Critical Review:
What is the evidence of the effectiveness of Lee Silverman Voice Treatment (LSVT) in increasing speech intensity in individuals with non-hypokinetic dysarthria?*

Sophia Neppel
M.Cl.Sc (SLP) Candidate
University of Western Ontario: School of Communication Sciences and Disorders

This critical review examined the effectiveness of Lee Silverman Voice Treatment (LSVT) on the speech intensity of individuals with non-hypokinetic dysarthria. One randomized control trial, two experimental single subject studies, one within groups study, one case series study, two case studies, and two systematic reviews were included in this critical review. Overall, results provided suggestive evidence of the effectiveness of LSVT in increasing speech intensity among individuals with non-hypokinetic dysarthria. Recommendations for clinical implications and future research are discussed.

Introduction

Lee Silverman Voice Treatment (LSVT) was originally designed for treating individuals with Parkinson's disease, which is also referred to as hypokinetic dysarthria (Mahler & Ramig, 2012), and is highly supported in the literature as a means of treating speech and voice symptoms associated with Parkinson's disease (Wenke, Theodoros, and Cornwell, 2011). These symptoms include: reduced loudness, reduced voice quality, reduced pitch inflection, reduced range of articulatory movements, short rushes of speech (Sapir, Ramig, & Fox, 2008) as well as vocal weakness and fatigue (Sapir et al., 2001). Reasons given for LSVT's success include its incorporation of motor learning and neural plasticity principles into its treatment protocol, whereby frequent and repetitive drill influences changes in the brain (Ludlow et al., 2008). LSVT's primary focus is on increasing loudness, which has also been reported to subsequently influence other areas of the speech mechanism, including amplifying articulatory movement (Dromey and Ramig, 1998b) and slowing speaking rate (Ramig et al., 1995a). Increased loudness can be referred to as a global variable because of these complementary impacts (Dromy & Ramig, 1998b).

Lee Silverman Voice Treatment is delivered in one-hour sessions four days a week for a duration of four weeks, having a total of sixteen one-hour sessions (Mahler, Ramig & Fox, 2009; Mahler & Ramig, 2012). Sessions are divided into two halves. The first half involves a drill component aimed at increasing phonatory effort in order to produce a loud voice with maximum efficiency. Tasks in this component include maximum duration of sustained vowel "ah", maximum fundamental frequency range exercises, and repetition of functional phrases. The session's second half involves functional speech tasks increasing in a hierarchical fashion from phrases, to reading, to conversation in order to promote generalizability. Daily homework exercises are included as part of treatment protocol to support gains made in session and promote generalizability (Mahler, Ramig & Fox, 2009; Mahler & Ramig, 2012).

The potential effects of LSVT on individuals with non-hypokinetic dysarthria subtypes have been under increasing interest (Wenke, Theodorous, & Cornwell, 2011). Yorkston, Spencer, and Duffy (2003) highlight symptom similarities that can exist between individuals with Parkinson's disease and individuals with other sybtypes of dysarthria, including reduced loudness and poor respiratory support/effort, and put forth a "candidacy profile" (p. xxxii) into which both hypokinetic and non-hypokinetic dysarthrias can fit. LSVT applied to individuals with Parkinson's disease and individuals with non-hypokinetic dysarthrias could result in similar physiological changes, including improved vocal fold adduction and vibration (Sapir et al., 2001). The beneficial effects which individuals with Parkinson's disease experience with LSVT could also be experienced by individuals with other subtypes of dysarthria, including those from both progressive and nonprogressive etiologies (Wenke, Theodorous, & Cornwell, 2011). The presence of comparable symptoms between a number of dysarthria subtypes could facilitate treatment carryover from one subtype to another (Yorkston, Hakel, Beukelman, & Fager, 2007).

Thus, an evaluation of the treatment effects of LSVT on individuals with dysarthria subtypes of a non-hypokinetic nature is warranted. Using LSVT as a treatment protocol for increasing speech intensity among both non-hypokinetic and hypokinetic dysarthria subtypes alike, regardless of etiology, would increase efficiency in treating individuals with dysarthrias having symptoms of lower speech intensities.

