The effects of Lee Silverman Voice Treatment (LSVT) on speech and voice characteristics of individuals with Parkinson's disease: A Critical Review of the literature *

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This critical review examines the effectiveness of Lee Silverman Voice Treatment (LSVT) in improving speech and voice characteristics, other than vocal loudness, of individuals with Parkinson's disease. Five articles were included in this review. Study designs included: three randomized control trials, and two within group repeated measures design. Overall, the results of the review provide suggestive evidence for the efficacy of LSVT in improving various aspects of speech and various, in addition to vocal loudness, in individuals with PD. Implications for clinical practice and recommendations for future research are discussed.

Introduction

Parkinson's disease (PD) is a progressive neurodegenerative disease affecting motor and non-motor functions of the brain (Choi, 2011). Approximately 7 million people in the world suffer from PD (Ramig, Fox & Sapir, 2008), and up to 90% of these individuals develop related speech and voice difficulties (Pahwa, Lyons & Kuller, 2007). These speech and voice problems include reduced vocal loudness, breathiness, monoloudness, reduced pitch inflection, hoarseness, imprecise articulation, reduced range of articulatory movements and voice tremor (Sapir, Spielman, Ramig, Story & Fox, 2007). Collectively, these speech characteristics, which are grouped under *hypokinetic dysarthria* (Duffy, 2013), can significantly impact intelligibility. Reduced speech intelligibility can affect an individual's ability to communicate effectively, thereby negatively impacting their social, psychological and economic well-being (Baumgartner, Sapir & Ramig, 2001). In fact, communication difficulties is one of the "most difficult aspects" of PD as reported by patients and their families (Fox, Morrison, Ramig & Sapir, 2002). To date, the Lee Silverman Voice Treatment (LSVT) is one of the most commonly used therapy approaches for hypokinetic dysarthria in PD (Sauvageau, Roy, Langlois & Macoir, 2015).

LSVT, an intensive voice treatment program, was developed by Ramig and her colleagues in 1987. The program was created to improve vocal fold adduction and respiratory functions in patients with Parkinson's disease. Through loud, effort phonation and self-monitoring, the primary goal of LSVT is to increase vocal intensity in individuals with PD (Ramig, Sapir, Countryman, Pawlas, O'Brien, Hoehn & Thompson, 2001).

For over a decade, Ramig and her colleagues have conducted numerous clinical efficacy studies to investigate the effects of LSVT on individuals with PD. These studies have reported short- and long-term effects of LSVT on increasing vocal intensity. However, a small number of studies have also reported improvements in other aspects of speech and voice, such as frequency (pitch), hoarseness and breathiness, articulation, and overall speech intelligibility. These findings are not surprising considering the dynamic nature of the laryngeal mechanism and the interrelatedness of different dimensions of speech and voice. The purpose of this review is to critically

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evaluate the current literature on the effects of LSVT on speech and voice characteristics, other than vocal loudness, of individuals with Parkinson's disease.

Objectives

The primary objective of this review is to critically evaluate the existing literature regarding the effects of LSVT on speech and voice characteristics, other than vocal loudness, of individuals with Parkinson's disease. A secondary objective is to provide speech language pathologists, who are interested in LSVT as an intervention option, evidence based practice recommendations regarding LSVT as a speech and voice therapy tool to improve aspects of speech other than vocal loudness.

Methods

Search Strategy

Computerized databases, including PubMed, PsycINFO, CINAHL, Cochrane library, Google Scholar and the Western University library search engine were searched. Keywords included: [(Parkinson's disease) AND (LSVT) OR (Lee Silverman Voice Treatment) AND (articulation) AND (speech)].

Selection Criteria

The studies selected for inclusion in this critical review were required to investigate the effects of LSVT in improving speech and voice deficits, other than vocal loudness, in patients with Parkinson's disease. No limits were set on research design or characteristics of research participants including, etiology of Parkinson's disease, time since diagnosis, stage, or the severity of the disease.

Data Collection

Results of the literature search yielded the following types of studies: randomized control trials (3) and within group repeated measures design (2).

Randomized control trial designs

Sapir, Spielman, Ramig, Story and Fox (2007) evaluated the effects of LSVT on vowel articulation in individuals with Idiopathic Parkinson's disease (IPD). Three groups of participants were included in this study: two groups consisted of participants with IPD and one group comprised of neurologically healthy individuals with normal speech. Participants with IPD were randomly assigned to either a treatment (n=14) or a non-treatment group (n=15). Participants did not differ significantly on any of the following variables: age, time since diagnosis, stage of disease, and severity of dysarthria prior to treatment. Participants receiving treatment underwent the standard LSVT protocol. Participants in the non-treatment group received no treatment during the experiment.

