The Effects of Pitch Increasing Training (PIT) on Voice and Speech of a Patient with Parkinson's Disease: A Pilot Study

Ok-Bun Lee* · Ok-Ran Jeong · Hong-Im Shim*** · Han-Jin Jeong***

ABSTRACT

The primary goal of therapeutic intervention in dysarthric speakers is to increase the speech intelligibility. Decision of critical features to increase the intelligibility is very important in speech therapy. The purpose of this study is to know the effects of pitch increasing training (PIT) on speech of a subject with Parkinson's disease (PD). The PIT program is focused on increasing pitch while a vowel is sustained with the same loudness. The loudness level is somewhat higher than that of the habitual loudness. A 67-year-old female with PD participated in the study. Speech therapy was conducted for 4 sessions (200 minutes) for one week. Before and after the treatment, acoustic, perceptual and speech naturalness evaluation was performed for data analysis. Speech and voice satisfaction index (SVSI) was obtained after the treatment. Results showed improvements in voice quality and speech naturalness. In addition, the patient's satisfaction ratings (SVSI) indicated a positive relationship between improved speech production and their (the patient and care-givers) satisfaction.

Keywords: Parkinson's disease, intelligibility, pitch increasing training (PIT), speech naturalness, speech and voice satisfaction index (SVSI)

I. Introduction

Although most patients with Parkinson's disease (PD) exhibit speech and voice problems, only a few of them receive speech therapy. Clinical researchers have been investigating their voice and speech perceptually, acoustically, and physiologically(Sapir, et al., 2003; Fox, et al., 2002; Ramig, et al., 1994). However, methods to intervene their speech and voice problems are still extremely demanded.

The primary goal of therapeutic intervention is to increase the speech intelligibility. The search of specific features of speech that affect intelligibility improvement is a current interest in clinical and theoretical aspects. Making a decision of critical feature affecting it leads to the

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selection of intervention targets (Whitehill & Ciocca, 2000).

The primary speech and voice problems in patients with PD include mono-pitch, mono-loudness, and poor speech intelligibility. Ramig et al. (1994) studied an intensive treatment program to improve vocal fold adduction and speech intelligibility in individuals with PD. The program, known as the Lee Silverman's Voice Therapy (LSVT), focuses on a simple task designed to maximize phonatory and respiratory functions (Fox, et al., 2002; Sapir, et al., 2003). The loud and effortful phonatory task is aimed to improve respiratory drive, vocal fold adduction, and more generally laryngeal muscle activity. In other words, the task facilitates thyroarytenoid (TA) muscle activity (Fox, et al., 2002).

Pitch and loudness interact with each another. Namely, it is natural that increasing pitch results in increased loudness. Therefore, in PD patient's speech and voice rehabilitation, it can be very important to treat pitch and loudness simultaneously.

Lee & Jeong (2002) studied the effects of 4 kinds of voice controlling technique on voice and speech of 3 patients with PD. The voice control training focused on changing pitch and loudness simultaneously in 4 different ways (Lee & Jeong, 2002; Lee, et al., 2001).

1) Method 1: Pitch ↑ + Loudness ↑
2) Method 2: P ↓ + L ↓,
3) Method 3: P ↑ +L ↓, and
4) Method 4: P ↓ +L ↑

The results showed that the training with increasing pitch and decreasing loudness (Method 3) improved the subjects' voice quality and speech intelligibility.

Increasing pitch in sustaining vowels will make the cricothyroid (CT) muscle function stronger. Simultaneously, this training will drive the activation of thyroaryteoid (TA) muscle decreasing the burden on laryngeal movement.

From a clinical standpoint, these results suggested that the training with systematically increasing pitch within controlled loudness level could have a significant impact on speech intelligibility.

Therefore, the current study investigated the effects of paradoxical performance of voice production mechanism; increasing pitch sustaining the loudness higher than the habitual loudness (PIT program). The purpose of this study is to examine the effects of pitch increasing training (PIT) on voice and speech of a subject with Parkinson's disease (PD).

II. Method

2.1 Subject

A 67-year-old female with PD participated in the study. She has been medicated from a year ago. Her overall PD symptom severity at the time was at the stage three (Hoehn and Yahr: Staging of Parkinson's Disease). Recently, she has been suffering from severe voice and speech problems. She complained that she could not communicate with her family members and neighbors. Her voice exhibits a severe breathiness and tremor in both /a/ prolongation and spontaneous speech. Figure 1 shows her voice and speech characteristics. This evaluation of speech severity was determined based on perceptual judgement made by 2 Korean-certified Speech-Language Pathologists.

