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# The effects of respiratory muscle strength training on individuals with Parkinson's disease

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The Effects of Respiratory Muscle Strength Training on
Individuals with Parkinson's Disease

By

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Accepted in Partial Completion
Of the Requirements for the Degree
Master of Arts

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# MASTER'S THESIS



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# THE EFFECTS OF RESPIRATORY MUSCLE STRENGTH TRAINING ON INDIVIDUALS WITH PARKINSON'S DISEASE

A Thesis
Presented to
The Faculty of
Western Washington University

In Partial Fulfillment
Of the Requirements for the Degree
Master of Arts

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**Abstract**

The purpose of this study was to determine if respiratory muscle strength training (RMST) results in increased measures of respiratory function, improved vocal quality, and improved quality of life as perceived by the participants. Data obtained by this study adds to the body of knowledge regarding clinical use of RMST for SLPs working with patients with Parkinson's disease (PD). The study was comprised of a 13-week ABAB within-subject design with a baseline period, five weeks of respiratory training (Phase 1), three weeks without training (Detraining Phase), and five weeks with training (Phase 2). Three individuals with moderate PD (1M, 2F) participated. They were taught to use the PowerLung® respiratory training device and completed twice daily sessions of expiratory and inspiratory muscle training, five days per week.

Outcome measures included maximum inspiratory and expiratory pressures (MIP and MEP, respectively); forced vital capacity (FVC), percent predicted forced vital capacity (FVC%), and forced expiratory volume in 1 second ($FEV_1$); and sustained vowel phonation. Measurements were taken at baseline, before and after detraining (where applicable), and at the end of the study. Results indicated sustained or improved maximum respiratory pressures for all participants from baseline to end of study. No participant showed significant changes in FVC, FVC%, and FEV 1, and results of sustained vowel phonation varied.

Participants' vocal quality was evaluated by three independent raters as well as the subjects themselves and two conversation partners. Two CSD graduate students and one certified SLP rated subjects' voices at baseline and at the end of treatment using recorded conversation samples and the GRBAS Voice Rating Scale (Hirano, 1981). Improvement in vocal quality was perceived in two participants, and no change was seen in the other.

Participants and two conversation partners completed the *Perceptual Rating Form* to report on vocal quality. Participants noted improvement in vocal quality; conversation partners reported both improvement and decline in various aspects of two participants' vocal quality.

Participants completed two surveys regarding the impact of their voice on overall communication and quality of life. These surveys, completed at the start of the study and at completion of each phase, were the Voice Handicap Index (VHI) (Jacobson, et al., 1997) and The Communicative Participation Item Bank General Short Form (Baylor et al. [under review]). Responses from participants revealed inconsistent effects of RMST on quality of life.

Results of this study demonstrate that the combination of inspiratory and expiratory muscle strength training in individuals with moderate Parkinson's disease may be a beneficial treatment to improve respiratory function and positively impact vocal quality and overall quality of life as it relates to communicative participation.

Results from this study revealed the potential for additional research on the effects of RMST on pulmonary functions such as vital capacity (VC) and total lung capacity (TLC), which are not dependent on maximum speed and effort. Additionally, further investigation of RMST on quality of life is warranted in areas related to voice and communication, as well as overall physical and emotional wellbeing.

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Parkinson's disease (PD) is a progressive neurologic disorder resulting from reduced dopamine production in the basal ganglia and brainstem. The disease is characterized by resting tremor, muscular rigidity, akinesia and/or bradykinesia, and postural instability (Yorkston, Beukelman, Strand, & Hakel, 2010). Among the sequelae of PD are difficulties with breathing, communicating, swallowing, and coughing, as well as cognitive decline, all of which typically worsen as the disease progresses (Miller, Noble, Jones, & Burn, 2006; Sapienze, Troche, Pitts, & Davenport, 2011). Cognitive deficits may include misperceptions of speech production, emotional responses, and/or time and space, which can present respectively as reduced vocal loudness, overt demonstration of emotion, and changes in gait and/or other motor movements (Hirsch & Farley, 2009; Kwan & Whitehill, 2011).

Although the cause of respiratory dysfunction associated with PD has not been confirmed, Silverman et al. (2006) reported evidence pointing toward lower and upper airway obstruction, lower airway restriction, respiratory muscle weakness, and/or respiratory muscle dysfunction. The authors identified numerous consequences of pulmonary dysfunction: reduced maximal inspiratory and expiratory airflow/pressures, abnormal flow volume loops, reduced peak expiratory airflow rates, decreased vital capacities, and impaired activity of respiratory muscles, particularly the intercostal muscles. They further suggested that persons with PD experience chest wall rigidity, which cannot be overcome due to weakened respiratory muscles. This has been thought to contribute to reduced lung volumes and respiratory pressures that negatively impact swallow, cough, and speech functions.

Speech and voice changes affect approximately 75-90% of persons with PD, interfering with their ability to communicate effectively (Miller at al., 2006; Sapir et al., 2002). Hypokinetic dysarthria is a common consequence of PD, with perceptual features associated with the characteristic reduced range of motion and bradykinesia, which includes slowness of movement and difficulty initiating movement (Brookshire, 2007; Duffy, 2005). According to Duffy (2005) and Yorkston et al. (2010), reduced range of motion contributes to monopitch, monoloudness, short phrases, short rushes of speech, and imprecise consonants.  Difficulties in initiating movement may lead to inappropriate silences.  Voice abnormalities such as breathiness, voice harshness, and low pitch are consequences of laryngeal musculature rigidity.

Such changes in speech and voice have been shown to negatively impact quality of life in individuals with PD by creating barriers to communicative participation.  During interviews conducted by Miller et al. (2006), adults with PD expressed greatest concerns regarding "detrimental effects of the effort required to overcome physical and mental limitations for anything beyond short periods….Communication changes directly impacted socialization, from apprehension at interaction to social withdrawal" (pp. 236-237).  These comments reveal the importance of treatment options that promote physical and mental stamina in persons with PD to counteract potential decline in quality of life as the disease progresses.

Qualitative research by Baylor, Burns, Edie, Britton, and Yorkston (2011) further highlights the complexity of managing a disease and its impact on communication and quality of life.  Subjects from different patient populations, including those with PD, identified factors that influenced communicative participation, including familiarity with communication partners, effects of the communication disorder and other health symptoms, and environmental influences (e.g. background noise, situations that demanded speed, etc.).

Such reports should prompt SLPs to consider communication treatment as one component of overall disease management for their patients.

Respiratory muscle strength training (RMST) has been proposed as a way to overcome the negative effects of muscle weakness and motor dysfunction that impact communication in persons with PD (Saleem, Sapienza & Okun, 2005; Silverman, et al., 2006; Troche et al., 2010). Adequate respiratory muscle strength is critical to establishing the necessary balance between ventilatory requirements and ventilatory capacity, a balance which is often compromised for persons with neurodegenerative diseases (Sapienza & Wheeler, 2006). Reduced strength and coordination of respiratory muscles, including intercostals, abdominal muscles, and the diaphragm, contribute to low lung volumes and insufficient positive subglottal pressure. The latter is necessary for adequate loudness levels of speech, extended durations of speech, and stress contrasts (Putnam & Hixon, 1987, as cited in Sapienza & Wheeler, 2006). The focus of RMST is to increase the force-generating capacity of respiratory muscles (Sapienze et al., 2011) based on principles of resistance training commonly used to strengthen limb muscles. Respiratory muscles, including the diaphragm, are skeletal muscles and share structural and functional characteristics with limb muscles; therefore, they should respond to training in the same way limb muscles respond when an appropriate physiological load is applied (Enright, Unnithan, Heward, Withnall, & Davies, 2006). Strengthening of limb muscles results in both neural adaptations (i.e. increase motor unit excitability, enhanced coordination, and more efficient motor programming) and muscular adaptations (e.g. increased muscle diameter). The same has been shown to occur in strengthened respiratory muscles (Saleem, Sapienza, & Okun, 2005).

