The clinical efficacy of voice therapy for adult cerebral palsy with dysarthria and dysphagia

Alyssa Mae Park

Graduate Program of Speech and Language Pathology

The Graduate School, Yonsei University

The clinical efficacy of voice therapy for adult cerebral palsy with dysarthria and dysphagia

Directed by Professor Sung-Rae Cho

The Master's Thesis submitted to the Graduate Program of Speech and Language Pathology, the Graduate School of Yonsei University in partial fulfillment of the requirements for the degree of Master of Science

Alyssa Mae Park

December 2020

This certifies that the Master's Thesis of
Alyssa Mae Park is approved.

_____

Thesis Supervisor: Sung-Rae Cho

_____

Thesis Committee Member #1: HyangHee Kim

_____

Thesis Committee Member #2: Yoon Ha

The Graduate School
Yonsei University

December 2020

Acknowledgements

First, I would like to thank my family, especially my parents Linda and Joe, my sister Cara, and my grandparents Beverly and Benjamin, for their patience and understanding during my extensive time abroad. It has been difficult to be so far away, and it weighs heavily on me to have missed the opportunities to say goodbye to my late grandfather Cornelius and uncle Glen in their final moments. I promise to make up for the lost time very soon, and I am humbled to be the first in the family to receive a Master's degree.

Second, I must recognize the educators who have challenged me and modelled excellence in clinical practice and academic research. Dr. HyangHee Kim, thank you for your endless support, teachings, and problem-solving in my pursuit of dual-national certification. Dr. Sung-Rae Cho, thank you for your guidance, mentorship, and generosity in allowing me to join your research team. Dr. Yoon Ha, thank you for your valuable input and guidance in the process of my research. I also extend my gratitude and utmost respect to Kerry Mees for her generosity and mentorship that have helped me develop my clinical skills.

Lastly, I want to thank my beloved classmates and friends who have been there through it all. Jieon, Sujeong, Sanga, Claire, Jeongeun, Alexis, Bonnie, Deanna, Yungi, and so many others: your friendship and help have brought so much light to my life in these difficult times. Thank you for adding levity to these long days, for encouraging me to take myself less seriously, and for providing valuable advice and comfort.

Alyssa

Table of contents

LIST OF TABLES

The clinical efficacy of voice therapy for adult cerebral palsy with dysarthria and dysphagia

Alyssa Mae Park

Graduate Program of Speech and Language Pathology
The Graduate School, Yonsei University

(Directed by Professor Sung-Rae Cho)

Cerebral palsy is the most common neurodevelopmental disorder, and it frequently results in comorbidities such as dysarthria and dysphagia. Children and adults with cerebral palsy experience restriction in activities and limitation in participation due to low speech intelligibility, negative social perception, complex dietary requirements, health risks from aspiration, and more effects of dysarthria and dysphagia. This study evaluated the clinical efficacy of intensive voice therapy in improving speech and swallowing functions and related quality of life measures in 11 Korean adults (males = 7, females = 4, mean age = 42.4±7.11) with cerebral palsy manifested with dysarthria and dysphagia. Significant post-treatment outcomes were found for speech functions (maximum phonation time, voice intensity, and diadochokinetic rate), swallowing functions (oral and pharyngeal phase symptoms for thick, semi-thin, and thin boluses), and quality of life measures (emotional impact of voice handicap, sleep distress, fatigue, and fear related to swallowing). Such improvements were observed in the all-participant group and the in-person LSVT-X group. These data support that LSVT-X and LSVT e-LOUD are equally effective in treating this population, and that voice

therapy can significantly improve speech and swallowing functions and related quality of life measures in adults with cerebral palsy.

Key words: cerebral palsy, dysarthria, dysphagia, voice therapy, LSVT, telepractice

The clinical efficacy of voice therapy for adult cerebral palsy with dysarthria and dysphagia

Alyssa Mae Park

Graduate Program of Speech and Language Pathology

The Graduate School, Yonsei University

(Directed by Professor Sung-Rae Cho)

I. INTRODUCTION

1. Financial disclosure

The author of this thesis is a Global Korea Scholarship scholar sponsored by the Korean Government.

2. Background

Cerebral palsy (CP) is a group of permanent neurodevelopmental disorders that affect the development of movement and posture[1]. Occurring in approximately two to three per 1,000 live births[1,2], CP is the most common developmental disorder that results in

chronic motor impairment and disability[3]. CP is caused by insults or injuries to the central nervous system in utero or in the first years of life, often from hypoxia, infection, stroke, hypotension, or trauma[1]. The most common cause of CP is in-utero events, accounting for approximately 80% of cases. Before 20 weeks gestation, maternal infections and genetic mutations can cause brain maldevelopment. In the early-mid stages of pregnancy, hypoxia, hypotension, sepsis, white matter disease of prematurity (periventricular leukomalacia), and pressure from intraventricular hemorrhage are common causes of brain injury due to vascular compromise. Later in pregnancy, injuries to the basal ganglia or middle cerebral artery territory infarctions can result in CP. Typically, gestational brain maldevelopments are associated with more severe phenotypes of CP that affect the whole body with comorbidities such as epilepsy, communication disorders, dysphagia, and cognitive impairment[1].

Classification of CP is based on the bodily distribution and the motor type. Distribution is described as unilateral or bilateral. Motor types include spastic, dyskinetic, ataxic, and mixed, with spastic being the most prevalent at 85-90% of cases. Spastic type CP is characterized by increased tone, hyper-reflexia, and upper motor neuron signs. Dyskinetic type, making up seven percent of CP cases, is characterized by recurring, uncontrolled, and involuntary movements with dystonia, chorea, or athetosis. Ataxic type, comprising only four percent of CP cases, features generalized

hypotonia and loss of muscle coordination due to cerebellar impairment. Mixed-type CP is characterized by a mixture of any of the motor types listed above, with a mixture of spasticity and dyskinesia being most common[1].

Historically, children with CP and multiple comorbidities had relatively high mortality rates, especially in cases with multiple comorbidities and cognitive impairment. However, modern medicine has greatly improved the rate at which children with CP reach adulthood, resulting in larger numbers of adults with CP in the population than before[4]. As a disorder characterized by non-progressive, lifelong impairments[1], CP continues to affect children who grow into adulthood, including symptoms of dysphagia and dysarthria[4–8].

Previous studies show that 90% of people with CP exhibit dysarthria[9], with symptoms such as phonation breaks, fluctuations in pitch and loudness, slow rate of speech, strained voice quality, hypo or hypernasality, and imprecise articulation[2,9,10]. Additionally, approximately 22% of children with CP experience limitations due to low speech intelligibility from dysarthria[2]. Spastic and dyskinetic CP types are most likely to show dysarthria that impacts all of the speech systems from respiration and phonation to resonance, prosody, and articulation[2]. Communicative impairments resulting from dysarthria cause social restrictions and limitations on participation, which negatively impact quality of life for people with CP[9]. One study found that

laypersons who listened to dysarthric speech by speakers with CP presumed that the speakers with CP were less intelligent, less likeable, and less sociable, and had negative emotions and behavioral intentions, as compared to non-dysarthric speakers[11]. Thus, the communicative impairments of people with CP in combination with the attitudes of communicative partners in the general population can cause people with CP to be socially isolated and experience lower quality of life.

Additionally, previous studies report that 90% of children with CP experience chronic gastrointestinal problems, including approximately 50.4% with swallowing disorders[12,13]. Difficulty with swallowing and poor oromotor skills are reportedly some of the first noticeable symptoms of CP in neonates[3]. Previous studies have shown that children with CP tend to swallow less frequently and less efficiently than typically developing children[14], and those with dysphagia have difficulty inhibiting activation of the muscles of mastication, exhibit abnormal respiratory-swallow coordination, and may have insufficient intrathoracic and subglottic pressure[15]. These symptoms of dysphagia present risks for aspiration during swallowing, which can lead to aspiration pneumonia, one of the leading causes of death for children with CP[4]. In addition to adverse health outcomes, dysphagia is associated with reduced quality of life due to social restrictions and limitations on participation in society[16,17].

As CP is a non-progressive, lifelong condition, interventions for CP are based on symptom management and meaningful improvement of quality of life measures related to the World Health Organization's International Classification of Functioning, Disability, and Health (ICF) model. The ICF model classifies disability as an interaction between bodily structure, activity, and participation. In the case of CP, the most meaningful outcomes generally pertain to activity (e.g., walking, singing, speaking) and participation (e.g., social engagement, employment), as the spasticity, dystonia, and dyskinesia associated with CP are not curable[1].

The Lee Silverman Voice Therapy (LSVT) has been demonstrated by multiple studies to improve the symptoms of dysarthria and dysphagia in Parkinson's disease and other neurological disorders through the process of motor learning and intensive intervention[18–22]. LSVT-LOUD is the standard treatment protocol comprised of 16 one-hour treatment sessions provided four consecutive days per week for one month. The exercises include multiple repetitions of sustained vowel phonation, pitch glides, functional phrase repetition, and reading or conversational tasks, and emphasis is given to constant use of a loud voice with good voice quality and to generalization or calibration of the louder voice. Two alternative modes of LSVT have been researched in previous studies: LSVT-X and LSVT e-LOUD. LSVT-X is an extended program following the same protocol as LSVT-LOUD, except that the frequency of treatments

is reduced to two times per week over an eight-week period. Meanwhile, LSVT e-LOUD is an adaptation of the LSVT-LOUD protocol through telepractice. Studies have supported that LSVT-LOUD, LSVT-X, and LSVT e-LOUD result in increased vocal loudness, increased maximum phonation time, and increased pitch range due to the repetitive and intensive exercise of the larynx and the vocal folds[23–29]. Additionally, evidence has shown that LSVT improves symptoms of dysphagia due to the similarity of related anatomy and physiology between speech and swallowing structures[18,20].

3. Purpose of study

This study aims to evaluate the potential for LSVT-LOUD as an intervention method for addressing dysarthria and dysphagia in adults with CP. Previous studies have shown preliminary results indicating that LSVT is effective at increasing vocal loudness, sustained vowel phonation, pitch variability, DDK rate, speech intelligibility, and even increased brain activity following treatment in children with CP[2,30,31]. Research in neuroscience has shown that the central nervous system retains a certain degree of plasticity through adulthood[3]. This suggests that intervention methods such as LSVT that incorporate repetitive, salient, intense, and transferable use[32] of the pharynx, larynx, and vocal folds could stimulate motor development related to speech and swallowing in both children and adults with CP.

This study also aims to demonstrate whether LSVT is an appropriate and effective intervention method in reducing the symptoms of dysarthria and dysphagia that negatively impact activity and participation in life for adults with CP. Children and adults with CP will benefit exceptionally from the availability of a treatment method that simultaneously targets multiple barriers to their success and happiness. Additionally, evidence supporting the provision of LSVT e-LOUD in this population will increase their access to healthcare, which is a barrier to adults with CP as they transition out of pediatric rehabilitation service models[4].

4. Hypotheses

Based on the above information, the hypotheses of this study are as follows.

For adults with dysarthria and dysphagia secondary to CP, voice therapy:

(1) reduces the severity of dysarthria assessed auditory-perceptually;

(2) reduces the severity of dysphagia assessed with a videofluoroscopic swallow study;

(3) improves self-reported speech-, voice-, and swallowing-related quality of life.

II. MATERIALS AND METHODS

1. Participants

The participants (n = 11) included seven males (64%) and four females (36%) with a mean age of 42.4 years (±7.11) and a mean K-MMSE score of 26 out of 30 (±1.272, range = 4). A total of 10 additional Korean adults with cerebral palsy were recruited but withdrew from the study prior to completing the treatment program. Seven participants (64%) participated in in-person therapy with a frequency of two sessions per week for eight weeks with 16 sessions total, and four participants (36%) participated in telepractice with a frequency of four sessions per week for four weeks with 16 sessions total.

The inclusion and exclusion criteria in this study are as follows.

The inclusion criteria were 1) diagnosis of CP, 2) signs and symptoms of dysarthria, 3) signs and symptoms of dysphagia, and 4) the ability to fully understand and follow the researcher's verbal instructions.

The exclusion criteria were 1) complaint of severe laryngeal or pharyngeal pain during the treatment process, and 2) failure to complete the treatment program.