Objectives

The primary objective of this paper was to critically evaluate the existing literature regarding the effectiveness of Lee Silverman Voice Treatment on speech intensity in individuals with non-hypokinetic dysarthria. The secondary objective was to make suggestions regarding the clinical implications of this body of evidence and to provide recommendations for future research.

Methods

**This paper was created as a required assignment for the CSD9639 Evidence Based Practice for Clinicians course at Western. While it has been evaluated by course instructors for elements of accuracy and style, it has not undergone formal peer-review.*

Search Strategy

Articles for this critical review were found using the CINAHL, EMBASE, PsychINFO, PubMed, and Scopus databases. The following key words were used for the search terms: (((LSVT) OR (Lee Silverman Voice Treatment) OR (intensive voice treatment)) AND (dysarthria))). Limitations placed included (English). The reference lists of relevant articles were manually searched to appropriate further studies for inclusion.

Selection Criteria

Studies selected for inclusion in this critical review were required to investigate the effects of LSVT on objective measures of speech intensity and/or subjective measures of speech loudness in individuals with non-hypokinetic dysarthria. No limitations were placed on the age of participants, time since diagnosis, and severity of the speech and/or voice problem.

Data Collection

The literature search generated nine articles that met selection criteria, including one randomized control trial, two experimental single subject studies, one within groups study, one case series study, two case studies, and two systematic reviews. Six of the studies assessed both speech intensity and loudness, two of the studies assessed only speech intensity, and one study assessed only speech loudness.

Results

Randomized Control Trial Studies

Wenke, Theodoros, and Cornwell (2011) compared the effects of LSVT (n=13) versus traditional therapy (TRAD) (n=13) on speech intelligibility, perceptual speech features (including loudness) and everyday communication in individuals with nonprogressive dysarthria. The authors hypothesized that the LSVT group would exhibit significantly greater improvements across all outcomes. Loudness was analyzed in a reading sample featuring "The Rainbow Passage". Results indicated a statistically significant increase from pre- to post-treatment for loudness in the LSVT group only. There was an increase in loudness from pre- to six-month follow-up in the LSVT group, which, though not statistically significant, still is considered clinically significant. Compared to the TRAD group, the LSVT group did have statistically greater improvements in loudness, providing support for LSVT resulting in an increase in speech intensity.

This level 1 study uses an ABAA design with equal group sizes and an individual not involved in the treatment and assessment phases randomly assigned participants to treatment groups. However, four participants completed only one post-treatment and follow-up assessment, and two received no follow-up assessments due to attrition, even though these two follow-up data were replaced with means generated by statistical procedures. Researchers did not state to which group all the above missing participants belonged: With sample sizes consisting of a limited number of participants (thirteen each), it is difficult to establish if the replacement data were representative of how participants would have performed. Taken together, these limit the generalizability of the results. Ten of the LSVT group participants were a historical treatment group from an earlier study (2008) by the same authors – using data from concurrent treatment and control groups is preferable as it increases generalizability. The perceptual evaluation of loudness was taken from the middle three sentences of "The Rainbow Passage", ensuring representativeness of the reading sample. The assessments conducted during the evaluation phases as well as listening for the perceptual analyses were conducted by SLPs independent of the study. Perceptual evaluation ratings demonstrated strong inter- and intra-rater reliability. Both LSVT and TRAD sessions were implemented according to LSVT protocol to control for frequency differences; however LSVT homework and maintenance tasks, though checked by the treating SLP on the following treatment day, were not reported as being completed or not, potentially affecting results of the LSVT treatment effects and statistical findings. Inclusion criteria included stimulability of participants for increasing loudness, which may limit the representativeness of participants of the population of interest, thus also affecting generalizability of this study's findings. The inferential statistical analyses conducted were appropriate for the study design. Even though results were supportive of LSVT resulting in increased loudness in individuals with non-hypokinetic dysarthria, the evidence from this study is deemed suggestive given the methodological issues raised.