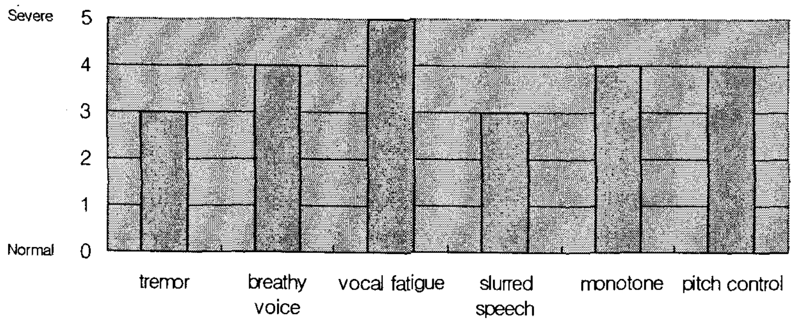

Figure 1. Severity ratings of the subject

2.2 Treatment

The PIT program was focused on increasing pitch while a vowel was sustained with the same loudness (see Table 1). The loudness level was kept somewhat higher (about 10 dB) than that of the habitual loudness. The level was named as 'training loudness level (T-Loud)' in the present study. The Real-time Pitch (CSL 4300) was used for the visual feedback of the level (T-Loud) (see Figure 2).

Table 1. Hierarchy of the PIT program

Step 1 : Sustaining Vowels in Habitual Loudness Level (HLL)
Step 2 : Sustaining Vowels in T-Loud.
Step 3 : Increasing pitch while sustaining vowels (glissando)
Step 4 : Increasing pitch simultaneously with sustaining same loudness in step 2.
Step 5 : Speaking

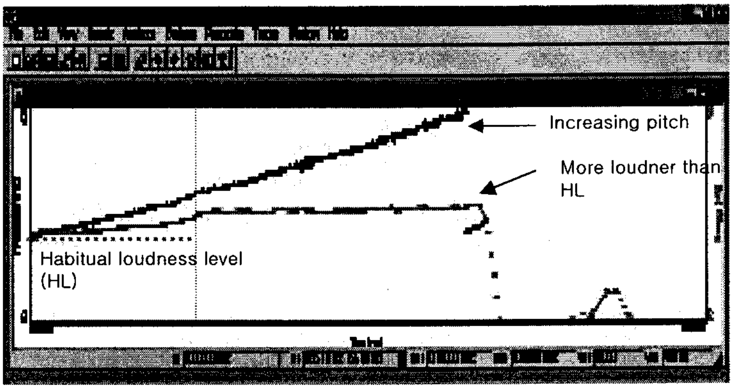

Figure 2. visual feedback: increasing pitch training

2.3 Data Analyses

2.3.1 Acoustic analysis

Voice samples of a sustained /a/ at a comfortable pitch and loudness level were captured and analyzed by the MDVP (CSL 4300, sampling rate 44,000 Hz). The pre- and post-treatment statistics were taken on jitter, shimmer, NHR, vAM, and vF_0.

In addition, the Vocal Assessment in Dr. Speech 4.0 was used for the evaluation of the severity of breathy voice.

2.3.2 Perceptual analysis

Voice quality

The GRBAS voice rating scale (Hirano, 1981) was conducted for the voice quality evaluation. The voice samples of the sustained /a/ at a comfortable pitch and loudness level and speech samples were collected. Six evaluators (2 speech-language pathologists, 4 undergraduate students majoring in SLP) evaluated the voice quality.

Speech Naturalness Evaluation

The passages 'Sancheck (Going for a walk)' (Jeong, 1994) including 200 syllables and 3 types of sentences (declarative, interrogative, and exclamatory) were used for the speech naturalness test. The speech naturalness scale (Lee, 2004) was administered.

The speech naturalness scales evaluated the rates, intonations, contents, articulatory agility, voice, tremor and speech intelligibility. It was scored by a 6-point scale: [0] being abnormal, [1] almost abnormal, [2] moderate, [3] mild, [4] almost normal, [5] normal. The examiners evaluated the subject's speech perceptually as well as the spectrographic display of the speech samples. Six evaluators (2 speech-language pathologists, 4 undergraduate students majoring in SLP) evaluated the speech naturalness.

2.3.3 Speech-Voice Satisfaction Index (SVSI)

The SVSI test was conducted after the treatment. This test was to determine the self-satisfaction of patient's voice and speech. The participants (patient and her family members) rated the perception regarding improvements of voice and speech of the patient via treatment. They also answered an evaluation form of Likert scale with 10 statements on a 5-point (1 = negative response to 5 = positive response).

