SWALLOWING AND VOICE EFFECTS OF LEE SILVERMAN VOICE TREATMENT (LSVT®)
Jeri Logemann, Ph.D., CCC-SLP
Ralph and Jean Sundin Professor
Department of Communication Sciences and Disorders
Northwestern University, Evanston
j-logemann@northwestern.edu

ABSTRACT
In addition to voice and articulatory disorders, swallowing disorders have been reported in as many as 95% of individuals with Parkinson’s Disease (PD). This paper addresses the effects of intensive voice treatment (Lee Silverman Voice Treatment, LSVT®) on swallowing and voice changes. After LSVT® there was an overall 51% reduction in the number of swallowing motility disorders. Voice changes included a significant increase in vocal intensity during sustained phonation and reading. The LSVT® seemingly improved neuromuscular control of the entire upper aerodigestive tract, improving oral tongue and tongue base function during the oral and pharyngeal phases of swallowing. The underlying mechanisms associated with these changes will be discussed.

1. INTRODUCTION
In addition to voice and articulatory disorders, swallowing disorders have been reported in as many as 95% of individuals with PD [1-5]. Dysphagia has sometimes been described as the presenting feature of PD [6]. It may cause life-threatening pneumonia [7], severe enough to require non-oral feeding.

1.1 Swallowing disorders
Swallowing disorders in individuals with PD have been described for all phases of the swallow [9]. Swallow motility disorders reported to affect the oral phase of the swallow include disturbed lingual motility resulting in prolonged oral transit time [10], difficulty in bolus formation and hesitancy in initiation of the oral pharyngeal response and decreased pharyngeal contraction [2,3,11].

Most investigations of oropharyngeal dysfunction in individuals with PD have evaluated the effect of PD on either speech or swallowing [3,4]. Only one group has examined the effects of PD on both speech and swallowing [1]. Blonsky and colleagues [1] used simultaneous videofluoroscopic and voice recordings which revealed reduced elevation of the posterior and middle portions of the tongue during speech and swallowing; they concluded that the motor abnormality of the tongue might reflect rigidity rather than weakness.

1.2 Voice treatment
Short and longterm efficacy data have been published supporting the effectiveness of intensive voice treatment for individuals with PD in improving speech production [12-13], particular the LSVT. Clinicians who have been trained in the LSVT have reported that individuals with idiopathic PD undergoing LSVT comment that their swallowing improved during and after therapy. No study has yet been completed to validate these observations. This pilot study was undertaken to evaluate swallowing and voice changes in eight individuals with idiopathic PD after receiving LSVT.

2. METHOD

2.1 Assessment
Each individual with PD (n=8) was evaluated before commencement of LSVT and immediately after. The evaluations consisted of assessment of voice function repeated 3 times before and 2 times after LSVT using standard protocols. Assessment of swallowing was carried out once pre- and once post-treatment. No subjects included in this study received any other swallow or speech treatment before or during the study. Pre- and post-LSVT studies were done at the same time of day and medicine cycle for each patient.

2.2 Swallow assessment
A videofluoroscopic study of the oropharyngeal swallow was completed using a standard protocol [14]. This protocol consisted of 14 swallows, two each of 1ml, 3ml, 5ml, 10ml and a cup of barium liquid, 2 ml of swallows of barium pudding (paste) and 2 pieces (1/4 each) of a Lorna Doone cookie coated with barium to chew and swallow. During the radiographic study, individuals were seated and viewed in the lateral plane. The fluoroscopic tube was focused on the lips anteriorly, the cervical vertebrae posteriorly, the soft palate superiorly and the cervical esophagus inferiorly. The videofluoroscopic studies were recorded on a VHS video recorder for later slow motion and frame-by-frame analysis.
2.3 LSVT Treatment

After baseline assessment of swallowing and voice, each individual received 16 sessions of LSVT®. The treatment was conducted over a four week period with therapy being given four times a week for 50-60 minutes at each session [15]. During each therapy session, individuals practiced three daily exercises including maximum duration of sustained vowel phonation, maximum fundamental frequency range and maximum functional speech loudness drill. Individuals were also trained to use louder voice while speaking, to accurately judge their loudness, and “to feel effort, feel loudness- that is what it need to feel like when you talk so that people understand you.” In addition, all individuals did daily homework and carryover exercises focusing on “think loud”.