Inspiratory and expiratory muscle strength training (IMST and EMST, respectively) have been studied both separately and together in various populations, including healthy adults (Enright et al., 2006), athletes (Guenette et al., 2006), and persons with chronic obstructive pulmonary disease (Battaglia, Fulgenzi, & Ferrero, 2009), paradoxical vocal fold movement (Mathers-Schmidt & Brilla, 2005), multiple sclerosis (Chiara, Martin, & Sapienza, 2007), and PD (Silverman et al., 2006). Reduced rigidity of the thorax is a particularly beneficial IMST outcome in persons with PD, as strengthened muscles more fully expand the rib cage, thereby increasing lung volumes (Silverman et al, 2006). EMST has been shown to increase positive airflow essential for speech, cough production, and swallowing (Kim & Sapienza, 2005; Sapienze et al., 2011; Troche et al., 2010). It has been suggested that a combination of EMST and IMST may be an effective method of addressing deficits in these various functions, as well as in lung volume and airflow (Battaglia et al., 2009, Silverman et al., 2006).

RMST relies on concentrated and repetitive efforts to maintain existing respiratory muscle function, retrain respiratory muscles whose function has declined, and improve neural connections in the brain (Hirsch & Farley, 2009; Kleim & Jones, 2008; Saleem et al., 2005). For persons with PD, this can mean reduced dyskinesia or bradykinesia of respiratory muscles, which promotes greater control over both inspiration and expiration. Additionally, the principle of transference (Kleim & Jones, 2008) suggests that strengthening of respiratory muscles may increase strength of peripheral muscles and neural connections to them, including muscles of the larynx. This was evidenced by reports from Sapienza (2008) that strength of the diaphragm is positively correlated to strength of the posterior cricoarytenoid muscle (PCA), as control of both muscles occurs in the brainstem. The author suggests a positive correlation between increased activation of the diaphragm and the PCA with IMST. It could be presumed, then, that increased activation of the PCA would increase the glottal aperture and improve vocal fold vibration. In conjunction with increased excursion of the thoracic cage on both inhalation and exhalation, then, resistance to airflow would reduce, thereby enhancing respiratory support for achieving optimal vocal loudness and quality. Indeed, improvement in vocal quality has been linked to increasing respiratory drive and vocal fold movement in persons with PD (Sapir et al., 2002).

Measurements of maximum inspiratory and expiratory pressures at the mouth (MIP and MEP, respectively) have long been accepted as valid tests of a person's general inspiratory and expiratory abilities (Polkey, Green, & Moxham, 1995). In recent research, pressure threshold training has been the means of strengthening respiratory muscles and increasing maximum pressures (Baker et al., 2005; Kim & Sapienza, 2005; Saleem et al., 2005; Sapienza et al., 2011; Troche et al., 2010). Unlike resistance training, pressure threshold training does not allow the trainee to adjust the airflow rate during the training stimulus. In other words, a steady airflow must be maintained, and training is not susceptible to variations in users' airflow rates (Saleem et al., 2005). According to Enright et al. (2006), failure to maintain an overload on the muscles throughout training accounts for conflicting findings regarding benefits of IMST in previous research. In pressure threshold training, the subject receives short durations of consistent, high intensity exercise targeted specifically at respiratory muscles.

Baker et al. (2005) reported evidence from limb strength training studies that within four weeks of exercise, neural adaptations occur, accounting for significant improvement in strength. Beyond four weeks, strength continues to improve, possibly as a result of peripheral or structural changes. Furthermore, research has shown that strengthened limb muscles maintain strength for two to four weeks after the end of a training program (Coyle et al., 1984; Hortobagyi et al., 1993; Mujika & Padilla, 2001, as cited in Baker et al., 2005). Baker and colleagues (2005) reported that studies of RMST which included detraining periods showed minimal loss of strength up to two months without training (Baker et al., 2005; Romer & McConnell, 2003) and post-training strength above baseline measurements after six months (Gosselink et al, 2000, as cited in Baker, et al., 2005).

The purpose of this study was to determine if specific inspiratory and expiratory muscle training results in increased measures of respiratory function, primarily MIP and MEP, improved vocal quality, and improved quality of life as perceived by the participants. Data obtained by this study will add to the body of knowledge regarding clinical use of RMST for speech-language pathologists (SLPs) working with patients with PD. It is proposed that exercise programs specifically designed to strengthen respiratory muscles may alter the symptoms of the disease by improving respiratory function, voice quality, and overall quality of life.

The following hypotheses were made in the present study:

1. With RMST, participants' MIP/MEP measurements will increase.
2. Increased MIP/MEP will result in increased lung volumes and capacity, as measured by FVC, FVC%, and $FEV_1$, and sustained vowel phonation.
3. Improved respiratory function will lead to improved vocal quality, greater participation in social and communicative interactions, and overall improved quality of life.

## Method

### Participants

Six individuals with idiopathic Parkinson's disease (2 females, 4 males) initially participated in the study. Three male participants withdrew from the study before its completion, due to scheduling and health complications. Ultimately, three participants completed the study. Table 1 presents the demographic data for these participants.

**Table 1.** Demographics of Participants

| **Subject** | **Gender** | **Age** | **Height (inches)** | **Weight (lbs.)** | **Education** | **Years since diagnosis** | **Smoker within 5 years** | **MoCA Score** |
|---|---|---|---|---|---|---|---|---|
| P1 | M | 64 | 70 | 225 | Bachelor's Degree | 3 | No | 24/30 |
| P2 | F | 68 | 63.5 | 140 | Master's degree | 8.5 | No | 29/30 |
| P3 | F | 44 | 65.5 | 135 | High School Diploma | 3 | Yes (~5 cig/day) | 23/30 |
| Mean (SD) Range: | | 56 (±12) | 66.75 (±3.25) | 180 (±45) | | 5.75 (±2.75) | | 26 (± 3) |

Medical clearance for each participant was obtained from his or her primary doctor and/or neurologist prior to the start of research. Structural/functional examination of each participant's oral and facial structures revealed no physical impairments that might interfere with completion of exercises or measurement tasks. Additionally, each participant demonstrated adequate respiratory driving pressure for speech by sustaining a steady respiratory driving pressure of 5cm $H_2O$ for 5 seconds (Netsell & Hixon, 1978).

The Montreal Cognitive Assessment (MoCA) (Nasreddine, 2010) was administered prior to baseline measurements. This rapid screening instrument assesses cognitive domains of attention and concentration, executive functions, memory, language, visuoconstructional skills, conceptual thinking, calculations, and orientation. A score of 26 or above is considered normal. Participant 2 scored within normal limits, while Participants 1 and 3 scored below normal limits.

Participants were not involved in any other therapy addressing respiratory, speech, or voice function. Participants reported being "on" in their medication cycles at all training and measurement sessions with the examiner, and they were instructed to refrain from altering other exercise programs for the duration of the study.