Table 1. Participant Information

No.	Sex	Age (years)	K-MMSE[2]	Treatment method	Dysarthria type	Dysarthria severity	Speech characteristics
P1[1]	M	39	28	In-Person, 2x/wk	Spastic	Severe	Strained-strangled voice quality, pitch breaks, excessive articulation, imprecise consonants, distorted vowels
P2	M	53	27	In-Person, 2x/wk	Mixed	Severe	Hypernasality, monopitch, imprecise consonants, distorted vowels
P3	M	28	26	In-Person, 2x/wk	Flaccid	Profound	Hypernasality, monopitch, variation in loudness, slow rate, inconsistent breathy voice quality, imprecise consonants, distorted vowels
P4	F	48	27	In-Person, 2x/wk	Mixed	Severe	Hypernasality, strained-strangled voice quality, monopitch, slow rate, low pitch, imprecise consonants, nasal emissions
P5	M	48	27	In-Person, 2x/wk	Spastic	Profound	Strained-strangled voice quality, occasional voice stoppages, inconsistent breathy harsh voice quality, slow rate, excessive articulation, imprecise consonants, distorted vowels
P6	M	33	30	In-Person, 2x/wk	Spastic	Moderate	Hyponasality, short phrases, intermittent hypernasality, strained-strangled voice quality, excessive articulation
P7	M	46	27	In-Person, 2x/wk	Mixed	Severe	Hypernasality, strained-strangled voice quality, imprecise consonants, short phrases, slow rate
P8	F	40	30	Telepractice, 4x/wk	Mixed	Profound	Strained-strangled voice quality, hypernasality, nasal emissions, imprecise consonants, slow rate

P9	F	44	28	Telepractice, 4x/wk	Mixed	Severe	Hypernasality, strained-strangled voice quality, short phrases, slow rate, voice breaks
P10	M	43	27	Telepractice, 4x/wk	Spastic	Profound	Rough, strained, glottal fry, diplophonia, imprecise consonants, palilalia, hypernasality, poor SMRs, slow rate
P11	F	44	30	Telepratice, 4x/wk	Mixed	Moderate	Rough, strained, variable pitch, hypernasality, imprecise consonants, short phrases

[1]P: Participant.

[2]K-MMSE: Korean Mini-Mental State Examination.

2. Methods

A. Data collection

This study was conducted under the approval of the Sinchon Severance Hospital Institutional Review Board (IRB) (No. 4-2012-0468). According to the Korean Ministry of Health and Welfare[33], approximately 3,891 Korean adults with CP live in the capital area and have comorbid dysarthria and dysphagia. Thus, representative sample would ideally include 350 participants for a 5% margin of error at 95% confidence. Unfortunately, this sample size is not feasible at the time of this study for three reasons. First, the sample is limited to the caseload of Dr. Sung-Rae Cho at Sinchon Severance Rehabilitation Hospital in Seoul, South Korea. Second, the clinical nature of this study requires roughly 18 hours of direct contact with each participant. With two student clinicians providing treatment and assessments, the study would take a minimum of 24 months to complete 350 treatment programs. Third, the COVID-19 pandemic has resulted in fewer willing participants and restrictions on facility access. A smaller sample would allow for preliminary findings on which further research can be based. A convenience sampling of ten Korean adults with CP, dysarthria, and dysphagia in the capital area have been recruited to this study.

After explaining the purpose and method of the study, verbal and written consent for participation in the study were obtained from the participants or their legal representatives. After obtaining consent, each participant underwent the research protocol in the order of muscle tension assessment, cognitive assessment, pre-treatment assessment, voice therapy, post-treatment assessment, and follow-up assessment. The participant was instructed to complete the quality of life-related questionnaires individually or with the assistance of his or her guardian; however, the clinician was available to clarify the questionnaire items.

(A) Cognitive assessment

A researcher used the Korean Mini-Mental State Examination (K-MMSE)[34] to assess cognitive function.

(B) Speech tasks

All the speech assessment tasks were recorded in a quiet room with environmental noise less than 50 dB. The participant was seated across from a researcher in a chair in a comfortable, upright position. The SONY ECM-MS907 (SONY Corp., Tokyo, Japan) condenser microphone was consistently held at a 10 cm distance and a 90-degree angle from the participant's mouth and connected to the ICD-UX560F (SONY

Corp., Tokyo, Japan) voice recorder. The voice recorder was set to a sample rate of 44.1 kHz and a bit depth of 16 bits with the recording level fixed at -12 dB. The speech data collected were as follows.

(a) Prolonged /a/ vowel phonation

The participant produced the vowel /a/ at a comfortable pitch and intensity for five seconds for the purpose of assessing voice quality and phonation characteristics.

(b) Maximum phonation time (MPT)

The MPT task is used to assess respiration and phonation in isolation from the characteristics other speech subsystems[35]. The participant produced the vowel /a/ for as long as possible for a total of three repetitions.

(c) Diadochokinetic rate (DDK)

DDK involves the tasks of repeating a single syllable (alternating motion rate, AMR) and repeating a sequence of three different syllables (/puh/, /tuh/, /kuh/) (sequential motion rate, SMR). AMR allows analysis of the motor rate and regularity of the jaw, lips, and tongue, as well as respiration, phonation, velar function, and articulation

control in dysarthric speakers. Additionally, SMR allows evaluation of the characteristics of sequential articulatory movements.

For AMR, the participant repeated the syllables /puh/, /tuh/, and /kuh/ as rapidly and regularly as possible for five seconds. For SMR, the participant repeated the sequence /puh tuh kuh/ as rapidly and regularly as possible for five seconds.

(d) Functional phrase

Voice intensity was calculated based on the participant's utterance of an everyday functional phrase, [a̠nŋjʌ̹ŋɦa̠sʰe̞jo], meaning *hello* in Korean.

(e) Phonetic feature phrases

The participant read or repeated phrases containing specific phonetic features for analysis of speech function, dysarthria type, and dysarthria severity.

The phonetic features considered include nasal resonance, oral resonance, bilabial stop-plosives, post-alveolar stop-plosives, velar stop-plosives, palatal affricates, dental-alveolar fricatives, lateral liquids, and alveolar taps.

(f) Connected speech sample

Connected speech samples allow analysis of speech intelligibility and speech rate. The participant provided extemporaneous, natural responses to the researcher's questions for a one- to two-minute connected speech sample.

(C) Speech-related quality of life

The participant completed standardized questionnaires related to speech and quality of life.

(a) Voice Handicap Index (VHI)

The VHI provides self-reported insight into the impact of voice disorders on the participant's psychological well-being, divided into physical, functional, and emotional sections. Each section has 10 items, for a total of 30 items[36].

(b) Speech Handicap Index-15 (SHI-15)

The SHI-15 is a short form questionnaire that provides self-reported insight on the impact of dysarthria and other speech problems on the participant's psychosocial well-being. It has a total of 15 items[37].

(D) Swallowing function

(a) Videofluoroscopic swallowing study (VFSS)

After obtaining videos of each participant's VFSS administrated by rehabilitation specialists at Sinchon Severance Rehabilitation Hospital, the researcher scored the swallowing functions using the Penetration Aspiration Scale (PAS)[38] and the Videofluoroscopic Dysphagia Scale (VDS)[39]. During the VFSS, the participant consecutively swallowed thick, semi-thin, and thin boluses of 12% barium solutions, each in the volumes of 5 ml and 15 ml.

For each bolus, the PAS evaluates the presence of penetration and aspiration on a scale of 1 to 8, and the VDS evaluates various swallowing functions of the oral and pharyngeal phases of swallowing.

The scale for the PAS is as follows: 1 = food does not enter the airway; 2 = food enters the airway, stays above the vocal folds, and exits the airway; 3 = food enters the airway, stays above the vocal folds, and does not exit the airway; 4 = food enters the airway, reaches the vocal folds, and exits the airway; 5 = food enters the airway, reaches the vocal folds, and does not exit the airway; 6 = food enters the airway, passes below the vocal folds, and exits the larynx or airway; 7 = food enters the airway, passes below the vocal folds, and does not exit the larynx or airway; 8 = food enters

the airway, passes below the vocal folds, and there is no reflex to expel it from the airway.

(E) Swallowing-related quality of life

The participants completed a standardized questionnaire related to swallowing and quality of life.

(a) Swallowing-quality of life (SWAL-QOL)

The SWAL-QOL provides self-reported insight into the participant's swallowing functions and dysphagia symptoms as well as the impact of dysphagia on the participant's quality of life. There are 44 items divided into 11 sub-categories[17].

(F) Voice treatment

This study utilized the LSVT-X and LSVT e-LOUD modifications to the LSVT LOUD protocol to provide voice treatment to the participant. Two speech-language pathology graduate students certified in LSVT-LOUD provided LSVT treatments to the participant inside the hospital's speech therapy practicum room, or virtually using the Zoom software.

LSVT-LOUD consists of 16 sessions that are 60 minutes each, at a frequency of four sessions per week for one month. LSVT-X is a modification that prescribes the same amount of sessions at a frequency of two sessions per week for two months. LSVT e-LOUD refers to the provision of therapy via telepractice. These modifications were applied during the study period to accommodate for facility requirements and patient schedules.

LSVT-LOUD treatment sessions contain 30 minutes of functional exercises (prolonged /a/ vowel phonation, low-to-high pitch glide phonation, high-to-low pitch glide phonation, and functional phrase recitation) followed by 30 minutes of hierarchy exercises (session 1-4: word/phrase level; session 5-8: sentence level; session 9-12: paragraph level; session 13-16: conversational level).

The participant was assigned homework after each session, to be completed for 5-10 minutes one time on treatment days and two times on non-treatment days. Calibration assignments were also given each session to facilitate generalization of treatment results into daily life.

B. Data analysis

(A) Dysarthria type and severity classification

The author listened to the recorded prolonged vowel phonation, DDK, reading (functional phrases, phonetic feature phrases, standardized Autumn/Travel passages), and connected speech samples for each participant to determine the type and severity of dysarthria. The features assessed auditory-perceptually consist of those identified in previous studies, scored on a five-point scale: '0' = normal, '1' = mild, '2' = moderate, '3' = severe, '4' = profound[35].

The intra-rater reliability measured by Cohen's Kappa across two trials was found to be .694 for dysarthria type, .861 for pre-treatment dysarthria severity, and .728 for post-treatment dysarthria severity.

(B) Speech functions

The speech data files collected were analyzed using the Praat (Ver. 5.2.23) software.

(a) Maximum phonation time (MPT)

MPT was analyzed using Praat, by obtaining the length in seconds of the total uninterrupted phonation time. The best performance of the three MPT attempts was used for analysis.

(b) Diadochokinetic rate (DDK)

DDK was obtained using Praat to count the number of repetitions of each AMR and SMR within a five-second section.

(c) Voice intensity

Intensity was obtained in decibels (dB) using Praat by opening the file for the functional phrase, selecting the entire phrase, and obtaining the 'Intensity' of the selected section.

(C) Speech-related quality of life

(a) Voice Handicap Index (VHI)

All 30 items on the VHI are rated on a five-point scale (0 = never, 1 = almost never, 2 = sometimes, 3 = almost always, 4 = always). The total score ranges from 0 to 120, where a higher score indicates high levels of handicap.

(b) Speech Handicap Index-15 (SHI-15)

All 15 items on the SHI-15 are rated on a five-point scale (0 = never, 1 = almost never, 2 = sometimes, 3 = frequently, 4 = always). The total score ranges from 0 to 75, where a higher score indicates high speech problem index.

(D) Swallowing function

The video file from the videofluoroscopic swallowing study (VFSS) were analyzed by the researcher to assess swallowing function. The two scales listed below were used to quantify the dysphagia severity.

(a) Penetration-Aspiration Scale (PAS)

The PAS is divided into eight stages of laryngeal penetration and tracheal aspiration based on location of the bolus in respect to the vocal folds[38]. A rating of 1 indicates no aspiration, and a rating of 8 indicates the most severe aspiration. Scores for all six boluses during the swallowing study were totaled and analyzed with a score range between 6 and 48.

(b) Videofluoroscopic Dysphagia Scale (VDS)

The VDS is a scale for recording the presence and severity of various oral and pharyngeal phase swallowing functions for a total of six bolus swallows from thick to thin viscosity. The total score for each bolus ranges from 0 to 100, where a higher score indicates more severe dysphagia[39]. The scores were divided into oral phase (items 1 to 7), pharyngeal phase (items 8 to 14), and total score (items 1 to 14), and the scores of all six boluses were totaled for analysis.