2.4 Data reduction

Swallowing measures

Videofluorographic data reduction involved two types of analysis: 1) identification of physiologic motility disorders in the oropharyngeal swallow, and 2) temporal measures of the oropharyngeal swallow. Motility disorders were identified by reviewing the videotape of each swallow in slow motion. Temporal measures and observations were completed for each swallow as described in Pauloski et al., 1993 [16] and Lazarus et al., 2000 [17]: 1) oral transit time; 2) pharyngeal transit time; 3) pharyngeal delay time; 4) pharyngeal response time; duration (in sec) of 5) tongue base movement to the posterior pharyngeal wall; 6) tongue base contact to the pharyngeal wall at mid C2 level; 7) tongue base contact to the posterior pharyngeal wall at inferior C2 level; 8) tongue base contact to the posterior pharyngeal wall at superior C3 level; and 14) the time interval (in sec) between first laryngeal entrance closure and first cricopharyngeal opening; 9) velopharyngeal closure; 10) laryngeal closure; 11) cricopharyngeal (CP) opening; 12) hyoid movement; 13) laryngeal elevation. In addition, observations were made regarding presence or absence of aspiration, approximate percent of the bolus remaining in the oral cavity (oral cavity residue) and in the pharynx (pharyngeal residue) after each swallow.

In both analyses, the clinician who performed the data reduction was not informed as to whether the x-ray studies of an individual were done before or after the LSVT®. No clinician who provided LSVT® was involved in the swallow analysis.

The oropharyngeal swallow efficiency (OPSE) measure was calculated for each swallow as follows:

\[ \text{OPSE} = \frac{100 - (\text{ORES} + \text{PRES} + \text{ASPB} + \text{ASPD})}{\text{OTT} + \text{PTT}} \]

where ORES = percentage of oral residue; PRES = percentage of pharyngeal residue; ASPB = aspiration before the swallow; ASPD = aspiration during the swallow; OTT = oral transit time; PDT = pharyngeal transit time; PRT = pharyngeal transit time.

This index was developed as a global measure to reflect the ability of the oral cavity and pharynx to move food efficiently and safely into the esophagus.[18]

2.5 Statistical analysis.

Changes in swallowing measures pre to post LSVT® were assessed for statistical significance separately for each bolus type (consistency/volume combination). No statistical test across bolus types was done. Data were analyzed using a two-factor analysis of variance with time and person as the two factors. Statistical significance was indicated if \( p<0.05 \). Analysis of data was conducted using PROC MIXED in SAS. A similar analysis of variance was done to compare measures of vocal intensity and fundamental frequency before and after treatment. Correlations between voice and swallowing changes as an effect of LSVT® were done using Pearson correlation coefficients.

2.6 Swallow motility disorders

Before LSVT®, reduced tongue coordination and reduced tongue lateralization impaired the ability of the tongue to hold the bolus as a cohesive mass prior to the swallow and were the only swallow motility disorders found in the oral preparatory phase of the swallow. After LSVT®, these disorders were identified in fewer individuals during all 7 types of swallows. Reduced tongue lateralization on cookie bolus prior to LSVT® treatment completely disappeared after treatment.