The research compliance officer of Western Washington University conducted the human subjects review and approved the study. All participants provided informed consent prior to commencing the study.

**Materials and Procedure**

The study was comprised of a 13-week ABAB within-subject design with a baseline period, five weeks of respiratory training (Phase 1), three weeks without training (Detraining Phase), and five weeks with training (Phase 2). Training phases consisted of twice daily sessions of expiratory and inspiratory muscle training, using a PowerLung® trainer (PowerLung, Inc., Houston, TX), five times per week. Instruction of respiratory muscle strength training, weekly meetings between participants and the examiner, and outcome measurements were performed in a research laboratory, with a noise level of no greater than 20 dB and adequate lighting.

Baker et al. (2005) cited a number of studies in which four-week respiratory muscle strength training regimens were followed with both healthy and patient populations. The four-week duration was based on evidence from limb strength training studies. According to the authors, neural adaptations within the first four weeks appear to be the primary source of increased muscle strength; beyond four weeks, peripheral or structural changes may account for improvements in strength. The current study followed a 5-week protocol to allow for maximum benefit for subjects with compromised respiratory systems and greater potential for strengthening of peripheral laryngeal musculature.

Inclusion of a detraining phase allowed the researcher to examine participant behavior upon removal of treatment. In ABAB design, a return to baseline performance following detraining typically indicates distinct treatment effect (Schiavetti, Metz, & Orlikoff, 2011). However, evidence shows that the effects of skeletal muscle strengthening can last up to four weeks after training has ceased (Coyl et al., 1984; Hortobagyi et al., 1993; Mujika & Padilla, 2001, as cited in Baker et al., 2005). Therefore, in the current study, it was anticipated that participants' maximum respiratory pressures would either be maintained or decline toward baseline measurements with removal of treatment.

**RMST exercise.**

PowerLung® is a hand-held, spring-loaded device designed to strengthen respiratory muscles and equipped with independently adjustable control dials to set levels of resistance for both inhalation and exhalation. The device is set to a challenging level of resistance, which ideally, according to Enright et al. (2006), is 60-80% of the individual's maximum inspiratory and expiratory pressure abilities. Users must generate enough pressure when inhaling or exhaling to open and maintain opening of a one-way valve, allowing air to pass through the valve. The resistance creates a load against which respiratory muscles must work and overcome, increasing muscle strength and endurance with continued exercise (PowerLung, Inc., 2013).

Using the PowerLung®, participants were coached to produce two sets of 10 repetitions for each task (i.e. inhalation and exhalation) per exercise session. One session was to be completed in the morning and another in the afternoon or evening each day, five days a week, for five weeks. The participants met individually with the examiner once each week. During these meetings, participants demonstrated use of the PowerLung®, and the examiner modified the resistance levels according to performance gains, based on manufacturer guidelines.

Participants were seated and wore nose clips when performing RMST exercises. The examiner instructed each participant on the use of the PowerLung® and monitored diaphragmatic breathing and adequate lip seal during the exercises. Once a participant demonstrated correct independent use of the device, he/she completed training sessions four days per week at home and one day per week in the university clinic under the supervision of the examiner. Participants kept a daily exercise log for the duration of the study, in which they recorded all RMST exercises as well as other exercises completed at any time during the study and any changes made to resistance levels. The examiner reviewed exercise logs at weekly visits at the university clinic.

**Outcome measures.**

***Respiratory function measurements.***

Changes in respiratory function were determined by measuring maximum inspiratory pressure (MIP) and maximum expiratory pressure (MEP) before and after Phase 1, after the Detraining Phase, and upon completion of Phase 2. The MIP and MEP measures quantify the respiratory muscle strength in terms of force generation. The measurement apparatus was consistent with that used by Mathers-Schmidt and Brilla (2005). It was comprised of a mouthpiece with a two-way valve connected via a vacuum hose to the electronics of a calibrated custom pressure sensing device, with output displayed on a Fluke True-rms

Multimeter (Model 110). Participants stood and wore nose clips during all MIP and MEP measurements.

Participants' forced vital capacity (FVC), percent predicted forced vital capacity (FVC%), and forced expiratory volume in 1 second ($FEV_1$) were measured using a *SpiroVision 3+ Version 8.1a Diagnostic Spirometer for Windows* (Futuremed, Granada Hills, CA). Participants stood and wore nose clips during the tasks. Measurements were obtained at baseline and after Phases 1 and 2.

Finally, sustained vowel phonation ("ah") was measured at baseline and at the end of Phases 1 and 2. Participants were seated, and the same timer displaying seconds was used for all measurements.

***Vocal quality measurements.***

The *GRBAS Voice Rating Scale* (Hirano, 1981) was used to rate participants' quality of voice based on grade, roughness, breathiness, asthenics (i.e. power), and strain. Voice samples were obtained prior to Phase 1 and after completion of Phase 2. Three judges, including two second-year CSD graduate students and a certified SLP, independently rated recorded voice samples. Inter-rater reliability was found to be high at both baseline (intraclass correlation coefficient [ICC] = 0.99) and end of study (ICC = 0.93).

Participants indicated self-perception of their voices and tendencies of vocal use using the *Perceptual Rating Form* (LSVT Global, Inc., 2012). This survey was completed at baseline, after Phase 1, and after Phase 2. Items include such characteristics as vocal quality (e.g. hoarseness, loudness, etc.) intelligibility, and use of speech (e.g. participation/initiation of conversation). Because PD commonly impacts an afflicted person's self-perception abilities (Hirsch & Farley, 2009; Kwan & Whitehill, 2011), each participant was asked to recruit a conversation partner familiar with the participant's typical speech to complete the survey, as well. Comparison of results from participants to those of their conversation partners was used to gain insight into such potential differences in perceptions. Two conversation partners were available to do so and submitted forms at the end of each phase for comparison to participants' self-perception ratings.

#### *Impact on quality of life measurements.*

Participants completed two surveys regarding the impact of their voice disorder on communicative participation and quality of life. These surveys were completed at the start of the study and again after each phase. *Voice Handicap Index (VHI)* (Jacobson, et al., 1997) measures individuals' perception of their voices and how their voices affect them physically, functionally, and emotionally. *The Communicative Participation Item Bank General Short Form* (Baylor, Yorkston, Eadie, Kim, Chung, & Amtmann [under review]) examines the extent to which voice and/or speech impairments impact individuals' communicative participation.