(E) Swallowing-related quality of life

(a) Swallowing-quality of life (SWAL-QOL)

The SWAL-QOL contains 44 items related to 11 categories: burden, eating duration, eating desire, symptom frequency, food selection, communication, fear, mental health, social functioning, sleep, fatigue, and dysphagia symptoms. Each item is scored on a five-point scale. Excluding the dysphagia symptom section, the total score ranges between 0 and 100, where a higher score indicates better quality of life[17].

C. Statistical analysis

IBM SPSS (Statistical Package for the Social Science, version 25.0) for Windows was used for statistical analysis.

First, Mann-Whitney U-tests were performed to assess the normality of the pre-treatment and post-treatment data across the whole sample and within treatment groups for auditory-perceptual scores of dysarthria severity, acoustic measures of voice quality, swallowing function scores, speech-related quality of life scores, and swallowing-related quality of life scores.

Second, Wilcoxon signed rank tests were performed to analyze the differences in data over time and presence of group, time, and group-by-time interaction effects for the speech, swallowing, and quality of life measures.

Mann-Whitney U tests were conducted to analyze significant differences in the pre- and post-treatment outcomes between treatment groups, divided by treatment group (LSVT-X: in-person twice weekly vs. LSVT e-LOUD: telepractice four times weekly). The Wilcoxon signed rank tests were conducted to analyze significant differences in the pre- and post-treatment outcomes for the two treatment groups.

III. RESULTS

A. Changes in speech function after treatment

(A) Dysarthria severity

The participants' dysarthria types and severity were assessed auditory-perceptually using speech sample recordings. By type, six were mixed type (54.5%), four were spastic type (36.4%), and one was flaccid type (9.1%); by severity, the mean dysarthria severity was 3.18 out of 4.0 (severe; ±.751), and the distribution was 18.2% moderate (n = 2), 45.5% severe (n = 5), and 36.4% profound (n = 4).

No significant differences were revealed in pre-treatment or post-treatment auditory-perceptual dysarthria severity scores between treatment groups (Table 2). Also, no changes were found in auditory-perceptual dysarthria severity scores after voice treatment (Table 3 and 4).

(B) Dysphonia severity

No significant differences were revealed in pre-treatment or post-treatment auditory-perceptual dysphonia severity scores between treatment groups (Table 2). Also, no significant differences were found in auditory-perceptual dysphonia severity scores after voice treatment (Table 3 and 4).

(C) Maximum phonation time (MPT)

No significant differences were revealed in pre-treatment or post-treatment MPTs between groups (Table 2).

A significant difference was found in MPTs after voice treatment for all participants (p = .003) and in the in-person group (p = .018). With a mean pre-treatment MPT of 7.9 seconds and a mean post-treatment MPT of 11.9 seconds, this indicates an increase in sustained phonation time for the in-person group (Table 3 and 4).

(D) Voice intensity

No significant differences were revealed in pre-treatment or post-treatment voice intensity levels (dB) between treatment groups (Table 2).

A significant difference was found in voice intensity levels after voice treatment for all participants (p = .013), but not in each treatment group. This suggests that the combined group showed significant improvement in loudness after treatment (Table 3 and 4).

(E) Diadochokinetic rate (DDK)

No significant differences were revealed in pre-treatment or post-treatment DDK rates for AMRs and SMRs between treatment groups (Table 2).

A significant difference was found in DDK rates for /puh/ (p = .020) and /puh tuh kuh/ (p = .024) after voice treatment (Table 3); however, neither group separately showed significant changes (Table 4). With a mean pre-treatment DDK rate of 15.6 and 4.8 times per five seconds for /puh/ and /puh tuh kuh/, respectively, and mean post-treatment rates of 17.1 and 6.1 times per five seconds, this indicates an increased rate of articulation for both treatment groups when viewed together.

Table 2. Differences in speech functions between groups

	Pre-Treatment (S.D.)			**Post-Treatment (S.D.)**		
Measure	LSVT-X (n = 7)	e-LOUD (n = 4)	*p*-value	LSVT-X (n = 7)	e-LOUD (n = 4)	*p*-value
Dysarthria Severity (0-4)	3.14 (.690)	3.25 (.957)	.760	3.14 (.690)	3.00 (1.155)	.841
Dysphonia Severity (0-4)	2.86 (.690)	3.00 (.816)	.754	2.71 (.488)	3.00 (.816)	.903
MPT (s)	7.62 (3.428)	8.39 (3.274)	.571	11.02 (4.462)	13.68 (3.079)	.257
Voice Intensity (dB)	80.21 (1.959)	79.74 (1.444)	.345	80.79 (1.129)	82.42 (1.929)	.131
DDK (/puh/)	15.00 (5.538)	16.75 (4.272)	.634	16.86 (6.176)	17.7 (4.031)	1.000
DDK (/tuh/)	14.43 (5.350)	17.25 (5.795)	.287	17.00 (7.439)	20.50 (4.796)	.636
DDK (/kuh/)	15.71 (6.264)	14.50 (4.435)	.449	15.14 (6.568)	15.75 (3.775)	.849
DDK (/puh tuh kuh/)	5.00 (1.732)	4.50 (2.380)	.772	5.86 (1.864)	6.50 (1.732)	.922

*p < .05

Table 3. Changes in speech function over time for all participants

Measure	Pre-Treatment	Post-Treatment	*p*-value
Dysarthria Severity (0-4)	3.18 (.751)	3.09 (.831)	.317
Dysphonia Severity (0-4)	2.91 (.701)	2.73 (.467)	.157
MPT (s)	7.90 (3.227)	11.99 (4.073)	.003**
Voice Intensity (dB)	80.04 (1.728)	81.38 (1.600)	.013*
DDK (/puh/)	15.64 (4.965)	17.1 (5.288)	.020*
DDK (/tuh/)	15.45 (5.410)	18.27 (6.574)	.092
DDK (/kuh/)	15.2 (5.461)	15.36 (5.500)	.511
DDK (/puh tuh kuh/)	4.82 (1.888)	6.09 (1.758)	.024*

*$p < .05$

**$p < .01$

Table 4. Changes in speech function over time by group

Measure	LSVT-X			LSVT e-LOUD		
	Pre	Post	*p*-value	Pre	Post	*p*-value
Dysarthria Severity (0-4)	3.14 (.690)	3.14 (.690)	1.00	3.25 (.957)	3.00 (1.155)	.317
Dysphonia Severity (0-4)	2.86 (.690)	2.71 (.488)	.317	3.00 (.816)	3.00 (.816)	.317
MPT (s)	7.62 (3.428)	11.02 (4.462)	.018*	8.39 (3.274)	13.68 (3.079)	.068
Voice Intensity (dB)	80.21 (1.959)	80.79 (1.129)	.128	79.74 (1.444)	82.42 (1.929)	.068
DDK (/puh/)	15.00 (5.538)	16.86 (6.176)	.062	16.75 (4.272)	17.7 (4.031)	.157
DDK (/tuh/)	14.43 (5.350)	17.00 (7.439)	.397	17.25 (5.795)	20.50 (4.796)	.102
DDK (/kuh/)	15.71 (6.264)	15.14 (6.568)	.916	14.50 (4.435)	15.75 (3.775)	.102
DDK (/puh tuh kuh/)	5.00 (1.732)	5.86 (1.864)	.063	4.50 (2.380)	6.50 (1.732)	.144

*$p < .05$

B. Changes in swallowing function after treatment

(A) Videofluroscopic Dysphagia Scale (VDS)

No significant differences were revealed in pre-treatment or post-treatment VDS scores, divided into oral phase, pharyngeal phase, and total score, between treatment groups (Table 5).

Significant differences were found in the VDS's oral phase (p = .008), pharyngeal phase (p = .010), and total scores (p = .008) after treatment for all participants. Analysis of each bolus revealed significant differences in the oral phase in the semi-thin 15 ml bolus (p = .011), thin 5 ml bolus (p = .038), and thin 15 ml bolus (p = .030); as well as in the pharyngeal phase for the thick 5 ml bolus (p = .028), the semi-thin 5 ml bolus (p = .038), the thin 5 ml bolus (p = .005), and the thin 15 ml bolus (p = .008) (Table 6). Divided into treatment groups, only the in-person group was found to have significant changes in the oral phase (p = .043), pharyngeal phase (p = .028), and total score (p = .028) of the VDS (Table 7). These differences indicate meaningful reductions of symptoms of dysphagia in the oral and pharyngeal phases of the swallow over time for boluses of each consistency, especially for the in-person group.

(B) Penetration-Aspiration Scale (PAS)

No significant differences were revealed in pre-treatment or post-treatment PAS total scores between treatment groups (Table 5). Additionally, no significant differences were found in PAS scores after voice treatment for any boluses. However, it is relevant to note that the mean PAS score for each bolus pre- and post-treatment did not surpass two points, which indicates mild penetration of the bolus into the airway (Table 6 and 7).

Table 5. Differences in swallowing functions between groups

	Pre-Treatment (S.D.)			**Post-Treatment (S.D.)**		
Measure	LSVT-X (n = 7)	e-LOUD (n = 4)	*p*-value	LSVT-X (n = 7)	e-LOUD (n = 4)	*p*-value
VDS Oral Phase[1]	59.42 (40.347)	40.37 (11.643)	.450	36.64 (26.436)	25.25 (16.168)	.570
VDS Pharyngeal Phase[2]	110.87 (64.814)	63.50 (27.291)	.345	40.14 (23.905)	40.12 (22.399)	.925
VDS Total Score[3]	169.57 (102.905)	103.87 (35.122)	.450	79.78 (47.622)	65.37 (35.666)	.705
Penetration-Aspiration Scale	7.86 (3.185)	6.75 (.957)	.684	6.29 (.488)	7.75 (2.363)	.272

*$p < .05$

**$p < .01$

[1]Score represents total for all six boluses, with a maximum score of 240.

[2]Score represents total for all six boluses, with a maximum score of 360.

[3]Score represents total for all six boluses, with a maximum score of 600.

Table 6. Changes in swallowing function over time for all participants

Measure	Pre-Treatment	Post-Treatment	*p*-value
Oral Phase	49.90 (10.537)	30.946 (7.370)	.008**
Thick 5 ml	7.54 (6.46)	5.77 (4.931)	.109
Thick 15 ml	7.77 (7.107)	5.36 (4.153)	.213
Semi-thin 5 ml	16.68 (26.953)	13.63 (27.430)	.183
Semi-thin 15 ml	9.86 (7.396)	5.36 (4.884)	.011*
Thin 5 ml	16.50 (26.679)	5.13 (4.879)	.038*
Thin 15 ml	9.81 (6.611)	5.00 (4.387)	.030*
Pharyngeal Phase	87.18 (17.304)	40.134 (7.338)	.010**
Thick 5 ml	17.09 (10.331)	10.22 (9.566)	.028*
Thick 15 ml	16.04 (11.323)	6.68 (6.290)	.050
Semi-thin 5 ml	13.95 (11.550)	4.40 (4.122)	.038*
Semi-thin 15 ml	15.95 (12.538)	8.31 (8.497)	.139
Thin 5 ml	17.27 (8.928)	5.727 (6.783)	.005**
Thin 15 ml	19.00 (14.122)	4.77 (5.542)	.008**
Total Score	136.72 (27.088)	71.08 (13.789)	.008**
PAS	7.30 (.833)	7.018 (.445)	.606
Thick 5 ml	1.00 (.000)	1.00 (.000)	1.00
Thick 15 ml	1.00 (.000)	1.00 (.000)	1.00
Semi-thin 5 ml	1.00 (.000)	1.00 (.000)	1.00
Semi-thin 15 ml	1.18 (.603)	1.09 (.301)	.655
Thin 5 ml	1.36 (.504)	1.54 (1.507)	1.00
Thin 15 ml	1.90 (2.071)	1.18 (.404)	.157

*$p < .05$

**$p < .01$

Table 7. Changes in swallowing function over time by group

	LSVT-X			LSVT e-LOUD		
Measure	Pre	Post	*p*-value	Pre	Post	*p*-value
VDS Oral Phase	59.42 (40.347)	36.64 (26.436)	.043*	40.37 (11.643)	25.25 (16.168)	.068
VDS Pharyngeal Phase	110.87 (64.814)	40.14 (23.905)	.028*	63.50 (27.291)	40.12 (22.399)	.068
VDS Total Score	169.57 (102.905)	79.78 (47.622)	.028*	103.87 (35.122)	65.37 (35.666)	.068
Penetration-Aspiration Scale	7.86 (3.185)	6.29 (.488)	..059	6.75 (.957)	7.75 (2.363)	.285

*$p < .05$

**$p < .01$

C. Changes in quality of life after treatment

(A) Speech Handicap Index (SHI-15)

No significant differences were revealed in pre-treatment or post-treatment SHI scores, between treatment groups (Table 8). Additionally, no significant changes were found between pre- and post-treatment data (Table 9 and 10). This suggests that there was no significant subjective improvement in speech-related quality of life measures for the participants.