Speech data was collected just before and after treatment for acoustic analyses and perceptual ratings of vowel articulation. The speech task included reading aloud phrases containing the words *key*, *stew*, and *Bobby*, for analysis of the vowels /i/, /u/, /a/, respectively. Perceptual analysis included ratings of "vowel goodness". The judges were presented with recordings of pairs of the same vowel spoken by each participant, with the pair containing one vowel that had been produced before treatment and one vowel production post-treatment. Judges were asked to rate the second vowel in the pair relative to the first vowel.

A repeated measures ANOVA was used to assess acoustical changes in vowel articulation from pre-treatment to post-treatment. Results indicated statistically significant post-treatment improvements in vowel articulation in the LSVT group only. A MANOVA analysis, used to assess perceptual vowel ratings, revealed statistically significant post-treatment improvements in vowel productions in the LSVT group, but not in the control groups. Statistically significant post-treatment between-group differences were also reported. Sapir et al. (2007) concluded that LSVT is effective in improving vowel articulation in individuals with PD.

The strength of this study lies in its research design. Due to the randomized control design, it can be concluded with confidence that the results of the study were treatment-specific. In addition, the statistical analyses used were appropriate for the research design. Also, this was the only study included in this review that consisted of equal number of male and female participants with PD in all experimental and control groups. This allows for the findings of the study to be generalized across both genders. Intra-rater and inter-rater reliability measures were conducted to ensure the conclusions of the study were reliable. Another strength of this study is found in its use of both acoustic and perceptual analyses to evaluate post-treatment changes in vowel articulation.

While the study provides level 1 evidence for the efficacy of LSVT in improving vowel articulation, certain limitations should be considered. For perceptual ratings of vowel goodness, the authors do not state whether the judges were aware of the research hypotheses. Another limitation of this study is that majority of the research participants had mild or moderate speech problems. The results of the study, therefore, may not be applicable to all individuals with PD, specifically individuals with severe speech difficulties.

Baumgartner, Sapir and Ramig (2001), evaluated the effects of LSVT compared with Respiratory Effort Treatment (RET) on voice quality of individuals with IPD. Specifically, the researchers examined post-treatment changes in hoarseness and breathiness.

Twenty participants, all of whom had been identified as having “moderately” breathy and hoarse voice, were randomly assigned to either the LSVT group (n=13) or the RET group (n=7). The two groups did not differ significantly on any of the following variables: age, time since diagnosis, severity rating, score on the motor exam, Beck Depression Inventory, and the Montgomery Asberg Depression Rating Scale.

Participants in the LSVT group received standard LSVT protocol emphasizing maximized phonatory effort, vocal fold adduction and improved laryngeal muscle activity. The RET program targeted increased respiratory muscle activity to increase respiratory volume, increase subglottal air pressure and increase loudness. Both groups received four 1-hour sessions per week for four weeks.

Voice data was collected for both groups just before treatment and after treatment during the reading of the “Rainbow Passage”. Perceptual ratings were done by two SLPs who had no knowledge of the participants’ conditions, group assignments, or the experimental hypotheses.

Statistical analysis, one-way ANOVA for unequal sample sizes, was completed. Results revealed statistically significant improvements in both mean hoarseness and mean breathiness in the LSVT group post-treatment, but not in the RET group. The post-treatment between-group differences for hoarseness and breathiness were found to be statistically significant. The researchers concluded that LSVT is effective in improving breathiness and hoarseness in individuals with PD.

The strength of this study is found in its randomized control design and the use of appropriate statistical analyses. In addition, the inter-rater and intra-rater reliability measures were performed for perceptual ratings and yielded adequate agreement between raters and between ratings of breathiness and hoarseness by the same rater ensuring reliable findings.

The most important limitation of this study is the unequal sample sizes. The RET group had approximately half the number of participants as the LSVT group. This unequal sample size, although acknowledged by the authors, could significantly impact the results. As the authors explain, the small sample group could have prevented the results from showing statistically significant effects in the RET group. Moreover, the perceptual data were collected during the reading of the “Rainbow Passage” only. Reading aloud tasks are not natural and not representative of how people normally communicate. Therefore, the improvements in breathiness and hoarseness should be assessed in more normal speaking situations. Overall, Sapir et al. (2007) provide Level 1 evidence demonstrating improvements in hoarseness and breathiness following LSVT.