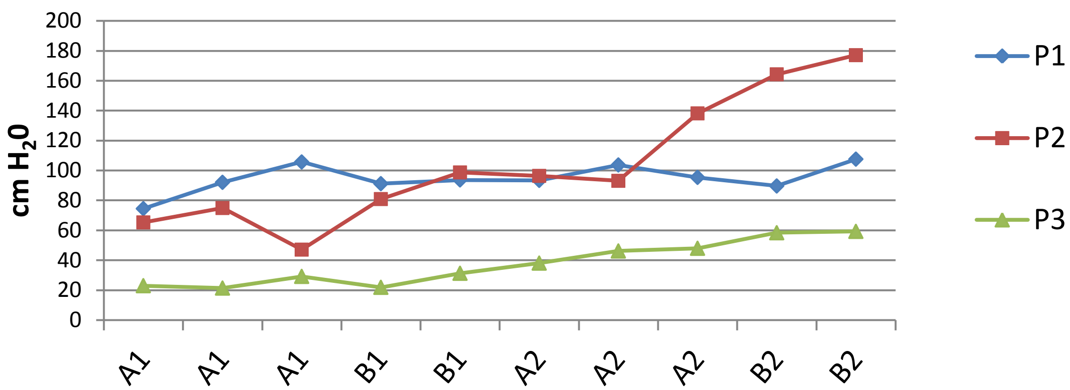
## Results

### Respiratory measurements

#### MIP and MEP.

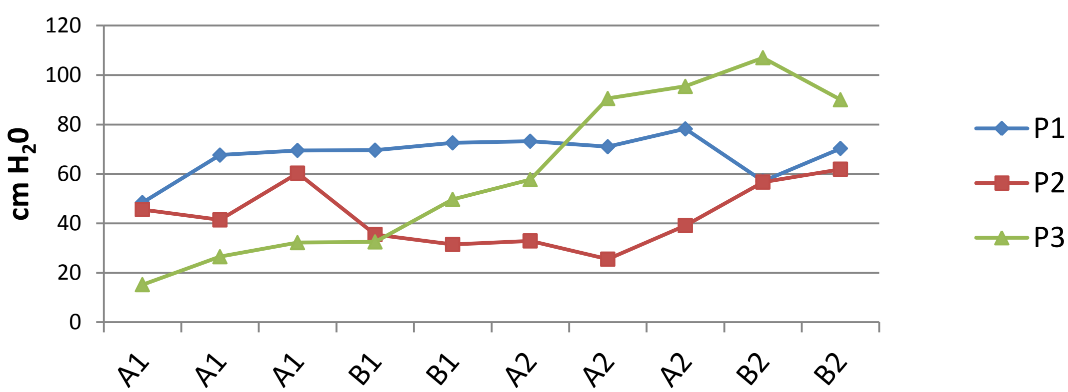
All participants demonstrated maintenance or improvement of both MIP and MEP from beginning to end of the study (Figures 1 and 2). Two instances of decline were noted in MIP measurements and three instances in MEP; however, recovery was noted in all but one case. The latter occurred at the final measurement of the study, leaving no opportunity to determine subsequent effects. In both areas of measurement, Participant 1 demonstrated maintenance of ability with minor fluctuations. Participant 2 showed marked improvement in MIP; however, measurements of MEP indicate initial decline followed by recovery to slightly above baseline ability. Participant 3 demonstrated consistent improvement in both MIP and MEP throughout most of the study. Although the participant's final measurement of MEP resulted in a decline, notable improvement was seen from beginning to end of study.

**Figure 1.** Maximum Inspiratory Pressure (MIP)




Ph = Phase; Wk = Week; P = Participant
Note: Detraining Phase = Time between Ph 1, Wk 5 and Ph 2, Wk 1

**Figure 2.** Maximum Expiratory Pressures (MEP)




Ph = Phase; Wk = Week; P = Participant
Note: Detraining Phase = Time between Ph 1, Wk 5 and Ph 2, Wk 1

**FVC, FVC%, and FEV$_1$.**

Participants' forced vital capacity (FVC), percent predicted forced vital capacity (FVC%), and forced expiratory volume in 1 second (FEV$_1$) are displayed in Tables 2, 3, and 4, respectively. Slight decline was noted in all participants from baseline to end of study; however, Participants 1 and 2 demonstrated above normal FVC, FVC%, and FEV$_1$ levels across all measurements. Participant 3 demonstrated below normal measurements at baseline and did not improve with RMST exercises.

**Table 2.**

*Forced Vital Capacity (FVC)*

| Participant | Baseline | Ph 1, Wk 5 | Detraining | Ph 2, Wk 1 | Ph 2, Wk 5 |
|---|---|---|---|---|---|
| 1 | 6.56L | 6.73L | | 5.14L | 5.09L |
| 2 | 3.46L | 3.22L | | 3.06L | 3.06L |
| 3 | 2.85L | 2.89L | | 2.72L | 2.72L |

*Note:* Ph = Phase; Wk = Week; L= Liters

**Table 3.**

*Percent Predicted Forced Vital Capacity (FVC%)*

| Participant | Baseline | Ph 1, Wk 5 | Detraining | Ph 2, Wk 1 | Ph 2, Wk 5 |
|---|---|---|---|---|---|
| 1 | 141.4% | 145.0% | | 110.7% | 109.7% |
| 2 | 115.2% | 107.1% | | 101.7% | 103.2% |
| 3 | 74.0% | 75.4% | | 71.1% | 71.1% |

*Note:* Ph = Phase; Wk = Week

**Table 4.**

*Forced Expiratory Volume in 1 Second (FEV$_1$)*

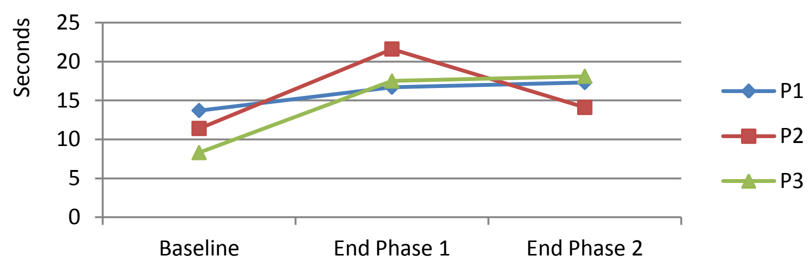
| Participant | Baseline | Ph 1, Wk 5 | Detraining | Ph 2, Wk 1 | Ph 2, Wk 5 |
|---|---|---|---|---|---|
| 1 | 6.47L | 6.6L | | 4.21L | 4.11L |
| 2 | 3.06L | 3.02L | | 2.39L | 2.53L |
| 3 | 2.77L | 2.87L | | 2.36L | 2.38L |

*Note:* Ph = Phase; Wk = Week; L= Liters

**Sustained vowel phonation.**

Figure 3 displays measurements of sustained vowel phonation ("ah"). Each participant demonstrated overall improvement from baseline to end of study. Despite this improvement, Participant 1 remained below normal limits. Participants 2 and 3 began the study with maximum phonation times below normal limits; however, both were within normal limits by the end of Phase 1. Participant 2 demonstrated improvement during Phase 1 but declined in Phase 2, yet improving overall and staying within normal limits. Participant 3 exhibited steady improvement throughout the study and demonstrated the greatest increase of phonation time.

**Figure 3.** Duration of Sustained Vowel Phonation




*Note*: P = Participant

**Subjective Measurements of Voice and Communication Participation**

**GRBAS Scale.**

Three judges (two second-year CSD graduate students and a certified SLP) rated participants' quality of voice using *GRBAS Voice Rating Scale* (Hirano, 1981) pre- and post-intervention. Scores reflected the amount of abnormality in vocal quality. Lower numbers represent less abnormality than higher numbers; therefore, low scores are preferred. Results revealed improved vocal quality in Participants 1 and 2, and no change in vocal quality in Participant 3 (Table 5).

