# Critical Review: Examining the efficacy of a telerehabilitation model for the delivery of Lee Silverman Voice Treatment

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This critical review examines the current evidence regarding the efficacy of telerehabilitation delivery of the Lee Silverman Voice Treatment (LSVT) to patients with Parkinson's disease. Telerehabilitation includes delivery of therapy to a patient in a remote location through the use of any information or communication technologies. Examination of the studies revealed that results comparable to those achieved in face-to-face LSVT are possible, however more rigorous guidelines and protocols for delivery are necessary. Recommendations for further clinical research and clinical implications are provided.

## *Introduction*

The Lee Silverman Voice Treatment (LSVT) has been shown to be an effective therapy with long-term results in treating reduced speech intensity associated with hypokinetic dysarthria suffered by many patients with Parkinson's disease (PD) **(**Ramig, Sapir, Fox, & Countryman, 2001a). Originally developed by Lorraine O. Ramig and her colleagues in 1987 (Ramig, Sapir, Countryman, Pawlas, O'Brien, Hoehn, & Thompson, 2001b), LSVT aims to "improve vocal fold adduction and overall voice and speech production in patients with Parkinson's disease" (Ramig, 2001b). It does this by improving respiratory function, vocal fold adduction, and laryngeal and supralaryngeal muscle activity (Ramig, 2001b).

The primary goal of LSVT, to increase vocal intensity, is achieved through a series of tasks that promote increased breath support and the development a new internal standard of the effort required to achieve a sufficient increase in loudness. The therapy has been shown to successfully increase the vocal intensity in patients with PD with hypokinetic dysarthria (Ramig et al., 2001a). Further, the patients receiving LSVT have been shown to maintain those skills for 6 months post-treatment (Ramig et al., 2001a), and are likely to maintain that success for up to 2 years post-treatment (Ramig et al., 2001b). The intensive therapy requires patients to attend multiple weekly sessions with a speech-language pathologist (SLP) over the course of four weeks.

The frequency and intensity of the therapy subjects patients to a number of access barriers including time and cost of transportation to and from therapy sessions, and an inability to access a speech-language pathologist when living in a remote area. Further, there are a limited number of SLPs trained to administer LSVT. Telerehabilitation, also referred to as 'telehealth' services, is the "delivery of medical rehabilitation services at a distance using electronic information and communication technologies" (Rosen, 1999). Telerehabilitation makes it possible to deliver services to those who may not otherwise receive any.

The efficacy of telerehabilitation delivery of LSVT is of particular interest given the geographically dispersed nature of the Canadian population. For many Canadians, speech and language services are not readily available. Mobility and other access issues also pose great barriers to accessing services for patients with PD and their families. Provided that this delivery model is able to preserve the success seen in traditional LSVT treatment, telerehabilitation delivery of LSVT may allow a far greater number of individuals with Parkinson's disease to receive treatment for hypokinetic dysarthria.

## *Objectives*

The primary objective of this paper is to critically evaluate the current research on the efficacy of delivering LSVT treatment to patients with PD using a telerehabilitation model. The secondary objective is to evaluate the feasibility of the model and the patients' satisfaction with receiving treatment via telerehabilitation.

## *Methods*

<u>Search Strategy</u>
Computerized databases including CINAHL, PubMed, and Medline were searched using the following search strategy: ((Parkinson's Disease)), AND ((telerehabilitation) OR (telehealth) OR (eRehab)), AND ((LSVT) or (Lee Silverman Voice Treatment)).

<u>Selection Criteria</u>
Studies selected for inclusion in this review were required to examine the use of information technology to deliver speech and language treatment for hypokinetic dysarthria to patients with PD in their

homes. Studies not specifically using LSVT treatment were eliminated from this review.

Data Collection

The search strategy yielded five articles that fit with the selection criteria. Study designs included: single subject multiple baseline trial (1), randomized controlled non-inferiority trial (1), repeated measure mixed design trial (2), and single group repeated measures trial (1).

## *Results*

The efficacy and feasibility of delivering LSVT to patients with Parkinson's disease via telerehabilitation were examined in the literature using a variety of delivery methods. Tindall, Huebner, Stemple, and Kleinert (2008) delivered LSVT treatment to 24 participants via videophone in a repeated measures, mixed design study. They compared results of the current study to the results of traditional LSVT delivery as reported by Ramig et al. (2001a).