Ⅲ. Results

3.1 Voice Improvement

3.1.1 Acoustic analysis

Table 2 and Figure 3 show the voice improvements. The jitter, shimmer, vAm, and vF0 values were significantly decreased.

Table 2. Results of acoustic analysis on pre- and post-treatment

	Pre-Rx		Post-Rx	
	Mean	SD	Mean	SD
F0 (Hz)	284.34	15.27	285.74	9.88
jitter (%)	3.862	1.21	0.931	0.58
shimmer (dB)	7.454	2.22	2.724	1.04
vAm	20.412	3.88	9.662	1.14
NHR	0.176	0.55	0.108	0.32
vFo	5.355	1.01	3.984	0.88

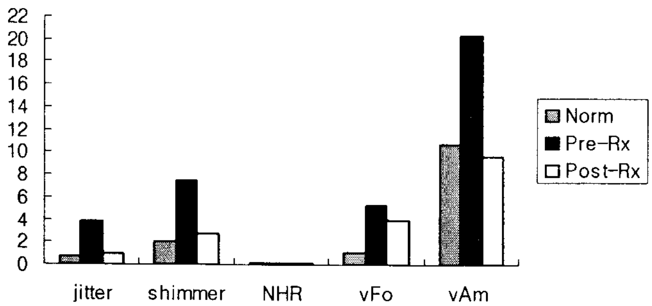

Figure 3. Results of acoustic analysis

3.1.2 Perceptual analysis

As shown in Table 3 and Table 4, the results showed the improvements in her voice after the treatment.

Table 3. Vocal assessment and GRBAS results

	Vocal assessment	GRBAS				
		Grade	Rough	Breathy	Asthenic	Strained
Pre-Tx	**3***	3	2	3	2	0
Post-Tx	**2***	2	1	2	1	0

* Breathiness severity [0]: Normal - [3]: severe (by Dr. Speech 4.0)
GRBAS scale [0]: Normal - [3]: Severe

Table 4. Independent t-test results of 6 evaluators on the subjects voice samples

	Pre		Post		t
	Mean	SD	Mean	SD	
Grade	2.40	.548	1.20	.447	**6.000****
Rough	1.80	.447	1.00	.000	4.000*
Breathy	2.80	.447	1.60	.548	**6.000****
Asthenic	2.00	.707	.60	.548	3.500*
Strained	1.00	.000	.40	.548	2.449

* p<.05, ** p<.01, *** p<.001

3.2 Speech Naturalness

3.2.1 Perceptual judgement

As shown in Table 5, Table 6 and Figure 4, the results showed the improvements in her voice and speech after the treatment. Particularly, the articulation, tremor and voice improved significantly.

Table 5. Speech Naturalness

	Pre-Rx		Post-Rx	
	Mean	SD	Mean	SD
Rate	2.00	.76	3.13	.52
Intonation	2.25	.46	3.63	.35
Articulation	2.25	.46	3.13	.35
Voice	2.25	.71	3.50	.53
Tremor	2.00	.76	3.48	.35
Contents	2.88	.35	3.38	.52

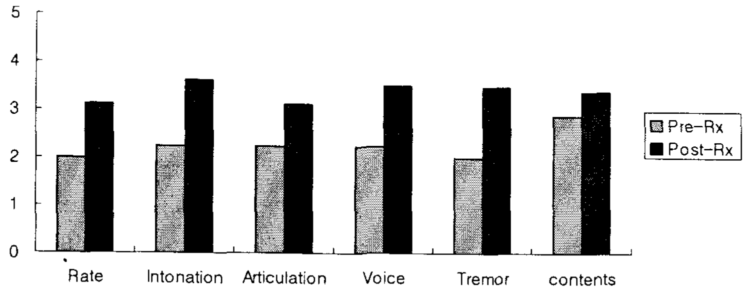

Figure 4. Pre- and post-treatment in naturalness

Table 6. Independent t-test results of 6 evaluators on the subjects speech samples

	Pre-Tx		Post-Tx		t
	Mean	SD	Mean	SD	
Rate	2.33	.516	3.33	.516	-3.354**
Intonation	1.33	.516	3.17	.408	**-6.822*****
Articulation	2.33	.516	3.50	.548	-3.796**
Voice	2.00	.000	3.00	.632	-3.873*
Tremor	1.33	.516	2.33	.816	-2.535*
Contents	3.17	.753	4.00	.000	-2.712*