**Table 5.**
*Summary of GRBAS Ratings*

| | P1 | | P2 | | P3 | |
|---|---|---|---|---|---|---|
| Rater | Baseline | End Ph 2 | Baseline | End Ph 2 | Baseline | End Ph 2 |
| 1 | 7 | 6 | 3 | 1 | 2 | 2 |
| 2 | 7 | 4 | 2 | 2 | 2 | 2 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 3 | 8 | 7 | 3 | 2 | 2 | 2 |
| Average Rating | 7.3 | 5.7 | 2.7 | 1.67 | 2 | 2 |

**Perceptual Rating Form.**

A summary of responses to the *Perceptual Rating Form* (LSVT Global, Inc., 2012) is presented in Table 6 and indicates areas of improvement and decline, as perceived by participants and their conversation partners. Detailed responses appear in Appendix A. Participants noted more areas of improvement than decline from beginning to end of study. Two participants recruited conversation partners, who rated fewer areas of improvement than did the participants.

**Table 6.**

*Summary of Responses to Perceptual Rating Form*

| | Participant Responses | | Conversation Partner Responses | |
|---|---|---|---|---|
| Participant | Number of Areas of Improvement | Number of Areas of Decline | Number of Areas of Improvement | Number of Areas of Decline |
| 1 | 7 | 3 | - | - |
| 2 | 8 | 2 | 4 | 6 |
| 3 | 9 | 1 | 2 | 8 |

*Note:* No conversation partner rated typical voice for P1.

## Impact on Quality of Life Measures

### Voice Handicap Index (VHI).

The *Voice Handicap Index* (Jacobson et al., 1997) was used to measure participants' perception of their voices and how their voices affected them physically (P Scale), functionally (F Scale), and emotionally (E Scale). Participants completed the VHI independently at baseline, after the Detraining Phase, and after Phase 2. Results generate a number score per category, which corresponds to a severity level of impact from mild to severe. Table 7 presents overall severity ratings from baseline to end of study. Detailed results including raw scores for each scale are included in Appendix B. While minor fluctuation occurred in distinct categories, overall severity ratings improved for Participant 1 and remained consistent for Participant 2. Severity increased slightly for Participant 3.

**Table 7.**

*Levels of Severity per Voice Handicap Index (VHI)*

| Participant | Baseline | End Phase 2 |
|---|---|---|
| 1 | Moderate-Severe | Mild-Moderate |
| 2 | Mild | Mild |
| 3 | Moderate-Severe | Severe |

### Communication Participation Item Bank – General Short Form.

The *Communication Participation Item Bank General Short Form* (Baylor et al., under review) was used to measure the extent to which participants' communicative participation was impacted by voice and/or speech impairments resulting from Parkinson's disease. Table 8 indicates ratings of interference from mild to severe at baseline and end of study. Summary scores, IRT theta scores, and T scores at baseline, beginning of Phase 2, and at end of study are presented in Appendix C. Higher scores indicate less interference in participation than lower scores and, therefore, are preferable. Results varied with one participant demonstrating reduced interference in participation, one participant showing no change in interference level, and one participant exhibiting slight increase in interference.

**Table 8.**

*Levels of Severity per Communication Participation Item Bank – General Short*

| Participant | Baseline | End Phase 2 |
|---|---|---|
| 1 | Mild | Mild |
| 2 | Mild-Moderate | Moderate |
| 3 | Moderate | Mild-Moderate |

## Discussion

This study investigated the impact of combined inspiratory and expiratory muscle strength training on respiratory functions, vocal quality, and quality of life in three individuals with moderate PD. In response to RMST exercises, all participants sustained or improved respiratory muscle strength, as measured by maximum inspiratory and expiratory pressures. Likewise, participants maintained or improved strength during a three-week detraining period. However, decline in FVC, FVC%, and $FEV_1$ measurements was seen across the participants, indicating no benefit from RMST exercises with regard to lung capacity. Measurements of sustained vowel phonation time, vocal quality, and quality of life revealed varied results, reflecting the complexity of the disease and the influence of external factors on RMST effects.

**MIP and MEP**

Although findings in MIP and MEP measurements varied across participants, beginning- to end-of-study results indicate either increase or maintenance of respiratory muscle strength for each individual following treatment with RMST exercises. Increases in MIP measurements were seen in Participants 2 and 3, while inspiratory muscle strength, as measured by MIP, was maintained by Participant 1. Marked increase in MEP measurements was demonstrated by Participant 3, and minimal MEP improvement was noted in Participant 1. Participant 2 demonstrated initial MEP decline followed by improvement slightly above baseline by the end of the study.

Strength training of respiratory muscles is hypothesized to be similar to that of limb muscles, in which strength is typically seen within four weeks of training, potentially resulting from neural adaptations (Baker, 2005; Saleem et al., 2005; Silverman et al., 2006). However, Baker et al. (2005) reported that individuals with PD may experience slower neural adaptation than healthy individuals. Postponement in increase of strength in the participants of this study may reflect such delays in neural adaptations. This suggests that clinicians using RMST as treatment for clients with PD might anticipate more dramatic results after four weeks of exercises. However, as demonstrated by this study, results may vary with individuals. Although closer examination of each participant gives insight into potential reasons for this variance, these findings suggest the need for additional research, including short-term efficacy studies as well as longitudinal studies with larger sample sizes.

Participant 1 exhibited temporary decline in measurements of both MIP and MEP at Week 3 of Phase 2. Review of homework records revealed no change in exercise routines or device settings, and subsequent measurements taken in Week 5 resulted in improved strength to levels near or above previous pressure levels. Likewise, Participant 3 demonstrated sudden decline in MEP levels during the final measurement. Because no subsequent measures were taken, it is unknown whether she would have regained previous pressure levels. Review of other studies reveals similar occurrences, indicating that fluctuations in strength appear not to be abnormal in RMST programs (Baker et al., 2005; Mathers-Schmidt & Brilla, 2005; and Saleem et al., 2005).

A variety of external factors, such as medication, personal events, and/or overall physical condition, may have impacted participants' performance during data collection. Individuals in this study frequently reported having "good days" and "bad days". In addition to daily medication, for example, Participant 1 received periodic intravenous nutrient therapy. On a day when MIP/MEP measurements were taken, the participant received IV nutrient therapy prior to meeting with the researcher. This may have negatively impacted his performance while MIP and MEP measurements were taken. On the other hand, Participant 3 demonstrated unusually high expiratory pressure levels in Week 3 of Phase 2. During this testing period, the participant commented on feeling more rested and having higher energy levels, which she attributed to RMST exercises, although that cannot be directly determined.

The potential influence of such external factors complicates determination of the efficacy of RMST.

Other changes in maximum pressures may be due to progression of the disease. Cognitive abilities, for example, are known to decline over time in individuals with PD. Participant 2 had the greatest number of years since diagnosis; therefore, one might anticipate greater decline from this participant than from the others. In fact, Participant 2 expressed difficulty coordinating the steps involved in performing the MEP measurement task during Phase 2, and results of MEP measurements did indeed reflect decline in performance. At baseline, Participant 2 was determined to be within normal cognitive limits, based on the MoCA screening tool. However, progression of the disease over the span of the study may have impacted her ability to perform the MEP task. Interestingly, however, she did not demonstrate similar difficulty when performing the MIP task, which differed only in the direction of airflow and subsequent physical sensation. MIP measurements demonstrated increase at the same time that MEP measurements showed decrease. Furthermore, expiratory exercises with PowerLung® were successfully achieved by the participant with no complaints of the challenges experienced during measurement tasks. This resulted in regular increases to the resistance level on the device. Consequently, the participant's performance on measurement tasks inaccurately reflected abilities demonstrated with the exercise device.

