

The Combined Effects of Lee Silverman Voice Treatment and Abdominal Respiration on the Maximum Phonation Time in Parkinson's Disease

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Abstract

Background/Objectives: The purpose of our study was to evaluate the effects of a respiratory rehabilitation the forced vital capacity, voice intensity, and maximum phonation time (MPT) of patients with hypokinetic dysarthria.

Methods/Statistical analysis: This study was carried out on 32 patients with Parkinson's disease (PD). All subjects were randomly assigned to a treatment group (n = 17), which received both abdominal breathing training and LSVT, and a control group (n = 15), which only received abdominal breathing training. The forced expiratory volume at one second (FEV1) was measured in the sitting position. The coordination of respiration and vocalization was measured by using MPT.

Findings: The results of ANCOVA, which controlled the pre-test with a covariate, showed that the control group (CG) and the treatment group (TG) were significantly (p<0.05) different in FEV1, MPT, and vocal intensity. The results of parameter estimation revealed that the TG had significantly longer MPT (1.9 seconds longer on average) than the CG and the vocal intensity of the TG was significantly stronger (3.1dB higher on average). On the other hand, FEV1 significantly increased in the TG and the CG after 4 weeks of treatments compared to the baseline. However, there was no significant difference between TG and CG.

Improvements/Applications: The respiratory rehabilitation composed of LSVT and abdominal breathing was effective in improving not only the vocal intensity of patients with PD but also the coordination of respiration and vocalization.

Keywords: Lee Silverman Voice Treatment, abdominal breathing, LSVT, speech language pathology, Parkinson's disease, maximum phonation time, voice therapy

1. Introduction

Aging is a common worldwide phenomenon and the occurrence of geriatric diseases are increasing rapidly. Parkinson's disease (PD), which occurs mainly in old age, is a typical neurodegenerative disease characterized by a decrease in motor ability [1]. Although previous studies have suggested encephalitis, brain disease, drug addiction, and genetic factors as the causes of PD, the exact cause of PD has not been elucidated [2]. It is known that the occurrence of Parkinson's disease is higher in older males than other classes [2]. In South Korea, the number of patients with PD increased from 33,965 in 2004 to 60,545 in 2008, a 1.7-fold increase over the past five years [3]. It is expected that the number will continue to increase due to the aging pattern of South Korea [3].

Previous studies have shown that PD declines the cognitive and motor abilities of patients gradually with aging [4]. PD decreases motor abilities such as rigidity, bradykinesia, and postural instability due to the reduced dopamine secretion, which is a neurotransmitter. As the disease progresses, respiratory control associated problems commonly occur due to the rigidity of respiratory muscles and complications such as aspiration pneumonia can lead to death. Particularly, the rigidity of the respiratory muscles causes abnormalities in the coordination capability of the diaphragm and the abdominal muscles [5] and it is a cause of the hypokinetic dysarthria along with the rigidity of

the vocal cord muscle [6]. It has been reported that the 70% of Parkinson's patients accompanied with hypokinetic dysarthria. These problems gradually deteriorate the motor abilities of patients with PD and cause severe dysarthria as the disease progresses [7]. Consequently, they restrain the patients from conducting common actions required for the ordinary social life [7].

Particularly, the progressive respiratory muscle dysfunction is known to be a common symptom of PD and nine out of ten patients with PD express dysarthria due to respiratory problems [8]. The decreased respiratory function not only reduces communication abilities and the quality of life, but also negatively affects daily activities, activity levels, and motor performance [9]. Since no cure for this disease has been discovered, the current treatments focus on the alleviation and inhibition of the symptoms of PD. Therefore, effective respiratory rehabilitation is a prerequisite for improving the activity levels and the life quality of patients with PD by enhancing their respiratory function. Multiple studies have reported that the expiratory muscle strength training was effective in reinforcing the respiratory functions of patients with PD [10, 11]. Abdominal breathing training is known to improve the muscle strength and endurance by applying loads to the diaphragm and inspiratory accessory muscle [12]. However, previous studies have focused mainly on the effects of single breath technique on the improvement of lung capacity or muscle functions.