(B) VHI Handicap Index (VHI)

No significant difference in pre-treatment or post-treatment VHI scores between treatment groups (Table 8).

Significant differences were found in the emotional subcategory ($p = .005$) and the total score ($p = .018$) for all participants (Table 9). With the groups viewed separately, only the in-person group was found to have significant changes in the emotional subcategory ($p = .028$) and the total score ($p = .028$) (Table 10). This indicates that there was meaningful subjective improvement of the participants' voice-related quality of life, particularly in emotional aspects, after voice treatment, with more significant changes seen in the in-person group.

(C) Swallowing-Quality of Life (SWAL-QOL)

A significant difference was revealed in pre-treatment SWAL-QOL fatigue scores (p = .022) between treatment groups (Table 8). This suggests that the treatment groups had significantly different baseline scores for these categories pre-treatment, while the rest of the measures were not found to be meaningfully different between treatment groups.

Significant differences were found in the fear (p = .027), sleep (p = .027), and fatigue (p = .018) subcategories for all participants (Table 9). Viewing the groups separately, only the in-person group was found to have a significant change in the sleep (p = .042) and fatigue (p = .027) scores (Table 10). This indicates that there was meaningful subjective improvement of the participants' swallowing-related quality of life in regard to fears, levels of fatigue, and trouble sleeping related to dysphagia, especially in the in-person group.

Table 8. Differences in quality of life between groups

	Sub-category	Pre-Treatment			Post-Treatment		
		LSVT-X (n = 7)	e-LOUD (n = 4)	*p*-value	LSVT-X (n = 7)	e-LOUD (n = 4)	*p*-value
SHI-15	Speech	16.28 (5.707)	19.25 (7.889)	.345	14.28 (8.557)	15.25 (9.878)	.849
	Psycho-social	18.71 (5.794)	10.00 (7.438)	.106	15.85 (11.466)	6.75 (3.774)	.256
	Total Score	33.71 (11.499)	29.25 (14.818)	.507	29.57 (16.561)	21.50 (13.625)	.394
VHI	Functional	18.00 (10.567)	12.00 (11.916)	.298	12.85 (9.856)	675 (2.753)	.449
	Physical	20.71 (9.911)	20.25 (7.719)	.850	14.28 (12.539)	16.75 (8.180)	1.00
	Emotional	19.00 (11.180)	12.00 (11.916)	.705	11.42 (9.997)	7.75 (1.258)	.704
	Total Score	57.71 (28.819)	49.25 (2.958)	.704	38.5 (31.463)	31.25 (7.410)	.705
SWAL-QOL	Burden	7.57 (1.618)	7.25 (2.362)	.921	7.57 (2.636)	8.75 (.500)	.625
	Eating Duration	7.00 (2.160)	8.75 (.957)	.171	6.85 (2.267)	8.25 (1.707)	.337
	Eating Desire	12.28 (1.889)	14.25 (.957)	.083	12.85 (1.772)	14.00 (.816)	.333
	Symptom Frequency	50.00 (8.602)	43.00 (25.806)	.776	52.42 (11.193)	59.75 (9.178)	.256
	Food Selection	8.42 (2.935)	10.00 (.000)	.149	8.57 (2.992)	10.00 (.000)	.262
	Commun-ication	6.71 (2.058)	7.00 (2.581)	.849	7.00 (3.109)	7.00 (1.825)	.775
	Fear	14.42 (6.133)	17.25 (1.500)	.702	16.57 (5.652)	19.00 (.816)	.437
	Mental Health	21.28 (7.319)	24.25 (.957)	.689	21.57 (7.114)	24.50 (1.000)	.718
	Social Function	23.85 (2.035)	24.25 (.957)	.827	23.28 (4.535)	25.00 (.000)	.450
	Sleep	5.42 (3.258)	7.50 (1.732)	.291	7.57 (3.047)	8.50 (1.732)	.550
	Fatigue	7.00 (2.516)	12.25 (2.753)	.022*	9.42 (3.359)	13.25 (2.872)	.123
	Total Score	164.00 (27.184)	188.75 (10.750)	.130	173.71 (39.368)	198.00 (8.366)	.257

*$p < .05$

Table 9. Changes in quality of life over time for all participants

	Sub-category	Pre-Treatment (SD)	Post-Treatment (SD)	*p*-value
SHI-15	Speech	17.36 (6.360)	14.63 (8.570)	.332
	Psychosocial	15.54 (7.488)	12.54 (10.211)	.167
	Total Score	32.09 (12.259)	26.63 (15.390)	.182
VHI	Functional	15.81 (10.897)	10.63 (8.369)	.075
	Physical	20.54 (8.767)	15.18 (10.768)	.074
	Emotional	18.27 (9.696)	10.09 (7.993)	.005**
	Total Score	54.63 (26.522)	35.90 (24.981)	.018*
SWAL -QOL	Burden	7.45 (1.809)	8.00 (2.144)	.397
	Eating Duration	7.63 (1.963)	7.36 (2.110)	.621
	Eating Desire	13.00 (1.843)	13.27 (1.555)	.863
	Symptom Frequency	47.45 (16.021)	55.09 (10.681)	.083
	Food Selection	9.00 (2.408)	9.09 (2.427)	.317
	Communication	6.81 (2.136)	7.00 (2.607)	.586
	Fear	15.45 (5.027)	17.45 (4.568)	.027*
	Mental Health	22.36 (5.886)	22.63 (5.731)	.317
	Social Function	24.00 (1.673)	23.90 (3.618)	.715
	Sleep	6.18 (2.892)	7.90 (2.586)	.027*
	Fatigue	8.90 (3.618)	10.81 (3.600)	.018*
	Total Score	173.00 (25.179)	182.54 (33.182)	.062

*$p < .05$

**$p < .01$

Table 10. Changes in quality of life by group

	Sub-category	LSVT-X			LSVT e-LOUD		
		Pre	Post	*p*-value	Pre	Post	*p*-value
SHI-15	Speech	16.28 (5.707)	14.28 (8.557)	.735	19.25 (7.889)	15.25 (9.878)	.109
	Psycho-social	18.71 (5.794)	15.85 (11.466)	.344	10.00 (7.438)	6.75 (3.774)	.141
	Total Score	33.71 (11.499)	29.57 (16.561)	.553	29.25 (14.818)	21.50 (13.625)	.068
VHI	Functional	18.00 (10.567)	12.85 (9.856)	.176	12.00 (11.916)	675 (2.753)	.273
	Physical	20.71 (9.911)	14.28 (12.539)	.089	20.25 (7.719)	16.75 (8.180)	.465
	Emotional	19.00 (11.180)	11.42 (9.997)	.028*	12.00 (11.916)	7.75 (1.258)	.068
	Total Score	57.71 (28.819)	38.5 (31.463)	.028*	49.25 (2.958)	31.25 (7.410)	.273
SWAL-QOL	Burden	7.57 (1.618)	7.57 (2.636)	.916	7.25 (2.362)	8.75 (.500)	.180
	Eating Duration	7.00 (2.160)	6.85 (2.267)	.786	8.75 (.957)	8.25 (1.707)	.593
	Eating Desire	12.28 (1.889)	12.85 (1.772)	.671	14.25 (.957)	14.00 (.816)	.317
	Symptom Frequency	50.00 (8.602)	52.42 (11.193)	.310	43.00 (25.806)	59.75 (9.178)	.197
	Food Selection	8.42 (2.935)	8.57 (2.992)	.317	10.00 (.000)	10.00 (.000)	1.000
	Commun-ication	6.71 (2.058)	7.00 (3.109)	.595	7.00 (2.581)	7.00 (1.825)	1.000
	Fear	14.42 (6.133)	16.57 (5.652)	.144	17.25 (1.500)	19.00 (.816)	.102
	Mental Health	21.28 (7.319)	21.57 (7.114)	.317	24.25 (.957)	24.50 (1.000)	.655
	Social Function	23.85 (2.035)	23.28 (4.535)	.655	24.25 (.957)	25.00 (.000)	.180
	Sleep	5.42 (3.258)	7.57 (3.047)	.042*	7.50 (1.732)	8.50 (1.732)	.317
	Fatigue	7.00 (2.516)	9.42 (3.359)	.027*	12.25 (2.753)	13.25 (2.872)	.317
	Total Score	164.00 (27.184)	173.71 (39.368)	.176	188.75 (10.750)	198.00 (8.366)	.141

*$p < .05$

D. Participant retention

A Chi-square (χ^2) test was conducted to analyze the dropout rates and reasons for dropping out with an aim to ascertain any meaningful trends. The results of the analysis found that there is no significant difference in dropout rates for the treatment groups (Table 11), and there is no significant correlation between the treatment groups and specific reasons for dropping out (Table 12). This indicates that the factors of having treatment in-person and through telepractice, as well as twice per week or four times per week, are not expected to cause unequal dropout rates.

Table 11. Participant retention

Treatment Group	No. Recruited	No. of Dropouts	Dropout Rate (%)	χ2 / *p*-value
In-Person, 2x/wk	15	8	53.3%	.687 / .407
Telepractice, 4x/wk	6	2	33.3%	
Total	21	10	47.6%	

*$p < .05$

Table 12. Reasons for dropping out

Treatment Group	In-Person, 2x/wk	Telepractice, 4x/wk	Total	χ2 / *p*-value
Too physically taxing	5 (62.5%)	1 (50%)	6 (60%)	.625 / .732
Does not work with schedule	2 (25%)	1 (50%)	3 (30%)	
Interruption due to COVID-19	1 (12.5%)	0 (0%)	1 (10%)	

*$p < .05$

IV. DISCUSSION

While there is extensive research on the efficacy of LSVT's standard protocol in treating disordered speech and swallowing in Parkinson's disease (PD)[18,19,25,26,40,41], there is not yet a strong body of evidence supporting LSVT as an effective treatment method for children or adults with CP. Further, there have been no published studies examining the treatment effect of LSVT delivered with an extended protocol or via telepractice on adults with CP. In this light, an investigation into the efficacy of LSVT-X, and e-LSVT for adults with CP is warranted.

Although this study has a small sample size, the results show that the alternative protocols of LSVT have a significant effect on several speech, swallowing, and quality of life indicators (Table 3, 4, 6, 7, 9, 10). In other words, this study has indicated objectively and subjectively that LSVT may improve the physiology related to speech and swallowing, thus reducing communicative difficulties, risks of poor health outcomes from dysphagia, and restrictions and limitations on daily life for adults with CP. However, these preliminary data are promising and suggest that many adults with CP, who can withstand this intensive program, would see significant benefits.

Previous studies have shown that LSVT is an effective treatment method for dysarthria in patients with neurological disorders that affect motor speech physiology,

such as PD and Down syndrome[22–24,26,42,43]. Specifically, it has been shown to improve vocal intensity, sustained phonation time, pitch range, and intelligibility, among other speech parameters[2,10,23,42,44]. Likewise, this study exhibited significant improvements in MPT, voice intensity, and DDK rates (Table 3), indicating a treatment effect from LSVT on the speech mechanism of adults with CP. Increased MPT, voice intensity, and DDK rates imply the ability to produce longer and louder utterances with more rapid and precise articulation[45], which improves communicative efficiency[46]. Unfortunately, there was no significant post-treatment change in the severity of dysarthria or dysphonia, assessed auditory-perceptually (Table 3 and 4). This study did not control for CP type, dysarthria type, or dysarthria severity, resulting in heterogeneous baseline data for the participants; thus, it is difficult to speculate on the validity of this result. It is possible that the nature of dysarthria and dysphonia in adults with CP may be resistant to change through voice treatment and that treatment techniques more specifically targeted to dysarthria would be necessary to significantly improve dysarthria severity in CP.

The participants in this study all received an instrumental swallowing assessment, which represents the gold-standard in dysphagia assessment as it allows the clinician to accurately visualize the bolus as it moves through the oropharyngeal cavity, as well as identify the anatomical and physiological symptoms of dysphagia

present during the act of swallowing[47]. Utilizing the pre- and post-treatment results of this assessment, this study showed significant improvements in dysphagia severity for the oral and pharyngeal phases for thick, semi-thin, and thin liquid boluses (Table 6, 7, and 8). These findings were consistent regardless of treatment setting and frequency, with only the pharyngeal phase of the liquid 5 ml bolus showing a significant difference between treatment groups (Table 7). This indicates that both in-person therapy and telepractice, as well as four sessions per week and two sessions per week, result in meaningful reduction of dysphagia severity. However, it is notable that the participants did not show frequent instances of severe penetration or aspiration (Table 6), indicating a mean baseline of mild penetration and aspiration in this sample[38].