Methodology for collecting pre- and post-treatment measures in the face-to-face condition outlined in Ramig et al. (2001a) was replicated by the current study. Comparisons of gender and age differences between the two groups of participants were not found to be significant. There was a significant difference between the mean time post-onset of PD between the two groups (Ramig et al. = 8.6 ± 6.3 years; current study = 3.2 ± 1.5 years) which the authors attribute to the presence of four outliers in the Ramig, et al. (2001a) data. One-sample t-tests used to compare pre-treatment results of the two groups were found to be non-significant for all variables. Standard LSVT therapy protocol was delivered to participants of the current study using videophones installed in participants' homes. The phones used a standard telephone line to deliver voice and colour video. In order to receive sound pressure level (SPL) information, participants were instructed at the start of each session to set up a digital sound level meter so that it could be easily read by the treating clinician.

Paired sample t-tests (Bonferroni corrected to 0.0125), were used to compare pre- and post-treatment results for the participants of the current study. It was found that there were significant changes for all measures of prolonged vowel ($p < 0.01$), reading ($p < 0.01$), monologue ($p < 0.01$), and picture description tasks ($p < 0.01$). Analysis of covariance (ANCOVA) was used to measure the power of the observed interactions, which was found to be significant for all four measures.

One sample t-tests were used to compare post-treatment means, measured in decibels (dB), from Ramig et al. (2001a) to the post-treatment means of the current study. The differences were not statistically significant for prolonged vowel ($p < 0.93$), reading passage ($p < 0.27$), and picture description ($p < 0.59$) tasks. This indicates that results of videophone delivery for these three tasks are similar to those achieved in the traditional delivery method. However, a significant difference in mean change of dB was found for the monologue task ($p < 0.01$) between the two studies, indicating that a comparable result was not achieved using videophone delivery.

Participants performed a cost analysis of the two treatments, which estimated that 16 hours of traditional face-to-face therapy costs a patient $1,222.00 USD in travel and other expenses (e.g., meals) and required 51 hours of the patients' time including therapy and travel time. Conversely, all of these costs were eliminated with the telerehabilitation delivery model and required only the 16 hours of therapy time to complete, as travel was not a factor.

A 5-point satisfaction questionnaire completed by 23 participants revealed that the participants were highly satisfied with the telerehabilitation method of delivery (mean = 4.36).

Tindall et al. (2008) was the only study reviewed to employ a method of delivery which did not involve the use of computers. Theodoros, Constantinescu, Russell, Ward, Wilson, and Wootton (2006) employed a single group, repeated measures design to evaluate the effects of delivering LSVT to participants with PD via telerehabilitation. Ten participants who exhibited hypokinetic dysarthria ranging in severity from mild to moderate-severe received therapy via computers enabled with videoconferencing. The system enabled the clinician to receive real-time pitch and SPL information and allowed the clinician to send materials to the participants during treatment sessions. All pre- and post-treatment assessments and ratings were conducted by non-treating researchers; treatment was delivered by LSVT certified clinicians following the guidelines for face-to-face LSVT delivery set out by Ramig, Bonitati, Lemke, and Horii (1994).

Statistical paired t-tests revealed significant increases ($p < 0.05$) in acoustic measures of SPL during sustained phonation ($p = 0.0001$), reading ($p = 0.0001$), and monologue ($p = 0.0001$) tasks, as well as a significant increase in mean pitch range ($p = 0.032$). Perceptual ratings, evaluated on a 5-point scale, were analyzed using a Wilcoxon signed ranks test. Improvements were found in breathiness ($p = 0.011$), pitch variability ($p = 0.005$), loudness variability ($p = 0.008$), and loudness level ($p = 0.008$). Non-significant increases were found in the measures of hoarseness (p = 0.083), articulatory precision (p = 0.083), and speech intelligibility (p = 0.102).

The current results indicate that an increase in vocal intensity using LSVT can be achieved by delivering the therapy via telerehabilitation methods.

A satisfaction questionnaire completed by participants following treatment revealed that 70% of participants were "more than satisfied" with the online treatment. 90% of participants rated the audio quality of the system as "adequate to excellent", and 70% rated the visual quality to be "adequate or better".

Telerehabilitation delivery of LSVT was also examined in a model which combined online and face-to-face delivery of treatment. Howell, Tripoliti, and Pring (2009) used a repeated measures, mixed design to examine the feasibility of delivering LSVT to 3 patients with PD via telerehabilitation. Participants displayed hypokinetic dysarthria due to PD that ranged from mild to moderate.

LSVT therapy was delivered as per the traditional method outlined by Ramig et al. (1994). LSVT via telerehabilitation was delivered in 3 sessions per week via webcam and the fourth session was delivered in the traditional face-to-face method. The researchers cite building client-clinician relationship, the need to objectively measure sound pressure levels, reviewing homework and delivering new materials as reasons for the lack of a completely web-based delivery of the treatment.