Single Subject Studies

Mahler, Ramig, and Fox (2009) evaluated the effects of LSVT on, among others outcomes, voice and speech characteristics (including speech intensity) of two individuals with dysarthria secondary to stroke. Given this was an exploratory study assessing the feasibility of LSVT, the authors hypothesized that, if a treatment effect was found, further research on LSVT's functional outcomes in this population would be warranted. Participants' maximum duration of sustained vowel "ah", reading "The Rainbow Passage", picture description, and a monologue were assessed for changes in speech intensity. Analyses of results of both participants revealed increased intensity in maximum phonation, reading, and monologue. These increases in speech intensity were present at follow-up for both participants, with minimal increase and/or decrease from post-treatment values. Taken together, these results provide support for LSVT resulting in an increase in speech intensity in individuals with non-hypokinetic dysarthria, and warrant further investigation by the authors.

This level 1 study uses an experimental ABAA single subjects design. Each participant underwent three baseline assessments, which allowed for a reliable gauge of participants' pre-treatment performance. Two assessments were taken in each assessment phase following treatment. Data were analyzed three ways: visual inspection, mean/grand mean and standard deviation comparison, and effect size, permitting a thorough analysis of the results and adding to the reliability and generalizability of the results. Participant one showed a stable baseline for all tasks, establishing a

strong control. Significant differences and large effect sizes were found between pre- and post-, and pre- and follow-up assessments for this participant, however no confidence intervals were reported. Post- to follow-up grand means were almost identical, indicating stability of treatment effect. Results for participant two were less promising. Baseline data showed variability within and between some tasks, resulting in a weak control. Post- and follow-up data revealed some overlap and variability between phases, weakening the effects of treatment and treatment generalizability. Post- to follow-up grand means were variable, with some minimal increases and decreases. Overall, participant two's post- and follow-up grand means were greater than one standard deviation from pre-treatment across all speech tasks, and a moderate effect size was found, though no confidence intervals were reported. Individuals conducting assessment sessions and analyzing the data were independent from administering treatment and blind to the time data was collected respectively, reducing bias. Carryover activities were given, but compliance of participants was not reported, which could affect treatment and post-treatment results, thus generalizability of study findings. The low number of participants and differences between the vocal fold status of participants (e.g. normal vs. reduced adduction and bowing) weakens the external validity of this study. The descriptive and inferential statistical procedures conducted were appropriate for this treatment design. Though the treatment results obtained warrant additional research on LSVT's functional outcomes on individuals with non-hypokinetic dysarthria, the evidence from this study is deemed suggestive given the methodological issues raised.

Mahler and Ramig (2012) evaluated the effects of LSVT on, among other outcomes, the acoustic and perceptual speech characteristics of four individuals with dysarthria secondary to stroke. Given that this was an exploratory study assessing the feasibility of LSVT, the authors sought evidence of treatment effects and magnitude of change. Participants' maximum duration of sustained vowel "ah", reading a "Farm Passage", picture description, and a monologue were assessed for changes in speech intensity. Loudness was assessed in a sentence reading task and results supported increased loudness for post-treatment samples. Analysis of the results indicated significant improvement in all four tasks for all participants from pre- to post-treatment, providing support for LSVT resulting in an increase in speech intensity in individuals with non-hypokinetic dysarthria, and providing evidence of treatment effects and magnitude change to the authors.