Swallow motility disorders during the oral phase of swallowing included reduced anterior to posterior tongue movement, antero/lateral tongue stabilization and the characteristic “rocking-like” tongue motion resulting in prolongation of oral transit time [11] This characteristic movement completely disappeared after LSVT® therapy resulting in reduction in oral transit time. Reduced tongue strength resulting in tongue and/or palatal residue after the swallow was reduced by 50% during swallows of liquid, by 12.5% during swallows of paste and by 25% during swallows of cookie after treatment. Reduced anterior/lateral stabilization of the tongue increased as bolus volume increased, resulting in subsequent splashing of the bolus throughout the oral cavity as well as increased oral residue after the swallow and completely disappeared after LSVT®. Reduced anterior to posterior tongue movement was a common disorder before LSVT®. After LSVT®, improvement in this disorder was dependant upon the size and viscosity of the bolus. This disorder completely disappeared in all individuals during cup drinking.

Delayed triggering of the pharyngeal swallow, usually resulting in prolongation of the PTT, and mild laryngeal penetration before the swallow occurred frequently before LSVT®. After LSVT®, this disorder completely disappeared during swallows of liquids with a 25% and 66% reduction in the frequency of this disorder in paste and cookie, respectively, resulting in reduction in PTT and percentage of laryngeal penetration before the swallow.

Reduced tongue base retraction and delayed laryngeal vestibule closure were the most common swallow motility disorders during the pharyngeal phase of the swallow. Reduced tongue base retraction, resulting in residue over the base of tongue, in the valleculae and/or the posterior pharyngeal wall increased in severity as bolus size and consistency increased. After LSVT®, there was a 50% reduction in the frequency of this disorder,
resulting in reduction in the amount of residue over the tongue base and in the valleculae.

Delayed laryngeal vestibule closure occurred frequently, resulting in penetration of material into the airway entrance, and did not change after LSVT®. However, this penetration was cleared as the swallow progressed and never resulted in aspiration. No individual had reduced closure of the entire larynx during swallow either before or after LSVT®. No aspiration was found in any individual before, during or after any swallows before or after LSVT®.

2.7 Effects of LSVT® on perceptual and acoustic parameters of voice

Analysis of vocal intensity during sustained vowel phonation revealed a statistically significant main effect of LSVT®. Mean vocal intensity was 74.6dB at 30 cm before LSVT® and 83.0dB at 30 cm after, p<0.001.

Vocal intensity during reading of the “Rainbow Passage” significantly increased after LSVT®. Average vocal intensity was 71.6dB before LSVT® and 77.9dB after, p<0.001. A significant change in the mean vocal intensity after LSVT® was also noted during reading of the “Happy Day Passage.” The average intensity was 70.1dB before LSVT® and 75.3dB after, p=0.002.

The average fundamental frequency during reading of the “Rainbow Passage” increased after LSVT® but not significantly so. The same findings were noticed during reading of the “Happy Day Passage.”

Before to after LSVT® comparison of scores obtained from Speech Assessment Scale, Visual Analogue Scale and Voice Handicap Index revealed improvement in the perception of speech indicating better speech intelligibility. These changes were not statistically significant, however.

Correlation of differences in voice and self perception variables with differences in swallowing variables. For all swallow volumes and viscosities, no consistent pattern of correlation was seen between changes in voice and self-perception variables and changes in swallowing measures across bolus types. The number of significant correlations obtained from statistical analysis did not exceed the number expected by chance.

Discussion.

The purpose of this pilot study was to document the effects of LSVT® on swallowing and voice in individuals with idiopathic PD. Before LSVT®, individuals with PD experienced swallow motility patterns that affected all phases of the swallow. The incidence of the swallow motility disorders was consistently reduced after LSVT® and some temporal swallowing measures improved significantly. The motility disorders in individuals in this study with PD prior to LSVT® are similar to the disorders reported by other investigators.[4] [6] [8] [10] [11] Our findings confirm the observation of other investigators [4] [10] who indicated that individuals with PD usually demonstrate multiple swallowing disorders. However, our study did not show any evidence of cricopharyngeal dysfunction as reported in the literature.[19]

The frequency of reduced range of motion and/or coordination of the tongue in this study is consistent with previous reports.[2] [10] These lingual disorders decreased the individuals’ ability to chew the cookie bolus completely, to propel it efficiently from the mouth and led to accumulation of oral residue over tongue and palate with frequent repeated swallows needed to clear the residue.