Ramig, Countryman, Pawlas, O’Brien, Hoehn and Thompson (2001) evaluated the short- and long-term effects of LSVT compared with RET on individuals with PD. The study evaluated effects of LSVT on vocal loudness as well as fundamental frequency and its variability. Only data pertaining to frequency will be discussed.

Thirty-three participants with IPD were recruited for the study. Participants were stratified on variables of age, time since diagnosis, severity rating according to the scores on unified Parkinson’s disease rating scale, stage of disease, and clinical severity ratings of speech and voice. Participants were randomly assigned to one of the two treatments groups: LSVT (n=21) or RET (n=12). The treatment intensity, daily homework and clinician feedback were consistent between the groups.

The voice data was collected during reading of the “Rainbow Passage” and a 25- to 30-second monologue. The data was collected before treatment, immediately after treatment, at 6- and 12-month follow-up, and at 24-month follow up. Only results of the data collected pre-treatment, immediately post-treatment and at 24-month follow-up were reported in this article.

Statistical analysis, ANOVA, was completed for acoustic measures of fundamental frequency and its variability. Fundamental frequency variability was measured in terms of semitone standard deviation (STSD). Statistically significant between-group differences were found only for mean STSD for the “Rainbow Passage” from pre- to immediately post-treatment. No other between-group differences were significant for STSD between the LSVT and RET groups. Other findings included statistically significant improvements in mean STSD from pre-treatment to immediately post-treatment, and at 24 month follow-up, for *all* speech tasks for the LSVT group. Contrastively, the RET group only showed statistically significant improvements for one measure: pre-treatment to immediately post-treatment measures of mean STSD for the “Rainbow Passage”. The authors concluded that individuals with IPD treated with LSVT are likely to maintain treatment-specific improvements up to 2 years after treatment.

The strength of this study is the use of randomized control trial and the stratification of participants followed by random assignment of groups. This allows for conclusion that the outcome measures were specific to LSVT, and likely not any extraneous factors. The statistical analyses used was also appropriate for the research design. Another strength of this study was found in the methodology of data collection. All data was collected by an experimenter who was not involved in the treatment and was blind to the group assignment of each participant. Furthermore, unlike the earlier studies discussed in this paper, the researchers in this experiment attempted to include a more natural speech sample. Although the monologue was only 25 to 30 seconds in duration, it does provide for a more natural speaking situation compared to the reading aloud tasks. Finally, this was the only study that investigated the effects of LSVT 24 months post-treatment. Studying the long-term effects of therapy programs have important clinical implications.

The primary limitation of this study is the lack of statistically significant between-group differences. The LSVT program failed to demonstrate statistically significant superiority over the RET program with regards to improvements in STSD values post-treatment. Similar to the research conducted by Baumgartner et al. (2001), the treatment and control groups in this study consisted of a higher proportion of male participants than female participants. Thus, the results of this study should be interpreted with caution when applying to all individuals with PD. While Ramig et al. (2001) provide Level 1 evidence for the long-term effectiveness of LSVT in improving STSD values, they fail to establish statistically significant between-group differences for LSVT and RET.

Within group repeated measures design

Sauvageau, Roy, Langlois and Macoir (2015) investigated the effects of LSVT in improving vowel articulation and coarticulation in individuals with PD. The primary objectives of the study included, studying the impact of LSVT on speech loudness in French-speaking individuals with PD, evaluating the effects of LSVT on acoustical measures of vowel articulation, and examining the impact of LSVT on consonant-vowel (C-V) coarticulation. Only results pertaining to vowel articulation and coarticulation will be reported.

Nine participants with IPD, all of whom were native speakers of Quebec French, were recruited for the study. The severity of their speech and voice deficits ranged from mild to severe. All nine participants received the standard LSVT protocol outlined earlier.

Voice and speech data were collected on two different days one month prior to treatment to establish baselines. The post-treatment data was collected day after the treatment, and at 1- and 2-month post-treatment. All recordings were made by a research assistant not involved in the treatment sessions. During the recordings, various speech tasks were administered for acoustic analysis of speech loudness, vowel articulation and C-V coarticulation. For measurement of vowel articulation, the speech task included a reading aloud task. The vowels analyzed were /i, u, a/. Coarticulation was measured with a reading aloud task where the CVCV combinations for analysis were embedded within a carrier phrase. The target vowels included /i, u, a/; the target consonants included /b, d, g/.