In evaluating whether LSVT improved the participants quality of life related to speech, voice, and swallowing, the pre- and post-treatment outcomes were analyzed. While both treatment groups showed similar results across most measures (Table 8), ultimately the only measures exhibiting significant improvements post-treatment were the VHI's emotional subscore and total score, and the SWAL-QOL's fear, sleep, and fatigue subscores (Table 10). The VHI contains subjective questions pertaining to the functional, emotional, and physical aspects of voice handicap in everyday life (Appendix 6), and the SWAL-QOL contains questions pertaining to dysphagia's burden, impact on eating duration and desire, symptom frequency, food selection,

communication, fear, mental health, social function, sleep, and fatigue (Appendix 8). As LSVT is already considered an evidence-based treatment for voice and motor speech disorders[24], the significant improvements in voice-related quality of life reinforce the efficacy of LSVT in reducing the subjective hardships related to disordered phonation in adults with CP. The improvements in fear related to swallowing demonstrates that the participants may have experienced fewer or less severe symptoms of dysphagia, resulting in less reason to be fearful while eating. While the indicators on the SWAL-QOL related to fatigue and sleep appear to be unrelated to the participants' symptoms of dysphagia, the outcomes of reduced fear when eating and reduced emotional impact of the voice handicap are significant findings that support the use of LSVT for adults with CP. It has been well documented that communication disorders and dysphagia impact people's social and psychological well-being, including their dignity, self-esteem, confidence, and anxiety[4,48]. By showing a reduced impact of these disorders on psychosocial well-being through the alleviation of voice, speech, and swallowing symptoms, this study suggests that LSVT may be effective beyond the physiological level.

Unfortunately, these results fail to support a significant improvement in subjective quality of life related to speech, and little difference in that of swallowing. While the mean scores showed improvement after treatment, the differences in the

SHI-15 and many SWAL-QOL subscores were negligible (Table 9 and 10). This suggests that, while adults with CP may experience significant improvements to their speech and swallowing functions (Table 2-7) as evaluated with instrumental exams, systematic protocols, and experienced clinicians' judgment, they may not perceive a substantial impact on their restrictions and limitations to activity and participation. This could be explained by the fact that CP is a lifelong, non-progressive disorder that cannot be cured[1], meaning that improvements to speech and swallowing function through LSVT may not be substantial or permanent. Additionally, it is possible that participation in the research study and in the extensive and intensive treatment program increased the participants' awareness of their symptoms and the ways in which their lives are impacted on a daily basis. In fact, Participant 9 explicitly stated that she felt more aware of her voice quality and had been putting in effort to speak with a clearer voice since starting the treatment program. Like so, this increased level of awareness may have impacted the results of quality of life indicators. Further research is needed to add insight and substance to this result.

In evaluation the potential for LSVT as a treatment program for adults with CP, it is necessary to observe the reasons for which some participants withdrew from the study. In total, 21 adults with CP were recruited for the study, and 10 (47.6%) participants withdrew from the study prior to completing the treatment program.

Viewed in terms of the treatment groups, eight drop-outs belonged to the in-person LSVT-X group, and two drop-outs to the telepractice LSVT e-LOUD group, resulting in a 53.3% dropout rate for LSVT-X and a 33.3% dropout rate for LSVT e-LOUD (Table 11). The reasons for withdrawing were as follows: 1) the treatment method is too physically taxing (n = 6, 60%; LSVT-X = 5, LSVT e-LOUD = 1); 2) the treatment schedule conflicts with the participant's schedule (n = 3, 30%; LSVT-X = 2, LSVT e-LOUD = 1); and 3) the COVID-19 pandemic resulted in a sudden interruption of services mid-way through the treatment program (n = 1, 10%; LSVT-X = 1, LSVT e-LOUD = 0) (Table 12).

Of course, the nature of the LSVT treatment method necessitates intense use of the voice with long, frequent treatment sessions as well as practice outside of treatment. As a result, previous studies have already shown that withdrawal from the treatment program is relatively common in other patient groups such as PD and multiple sclerosis[49,50]. It is possible that the dropout rate for this study is higher than other studies have shown because intense phonation and speaking tasks are more physically taxing for adults with CP, especially those with spastic dysarthria and/or uncontrollable muscle tension in the head and neck. A $\chi 2$ test comparing the dropout rates and reasons for dropouts in each treatment group demonstrates that there is no significant difference between the treatment groups. In other words, neither the higher

frequency of treatment sessions nor the setting of treatment appear to result in higher dropout rates or different reasons for dropping out. Further research on the reasons for adults with CP withdrawing from LSVT would provide more insight on the accessibility of this treatment for this patient group.

There are several limitations to this study. First, the number of participants recruited for the study is ten, and the treatment groups divided by setting and frequency are too small to determine strong evidence of treatment efficacy for adults with CP and comorbid dysarthria and dysphagia. Second, the treatment groups are inadequately balanced, with a ratio of 7:4. Due to the small sample size (n = 4) in the telepractice group, few measures were found to have significant outcomes pre-post treatment; however, the individual outcome data (Appendix 9) show promising outcomes on an individual level. This indicates the need to recruit more participants for the current study to fortify the data and to get a clearer view of the outcomes. Further research with larger sample sizes and a control group will provide more insight into the effects of LSVT on a more diverse sample of adults with CP in order to consider LSVT as an evidence-based practice for treating dysarthria and dysphagia in adult CP.

Nonetheless, this study is novel in its offering of data showing the outcomes of speech functions, swallowing functions, and self-reported quality of life measures after LSVT in adults with CP, especially with the additional application of LSVT-X and e-

LSVT protocols. These modified protocols provide more accessibility of treatment to the adult CP population who may be preoccupied with other medical treatments and educational, domestic, and occupational commitments. Further research that reproduces this experiment will be needed to add strength to the evidence supporting LSVT as an effective treatment method for dysarthria and dysphagia for adults with CP.

V. CONCLUSION

In this study, 11 Korean adults with CP were provided with 16 sessions of LSVT in person or through telepractice, and their treatment outcomes were assessed in terms of speech functions, swallowing functions, and subjective self-reported quality of life. As expected, several speech functions, including MPT, vocal intensity, and DDK rates, exhibited improvements after the therapy program in both treatment groups, especially LSVT-X. Swallowing functions, assessed visually with VFSS recordings, also showed significant improvements after the voice treatment program, reducing symptoms of both oral and pharyngeal dysphagia. Moreover, the participants reported significant decreases in emotional stress, fear, sleep distress, and fatigue via the questionnaires on voice-, speech-, and swallowing-related quality of life.

These results show potential for multidimensional improvements to bodily function, social participation, and activities. Accordingly, this novel research provides valuable information supporting the use of voice therapy for adults with CP; of the extended LSVT-X program for those with busier schedules; and of LSVT through telepractice for people with less mobility. Further research investigating the factors that complicate LSVT, LSVT-X, or LSVT e-LOUD for adults with CP, as well as participants' personal insight on the suitability of LSVT for their goals, would aid the clinical decision of applying LSVT to this patient population.

REFERENCES

1. Wimalasundera N, Stevenson VL. Cerebral palsy. Pract Neurol 2016;16:184-194.

2. Pennington L, Lombardo E, Steen N, Miller N. Acoustic changes in the speech of children with cerebral palsy following an intensive program of dysarthria therapy*. Int J Lang Commun Disord 2018;53:182-195.

3. Aisen ML, Kerkovich D, Mast J, et al. Cerebral palsy: clinical care and neurological rehabilitation. Lancet Neurol 2011;10:844-852.

4. Haak P, Lenski M, Hidecker MJC, Li M, Paneth N. Cerebral palsy and aging. Dev Med Child Neurol 2009;51:16-23.

5. Yi YG, Oh B-M, Seo HG, Shin H-I, Bang MS. Dysphagia-Related Quality of Life in Adults with Cerebral Palsy on Full Oral Diet Without Enteral Nutrition. Dysphagia 2019;34:201-209.

6. Fox CM, Boliek CA. Intensive Voice Treatment (LSVT LOUD) for Children With Spastic Cerebral Palsy and Dysarthria. J Speech Lang Hear Res 2012;55:930-945.

7. Benfer KA, Weir KA, Bell KL, Ware RS, Davies PSW, Boyd RN. Oropharyngeal Dysphagia and Cerebral Palsy. Pediatrics 2017;140:e20170731.

8. Seo HG, Yi YG, Choi Y-A, et al. Oropharyngeal Dysphagia in Adults With Dyskinetic Cerebral Palsy and Cervical Dystonia: A Preliminary Study. Arch Phys Med Rehabil 2019;100:495-500.e1.

9. Schölderle T, Staiger A, Lampe R, Strecker K, Ziegler W. Dysarthria in Adults With Cerebral Palsy: Clinical Presentation and Impacts on Communication. J Speech Lang Hear Res 2016;59:216-229.

10. Ansel BM, Kent RD. Acoustic-Phonetic Contrasts and Intelligibility in the Dysarthria Associated With Mixed Cerebral Palsy. J Speech Lang Hear Res 1992;35:296-308.

11. Schölderle T, Staiger A, Schumacher B, Ziegler W. The Impact of Dysarthria on Laypersons' Attitudes towards Adults with Cerebral Palsy. Folia Phoniatr Logop 2019;71:309-320.

12. Gulati S, Sondhi V. Cerebral Palsy: An Overview. Indian J Pediatr 2018;85:1006-1016.

13. Speyer R, Cordier R, Kim J, Cocks N, Michou E, Wilkes-Gillan S. Prevalence of drooling, swallowing, and feeding problems in cerebral palsy across the lifespan: a systematic review and meta-analyses. Dev Med Child Neurol 2019;61:1249-1258.

14. Senner JE, Logemann J, Zecker S, Gaebler-Spira D. Drooling, saliva production, and swallowing in cerebral palsy. Dev Med Child Neurol 2004;46.

15. Mishra A, Malandraki GA, Sheppard JJ, Gordon AM, Levy ES, Troche MS. Voluntary Cough and Clinical Swallow Function in Children with Spastic Cerebral Palsy and Healthy Controls. Dysphagia 2019;34:145-154.

16. Kim G-H, Choi SH, Lee K-J, Choi C-H. Dysphagia Handicap Index and Swallowing Characteristics based on Laryngeal Functions in Korean Elderly. Phon Speech Sci 2014;6:3-12.

17. Kim JY, Kim DY, Kim H, Cho S-R. A Validation Study of the Korean Version of the Swallowing-Quality of Life Scale. Commun Sci Disord 2013;18:341-347.

18. Miles A, Jardine M, Johnston F, de Lisle M, Friary P, Allen J. Effect of Lee Silverman Voice Treatment (LSVT LOUD®) on swallowing and cough in Parkinson's disease: A pilot study. J Neurol Sci 2017;383:180-187.

19. Körner Gustafsson J, Södersten M, Ternström S, Schalling E. Long-term effects of Lee Silverman Voice Treatment on daily voice use in Parkinson's disease as measured with a portable voice accumulator. Logoped Phoniatr Vocol 2019;44:124-133.

20. Sharkawi AE. Swallowing and voice effects of Lee Silverman Voice Treatment (LSVT(R)): a pilot study. J Neurol Neurosurg Psychiatry 2002;72:31-36.

21. Sharkawi AE, Ramig L, Logemann JA, et al. Swallowing and voice effects of Lee Silverman Voice Treatment (LSVT®): a pilot study. :7.

22. Mahler LA, Jones HN. Intensive treatment of dysarthria in two adults with Down syndrome. Dev Neurorehabilitation 2012;15:44-53.

23. Ramig LO, Sapir S, Fox C, Countryman S. Changes in vocal loudness following intensive voice treatment (LSVT) in individuals with Parkinson's disease: a comparison with untreated patients and normal age-matched controls. Mov Disord Off J Mov Disord Soc 2001;16:79-83.

24. Fox CM, Morrison CE, Ramig LO, Sapir S. Current Perspectives on the Lee Silverman Voice Treatment (LSVT) for Individuals With Idiopathic Parkinson Disease. Am J Speech Lang Pathol 2002;11:111-123.