One of the common effects of PD on the oral tongue was the characteristic “rocking like” tongue movement reported here. This back and forth tongue movement ended when sufficient tongue elevation was maintained to propel the bolus posteriorly into the pharynx. This movement resulted in prolongation of oral transit time. The occurrence of this disorder in individuals with PD might reflect the increased difficulty in switching from the voluntary initiation of the swallow to the more automatic continuation in the pharyngeal phase of swallow, resembling the well-known problem of switching to the automatism of walking in individuals with PD.

Since rigidity and/or bradykinesia might affect the coordination of fine motor acts like tongue movement, reduced anterior and lateral stabilization of the tongue might be related to effect of these disorders on the tongue. The reduced tongue strength found in many individuals might reflect weakness rather than rigidity as the tongue generally moved to the same extent as in normal subjects.

One of the interesting findings in our study was the decrease in pharyngeal delay with increasing bolus volume. This finding results from increased stimulation of sensory receptors by the increasing bolus volume.

Another important motility disorder demonstrated by our patients was reduced tongue base retraction which results in residual food remaining in the valleculae. This disorder, in addition to the pharyngeal delay, may be responsible for the erratic absorption of medicines in individuals with PD, reducing the response of these individuals to medical treatment.

Unlike other investigators [8] [11] who reported frequent aspiration among individuals with PD, no aspiration was found in any individual in this study. In addition, only mild laryngeal penetration occurred and only in a few individuals. This penetration occurred before and during the swallow and might be related to the effect of bradykinesia on laryngeal movements. Absence of aspiration indicates that the laryngeal involvement in these individuals was not severe enough to affect airway closure.

Our findings indicate that PD affected the timing measures of the swallow. OTT was prolonged in individuals with PD before LSVT®. This finding is consistent with findings of other investigators [1] who reported increased OTT for individuals with PD compared to age matched controls. Unfortunately, other investigators [2] [4] [8] [10] have not given a specific value for this duration.
Although no previous studies have been done to evaluate the effects of LSVT® on swallowing, the findings of this preliminary investigation suggest that LSVT® may have important effects on the oral and pharyngeal phases of swallow. During the oral preparatory phases, LSVT® was effective in improving bolus control by the tongue. This was manifested by increased ability of the individual to hold the bolus as a cohesive mass prior to the swallow. It also resulted in reduction of the mean duration of OTT compared to pre-treatment. LSVT® was effective in improvement of both oral and pharyngeal (tongue base) lingual function including improvements in anterior/posterior tongue movement, tongue strength, anterior/lateral lingual stabilization of the bolus and ability of the individual to lateralize the bolus during chewing of cookie. Interestingly, these lingual effects are not the focus of LSVT®.

Our findings suggest that LSVT® may activate neuromuscular control of the entire aerodigestive tract, improving function in both the oral tongue and the tongue base during the oral and pharyngeal stages of swallowing. This may reflect an overflow of effort from the habituated increase in phonatory effort. LSVT® may also increase the individuals’ awareness of the overall function of the vocal tract.

3. RESULTS

Prior to LSVT, the most prevalent swallowing motility disorders were oral phase problems including reduced tongue control and strength. Reduced tongue base retraction resulting in residue in the vallecula was the most common disorder in the pharyngeal stage of the swallow. Oral transit time (OTT) and pharyngeal transit time (PTT) were prolonged. After LSVT, there was an overall 51% reduction in the number of swallowing motility disorders. Some temporal measures of swallowing were also significantly reduced as was the approximate amount of oral residue after 3 and 5 ml liquid swallows. Voice changes after LSVT included a significant increase in vocal intensity during sustained vowel phonation as well as during reading.

4. CONCLUSIONS

LSVT seemingly improved neuromuscular control of the entire upper aerodigestive tract, improving oral tongue and tongue base function during the oral and pharyngeal phases of swallowing as well as improving vocal intensity.

5. REFERENCES