Acoustic analyses of vowel articulation involved similar procedures as the Sapir et al., (2007) study discussed earlier. Data on F1 and F2 frequencies were collected to calculate Acoustic Vowel Space (AVS). Acoustic measures of coarticulation included use of the Locus Equation (LE).

Statistical analyses, MANOVA, was completed to evaluate the effects of treatment (pre versus post) on vowel articulation and C-V coarticulation. The results yielded a statistically significant increase in acoustic vowel space and vowel duration post-treatment. Together, these results indicate improved vowel articulation post-treatment. Results also revealed a statistically significant overall improvement in C-V coarticulation. It should be noted, however, that for anticipatory coarticulation, only statistically significant improvements for the /b/ and /g/ voiced consonants were noted. The researchers also studied the relationship of acoustic vowel space to vowel loudness and duration. Sauvageau et al. concluded that improvements in vowel articulation post-treatment were directly related to vowel loudness and duration. The study reports that improvements in coarticulation post-treatment were also directly related to vowel loudness. No differences in post-treatment values were observed between immediately post-treatment recordings and at 1- and 2-month follow up. Overall, Sauvageau et al. concluded that LSVT is effective in improving vowel articulation and C-V coarticulation patterns for average and high anticipatory coarticulation contexts (/bV/ and /gV/, respectively), but not for low anticipatory co-articulation contexts (/dV/).

The major strength of this study can be found in its research hypotheses. This was the first time that a study had investigated the effects of LSVT on C-V coarticulation patterns. The acoustic measures of vowel articulation and C-V coarticulation, and statistical methods chosen were appropriate for the research hypotheses and research design, respectively. Reliability measures revealed highly reliable acoustic measures for statistical analysis. Another key strength of the study was that it demonstrated the effectiveness of LSVT in improving speech and voice in French-speaking PD patients, where most other LSVT efficacy studies have included English-speaking participants only. Finally, this was one of the few studies that examined the effects of LSVT in PD that was not conducted by Ramig and/or her colleagues.

The research, however, is not without limitations. As the authors themselves recognize, the study included a small number of participants with PD, and only one participant was a female. Considering the large number of individuals suffering from PD-related speech and voice deficits, both males and females, and accounting for individual variability, one should be careful when applying these results to all individuals with PD. In addition, the research design included a within group repeated measures design with no control group. All participants received the same treatment. Thus, this research provides Level 2 evidence for improvements in vowel articulation and C-V coarticulation following LSVT.

Cannito, Suiter, Beverly, Chorna, Wolf and Pfeiffer (2011) examined the effects of LSVT on intelligibility, in connected speech, in individuals with IPD. The researchers hypothesized that following LSVT, speech intelligibility will improve in association with increased vocal intensity.

Eight participants, all of whom had a diagnosis of IPD, were recruited for the study. Prior to treatment, all participants were evaluated for speech and voice deficits to confirm the presence of hypokinetic dysarthria and its severity. Seven of the eight participants were found to have impaired speech intelligibility. Participants differed from each other with regards to the years since diagnosis and the degrees of severity of the disease and speech deficits. All participants received the standard LSVT protocol consistent with the methodologies described earlier.

Speech data was collected through audio recordings of the participants reading aloud lists sentences ranging in length from five to 15 words, taken from the Sentence Intelligibility Test (SIT). Audio recordings were made on three days pre-treatment and three days post-treatment. The audio recordings were presented to the judges, 24 graduate student volunteers, in a sound-treated booth with competing background noise in order to simulate more natural listening conditions. The judges were unfamiliar with the participants and were not aware of the treatment conditions. Speech intelligibility was measured by calculating the percentage of words correctly understood in the sentences.

A two-way repeated measures ANOVA was completed to evaluate improvements in speech intelligibility post-treatment. Results revealed statistically significant mean improvements in speech intelligibility post-treatment.

The strengths of this study can be found in its research hypotheses. Numerous efficacy studies have investigated the impact of LSVT on vocal intensity and other speech characteristics. However, only a few of these studies have examined the outcome measure of speech intelligibility as it relates to the improved aspects of speech and voice resulting from LSVT. An attempt to evaluate speech intelligibility in connected speech, as opposed to single words, is also commendable. Connected speech is more representative of how individuals normally speak. Also, this study was the first that examined the effects of LSVT on speech intelligibility in competing background noise. As researchers explain, presence of background noise is more representative of normal listening conditions and thus, can provide important information regarding the effects of LSVT on speech intelligibility in more natural settings. Through use of "equalized intensity" during presentation of audio recordings of sentences produced by the participants to the listeners, Cannito et al. (2011) demonstrated that post-treatment increases in speech intelligibility were not a result of increased vocal loudness. This finding can yield significant clinical implications for use of LSVT to increase speech intelligibility in patients with PD who do not have hypophonia (soft voice).