* p<.05, ** p<.01, *** p<.001

Pretreatment	Treatment

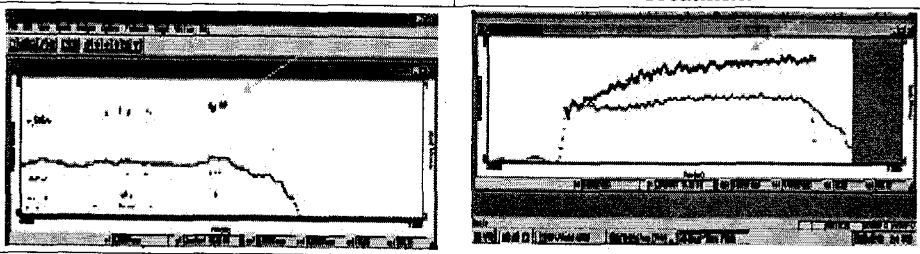

Figure 5. Increasing pitch training

3.2.2 Spectrographic analysis of speech

The results of spectrogram analyses is as follows (see Figure 6). Harmonic ratios were increased. The excursions and structures of vowel formants became more evident. These results were consistent with the results of perceptual judgment on speech naturalness as shown above (see Table 4 and Table 5). The overall spectrograms showed stronger (darker) formant energy for each syllable.

Pre-Rx	Post-Rx
Speech sample: [yəgɪga urinarayeyo?] (Meaning: this is our country?)	

Figure 6. Spectrographic display of the subject's connected speech

3.3 Speech and Voice Satisfaction Index

The participants' ratings of perceived voice and speech were improved. The overall mean ratings on the 10 statements were ranged from 3 to 3.8 (see Figure 7).

< Speech and Voice Satisfaction Index>

1. pitch control	6. this therapy helpful
2. loudness control	7. recommend this therapy to others
3. voice quality (breathiness)	8. vocal fatigue
4. voice tremor	9. speech therapy needs
5. slurred speech	10. efforts to communicate

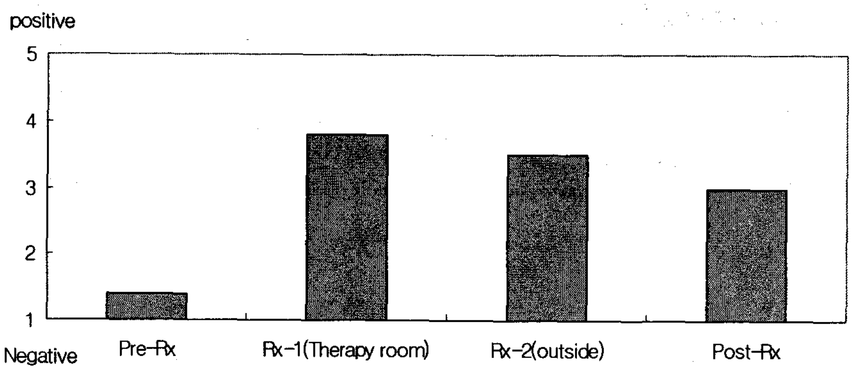

Figure 7. SVSI Results

IV. Discussion

In this study, a female with PD was treated with PIT program. She showed improvements in voice quality and speech naturalness. In addition, patient satisfaction ratings (SVSI) revealed a positive relationship between improved speech production and their (patient and care-givers) satisfaction.

The PIT program is the program which increases pitch while a vowel is sustained with a loudness level higher than that of the habitual loudness. The focus of this procedure is the paradoxical increasing of pitch. This supported previous results that the loud and effortful phonatory tasks are helpful to improve vocal fold adduction, laryngeal muscle activity and synergy (Fox, et al., 2002; Ramig, et al., 2001; Ramig, et al., 1994). These physiological changes lead directly to the improvement of voice quality, articulatory precision, prosodic inflection and speech intelligibility (Dromey & Ramig, 1998; Dromey, et al., 1995).

Monopitch and reduced pitch range depend on muscular rigidity in CT muscle. This treatment (e.g., 'Increasing pitch sustaining the same loudness') increased longitudinal tension (LT) muscle tone and decreased glottal chink and Breathiness. In addition, it was effective in decreasing voice tremor. This training seemed to be helpful in an effective phonatory function. Furthermore, it facilitated a reflective listening and thinking of her own voice.

Despite these findings, there remain some limitations in this approach. The number of subjects, therapeutic period(long-term effect) and more objective data analysis must be considered in further studies. In addition, the effects of this training need to be compared with other voice therapeutic technique(e.g., increasing or decreasing pitch(loudness) on the controlled loudness(pitch)).

This study also showed the perceptual judgement of 6 listeners to the voice and speech improvement. Though, the correlation between perceptual judgement and acoustic data was not studied. In the future, the increase in intelligibility should be analyzed with acoustic and perceptual measures with both listener and speaker judgements.

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