25. Fox C, Halpern A, Petska J, Spielman J, Will L, Ramig L. Voice Treatment (LSVT®) for Individuals With Parkinson Disease: New Horizons. Perspect Voice Voice Disord 2005;15:9-16.

26. Fox C, Ramig L, Ciucci M, Sapir S, McFarland D, Farley B. The Science and Practice of LSVT/LOUD: Neural Plasticity-Principled Approach to Treating Individuals with Parkinson Disease and Other Neurological Disorders. Semin Speech Lang 2006;27:283-299.

27. McAuliffe MJ. Extended version of the Lee Silverman Voice Treatment (LSVT) results in changes to vocal sound pressure level comparable to those resulting from traditional LSVT in a group of 12 participants1. Evid-Based Commun Assess Interv 2008;2:11-13.

28. Howell S, Tripoliti E, Pring T. Delivering the Lee Silverman Voice Treatment (LSVT) by web camera: a feasibility study. Int J Lang Commun Disord 2009;44:287-300.

29. Theodoros D, Aldridge D, Hill AJ, Russell T. Technology-enabled management of communication and swallowing disorders in Parkinson's disease: a systematic scoping review: Technology-enabled management in Parkinson's disease. Int J Lang Commun Disord 2019;54:170-188.

30. Pennington L, Stamp E, Smith J, et al. Internet delivery of intensive speech and language therapy for children with cerebral palsy: a pilot randomised controlled trial. BMJ Open 2019;9:e024233.

31. Bakhtiari R, Cummine J, Reed A, et al. Changes in brain activity following intensive voice treatment in children with cerebral palsy: Changes in Brain Activity Following Intensive Voice Treatment in Children With Cerebral Palsy. Hum Brain Mapp 2017;38:4413-4429.

32. Kleim JA, Jones TA. Principles of Experience-Dependent Neural Plasticity: Implications for Rehabilitation After Brain Damage. J Speech Lang Hear Res 2008;51.

33. Kim HS. 장애인 등록 현황(2018 년 12 월말 기준). April 2019.

34. Kang YW, Na DL, Hahn SH. A validity study on the korean mini-mental state examination (K-MMSE) in dementia patients. J Korean Neurol Assoc 1997;15:300-308.

35. Suh MK, Kim H. Auditory-Perceptual Variables of Speech Evaluation in Dysarthria Literature. Speech Sci 2006;13:197-206.

36. Yun Y-S, Kim H, Son Y-I, Choi HS. Validation of the Korean Voice Handicap Index(K-VHI) and the Clinical Usefulness of Korean VHI-10. Commun Sci Disord 2008;13:216-241.

37. Wee S-A, Choi E-C, Cho S-R, Choi SH, Kim H. Development of Short-Form of the Speech Handicap Index and Its Application to Tongue Cancer Patients. Commun Sci Disord 2018;23:218-227.

38. Rosenbek JC, Robbins JA, Roecker EB, Coyle JL, Wood JL. A penetration-aspiration scale. Dysphagia 1996;11:93-98.

39. Kim DH, Choi KH, Kim HM, et al. Inter-rater Reliability of Videofluoroscopic Dysphagia Scale. Ann Rehabil Med 2012;36:791.

40. Spielman J, Ramig LO, Mahler L, Halpern A, Gavin WJ. Effects of an Extended Version of the Lee Silverman Voice Treatment on Voice and Speech in Parkinson's Disease. Am J Speech Lang Pathol 2007;16:95-107.

41. Griffin M, Bentley J, Shanks J, Wood C. The effectiveness of Lee Silverman Voice Treatment therapy issued interactively through an iPad device: A non-inferiority study. J Telemed Telecare 2018;24:209-215.

42. Boliek CA, Fox CM. Therapeutic effects of intensive voice treatment (LSVT LOUD ®) for children with spastic cerebral palsy and dysarthria: A phase I treatment validation study. Int J Speech Lang Pathol 2017;19:601-615.

43. Ramig LO. Intensive voice treatment (LSVT(R)) for patients with Parkinson's disease: a 2 year follow up. J Neurol Neurosurg Psychiatry 2001;71:493-498.

44. Wenke RJ, Cornwell P, Theodoros DG. Changes to articulation following LSVT® and traditional dysarthria therapy in non-progressive dysarthria. Int J Speech Lang Pathol 2010;12:203-220.

45. Dimauro G, Caivano D, Bevilacqua V, Girardi F, Napoletano V. VoxTester, software for digital evaluation of speech changes in Parkinson disease. In: *2016 IEEE International Symposium on Medical Measurements and Applications (MeMeA)*. Benevento, Italy: IEEE; 2016:1-6.

46. Maslan J, Leng X, Rees C, Blalock D, Butler SG. Maximum phonation time in healthy older adults. J Voice Off J Voice Found 2011;25:709-713.

47. Giraldo-Cadavid LF, Leal-Leaño LR, Leon-Basantes GA, et al. Accuracy of endoscopic and videofluoroscopic evaluations of swallowing for oropharyngeal dysphagia: Accuracy of FEES and VFSS. The Laryngoscope 2017;127:2002-2010.

48. Ekberg O, Hamdy S, Woisard V, Wuttge-Hannig A, Ortega P. Social and Psychological Burden of Dysphagia: Its Impact on Diagnosis and Treatment. Dysphagia 2002;17:139-146.

49. Baldanzi C, Crispiatico V, Foresti S, et al. Effects of Intensive Voice Treatment (The Lee Silverman Voice Treatment [LSVT LOUD]) in Subjects With Multiple Sclerosis: A Pilot Study. J Voice August 2020:S0892199720302757.

50. on behalf of the PD COMM Pilot Collaborative Group, Sackley CM, Smith CH, et al. Lee Silverman Voice Treatment versus standard speech and language therapy versus control in Parkinson's disease: a pilot randomised controlled trial (PD COMM pilot). Pilot Feasibility Stud 2018;4:30.

APPENDIX 1. Phonetic feature phrases

Phonetic Feature	**Korean Phrase**	**IPA Transcription**
Nasal consonants	엄마 엄마 엄마	/ ʌmma ʌmma ʌmma /
Oral consonants	아가 아가 아가	/ aga aga aga /
Nasal consonants	엄마 마음이 내 마음	/ ʌmma maɯmi ne maɯm /
Nasal consonants	멍멍이는 멍멍, 매미는 맴맴	/ mʌŋmʌŋinɯn mʌŋmʌŋ, mɛminɯn mɛmmɛm /
Bilabial stop-plosives	발이 아파, 업어줘	/ paɾi apʰa, ʌbə tɕwʌ /
Alveolar stop-plosives	트럭 뒤에 타도 돼	/ tʰɯɾʌk twiɛ tʰado twe /
Velar stop-plosives	거북이가 기어가	/ kʌbugiga kiʌga /
Palatal affricates	저 자리가 제일 좋아	/ tɕʌ tɕaɾiga tɕɛil tɕoa /
Alveolar fricatives	서울에서 이사 왔어	/ sʌuɾɛsʌ isa waṣə /
Alveolar lateral approximants	위로 올라와라	/ wiɾo olla waɾa /
Alveolar taps	아래로 열어라	/ aɾɛɾo jʌɾʌɾa /

APPENDIX 2. Autumn passage

우리나라의 가을은 참으로 아름답다. 무엇보다도 산에 오를 땐 더욱더 그 빼어난 아름다움이 느껴진다. 쓰다듬어진 듯한 완만함과, 깎아놓은 듯한 뾰족함이 어우러진 산등성이를 따라 오르다 보면, 절로 감탄을 금할 수가 없게 된다. 붉은 색, 푸른 색, 노란 색 여러 가지 색깔들이 어우러져, 타는 듯한 감동을 주며 나아가 신비롭기까지 하다. 숲 속에 누워서 하늘을 바라보라. 쌍쌍이 짝지어져 있는 듯한 흰 구름, 높고 파란 하늘을 쳐다보고 있노라면 과연 예부터 가을을 천고마비의 계절이라 일컫는 이유를 알게 될 것만 같다. 가을에는 또한 오곡백과 등 먹거리가 풍성하기 때문에 결실의 계절이라고도 한다. 햅쌀, 밤, 호두 뿐만 아니라 대추, 여러 가지 떡, 크고 작은 과일들을 맛볼 수 있는데, 가을의 대표적인 명절인 추석에 우리는 이것들을 쌓아놓고 조상님들께 차례를 지내기도 한다. 또한, 가을은 독서의 계절이라고도 하여 책을 읽으며 시시때때로 명상에 잠기기도 하는데, 독서는 우리에게 마음을 살찌우고 아름답게 하는 힘을 주기 때문이다.

APPENDIX 3. Travel passage

일상이 문득 너무 무덤덤할 땐, 여행 같은 특효약이 또 있을까? 갑갑하고 빡빡한 생활의 흔적을 잊고 떠나자. 몸도 마음도 자신감 충만한 느낌이 가득해질 것이다. 지도 따라 자전거로 쌍쌍이 전국일주를 해보자. 캔 커피를 듬뿍 챙겨 자동차로 신나게 달려보자. 교외 고속도를 쭉 달리면서, 샘솟는 해방감 만끽해보자. 그러나, 참여행의 백미는 맛난 계란을 야금야금 까먹는, 멋이 좋은 기차 여행이 아닐까.

APPENDIX 4. Videofluoroscopic Dysphagia Scale (VDS)

VDS (Videofluorscopic dysphagia scale)							
Parameter	**Findings**	**12% semi(thick)**		**6% semi(thin)**		**liquid**	
		5 ml	**15 ml**	**5 ml**	**15 ml**	**5 ml**	**15 ml**
Lip Closure	Intact	0	0	0	0	0	0
	Inadequate	2	2	2	2	2	2
	None	4	4	4	4	4	4
Bolus formation	Intact	0	0	0	0	0	0
	Inadequate	3	3	3	3	3	3
	None	6	6	6	6	6	6
Mastication	Intact	0	0	0	0	0	0
	Inadequate	4	4	4	4	4	4
	None	8	8	8	8	8	8
Apraxia	None	0	0	0	0	0	0
	Mild	1.5	1.5	1.5	1.5	1.5	1.5
	Moderate	3	3	3	3	3	3
	Severe	4.5	4.5	4.5	4.5	4.5	4.5

Tongue to palate contact	Intact	0	0	0	0	0	0
	Inadequate	5	5	5	5	5	5
	None	10	10	10	10	10	10
Premature bolus loss	None	0	0	0	0	0	0
	<10%	1.5	1.5	1.5	1.5	1.5	1.5
	10-50%	3	3	3	3	3	3
	>50%	4.5	4.5	4.5	4.5	4.5	4.5
Oral transit time	<1.5s	0	0	0	0	0	0
	>1.5s	3	3	3	3	3	3
Triggering of pharyngeal swallow	Normal	0	0	0	0	0	0
	Delayed	4.5	4.5	4.5	4.5	4.5	4.5
Vallecularresidue	None	0	0	0	0	0	0
	<10%	2	2	2	2	2	2
	10-50%	4	4	4	4	4	4
	>50%	6	6	6	6	6	6
Laryngeal elevation	Normal	0	0	0	0	0	0
	Impaired	9	9	9	9	9	9
Pyriform sinus residue	None	0	0	0	0	0	0

	<10%	4.5	4.5	4.5	4.5	4.5	4.5
	10-50%	9	9	9	9	9	9
	>50%	13.5	13.5	13.5	13.5	13.5	13.5
Coating on the pharyngeal wall	No	0	0	0	0	0	0
	Yes	9	9	9	9	9	9
Pharyngeal transit time	<1.0s	0	0	0	0	0	0
	>1.0s	6	6	6	6	6	6
Aspiration	None	0	0	0	0	0	0
	Penetration	6	6	6	6	6	6
	TsAspiration	12	12	12	12	12	12
총점 :							
특이사항 :							

APPENDIX 5. Penetration-Aspiration Scale (PAS)

침습-흡인 척도(Penetration Aspiration Scale, PAS)							
척도	기준	결과					
		12% semi thick		6% semi thin		liquid	
		5 ml	15 ml	5 ml	15 ml	5 ml	15 ml
1	음식이 기도로 들어가지 않음	정상	정상	정상	정상	정상	정상
2	음식이 기도로 들어가고, 성대 위에 남아 있음. 기도 밖으로 나옴	침습	침습	침습	침습	침습	침습
3	음식이 기도로 들어가고, 성대 위에 남아 있음. 기도 밖으로 나오지 않음	침습	침습	침습	침습	침습	침습
4	음식이 기도로 들어가고, 성대에 닿음. 기도 밖으로 나옴	침습	침습	침습	침습	침습	침습
5	음식이 기도로 들어가고, 성대에	침습	침습	침습	침습	침습	침습

	닿음. 기도 밖으로 나오지 않음						
6	음식이 기도로 들어가고, 성대 아래를 지남. 후두 또는 기도 밖으로 나옴	흡인	흡인	흡인	흡인	흡인	흡인
7	음식이 기도로 들어가고, 성대 아래를 지남. 후두 또는 기도 밖으로 나오지 않음	흡인	흡인	흡인	흡인	흡인	흡인
8	음식이 기도로 들어가고, 성대 아래를 지남. 밖으로 나오려는 작용이 없음	흡인	흡인	흡인	흡인	흡인	흡인
총점							

APPENDIX 6. Voice Handicap Index (VHI)

본 설문은 목소리 문제 때문에 귀하께서 느끼는 어려움을 조사하고자 합니다.