On the other hand, Lee Silverman Voice Treatment (LSVT) is

widely used as a treatment to enhance the coordination between the respiration and voice of patients with PD in the language rehabilitation field. LSVT is a method that is designed to enhance the loudness of patients and it has been proven to be effective for improving the speech intelligibility of patients with PD [13]. It is a systematic rehabilitation method that helps patients generate much stronger and louder voice than the patients could generate themselves [13]. Previous studies have reported that LSVT increased the loudness of patients with PD and was also effective in improving vocal cord vibration, voice quality, pitch inflection, breathing capacity, and swallowing function [14,15].

Recent studies have proposed that a rehabilitation program that integrates interventions related to respiration would be more effective in improving the functional activities of patients with neurological impairment such as stroke than a single-treatment program [16]. Nonetheless, there is not enough evidence on the effects of LSVT on the lung capacity and the coordination between the respiratory muscle and muscularyngis of patients with PD. Moreover, only a few studies evaluated the effectiveness of comprehensive rehabilitation programs to enhance the respiratory capabilities of patients with PD.

The objective of this study was to evaluate the effects of a respiratory rehabilitation program (four weeks of abdominal breathing training and LSVT) on the forced vital capacity, voice intensity, and maximum phonation time (MPT) of patients with PD accompanied by hypokinetic dysarthria.

2. Methods

2.1. Research Participants

This study was carried out on 32 patients with PD who received rehabilitation treatments in hospitals located in Seoul and Incheon between August and December 2016. The subjects were those who: (1) did not have any orthopedic disease such as congenital deformation or fracture of the thorax; (2) did not have a pulmonary disease before or after the onset of PD; (3) had the score of the mini-mental state examination in Korean (MMSE-K) equal to or higher than 25; and (4) agreed to participate in the study. All subjects were randomly assigned to a treatment group (n = 17), which received both abdominal breathing training and LSVT, and a control group (n = 15), which only received abdominal breathing training [Figure 1].

The control group conducted abdominal breathing and pursed-lip breathing (breathing out with closing half of the mouth) 20 times per session and three sessions per week for four weeks (total 20 sessions). The procedure of the pursed-lip breathing is as follows. First, the starting posture is to purse the lips using a whistle in a sitting position. Second, a patient holds his or her breath more than five seconds after inhaling air through the nose as much as possible. Third, the patient slowly blows a whistle as strong as possible without letting the air leak. Then, the patient shall maintain the status at least five seconds. At this time, the patient feels the swelling of the abdomen with his/her hand. The treatment group performed LSVT in addition to the respiratory program performed by the control group during the same treatment frequency and duration. The procedure of LSVT refers to Ramig et al. (2001) [13].

2.2. Measurement

The forced expiratory volume at one second (FEV1) was measured in the sitting position by using Micro-Quark (COSMED, Albano Laziale, Italy) [Figure 2]. FEV1 means the volume of air for one second immediately after breathing out strongly. It is known as a sensitive index that can be used to determine the degree of the respiratory problem and it is highly reproducible for clinical diagnosis. To ensure the reliability of the test, a patient conducted this test three times and the maximum value was used

for the study when the second largest value was equal to or higher than the 95% of the largest value.