This level 1 study uses an experimental ABA single subjects design. Four baseline measures were taken within a two-week period immediately preceding treatment and support control stability. Four post-treatment assessments were taken over the two-week period immediately following-treatment. Acoustic data were thoroughly analyzed four ways: visual inspection, mean and standard deviation comparison and paired t-test, and effect size, adding to the reliability and generalizability of the results. Overall, acoustic data results were strong and revealed increases between pre- and post-assessment measures for all participants for all tasks with large effect sizes, but lacked reporting of confidence intervals. Differences between pre- and post-treatment means were statistically significant for all participants on all tasks, except for a single participant's post-treatment description task, whose results were excluded from analyses. Given the small sample size, loss of this data could impact generalizability of results. Separate individuals conducted the assessment phases and treatment phase. It is not reported if the individual conducting the assessments was blind or independent of the study, indicating a potential for bias. The person analyzing the data was blind to the time the data was collected, and a second analyzer participated in some of the analysis, permitting an excellent inter- and intra-rater reliability to be established. The SLP responsible for treatment did not participate in data analysis. Ten naïve and blinded listeners evaluated perceptual loudness, with a strong inter- and intra-rater reliability. Daily homework was given, but participant compliance was not reported, which could limit treatment results and generalizability of findings. The descriptive and inferential statistical procedures conducted were appropriate for this study design. Though results support LSVT increasing speech intensity in individuals with non-hypokinetic dysarthria, the evidence from this study is deemed suggestive given the methodological issues discussed.

Within Groups (Repeated Measures) Studies

Wenke, Theodoros, and Cornwell (2008) evaluated the effects of LSVT on perceptual and acoustic measures of voice and everyday communication in ten individuals with dysarthria following TBI or stroke. The authors hypothesized improvements on all outcomes after treatment. Loudness was assessed in reading from the middle three sentences of "The Rainbow Passage" and results indicated a significant increase in the post-treatment phase, but this decreased somewhat at follow-up. Participants' maximum duration of sustained vowel "ah", reading "The Rainbow Passage", and a conversational sample were assessed for changes in speech intensity. Speech intensity increased in statistical significance from pre- to post-treatment and from pre- to follow-up across all tasks, except for the sustained /ah/ at follow-up. Except for the conversational sample at follow-up (increase of 3.4 dB SPL), all increases were above 5 dB SPL and thus considered clinically significant though an increase in even 3.4 dB SPL could be considered to have some value. Though unreported, all intensities decreased somewhat from post-treatment to follow-up, but still remained much above pre-treatment levels. Analyses of results indicate improvement in all tasks for all participants, providing support for LSVT resulting in an increase in speech intensity in individuals with non-hypokinetic dysarthria.

This level 2b study followed an experimental ABAA within groups design. A main drawback of grouping the ten participants is that their individual responses to treatment remained unidentified. A researcher independent of the study conducted the assessment phases and assessment tasks were fully completed on each of two separate days to provide a more representative sample of behaviour. Two speech-language pathologists blind to treatment and

assessment phases made perceptual judgments of the loudness of participants speech in a reading of the three middle sentences of "The Rainbow Passage", providing a sample more representative of participants' speech. Good to very good intra- and inter-rater reliability was reported. Daily homework and maintenance exercises were provided, but participant compliance was not reported, which may impact individual participant outcome performances and the external validity of findings. Inclusion criteria included stimulability of participants for increasing loudness, which may weaken the representativeness of participants of the population of interest, thus also affecting generalizability of this study's findings. The inferential statistical analyses conducted were appropriate for this research design. Given the methodological issues indicated above, the evidence of this study is suggestive.

Case Series Studies

Sapir, Pawlas, Ramig, Seeley, Fox, and Corboy (2001) evaluated the effects of LSVT on vocal function in two individuals with dysarthria secondary to multiple sclerosis. Loudness was assessed via reading and picture description tasks for pre- to post-treatment only. Results indicated that statistically significant increases in loudness were found post-treatment; however, ratings were not taken at follow-up for these tasks. Four additional perceptual ratings of loudness given a forced choice between two stimuli indicated a preference for the post-treatment stimuli across all raters. Intensity was assessed via maximum duration of sustained vowel "ah", reading "The Rainbow Passage", picture description, and a monologue sample. Results indicated that both participants' speech intensity from pre- to post- and post- to follow-up was statistically significant on all four tasks, though there were some decreases in follow-up values. Taken together, these results provide support for LSVT resulting in an increase in speech intensity in individuals with non-hypokinetic dysarthria.