다음 문장을 읽고 해당하는 곳에 표시해 주세요.

0 = 전혀 그렇지 않다	1= 거의 그렇지 않다	2 = 가끔 그렇다	3 = 자주 그렇다	4 = 항상 그렇다
F1. 목소리 때문에 상대방이 내 말을 알아듣기 힘들어한다.				0 1 2 3 4
P2. 말을 할 때 숨이 차다.				0 1 2 3 4
F3. 시끄러운 곳에서는 사람들이 내 말을 이해하기 어려워한다.				0 1 2 3 4
P4. 하루 중에도 목소리가 자주 변한다.				0 1 2 3 4
F5. 집안 어디서든 내가 부르는 말소리를 가족들이 잘 듣지 못 한다.				0 1 2 3 4
F6. 목소리 때문에 전화통화를 가급적 줄인다.				0 1 2 3 4
E7. 목소리 때문에 타인과 대화를 할 때 긴장을 한다.				0 1 2 3 4
F8. 내 목소리 때문에 여러 사람이 모인 자리를 피하게 된다.				0 1 2 3 4
E9. 내 목소리 때문에 사람들은 짜증이 날 것이다.				0 1 2 3 4
P10. 사람들이 나에게 목소리가 왜 그러냐고 묻는다.				0 1 2 3 4

F11. 내 목소리 때문에 친구, 친척 혹은 이웃들과 대화를 덜 하게된다.	0 1 2 3 4
F12. 얼굴을 마주보고 대화할 때도 상대방이 다시 말해 달라고 한다.	0 1 2 3 4
P13. 목소리가 갈라지고 탁하다.	0 1 2 3 4
P14. 목소리를 내려면 힘을 주어야 나오는 것 같다.	0 1 2 3 4

0 = 전혀 그렇지 않다	1= 거의 그렇지 않다	2 = 가끔 그렇다	3 = 자주 그렇다	4 = 항상 그렇다

E15. 다른 사람들은 내 음성 문제를 잘 이해하지 못한다고 생각 한다.	0 1 2 3 4
F16. 음성문제로 개인 생활과 사회생활에 제한을 받는다.	0 1 2 3 4
P17. 목소리가 언제쯤 맑게 잘 나올지 알 수가 없다(예측이 어렵다).	0 1 2 3 4
P18. 목소리를 잘 나오게 하려고 음성을 달리 내보기도 한다.	0 1 2 3 4
F19. 내 목소리 때문에 대화에 끼지 못하여 소외감을 느낀다.	0 1 2 3 4
P20. 말할 때는 애를 많이 쓰게 된다.	0 1 2 3 4
P21. 저녁이 되면 목소리가 더 잠긴다.	0 1 2 3 4
F22. 음성 문제로 인해 소득(수입)에 감소가 생긴다.	0 1 2 3 4

E23. 내 목소리 문제로 속이 상한다.	0 1 2 3 4
E24. 내 목소리 문제로 적극적이지 못할 때가 있다.	0 1 2 3 4
E25. 음성 문제가 장애로(핸디캡으로) 여겨진다.	0 1 2 3 4
P26. 말하다가 목소리가 나오지 않아 말을 이을 수 없을 때도 있다.	0 1 2 3 4
E27. 사람들이 나에게 다시 말해 달라고 할 때 기분이 언짢다.	0 1 2 3 4
E28. 사람들이 나에게 다시 말해 달라고 할 때 창피함을 느낀다.	0 1 2 3 4
E29. 목소리 때문에 무능력하게 느껴져 자신감이 떨어진다.	0 1 2 3 4
E30. 목소리 때문에 수치심을 느낀다.	0 1 2 3 4

APPENDIX 7. Short form of Speech Handicap Index (Korean version) (SHI-15)

이름 :　　나이 :　　성별 : 남 /여

다음 문장을 읽고 현재 말 상태에 맞는 곳에 동그라미 표시 해주세요

0=전혀 없다 1=거의 없다 2=가끔 있다 3=자주 있다 4= 항상 있다					
1) 사람들은 내 말을 이해하기 어려워한다.	0	1	2	3	4
2) 나는 말 때문에 무능력하게 느껴진다.	0	1	2	3	4
3) 사람들은 왜 내말이 이해하기 어려운지를 내게 물어본다.	0	1	2	3	4
4) 나는 전화사용을 피한다.	0	1	2	3	4
5) 나는 발음이 부정확하다.	0	1	2	3	4
6) 나는 말의 문제로 인해 친구, 이웃 혹은 친척들과 말을 덜하게 된다.	0	1	2	3	4
7) 나는 말할 때 힘을 줘서 말해야 할 것 같다.	0	1	2	3	4
8) 다른 사람들은 나의 말 문제를 이해하지 못하는 것 같다.	0	1	2	3	4

9) 말 정확도를 예측할 수 없다.	0	1	2	3	4
10) 나는 말 문제 때문에 대화에서 소외감을 느낀다.	0	1	2	3	4
11) 나는 말을 정확하게 하기 위해 노력을 한다.	0	1	2	3	4
12) 저녁이 되면 말소리가 더 나빠진다.	0	1	2	3	4
13) 나는 말 문제 때문에 장애가 있다고 느껴진다.	0	1	2	3	4
14) 나는 말 문제 때문에 대화를 계속(지속)하기 어렵다.	0	1	2	3	4
15) 나는 사람들이 다시 말해달라고 하면 당혹 스럽다	0	1	2	3	4

APPENDIX 8. Swallowing-Related Quality of Life (SWAL-QOL)

SWAL-QOL

성함 :

이 설문지는 삼킴문제가 당신의 삶의 질에 얼마나 영향을 미치는지 알아보기 위해 제작되었습니다. 설문 내용을 주의 깊게 읽고 각 질문에 답해주십시오. 모든 항목이 다르게 구성되어 있으므로 유사한 질문에도 모두 답해주시기 바랍니다.

다음은 설문의 예시입니다.

<예시>
지난 한 달 동안, 다음의 증상을 얼마나 자주 경험하셨나요?

	항상 그렇다	대부분 그렇다	보통 그렇다	가끔 그렇다	전혀 아니다
신체적으로 약하다고 느낌	1	2	3	4	5

삼킴의 어려움은 다양한 신체적 문제를 동반할 것입니다. 그러나 본 설문에서는 삼킴문제에만 초점을 두고 답해주시기를 바랍니다. 설문에 참여해 주셔서 진심으로 감사드립니다.

	항상 그렇다	대부분 그렇다	보통 그렇다	가끔 그렇다	전혀 아니다
삼킴문제를 대하는 것이 매우 어렵다.	1	2	3	4	5
삼킴문제는 내 삶의 주 방해요소이다.	1	2	3	4	5

다음은 삼킴문제를 가진 사람들이 일반적으로 말하는 내용입니다. 지난 한 달 동안, 다음의 내용이 본인에게 얼마큼 해당했나요?

2. 다음은 삼킴문제를 가진 사람들이 먹는 것에 관해 가끔씩 얘기하는 내용입니다. 지난 한 달 동안, 다음의 내용이 본인에게 얼마큼 해당했나요?

	항상 그렇다	대부분 그렇다	보통 그렇다	가끔 그렇다	전혀 아니다
늘상 먹든 안 먹든 상관하지 않는다.	1	2	3	4	5
다른 사람들보다 먹는데 시간이 오래 걸린다.	1	2	3	4	5
거의 배고픔을 느끼지 못한다.	1	2	3	4	5
식사를 마치는데 오래 걸린다.	1	2	3	4	5
더 이상 먹는게 즐겁지 않다.	1	2	3	4	5

3. 다음은 삼킴문제를 가진 사람들이 가끔씩 경험하는 신체적인 문제입니다. 지난 한 달 동안, 본인은 삼킴장애로 인해 다음의 문제를 얼마나 자주 경험했나요?

	항상 그렇다	대부분 그렇다	보통 그렇다	가끔 그렇다	전혀 아니다
기침	1	2	3	4	5
음식을 먹을 때 숨이 막힘	1	2	3	4	5
액체를 마실 때 숨이 막힘	1	2	3	4	5
걸쭉한 침 또는 가래 생김	1	2	3	4	5
구역질	1	2	3	4	5
침 흘림	1	2	3	4	5
씹기 어려움	1	2	3	4	5
과도한 침 또는 가래 생김	1	2	3	4	5

목을 가다듬어야 함	1	2	3	4	5
목구멍에 음식물이 들러붙음	1	2	3	4	5
입에 음식물이 들러붙음	1	2	3	4	5
입 밖으로 음식 또는 액체가 흘러나옴	1	2	3	4	5
코로 음식 또는 액체가 나옴	1	2	3	4	5
음식물이나 액체가 목에 걸리면 기침을 해서 입 밖으로 뱉어냄	1	2	3	4	5

4. 지난 한 달 동안, 삼킴문제가 본인의 식사에 어떻게 영향을 미쳤나요?

	항상 그렇다	대부분 그렇다	보통 그렇다	가끔 그렇다	전혀 아니다
내가 먹을 수 있는 것과 먹을 수 없는 것을 구별하기가 어렵다.	1	2	3	4	5
내가 좋아하면서 동시에 먹는 것이 가능한 음식을 정하는 것이 어렵다.	1	2	3	4	5

5. 지난 한 달 동안, 삼킴문제로 인해 다음의 항목이 본인의 의사소통에 얼마나 자주 영향을 미쳤나요?

	항상 그렇다	대부분 그렇다	보통 그렇다	가끔 그렇다	전혀 아니다
사람들은 내 말이 이해하기 어려워한다.	1	2	3	4	5

명료하게 말하는 것이 어렵다.	1	2	3	4	5

6. 다음은 삼킴문제를 가진 사람들이 가끔씩 말하는 걱정에 관한 내용입니다. 지난 한 달 동안, 다음의 느낌을 얼마나 자주 경험했나요?

	항상 그렇다	대부분 그렇다	보통 그렇다	가끔 그렇다	전혀 아니다
나는 음식을 먹을 때 숨이 막힐까봐 두렵다.	1	2	3	4	5
나는 폐렴에 걸릴까봐 걱정이다.	1	2	3	4	5
나는 액체를 마실 때 숨이 막힐까봐 두렵다.	1	2	3	4	5
나는 음식을 먹으면서 언제 숨이 막힐지 알 수 없다.	1	2	3	4	5

7. 지난 한 달 동안, 삼킴문제로 다음의 내용을 얼마나 자주 경험했나요 ?

	항상 그렇다	대부분 그렇다	보통 그렇다	가끔 그렇다	전혀 아니다
삼킴문제는 나를 우울하게 한다.	1	2	3	4	5
조심해서 먹거나 마셔야 하는 것이 나를 화나게 한다.	1	2	3	4	5
삼킴문제는 나를 낙담시킨다.	1	2	3	4	5
삼킴문제는 나를 절망스럽게 한다.	1	2	3	4	5

삼킴문제를 대할 때 나는 참을성이 없어진다.	1	2	3	4	5

8. 지난 한 달 동안, 본인의 사회생활을 생각해 보세요. 다음의 항목에 얼만큼 동의하십니까?

	항상 그렇다	대부분 그렇다	보통 그렇다	가끔 그렇다	전혀 아니다
삼킴문제 때문에 외식을 하지 않는다.	1	2	3	4	5
삼킴문제 때문에 사회생활이 어렵다.	1	2	3	4	5
삼킴문제 때문에 나의 일 또는 여가 활동이 변했다.	1	2	3	4	5
삼킴문제 때문에 사람들과의 모임이 즐겁지 않다.	1	2	3	4	5
삼킴문제 때문에 가족과 친구들 사이에서 나의 역할이 바뀌었다.	1	2	3	4	5

9. 지난 한 달 동안, 다음의 신체적 증상을 얼마나 자주 경험했나요?

