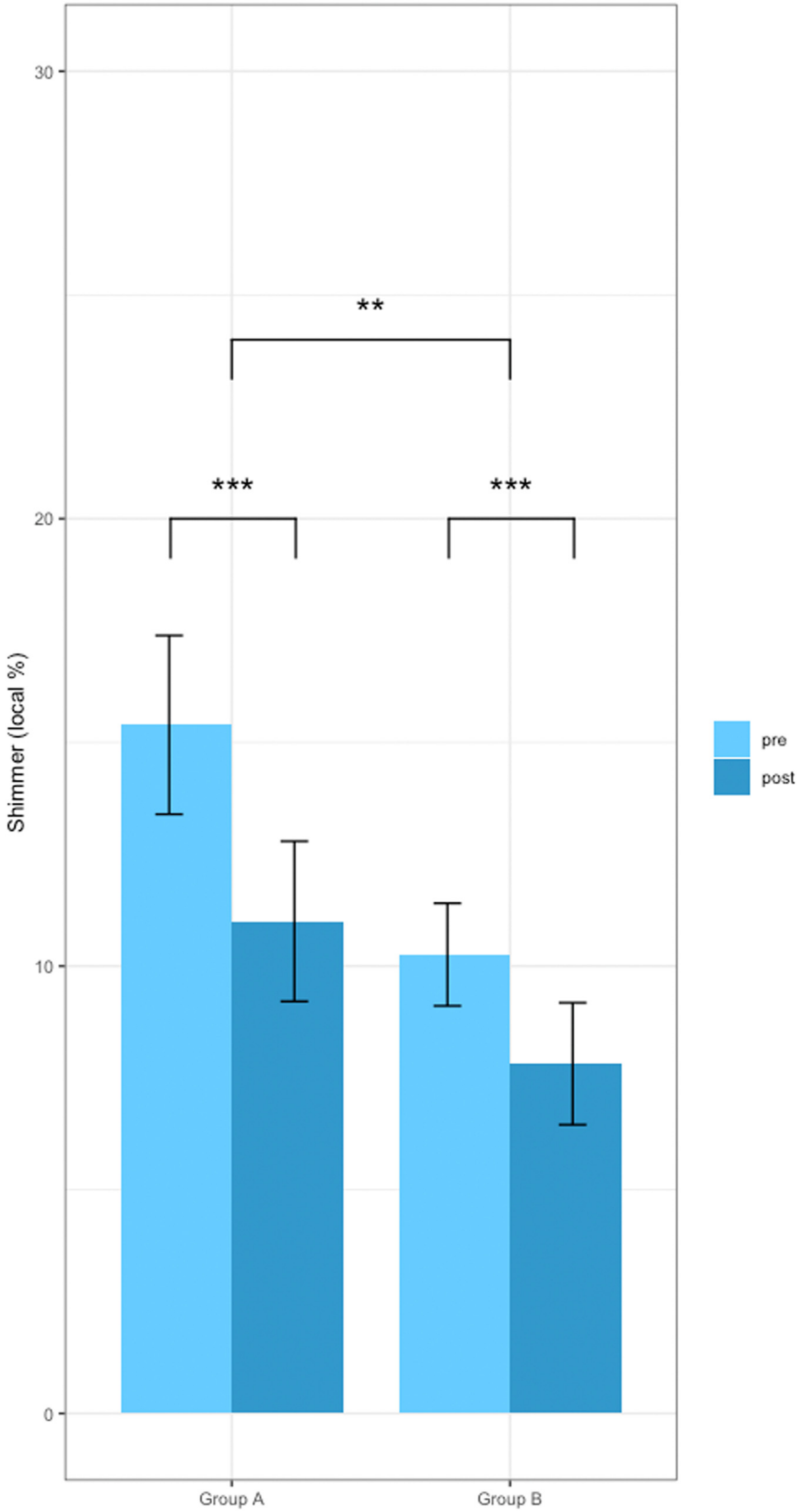

FIGURE 4. Continued

rehearsal that could contribute to a best practice guide to be used by future choir directors depending on the outcomes they would like to achieve. It will take considerable further research to disentangle the roles of such potentially important variables. In addition, many participants anecdotally reported subjective benefits in vocal confidence and overall engagement with others beyond the research context. It would be highly valuable to document and report such qualitative impacts, as well as possible improvements in vocal quality in contexts more true-to-life than brief vocal tasks. Lastly, since the aim of rehabilitating vocal communication is to improve the quality of life of people living with PD, research to this end is equally important. Some studies have already explored psychosocial and quality of life benefits of choir participation[19,25,47,48]; however, it would be useful to explore whether choir participation reduces other psychosocial impairments such as depression and anxiety, both of which are common in PD populations.[49]

CONCLUSION

Effective communication is essential to human life but is impaired in several ways in PD. Our findings suggest that an asset-based community choir is a viable intervention to mitigate vocal production deficits associated with PD. Vocal benefits are among the many that community choirs can offer PD populations, with other potential benefits in general wellbeing and psychosocial functioning.[47] When structured as a community-focused strength-based activity, singing tends to be highly enjoyable for most participants. In this way, group singing interventions have a natural advantage in terms of increasing likelihood of intervention adherence.[34] Anecdotally, it was clear that participants in our choirs highly enjoyed participating in the program, attendance was high, and the community choirs remained running beyond the research study. In addition, choral singing is scalable in that it is meant to be delivered as a group intervention, demonstrating its economic advantage and potential to provide greater access to those in need.

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SUPPLEMENTARY DATA

Supplementary data related to this article can be found online at doi:10.1016/j.jvoice.2022.12.001.

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