This level 3 study followed an experimental ABAA design. This case series design is not as rigorous as previous designs mentioned, impacting the strength of its findings. Three baseline measures for each participant were taken a few days apart immediately prior to treatment and had no significant differences between them, indicating stability; each participant's results were then pooled. Participants underwent two assessments per assessment phase after treatment. However, one participant only completed one assessment in the second "A" phase. Given that this study only had two participants, missing data from one assessment phase further impacts study results and generalizability of the findings. No comparison was made in speech intensity from post-treatment to six-month follow-up, but these follow-up means were still greater than pre-treatment means. Without additional longer-term data, it is difficult to establish the trend following the six-month timeframe. Blinding of the assessment phase data collectors is not reported and could lead to bias in reporting results. The eleven naïve listeners rated the loudness of randomized samples. In addition, four individuals rated loudness by selecting which one they perceived as being "louder" between pairs of participants' recordings that had been randomized. The randomization of samples protects for bias. Both sets of listeners demonstrated high intra- and inter-rater reliability, supporting validity and generalizability of results. Appropriate inferential statistical analyses were conducted given this research design. The evidence of this study is deemed suggestive due to the methodological concerns raised above.

Case Studies

Solomon, McKee, and Garcia-Barry (2001) report on acoustic and perceptual speech characteristics in LSVT compared to Combination Treatment in an individual with mixed hypokinetic-spastic dysarthria resulting from TBI. The participant successively underwent four weeks of LSVT, six weeks of Combination Therapy, and ten weeks of Follow-Up Treatment. Results were analyzed after each treatment block and lastly at three-months after all treatment ceased. Reading and monologue tasks underwent perceptual (loudness) and acoustic (intensity) ratings. Results indicated an increase in intensity and loudness following LSVT, and further increase in intensity following Combination Treatment; these gains were maintained to varying degrees after Follow-Up Treatment and the no-treatment period that followed. Gains made in intensity persisted after all treatment ceased, but it was reported that the individual independently continued home exercises, which could affect outcomes. Researchers do not attribute gains made to one specific treatment, hypothesizing a cumulative effect of all treatments. Thus the effects of LSVT alone on loudness and intensity in this individual with non-hypokinetic dysarthria remain uncertain.

This level 4 case study makes some attempts at establishing baseline and assessment phase controls, but repeated assessments during each of the assessment phases were not completed, hindering establishment of a stable baseline. The absence of a baseline prohibits valid comparisons to be made of post-treatment data to pre-treatment status. Endeavors in rating loudness along with other perceptual measures along a seven-point equal interval scale used random order and only intra-rater reliability was reported, weakening the study's already limited validity and reliability. It is not reported whether assessors of each assessment phase or individuals administering LSVT were independent of the study, resulting in potential bias and limiting study results. The authors adequately describe the procedures used in this research design. Given the above mentioned limitations in design and methodology, the strength of the evidence for this study is deemed equivocal.

Sapir, Spielman, Ramig, Hinds, Countryman, Fox, and Story (2003) report on acoustic and perceptual measures of speech after LSVT in an individual with ataxic dysarthria secondary to cerebellar dysfunction. Given that this was a phase two study (Yorkston, Hakel, Beukelman & Fager, 2007), the authors sought information on how LSVT affects their population of interest. Acoustic measures of intensity were taken for maximum duration of sustained vowel "ah", reading "The Rainbow Passage", reading three standard sentences, picture description, and monologue tasks at pre- and post- treatment, and at nine-month follow-up. Intensity measures indicated

increases from pre- to both post-treatment and follow-up for all speech tasks. These results lend greater support to LSVT's effects on speech intensity in individuals with non-hypokinetic dysarthria, and provide information to the authors on LSVT's effects on persons with ataxic dysarthria secondary to cerebellar dysfunction.