	항상 그렇다	대부분 그렇다	보통 그렇다	가끔 그렇다	전혀 아니다
신체적으로 약한가?	1	2	3	4	5
잠드는 게 어려운가?	1	2	3	4	5
피곤함을 느끼는가?	1	2	3	4	5
잠든 상태를 유지하는 게 어려운가?	1	2	3	4	5
신체적으로 지치는가?	1	2	3	4	5

10. 지금 섭식관으로 음식이나 액체를 먹고 있나요?

아니오	1
네	2

11. 지난 한 주 동안, 가장 자주 먹었던 음식의 농도가 질감을 가장 잘 묘사한 항목에 동그라미 치세요.

정상적인 식이(갈비, 당근, 빵, 샐러드, 팝콘과 같이 씹기 어려운 다양한 종류의 음식)	
씹기 쉽고 부드러운 음식 섭취(찜 요리, 과일 통조림, 부드럽게 익힌 야채, 다진 고기 또는 크림스프)	
갈거나 가공된 음식 섭취(푸딩이나 생크림)	
대부분 섭식관으로 영양을 섭취하지만 가끔 아이스크림, 푸딩, 사과주스, 또는 다른 군것질 섭취	
섭식관을 통해서만 영양 섭취	

12. 지난 한 주 동안, 가장 자주 마신 액체의 농도를 가장 잘 묘사하고 있는 항목에 동그라미 치세요.

물, 우유, 차, 과일주스, 커피와 같은 액체를 마신다.	
액체의 대부분이 농도가 짙어서 수저를 뒤집으면 천천히 아래로 흔든다. (예: 토마토 주스, 두유)	
액체가 중간 정도의 농도여서 빨대로 빨기 어렵고, 꿀과 같이 수저를 뒤집으면 한 방울씩 떨어진다.(예: 호박죽, 꿀)	
액체의 농도가 상당히 진해서 수저를 뒤집으면 수저에 붙어있다. (예: 푸딩, 생크림)	
입으로 액체를 전혀 마시지 못하거나 얼음조각만 먹는다.	

13. 일반적으로 당신의 건강은 어떠한지 동그라미 치세요.

약함	
보통	
좋음	
매우 좋음	
최상	

APPENDIX 9. Individual participant data

Appendix 9-1. Individual outcomes in speech functions

Pt.	Dysarthria Severity			Dysphonia Severity			MPT			Intensity		
	Pre	Post	Δ	Pre	Post	Δ	Pre	Post	Δ	Pre	Post	Δ
1	3	3	0	3	3	0	7.34	7.54	0.2	76.18	78.8	2.62
2	3	3	0	2	2	0	14.1	15.65	1.55	79.84	80.8	0.96
3	4	4	0	3	3	0	5.58	7.5	1.92	81.66	82.31	0.65
4	3	3	0	3	3	0	8.34	18.7	10.36	79.91	80.23	0.32
5	4	4	0	4	3	-1	3.64	10.67	7.03	80.6	80.5	-0.1
6	2	2	0	2	2	0	9.14	9.64	0.5	81.83	81.23	-0.6
7	3	3	0	3	3	0	5.25	7.48	2.23	81.51	81.68	0.17
8	4	4	0	3	3	0	9.24	12.59	3.35	79.13	83.51	4.38
9	3	2	-1	3	3	0	7.89	14.54	6.65	81.75	83.02	1.27
10	4	4	0	4	3	-1	4.27	10.16	5.89	78.38	79.56	1.18
11	2	2	0	2	2	0	12.16	17.44	5.28	79.73	83.62	3.89

Appendix 9-2. Individual outcomes in speech functions (cont.)

Pt.	Puh			Tuh			Kuh			Puh Tuh Kuh		
	Pre	Post	Δ	Pre	Post	Δ	Pre	Post	Δ	Pre	Post	Δ
1	18	21	3	16	18	2	17	17	0	5	6	1
2	17	22	5	16	17	1	17	18	1	5	7	2
3	9	8	-1	6	8	2	4	6	2	2	2	0
4	17	20	3	16	28	12	22	26	4	7	7	0
5	6	8	2	10	7	-3	11	9	-2	4	5	1
6	22	21	-1	23	19	-4	21	13	-8	7	7	0
7	16	18	2	14	22	8	18	17	-1	5	7	2
8	16	16	0	11	17	6	10	11	1	3	5	2
9	20	22	2	17	23	6	16	17	1	6	9	3
10	11	13	2	25	26	1	12	15	3	2	6	4
11	20	20	0	16	16	0	20	20	0	7	6	-1

Appendix 9-3. Individual outcomes in swallowing functions

Pt.	Oral Phase			Pharyngeal Phase			VDS Total			PAS		
	Pre	Post	Δ	Pre	Post	Δ	Pre	Post	Δ	Pre	Post	Δ
1	61	13.5	-47.5	147	31.5	-115.5	208	45	-163	7	6	-1
2	97.5	67.5	-30	201.1	77.5	-123.6	298.5	145	-153.5	15	7	-8
3	112.5	61.5	-51	153	29	-124	265.5	90.5	-175	6	6	0
4	28.5	19.5	-9	68	22.5	-45.5	91.5	42	-49.5	7	6	-1
5	6	3	-3	47	14	-33	53	17	-36	7	6	-1
6	26.5	30	3.5	24.5	37.5	13	51	67.5	16.5	6	6	0
7	84	61.5	-22.5	135.5	69	-66.5	219.5	130.5	-89	7	7	0
8	45	26	-19	94.5	17	-77.5	139.5	43	-96.5	6	6	0
9	39	6	-33	32.5	29.5	-3	71.5	35.5	-36	6	8	2
10	52.5	45.5	-7	76	69	-7	128.5	114.5	-14	8	11	3
11	25	23.5	-1.5	51	45	-6	76	68.5	-7.5	7	6	-1

Appendix 9-4. Individual outcomes in SHI-15

Pt.	SHI-15 Speech			SHI-15 Psychosocial			SHI-15 Total		
	Pre	Post	Δ	Pre	Post	Δ	Pre	Post	Δ
1	15	1	-14	16	2	-14	31	3	-28
2	19	25	6	17	21	4	36	46	10
3	16	21	5	22	22	0	38	43	5
4	24	21	-3	22	14	-8	46	35	-11
5	7	14	7	20	32	12	18	32	14
6	21	8	-13	26	20	-6	47	38	-9
7	12	10	-2	8	0	-8	20	10	-10
8	23	21	-2	9	6	-3	32	27	-5
9	8	5	-3	2	3	1	10	8	-2
10	26	26	0	20	12	-8	46	38	-8
11	20	9	-11	9	6	-3	29	13	-16

Appendix 9-5. Individual outcomes in VHI

Pt.	VHI Functional			VHI Physical			VHI Emotional			VHI Total		
	Pre	Post	Δ	Pre	Post	Δ	Pre	Post	Δ	Pre	Post	Δ
1	12	0	-12	18	2	-16	3	0	-3	33	2	-31
2	16	21	5	26	27	1	18	18	0	60	66	6
3	27	23	-4	14	15	1	19	15	-4	60	53	-7
4	22	23	1	29	28	-1	33	25	-8	84	76	-8
5	6	3	-3	14	1	-13	13	0	-13	33	4	-29
6	35	14	-21	36	25	-11	34	18	-16	105	57	-48
7	8	6	-2	8	2	-6	13	4	-9	29	12	-17
8	6	5	-1	25	24	-1	10	9	-1	41	38	-3
9	2	4	2	11	23	12	14	8	-6	27	35	8
10	11	8	-3	17	7	-10	16	6	-10	44	21	-23
11	29	10	-19	28	13	-15	28	8	-20	85	31	-54

Appendix 9-6. Individual outcomes in SWAL-QOL

Pt.	Burden			Eating duration			Eating desire			Symptom frequency			Food selection			Communication		
	Pre	Post	Δ	Pre	Post	Δ	Pre	Post	Δ	Pre	Post	Δ	Pre	Post	Δ	Pre	Post	Δ
1	9	10	1	6	10	4	12	15	3	66	70	4	10	10	0	8	10	2
2	5	3	-2	8	9	1	10	11	1	50	34	-16	2	2	0	5	2	-3
3	7	8	1	3	3	0	14	11	-3	38	44	6	10	10	0	4	4	0
4	6	9	3	6	6	0	12	12	0	51	56	5	8	8	0	5	6	1
5	9	5	-4	8	7	-1	10	15	5	47	56	9	10	10	0	9	10	1
6	8	8	0	9	6	-3	15	14	-1	45	55	10	9	10	1	7	9	2
7	9	10	1	9	7	-2	13	12	-1	53	52	-1	10	10	0	9	8	-1
8	9	9	0	8	8	0	14	14	0	55	57	2	10	10	0	8	8	0
9	9	9	0	10	9	-1	15	15	0	62	68	6	10	10	0	10	9	-1
10	4	8	4	8	10	2	15	14	-1	50	48	-2	10	10	0	6	5	-1
11	7	9	2	9	6	-3	13	13	0	5	66	61	10	10	0	4	6	2

Appendix 9-7. Individual outcomes in SWAL-QOL (cont.)

Pt.	Fear			Mental health			Social functioning			Sleep			Fatigue			SWAL-QOL Total		
	Pre	Post	Δ	Pre	Post	Δ	Pre	Post	Δ	Pre	Post	Δ	Pre	Post	Δ	Pre	Post	Δ
1	20	20	0	25	25	0	25	25	0	4	6	2	6	9	3	191	210	19
2	4	4	0	5	6	1	22	13	-9	2	2	0	3	5	2	116	91	-25
3	15	18	3	24	25	1	25	25	0	7	10	3	9	9	0	156	167	11
4	11	17	6	21	20	-1	20	25	5	4	6	2	5	6	1	149	171	22
5	20	20	0	25	25	0	25	25	0	10	10	0	9	15	6	182	198	16
6	11	18	7	24	25	1	25	25	0	2	9	7	7	11	4	162	190	28
7	20	19	-1	25	25	0	25	25	0	9	10	1	10	11	1	192	189	-3
8	19	19	0	25	25	0	25	25	0	7	7	0	14	14	0	198	196	-2
9	16	18	2	25	25	0	25	25	0	7	7	0	9	9	0	198	204	6
10	16	19	3	24	23	-1	23	25	2	10	10	0	15	15	0	181	187	6
11	18	20	2	23	25	2	24	25	1	6	10	4	11	15	4	178	205	27

성인 뇌성마비 환자의 마비말장애 및 삼킴장애에 대한 음성치료의 임상효능

〈지도교수 조 성 래〉

연세대학교 대학원 언어병리학협동과정

ALYSSA MAE PARK

본 연구에서는 성인 뇌성마비 대상자 11 명에게 LSVT 음성치료 16 회기를 대면 및 비대면 환경으로 제공한 후, 각 대상자의 말·삼킴 기능과 삶의 질을 평가하였다. 예상대로 최대연장발성, 음성의 강도 및 조음속도를 포함한 여러 말 기능은 두 치료 집단에서 유의한 개선을 나타내었다. 또한 VFSS 촬영으로 시각적으로 평가한 삼킴 기능은 음성치료 후 현저한 개선을 보여, 구강 및 인두 모두에서 삼킴장애 증상의 감소를 보였다. 이어서 대상자들이 말, 음성, 삼킴 관련 삶의 질에 대한 설문조사를 통해 정서적 스트레스, 두려움, 수면 및 피로 측면에서도 유의한 개선을 느꼈다고 보고하였다.

본 결과는 신체 기능, 사회적 참여 및 활동에 대한 다차원적 개선을 확인시킴으로써 성인 뇌성마비의 증상을 치료하는 데 LSVT 음성치료의 효능을 시사한다. 더 나아가 바쁜 일정을 위한 LSVT-X 연장 과정과 거동이 불편한 비대면 치료의 의의가 확인하였다. LSVT 를 임상에서 적용하는 데에 중요한 정보를 마련하기 위하여, 후속 연구는 LSVT-X 및 LSVT e-LOUD 를 어렵게 만드는 요인, 혹은 LSVT 의 적합성에 대한 성인 뇌성마비 대상자의 개인적 의견을 조사할 필요가 있다.

핵심되는 말: 뇌성마비, 마비말장애, 삼킴장애, 음성치료, 원격치료