Following the detraining phase, Participants 1 and 3 sustained or showed slight improvement in maximum inspiratory and expiratory pressures. This is consistent with findings in other studies in which the strength-training effect remained after exercising ceased (Baker et al., 2005; Mathers-Schmidt & Brilla, 2005; Saleem et al., 2005). Results for Participant 3, however, showed sharper improvement when treatment was removed.

All participants reported having ceased RMST exercises during this three-week phase. While increases in measurements were unexpected, it may be that, because participants' respiratory muscle strength had improved, their ability to engage in physical activity increased. Such increase in physical activity may have exercised respiratory muscles naturally, thereby continuing to strengthen them in spite of the removal of treatment.

Participant 3 demonstrated the greatest increase, particularly in MEP measurements. Although participants were instructed not to alter other exercise programs for the duration of the study, Participant 3 changed residences while the study was conducted, which inevitably added physical activity to her daily life. Furthermore, this participant reported feeling more energetic since having begun respiratory exercises, as well as sleeping better and experiencing less pain, particularly in her shoulders as a result of improved breathing posture required by the treatment. Considering these reports as well as the activities of Participant 3's life during the detraining phase, it is conceivable that respiratory muscle strength improved in the absence of direct treatment, leading to higher MIP and MEP measurements post-detraining. Such an effect should be considered a positive potential consequence of RMST treatment; however, as demonstrated by this study's participants, results will vary across individuals.

The effects of detraining are clinically significant when creating long-term treatment goals and determining the need for maintenance programs. Information regarding decline in strength and/or function following termination of treatment may influence client motivation to continue RMST exercises. Data from more time post-treatment is needed to better understand detraining effects on RMST treatment.

## FVC, FVC%, and $FEV_1$

Throughout the study, above normal limits were achieved by two of the three participants in FVC, FVC%, and $FEV_1$ measurements. Minimal decline was noted in Participant 3, who remained below normal limits. This participant reported being a cigarette smoker at the time of the study, which may account for the reduced respiratory function, as compared to Participants 1 and2. The results are consistent with other studies in which FVC, FVC%, and $FEV_1$were used as outcome measurements of inspiratory and/or expiratory muscle strength training (Baker et al., 2005; Enright et al., 2006; Sapienze et al, 2011; and Shahin et al., 2008). In these studies, little significant change was noted in these measurements. Enright et al. (2006) reported no change in FVC, FVC%, and $FEV_1$, yet they did note improvements in vital capacity (VC) and total lung capacity (TLC) in the treatment group with no such change in the control group. Interestingly, FVC, FVC%, and $FEV_1$ are speed- and effort-dependent tasks, while VC and TLC are not. Presumably, individuals with PD may experience greater difficulty completing tasks requiring effort and speed, as opposed to those that do not. Evidence from Enright and colleagues suggests that FVC, FVC%, and $FEV_1$ alone may not present a complete picture of the effects of RMST on respiratory capacity. Because the current study did not measure VC and TLC, the outcome of RMST on participants' respiratory functions may not be fully represented. Additional research in this area is suggested to further explore the effects of RMST on pulmonary abilities.

## Sustained vowel phonation

Results of sustained vowel phonation indicate that maximum respiratory pressures directly impact breath support necessary for speech. Participants 1 and 3 demonstrated increased maximum phonation time (MPT) consistent with increases in MIP/MEP measurements throughout the study. Although Participant 2's MPT decreased during Phase 2, despite simultaneous increases in MIP and MEP, overall results showed improvement from beginning to end of the study. A contradiction such as this suggests that adequate MIP/MEP, while influential, may not be the only requirement for sustaining phonation. Nevertheless, overall improvement in all participants is consistent with evidence from Sapienza and Wheeler (2006) and Putnam and Hixon (1987, as cited in Sapienza & Wheeler, 2006) that increasing strength of expiratory muscles, especially, assists in generating positive pressures necessary for increased sound durations. According to these authors, such muscle strength is particularly beneficial for individuals for whom inspiratory volumes are limited and subglottal pressure is compromised. For persons with PD, these limitations often present as short phrases and/or short rushes of speech (Duffy, 2005; Yorkston et al., 2010). RMST, therefore, appears to be a viable treatment option for addressing these effects of PD. Indeed, in this study, two participants achieved sustained vowel durations within normal limits as a result of RMST.

**Vocal quality**

In addition to their findings regarding duration of speech, Sapienza and Wheeler (2006) reported that airway pressure contributes to quality of voice. In the current study, vocal quality appeared to be positively impacted by RMST exercises. Participants who were judged to have the greatest vocal abnormality demonstrated the greatest improvement following RMST exercises. Participant 2 was judged to have the best vocal quality at baseline and maintained that vocal quality through the study.

Interestingly, Participant 1, who showed greatest improvement in vocal quality, demonstrated the least amount of change in maximum inspiratory and expiratory pressures.

One might expect consistency in results between the two measures. As with sustained vowel phonation, this disparity suggests that factors in addition to maximum respiratory pressures may influence vocal quality.  Transference, a principle of experience-dependent neural plasticity, as well as the 13-week duration of the study may have led to enhanced performance of peripheral laryngeal muscles and, hence, improved vocal quality (Baker et al., 2005; Kleim & Jones, 2008; Sapienza, 2008). Sapir and colleagues (2002) purported that enhancement of the PCA muscle secondary to diaphragm strengthening may improve vocal fold vibration.  Based on results from studies of limb muscles, Baker et al. (2005) maintained that peripheral and structural changes potentially contribute to strengthening of muscles when exercise programs extend beyond four weeks.  These potential secondary effects, in addition to increases in maximum respiratory pressures, may explain perceived improvements in participants' vocal quality.

Improved vocal quality was further reflected by responses to the *Perceptual Rating Form*.  Although each participant noted decline in some categories, these tended to be in areas of articulation.  Loudness and vocal quality, characteristics anticipated to be more directly impacted by increases in respiratory pressures, were generally reported as having improved. Two participants elicited ratings from conversation partners, in addition to completing the questionnaire themselves.  In both cases, conversation partners noted fewer overall gains than the participants reported.  However, improvements that were identified reflected changes in vocal quality. All participants indicated greater involvement in conversation after having completed RMST exercises, while conversation partners perceived more variable changes in this area.

Because of the subjective nature of questionnaires, one logically would anticipate some differences between perceptions of participants and their conversation partners. However, decline in self-perception accuracy is commonly associated with PD (Kwan and Whitehill, 2011) and also may have contributed to discrepancies participants' and conversation partners' responses. Nevertheless, RMST appears to have contributed to improvements in vocal quality as perceived by external raters and the participants themselves.

**Quality of life**

Engagement in physical strengthening activities is known to increase endorphins and improve overall sense of wellbeing in individuals who exercise. Exercise in general is recommended to persons with PD for maintenance of muscle strength and flexibility (Goodwin, Richards, Taylor, Taylor, & Campbell, 2008). It also is thought to be beneficial for combating depression and improving overall mental health (Bridgewater & Sharpe, 1996; Fox, 1999), all of which positively impact quality of life.

Two tools were used in this study to investigate the influence of RMST exercise on participants' quality of life. The *Voice Handicap Index* (VHI) specifically targeted the effects of voice, while the *Communication Participation Item Bank General Short Form* (CPIB) focused on impacts of a person's "condition" (i.e. Parkinson's disease). Results of the VHI showed improvement in one participant, no change in another, and decline in the third. The CPIB revealed the same mixed findings. However, results were not consistent between measurement tools for each participant: some participants experienced improvement or maintenance based on one tool while demonstrating decline based on the other, for example.