This level 4 case study established baseline and assessment phase controls with repeated assessments (three at pre-, two at post-, and one at follow-up), offering more stable points for comparison with later results. No reporting is made of whether assessors of each assessment phase, data analyzers, or individuals administering LSVT were independent of the study, resulting in potential bias and affecting study results. Inter- and intra-rater reliability is not reported nor can it be understood if more than one individual rated the perceptual and acoustic data, further limiting the study's generalizability. The authors adequately describe the procedures used in this research design. However, given the limitations in design and methodology, the strength of the evidence from is deemed suggestive.

These two level 4 studies are not as strong in design and methodology as studies of higher levels. Case studies lack experimental rigor and attempted methods of control are not robust enough to account for differences between assessment phases, offering limited support for a particular treatment's direct result on outcome measures of interest and weakening each studies' internal and external validity. As these are case studies, other variables that could influence results were difficult to control for and have a strong likelihood of considerably influencing results. As well, any generalizability is seriously affected given the sample sizes consisted of only a single participant.

Systematic Review Studies

Yorkston, Spencer, and Duffy (2003) completed a systematic review of the literature evaluating the effects of behavioural techniques in managing respiratory/phonatory dysfunction in individuals with dysarthria. Sixteen of the thirty-five articles obtained described LSVT across all dysarthria subtypes, with most including studies concerning Parkinson's Disease (PD), but other types of dysarthria were represented as well, such as individuals with dysarthria secondary to multiple sclerosis (MS) and TBI. The authors describe how similar symptoms between PD and other forms of dysarthria support the use of LSVT, originally developed to treat reduced loudness in PD, in treating those symptoms. They reference studies concerning MS (Sapir et al., 2001) and TBI (Solomon, McKee, & Garcia-Barry, 2001) that have had some success in treating reduced loudness, stating that "there is some evidence to support effectiveness of LSVT" (Yorkston, Spencer, & Duffy, 2003, p. xxxiv) in those populations.

Yorkston, Hakel, Beukelman, and Fager (2007) completed a systematic review of the literature evaluating the effectiveness of interventions targeting the loudness, rate, or prosodic global aspects of speech production for individuals with dysarthria. Of the twenty-one studies targeting loudness, most focus on increasing loudness in PD using LSVT, and the strongest evidence support base for the use of LSVT is held for the PD population. The authors report preliminary data on the success of LSVT in individuals with MS (Sapir et al., 2001), TBI (Solomon, McKee, & Garcia-Barry, 2001), and cerebellar dysfunction (Sapir, et al., 2003) while still holding that the usefulness of LSVT in non-dysarthric populations should be further explored.

These systematic reviews are robust in their design. They each bring together and systematically describe a comprehensive body of literature about a given treatment effect, behavioural techniques (including LSVT) for managing respiratory/phonatory dysfunction and effectiveness of interventions targeting global aspects of speech (including loudness). Methodological aspects include ratings of strength of evidence including types of study, psychometric adequacy of measurement, evidence of control, and outcomes for the first study. The latter study's methodological features include ratings of evidence strength via type of research presented in each study, and strength of description of both participants and consequences of the intervention. Other strengths in methodology include statements of inclusion and exclusion criteria. Results of both reviews were strongly relevant to this critical analysis paper's population of interest. Adequate procedures were used to describe the various studies included in these systematic reviews. However, the applicability of these earlier studies' findings to more recent literature on the effects of LSVT on individuals with non-hypokinetic dysarthria necessitates the evidence of Yorkston's studies (2003, 2007) to be deemed suggestive.

Discussion

Overall, the evidence from the literature is suggestive in supporting an increase in speech intensity and/or its perceptual correlate, loudness, as a result of LSVT intervention in individuals with non-hypokinetic dysarthria.

These encouraging results must be interpreted with caution. Lorraine Ramig, a developer of LSVT, appears as an author in four of the nine studies. This may contribute to potential bias in the research process. In addition, several other researchers appear as authors in more than one of the studies appraised. Taken together, this indicates that the use of LSVT in treating reduced speech intensity in individuals with non-hypokinetic dysarthria has not yet been subject to consistent external analysis by independent researchers.