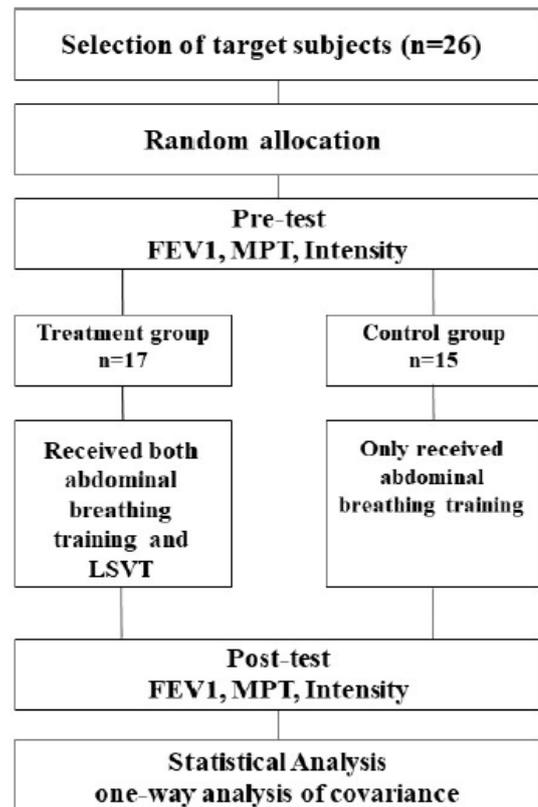


Figure 1: Flowchart of Study

The coordination of respiration and vocalization was measured by using MPT. MPT is a measurement index for identifying the coordination of them quantitatively. It measures the time in seconds that a subject makes /a/ sound as long as possible with maintaining a constant tone and intensity in a relaxed state. The vocal intensity was analyzed by averaging the 3-second continuous sound interval using Praatver 5.1 (Boersma & Weenink, 2007) [Figure 3].



Figure 2: Measurement of forced expiratory volume at one second using Micro-Quark

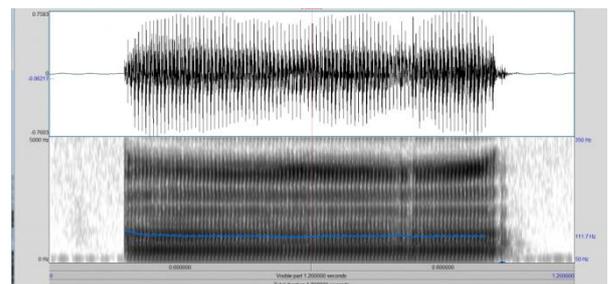


Figure 3: Measurement of vocal intensity using Praat

2.3. Statistical Analysis

In the baseline stage, the means and standard variations were presented for the characteristics of the research participants. The differences between the treatment and control groups were analyzed using the independent student's t-test for continuous variables and the χ^2 test for nominal variables. Additionally, treatment was considered as an explanatory variable, FEV1, MPT, and vocal intensity were treated as outcome variables, and the baseline was defined as a covariate. The changes in outcome variables before and after treatment were compared using one-way ANCOVA. All statistical analyses were conducted using R version 3.4.4: Windows.

3. Results

3.1. Characteristics of Research Participants

The characteristics of the research participants are shown in Table 1. The results of χ^2 test and t-test showed that there were no significant differences between the groups in gender, age, height, weight, education level, and the post-onset period.

Table 1: Characteristics of the research participants

Variables	CG (n=15)	TG (n=17)	p-value
Age (year \pm SD)	65.58 \pm 4.75	63.78 \pm 6.23	
Gender			0.655
Male	10	11	
Female	5	6	
Level of education (year)	9.53 \pm 3.13	9.53 \pm 3.13	0.860

Table 2: The changes in the breathing capacity, MPT, and vocal intensity of the treatment group and the control group by treatment method: ANCOVA

Variables	Control group		Treatment group		F-value	p-value
	Pre-Tx	Post-Tx	Pre-Tx	Post-Tx		
FEV 1	2.15 \pm 0.51	2.31 \pm 0.50	2.17 \pm 0.53	2.30 \pm 0.55	0.015	0.870
MPT	16.28 \pm 2.35	17.31 \pm 2.83	17.05 \pm 3.01	20.03 \pm 3.17	8.481	0.001
Intensity, dB	45.52 \pm 3.31	47.32 \pm 4.35	44.58 \pm 3.60	49.61 \pm 3.10	6.853	0.025

* Pre-Tx=Pre-treatment; Post-Tx=Post-treatment; Control group=abdominal breathing treatment; Treatment group=abdominal breathing and LSVT treatments

4. Discussion

The results of our study showed that FEV1 was significantly improved in both the respiratory rehabilitation only group (the control group) and the LSVT and respiratory rehabilitation group (the treatment group).