A variety of factors may have influenced these results. First, although both tools evaluated aspects of participants' quality of life, each targeted slightly different areas. Participants may have felt more or less impact from voice specifically, as opposed to the disease in general. Furthermore, as reported by Baylor et al. (2011), other factors may either facilitate or impede communicative participation for people with medical conditions. These researchers interviewed 44 adults across seven different medical conditions, including PD. Interviewees identified such variables as familiarity with communication partners, unpredictability of the communication disorder and other health symptoms, and environmental influences as having influenced quality of life. It can be expected that participants in the current study shared these experiences, which may have been reflected in their responses to the VHI and CPIB. This further highlights the complexity of Parkinson's disease and its impact on communication and quality of life. While shown to benefit many symptoms of PD, RMST therefore should be recognized as merely one component of speech and language treatment for individuals of this population. Further research is warranted to determine the efficacy of RMST treatment on quality of life.

**Limitations**

There were several limitations to this study:

- The study included a small sample size of only three participants, which restricts generalization of results to all individuals with PD.
- Participants were aware of the purpose of the study and had expressed desire for improvement in targeted areas. This may have created a placebo effect, especially regarding vocal quality and quality of life issues.

- Measurements of respiratory capacity and volumes were limited to FVC, FVC%, and $FEV_1$, which may have incompletely depicted of effects of RMST on respiratory function.
- Increased activities of daily life, particularly those requiring physical exertion, were not closely monitored and may have contributed to increased respiratory muscle strength during the detraining phase.
- The researcher was unable to accurately measure the load on participants' PowerLung® devices to ensure that optimal settings of 60-80% of MIP and MEP abilities, as suggested by Enright et al. (2006), were achieved.
- During weekly meetings with the examiner, participants demonstrated proper form and presented a written journal reporting completion of daily exercises and any changes made to settings. However, the examiner could not directly monitor training that occurred outside the clinic to ensure proper form and settings were observed.

## Conclusion

Results from this study suggest that RMST led to maintenance or improvement of participants' maximum inspiratory and expiratory pressures, vocal quality, and the quality of life in several areas related to voice and communicative participation. Respiratory training had inconsistent effects on participants' ability to sustain vowel phonation, with two participants increasing MPT and one participant decreasing MPT. RMST did not appear to improve FVC, FVC%, or $FEV_{1,}$ although measurement of additional respiratory functions (e.g. VC, TLC) may have provided a more complete depiction of its effects. Benefits of RMST varied across participants, and improvements in MIP and MEP did not guarantee parallel results in other outcome measures. SLPs working with individuals with PD should consider RMST as a treatment option for improving airway pressures and communication abilities dependent on adequate pressures. However, other factors related to PD, such as stage and progression of disease, pharmaceutical management, presentation of disease symptoms, and external influences on communication also should be considered, as well as the perceived benefit to the client.

Additional research in the areas of effects of RMST treatment on pulmonary function and quality of life is recommended. Other suggested research includes short-term efficacy studies, longitudinal studies with greater numbers of participants, time-series studies measuring outcomes from time of onset, and combined RMST with other speech therapy.

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Appendix A

Perceptual Rating Form

Please mark the place on the line that best represents the client's typical speech:

| | |
|---|---|
| Always loud enough | Never loud enough |
| Never a "shaky" voice | Always a "shaky" voice |
| Never a hoarse "scratchy" voice | Always a hoarse "scratchy" voice" |
| Never monotone | Always monotone |
| Never slurs | Always slurs |
| Never a "strained" voice | Always a "strained" voice |
| Never mumbles | Always mumbles |
| Always speaks so others can understand | Never speaks so others can understand |
| Always participates in a conversation | Never participates in a conversation |
| Always starts a conversation | Never starts a conversation |

Table A1:

*Responses to Perceptual Rating Form by Participant 1*

| Typical Speech | Baseline | Post-Detraining | End Phase 2 |
|---|---|---|---|
| | ------------ % of Time ---------- | | |
| Always loud enough | 42.8% | 56.9% | 44.4% |
| Never a "shaky" voice | 31.4% | 35.9% | 43.8% |
| Never a "hoarse/scratchy" voice | 23.5% | 35.9% | 21.6% |
| Never monotone | 36.4% | 55.2% | 42.8% |
| Never Slurs | 85.0% | 95.4% | 91.8% |
| Never a "Strained" voice | 38.2% | 38.6% | 41.8% |
| Never mumbles | 81.2% | 38.6% | 19.0% |
| Always speaks, others understand | 37.3% | 38.6% | 39.9% |
| Always participates in conversation | 85.0% | 62.7% | 17.3% |
| Always starts a conversation | 45.1% | 62.7% | 85.0% |

Table A2:

*Responses to Perceptual Rating Form by Participant 2 and Conversation Partner*

| | Participant 2 | | | Conversation Partner | |
|---|---|---|---|---|---|
| | ------------ % of Time ------------ | | | --- % of Time --- | |
| Typical Speech | Baseline | Post-Detraining | End Phase 2 | End Phase 1 | End Phase 2 |
| Always Loud enough | 81.7% | 80.0% | 90.2% | 74.5% | 77.8% |
| Never a "shaky" voice | 12.4% | 98.0% | 96.1% | 98.7% | 93.1% |
| Never a "hoarse/scratchy" voice | 80.4% | 95.4% | 95.4% | 98.7% | 99.4% |
| Never monotone | 92.2% | 88.0% | 80.1% | 73.9% | 72.9% |
| Never slurs | 96.1% | 96.0% | 95.8% | xx | 97.4% |
| Never a "strained" voice | 82.4% | 97.4% | 94.1% | 99.0% | 96.7% |
| Never mumbles | 84.3% | 94.1% | 91.5% | 71.9% | 77.8% |
| Always speaks, others understand | 73.9% | 92.0% | 87.9% | 86.9% | 81.4% |
| Participates in a conversation | 86.0% | 96.7% | 89.9% | 99.0% | 99.7% |
| Starts a conversation | 92.8% | 79.0% | 81.1% | 99.3% | 98.0% |

Table A3:

*Responses to Perceptual Rating Form by Participant 3 and Conversation Partner*

| | Participant 3 | | | Conversation Partner | |
|---|---|---|---|---|---|
| | ------------- % of Time ------------- | | | --- % of Time --- | |
| Typical Speech | Baseline | Post-Detraining | End Phase 2 | End Phase 1 | End Phase 2 |
| Always loud enough | 38.6% | 44.0% | 27.8% | 50.3% | 41.8% |
| Never a "shaky" voice | 50.0% | 44.0% | 81.4% | 67.2% | 72.9% |
| Never a "hoarse/scratchy" voice | 50.0% | 55.0% | 67.7% | 88.9% | 74.5% |
| Never monotone | 65.0% | 62.7% | 67.3% | 70.9% | 77.5% |
| Never Slurs | 48.7% | 73.9% | 74.8% | 91.2% | 69.9% |
| Never a "Strained" voice | 33.0% | 53.6% | 51.6% | 88.6% | 69.3% |
| Never mumbles | 53.6% | 43.0% | 71.2% | 69.3% | 58.5% |
| Always speaks, others understand | 45.1% | 50.0% | 49.7% | 89.5% | 64.1% |
| Always participates in conversation | 52.9% | 78.0% | 70.9% | 98.4% | 82.7% |
| Always starts a conversation | 43.1% | 43.0% | 46.1% | 97.4% | 85.0% |