In addition, these studies cover a wide range of non-hypokinetic dysarthrias with diverse etiologies. The majority of the studies appraised had samples consisting of stroke and traumatic brain injury participants. These "nonprogressive dysarthrias" (Wenke, Theodoros, & Cornwell, 2011), may have different treatment effects than dysarthrias resulting from multiple sclerosis or cerebellar dysfunction, inspite of the common "candidacy profile" (2003) put forth by Yorkston et al. The generalizability of results across all non-hypokinetic dyarthrias, regardless of etiology, should be made with caution.

Both of Yorkston et al.'s systematic reviews (2003, 2007) were conducted prior to the completion of the majority of studies evaluating LSVT's effect on speech intensity and/or loudness in individuals with non-hypokinetic dysarthria. Therefore, it is difficult to generalize the applicability the findings of these two studies to more current evidence in the literature concerning LSVT's effect on speech intensity in those with non-hypokinetic dysarthria.

Some general concerns are raised associated with the methodology of the studies appraised. There are inconsistencies in the use of otolaryngological examination and assessment of cognitive status prior to treatment. This is significant because differences between participants' vocal fold and cognitive status could interfere with treatment outcomes and performance during data collection. Inconsistencies were also shown between studies in assessing the stimulability of participants' capacity for increasing their loudness, which may limit the representativeness of participants included in these studies to the population of interest. Additional inconsistencies were shown in the LSVT certification status of SLPs administering treatment. Other inconsistencies were present in assigning, following-up, and reporting on homework and carryover activities. Differences in compliance between participants could limit treatment outcomes and results. There were differences between studies in establishing consistent baselines and use of controls, which weaken treatment effects. Overall, sample sizes were small, ranging between one and thirteen participants for the treatment groups, which weakens the generalizability of results. Additional methodological concerns include inconsistencies in reporting on inter- and intra-rater and test-retest reliability; the blinding of assessors, raters, and data collectors; and the reporting of confidence intervals for effect sizes found. As well, there was overlap between speech intensity measures and LSVT treatment protocol, which may have resulted in practice effects.

Some interesting themes arose in this critical appraisal. Studies conducting follow-up measures showed an overall trend of decreases in speech intensity or loudness from post-treatment to follow-up assessment, however, follow-up values remained well above baseline values. Though these values remained above baseline, they provided no indication of longer-term tendencies, whether speech intensity stabilized or continue to further increase or decrease with time. Another theme was that later studies provided stronger levels of evidence and research design than earlier studies. This is consistent with Yorkston et al.'s (2003) mention of hierarchical development of study design from earlier to later studies.

Conclusion and Recommendations

Overall, individuals with non-hypokinetic dysarthria demonstrated increased speech intensity and/or loudness as an outcome of LSVT.

Further research should consider conducting longer-term speech intensity follow-up to gauge the stability of LSVT's effects and examine the effects of post-treatment decline. Further studies should include stronger and more robust study designs from diverse researchers with larger sample sizes. As well, future studies should consider evaluating LSVT's effects on a greater number of both progressive and non-progressive dysarthrias resulting from non-hypokinetic etiologies.

Clinical Implications

The results of the nine studies included in this critical appraisal generally lend support for LSVT increasing speech intensity in individuals with non-hypokinetic dysarthria from pre-treatment to both post-treatment and follow-up. Therefore, LSVT can be recommended for increasing speech intensity in individuals with non-hypokinetic dysarthria, particularly in the cases where the dysarthria stems from stroke and TBI.

References

Dromey, C. & Ramig, L. O. (1998b). Intentional changes in sound pressure level and rate: Their impact on measures of respiration, phonation, and articulation. *Journal of Speech, Language, and Hearing Research, 41*(5), 1003-1018. Retrieved from http://jslhr.pubs.asha.org/

Dollaghan, C. A. (2007). *The handbook for evidence-based practice in communication disorders.* Baltimore, MD: Paul. H. Brookes Publishing Co.