Despite its many strengths, the research study was not without limitations. The most significant limitation was the small number of participants included in the research. Due to the dynamic nature of the disease and the differences in specific speech and voice deficits among patients with PD, the results of the study should be interpreted with caution when applying to all individuals with PD. While "equalized intensity" during presentation of audio recordings to the judges was important in concluding that increased speech intelligibility resulted from factors that were not associated with vocal loudness, the improvements in speech intelligibility should have also been investigated with participants' actual vocal loudness post-treatment. This is crucial because increase in speech intensity is predicted post-LSVT which does contribute to overall speech intelligibility for PD patients with reduced loudness pre-treatment. Similarly, improvements in speech intelligibility post-LSVT should have been evaluated with and without background noise to accurately study the actual improvements in speech intelligibility and the impact of competing background noise on this improvement. Overall, although Cannito et al. (2011) provide Level 2 evidence demonstrating improvements in speech intelligibility following LSVT, the results should be interpreted in the context of other larger scale studies with findings of improved speech and voice characteristics following LSVT.

Discussion

All of the literature evaluated reports improvements in speech and voice characteristics of individuals with PD following LSVT. Therefore, as a group the articles provide evidence for efficacy of LSVT in improving other aspects of speech and voice in addition to vocal loudness. However, a critical review of the literature suggests that a few limitations should be considered. First of all, because LSVT's primary aim is to increase vocal intensity, only a limited number of studies have investigated the effects of LSVT on other aspects of speech and voice. Secondly, four out of the five studies evaluated reported findings based on short-term effects of LSVT. With limited data on long-term effectiveness, it is difficult to truly determine the usefulness of LSVT in regards to maintaining gains made during therapy. Moreover, the studies evaluated, especially the within group designs, consisted of small sample sizes limiting the ability to generalize the findings to all individuals with PD. Furthermore, all of the acoustic and perceptual data was collected during speech tasks that do not represent natural speaking conditions such as, conversations. For example, reading aloud tasks are not typical of how individuals normally communicate. Thus, the results should be interpreted with caution when applying to more natural, conversational speech. Related to this is the fact that all of the speech and voice data was collected in the clinical setting. This limits the ability to generalize the improvements made as a result of LSVT to more natural settings outside of the clinic. Additionally, the studies evaluated did not examine the effects of improved articulation, frequency, hoarseness and breathiness as it relates to overall speech intelligibility. For clinical application, it is important to evaluate the changes in speech intelligibility as a result of improvements in these aspects of speech and voice. Another major concern is that all of the Level 1 evidence was reported by studies conducted by Ramig and her colleagues. Lorraine Ramig is the founder of LSVT and thus, it is possible that her personal biases may have influenced the results of the research.

Conclusion

The results of the review provide suggestive evidence for the efficacy of LSVT in improving various aspects of speech, in addition to vocal loudness, in individuals with PD. More research is needed to evaluate the long-term effectiveness of these improvements and to determine whether treatment gains are transferrable to more natural speaking conditions outside of the clinic setting.

Recommendations

Based on the aforementioned limitations of the current literature, further research is needed to investigate the effects of LSVT on speech and voice characteristics of individuals with PD. Future research should:

a) Employ study designs that incorporate larger sample sizes and more equal male to female participant ratios for better generalization of the results.

b) Investigate the long-term effectiveness of LSVT in improving these additional areas of speech and voice deficits in PD.

c) Use outcome measures that assess changes in overall communicative ability as a result of improvements in these aspects of speech and voice.

d) Evaluate the effects of treatment in more natural speaking situations (i.e. conversations) and natural settings outside of the clinic.

Clinical Implications

This critical review provides support for the use of LSVT in improving articulation, vocal frequency, breathiness, hoarseness, and overall speech intelligibility in individuals with PD, within the clinical setting. While future research is needed to determine the long-term effects of LSVT on these additional aspects of speech and voice, and to determine whether treatment gains are transferrable to more natural speaking situations outside of the clinic, current research does provide suggestive evidence for use of LSVT in improving these additional areas of speech and voice for patients with Parkinson's disease.

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