Appendix B

Voice Handicap Index (VHI)

Instructions: These are statements that many people have used to describe their voices and the effects of their voices on their lives. Check the response that indicates how frequently you have the same experience.

| | | Never | Almost Never | Sometimes | Almost Always | Always |
|---|---|---|---|---|---|---|
| F1 | My voice makes it difficult for people to hear me | | | | | |
| P2 | I run out of air when I talk | | | | | |
| F3 | People have difficulty understanding me in a noisy room | | | | | |
| P4 | The sound of my voice varies throughout the day | | | | | |
| F5 | My family has difficulty hearing me when I call them throughout the house | | | | | |
| F6 | I use the phone less often than I would like | | | | | |
| E7 | I'm tense when talking with others because of my voice | | | | | |
| F8 | I tend to avoid groups of people because of my voice | | | | | |
| E9 | People seem irritated with my voice | | | | | |
| P10 | People ask, "What's wrong with your voice?" | | | | | |
| F11 | I speak with friends, neighbors or relatives less often because of my voice | | | | | |
| F12 | People ask me to repeat myself when speaking face-to-face | | | | | |
| P13 | My voice sounds creaky and dry | | | | | |
| P14 | I feel as though I have to strain to produce voice | | | | | |
| E15 | I find other people don't understand my voice problem | | | | | |
| F16 | My voice difficulties restrict my personal and social life | | | | | |
| P17 | The clarity of my voice is unpredictable | | | | | |
| P18 | I try to change my voice to | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | sound different | | | | | |
| F19 | I feel left out of conversations because of my voice | | | | | |
| P20 | I use a great deal of effort to speak | | | | | |
| P21 | My voice is worse in the evening | | | | | |
| F22 | My voice problem causes me to lose income | | | | | |
| E23 | My voice problem upsets me | | | | | |
| E24 | I am less out-going because of my voice problem | | | | | |
| E25 | My voice problem makes me feel handicapped | | | | | |
| P26 | My voice "gives out" on me in the middle of speaking | | | | | |
| E27 | I feel annoyed when people ask me to repeat | | | | | |
| E29 | I feel embarrassed when people ask me to repeat | | | | | |
| E30 | I'm ashamed of my voice problem | | | | | |

Table B1:

*Participant 1: Results of Voice Handicap Index*

| | Baseline | | Post-Detraining | | End Phase 2 | |
|---|---|---|---|---|---|---|
| | Raw Score | Severity | Raw Score | Severity Rating | Raw Score | Severity Rating |
| P Scale (physical) | 19 | Moderate | 21 | Moderate-Severe | 20 | Moderate-Severe |
| F Scale (functional) | 18 | Severe | 17 | Moderate-Severe | 13 | Moderate |
| E Scale (emotional) | 9 | Mild | 8 | Mild | 9 | Mild |
| Total | 46 | Moderate-Severe | 46 | Moderate-Severe | 42 | Moderate-Severe |

Table B2:

*Participant 2: Results of Voice Handicap Index*

| | Baseline | | Post-Detraining | | End Phase 2 | |
|---|---|---|---|---|---|---|
| | Raw Score | Severity Rating | Raw Score | Severity Rating | Raw Score | Severity Rating |
| P Scale (physical) | 10 | Mild | 5 | Mild | 6 | Mild |
| F Scale (functional) | 7 | Mild | 5 | Mild | 11 | Mild-Moderate |
| E Scale (emotional) | 1 | Mild | 4 | Mild | 5 | Mild |
| Total | 18 | Mild | 14 | Mild | 22 | Mild |

Table B3:

*Participant 3: Results of Voice Handicap Index*

| | Baseline | | Post-Detraining | | End Phase 2 | |
|---|---|---|---|---|---|---|
| | Raw Score | Severity Rating | Raw Score | Severity Rating | Raw Score | Severity Rating |
| P Scale (physical) | 23 | Severe | 21 | Moderate-Severe | 23 | Severe |
| F Scale (functional) | 20 | Severe | 19 | Severe | 23 | Severe |
| E Scale (emotional) | 17 | Moderate-Severe | 15 | Moderate | 17 | Moderate-Severe |
| Total | 60 | Moderate-Severe | 55 | Moderate-Severe | 63 | Severe |

Appendix C

Communication Participation Item Bank

Instructions: The following questions describe a variety of situations in which you might need to speak to others. For each question, please mark how much your condition interferes with your participation in that situation. By “condition” we mean ALL issues that may affect how you communicate in these situations including speech conditions, any other health conditions, or features of the environment. If you speech varies, think about an AVERAGE day for your speech – not your best or your worst days.

| | **Not at all (3)** | **A little (2)** | **Quite a bit (1)** | **Very much (0)** |
|---|---|---|---|---|
| 1. Does your condition interfere with……**talking with people you know?** | ☐ | ☐ | ☐ | ☐ |
| 2. Does your condition interfere with……**communicating when you need to say something quickly?** | ☐ | ☐ | ☐ | ☐ |
| 3. Does your condition interfere with……**talking with people you do NOT know?** | ☐ | ☐ | ☐ | ☐ |
| 4. Does your condition interfere with……**communicating when you are out in your community (e.g. errands; appointments)?** | ☐ | ☐ | ☐ | ☐ |
| 5. Does your condition interfere with……**asking questions in a conversation?** | ☐ | ☐ | ☐ | ☐ |
| 6. Does your condition interfere with……**communicating in a small group of people?** | ☐ | ☐ | ☐ | ☐ |
| 7. Does your condition interfere with……**having a long conversation with someone you know about a book, movie, show or sports event?** | ☐ | ☐ | ☐ | ☐ |
| 8. Does your condition interfere with……**giving someone DETAILED information?** | ☐ | ☐ | ☐ | ☐ |
| 9. Does your condition interfere with……**getting your turn in a fast-moving conversation?** | ☐ | ☐ | ☐ | ☐ |
| 10. Does your condition interfere with……**trying to persuade a friend or family member to see a different point of view?** | ☐ | ☐ | ☐ | ☐ |

Table C1:

*Participant 1: Communication Participation Item Bank – General Short Form*

| | Baseline | Post-Detraining | End Phase 2 |
|---|---|---|---|
| Summary Score: | 27 | 25 | 25 |
| IRT Theta: | 1.22 | 0.92 | 0.92 |
| T score: | 62.2 | 59.2 | 59.2 |
| Interference in participation: | Mild | Mild | Mild |

Table C2:

*Participant 2: Communication Participation Item Bank – General Short Form*

| | Baseline | Post-Detraining | End Phase 2 |
|---|---|---|---|
| Summary Score | 21 | 17 | 17 |
| IRT Theta | 0.4 | -0.1 | -0.1 |
| T score | 54 | 49 | 49 |
| Interference in participation: | Mild-Moderate | Moderate | Moderate |

Table C3:

*Participant 3: Communication Participation Item Bank – General Short Form*

| | Baseline | Post-Detraining | End Phase 2 |
|---|---|---|---|
| Summary Score | 16 | 16 | 19 |
| IRT Theta | -0.22 | -0.22 | 0.15 |
| T score | 47.8 | 47.8 | 51.5 |
| Interference in participation: | Moderate | Moderate | Mild-Moderate |