The abdominal breathing is explained by the inspiration, which lowers the diaphragm, increases the volume of the thoracic cavity, and decreases the inner pressure of the thoracic cavity, and the expiration, which decreases the volume of the thoracic cavity by increasing the inner pressure of the thoracic cavity [17]. Previous studies reported that the abdominal breathing increased the lung capacity of patients with central nervous system impairment by helping them enhance their ventilation ability, reduce dyspnoea, optimize the thoracoabdominal motions, and recover the respiratory muscle functions by utilizing auxiliary muscles [18,19]. The pursed-lip breathing training is frequently used for patients with chronic obstructive pulmonary disease (COPD) suffering from weakened respiratory functions. It has been reported that the pursed-lip breathing training increases the expiration time and respiratory cycle to ultimately increase the lung capacity [20]. Therefore, the results of this study suggested that the abdominal breathing and pursed-lip breathing training would significantly increase the expiratory volume of patients with PD.

The results of this study showed that the vocal intensity and the coordination of respiration and vocalization of the treatment group (abdominal breathing and LSVT treatments) were significantly higher than those of the control group (abdominal breathing

Hight (cm)	165.73 \pm 6.13	167.48 \pm 4.52	0.783
Weight (kg)	64.81 \pm 6.35	66.13 \pm 4.26	0.230
Time since PD	5.53 \pm 2.13	4.86 \pm 1.85	0.297

* CG (control group)=abdominal breathing treatment; TG (treatment group)=abdominal breathing and LSVT treatments

3.2. Changes in Breathing Capacity and Coordination of Respiration and Vocalization

Pre-test and post-test were performed to identify the changes in the breathing capacity of the treatment group and the control group by treatment method [Table 2]. First, the interaction between the pre-test and treatment was analyzed to determine whether the data satisfied the assumptions of ANCOVA. Since the interaction was not significant, it was confirmed that the slope of pre-test regression was identical between the two groups. Moreover, the Levene test for testing the homoscedasticity also showed that the variances of the two groups were the same.

The results of ANCOVA, which controlled the pre-test with a covariate, showed that the control group and the treatment group were significantly ($p < 0.05$) different in FEV1, MPT, and vocal intensity. The results of parameter estimation revealed that the treatment group had significantly longer MPT (1.9 seconds longer on average) than the control group and the vocal intensity of the treatment group was significantly stronger (3.1dB higher on average). On the other hand, FEV1 significantly increased in the treatment and control group after 4 weeks of treatments compared to the baseline. However, there was no significant difference between treatment and control groups.

treatment). Ramig et al. [13] conducted a longitudinal study on 33 patients with idiopathic PD and reported that the abdominal breathing and LSVT treatments increased the vocal intensity and pitch significantly more than the abdominal breathing only treatment, which agreed with the results of this study.

Unlike normal breathing, the breathing during vocalization interacts with the vocalization system (e.g., vocal cords, larynx, and articulator) during speech production. Therefore, the maintenance of respiration and the balance between muscles are needed to maintain the vibration of vocal cords and it is impossible to sustain the vocal function of patients with PD by simply strengthening the respiratory function. Therefore, the results of this study suggested that breathing exercise alone could not improve the coordination of the respiratory muscles and vocal cord muscles of patients with PD.

The importance of this study was that it evaluated the coordination of the respiratory muscle and vocal cord muscle of patients with PD as well as the breathing capacity of them. However, this study had several limitations. First, it could not examine the effects of gender on the treatment. Second, the study only measured FEV1 among respiratory measurements. Respiratory dysfunction of PD not only appears in the upper airway muscles but also in the inspiration muscles located in the thorax and throat. Therefore, future studies need to measure various indicators such as mean expiration flow rate and subglottal pressure.

5. Conclusion

The respiratory rehabilitation composed of LSVT and abdominal breathing was effective in improving not only the vocal intensity

of patients with PD but also the coordination of respiration and vocalization. It will be necessary to develop and apply a comprehensive rehabilitation program combining the abdominal breathing and LSVT in order to improve the support of breathing and the maintenance of vocalization of patients with PD.

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