Ludlow, C. L., Hoit, J., Kent, R. D., Ramig, L., Shrivastav, R., Strand, E. A., Yorkston, K., & Sapienza, C. N. (2008). Translating principles of neural plasticity into research on speech motor control recovery and rehabilitation. *Journal of Speech, Language, and Hearing Research, 51*(1), S240-S258. Retrieved from http://jslhr.pubs.asha.org/

Mahler, L. A., Ramig, L. O., & Fox, C. (2009). Intensive voice treatment (LSVT® LOUD) for dysarthria secondary to stroke. *Journal of Medical Speech Language Pathology, 17*(4), 165-182. Retrieved from https://www.pluralpublishing.com/journals_JMSLP.htm

Mahler, L. A. & Ramig, L. O. (2012). Intensive treatment of dysarthria secondary to stroke. *Clinical Linguistics and Phonetics, 26*, 681-694. doi:10.3109/02699206.2012.696173

Oxford Centre for Evidence-Based Medicine (OCEBM) (2009). Levels of Evidence Working Group. "The Oxford 2011 Levels of Evidence". Oxford Centre for Evidence-Based Medicine. http://www.cebm.net/index.aspx?o=5653

Ramig, L. O., Countryman, S., Thompson, L. L., & Horii, Y. (1995a). Comparison of two forms of intensive speech treatment in Parkinson disease. *Journal of Speech and Hearing Research, 38*(6), 1232-1251. Retrieved from http://jslhr.pubs.asha.org/

Sapir, S., Pawlas, A. A., Ramig, L. O., Seeley, E., Fox, C., & Corboy, J. (2001). Effects of intensive phonatory-respiratory treatment (LSVT) on voice in two individuals with multiple sclerosis. *Journal of Medical Speech-Language Pathology, 9*(2), 141-151.

Sapir, S., Ramig, L. & Fox, C. (2008) Speech and swallowing disorders in Parkinson's disease. *Current Opinion in Otolaryngology & Head and Neck Surgery, 16*(3), 205-210. Retrieved from http://journals.lww.com/pages/default.aspx

Sapir, S., Spielman, J., Ramig, L. O., Hinds, S. L., Countryman, S., Fox, C., & Story, B. (2003). Effects of intensive voice treatment (the Lee Silverman Voice Treatment [LSVT]) on ataxic dysarthria: A case study. *American Journal of Speech-Language Pathology, 12*(4), 387-399. Retrieved from http://ajslp.pubs.asha.org/

Solomon, N. P., McKee, A. S., & Garcia-Barry, S. (2001). Intensive voice treatment and respiration treatment for hypokinetic-spastic dysarthria after traumatic brain injury. *American Journal of Speech-Language Pathology, 10*, 51-64. doi:10.1044/1058-0360(2001/008)

Wenke, R. J., Theodorous, D., & Cornwell, P. (2008). The short- and long-term effectiveness of LSVT® for dysarthria following TBI and stroke. *Brain Injury, 22*, 339-352. doi:10.1080/02699050801960987

Wenke, R. J., Theodorous, D., & Cornwell, P. (2011). A comparison of the effects of the Lee Silverman Voice Treatment and traditional therapy on intelligibility, perceptual speech features, and everyday communication in nonprogressive dysarthria. *Journal of Medical Speech-Language Pathology, 19*(4), 1-24. Retrieved from https://www.pluralpublishing.com/journals_JMSLP.htm

Yorkston, K.M., Hakel, M., Beukelman, D. R., & Fager, S. (2007). Evidence for effectiveness of treatment of loudness, rate, or prosody in dysarthria: A systematic review. *Journal of Medical Speech-Language Pathology, 15*(2), xi-xxxvi. Retrieved from https://www.pluralpublishing.com/journals_JMSLP.htm

Yorkston, K.M., Spencer, K. A., & Duffy, J.R. (2003). Behavioral management of respiratory/phonatory dysfunction from dysarthria: A systematic review of the evidence. *Journal of Medical Speech-Language Pathology, 11*(2), xiii-xxxviii. Retrieved from https://www.pluralpublishing.com/journals_JMSLP.htm