All participants were required to possess the necessary computer equipment and be familiar with the use of information technology prior to the start of the study. Online sessions with the treating SLP were conducted using a webcam via Skype, a headset, and microphone. Due to technological constraints of the setup, SPL levels could not be measured during webcam sessions, and so were only measured using a sound level meter at 30cm from the participant's mouth during face-to-face sessions. SPL levels were approximated during webcam sessions by placing the sound level meter in front of the SLP's computer speakers and maintaining a consistent level of volume of the computer across sessions.

All pre- and post-treatment measurements were taken by the treating clinician and were compared by a blind examiner to the findings of traditional LSVT therapy as reported by Ramig et al. (2001a). Data in the study by Ramig et al. (2001a) were collected in sound-treated booths, whereas this was not possible in the current study. Likewise, whereas data from the Ramig et al. (2001a) study were taken as a mean of three pre-therapy assessments, immediately post-treatment, and at a six month follow up, the current study reports data measures taken once two weeks pre-therapy, immediately pre- and post-therapy, and at a two month follow up. In both studies, data was collected during three tasks: sustained phonation of 'ah', reading of the 'Rainbow Passage', and a 60 second monologue.

Using an ANOVA, the participants' results showed improvement in loudness over time (p = 0.01), and a significant interaction between time and type of task (p = 0.01), with the prolonged 'ah' task showing the greatest improvement. Pre- and post-therapy scores of the telerehabilitation and face-to-face delivery groups were compared as a standard deviation, in which the Ramig et al. (2001a) group was treated as the normative sample. Findings showed that these scores were within half a standard deviation of each other. Conversely, the follow-up scores of the current study were much higher than the follow-up scores of the Ramig et al. (2001a) study (prolonged 'ah', SD=1.48; Rainbow passage reading, SD =1.93; monologue, SD =1.39).

The researchers concluded that delivering LSVT via telerehabilitation is feasible and can produce results comparable to traditional face-to-face delivery methods.

Constantinescu, Theodoros, Russell, Ward, Wilson, and Wootton (2010) used an 'n-of-1' case study, with a multiple baseline, repeated measures design to examine the efficacy of remotely delivering LSVT treatment to a patient with Parkinson's disease. The participant was a 65-year-old male, who had been diagnosed with PD 6 years prior. Assessment of his speech revealed a mild hypokinetic dysarthria, and the patient reported decreased loudness and decreased speech intelligibility as well as increased breathiness. The participant had not previously received any speech and language treatment.

Online delivery of the LSVT was performed by an SLP via a home computer system on which the participant was trained prior to commencement of the therapy. Standard LSVT protocols were followed during the delivery of therapy as outlined in Ramig et al. (1994; 1995).

Pre- and post-therapy assessments were completed in a face-to-face environment by two non-treating SLPs following standard LSVT protocol. All acoustic measures were taken using the computer system's acoustic speech processor. Perceptual measures (i.e., breathiness, roughness, articulatory precision, overall intelligibility, etc) were rated by two SLPs who were blinded to the purpose of the study using a Direct Magnitude Estimation (DME) scale. A 5-point satisfaction questionnaire was also administered to the participant to determine his level of satisfaction with the overall experience.

Results of the treatment revealed improvements for all speech intensity tasks: sustained vowel phonation (6.13 dB SPL increase), reading (12.28 dB SPL increase), and monologue (11.32 dB SPL increase). An improvement for duration of sustained vowel phonation (increase of 4s) was also found. Perceptual variables showed improvement in breathiness (30.33 DME reduction), roughness (14.86 DME reduction), speech intelligibility (12.43 DME increase). No statistical comparison of pre- and post-treatment measures was made to determine if the changes were significant.

On the questionnaire, the participant reported that he was very satisfied with the delivery of treatment and would prefer online delivery to traditional face-to-face sessions.

While the studies reviewed demonstrated minimal consistency in methodology between studies, Constantinescu, Theodoros, Russell, Ward, Wilson, and Wootton (2011) employed the identical protocol used in their preliminary study, Theodoros et al. (2006). The current study used a single-blinded, prospective, randomized, controlled, non-inferiority trial to compare telerehabilitation delivery to traditional face-to-face delivery of LSVT. The study involved 34 participants, 8 of whom were included from Theodoros et al. (2006). Criteria for inclusion in the study included a diagnosis of PD and the presence of hypokinetic dysarthria. All participants displayed mild or moderate hypokinetic dysarthria as classified by the principle investigator. Proficiency with computers was not a requirement for inclusion.

All participants were randomly assigned to either the telerehabilitation or face-to-face condition. As well, four SLPs were randomly assigned to both a treatment environment and to participants within those environments. LSVT was administered in both conditions following standard LSVT protocol (delivered 1 hr/day, 4x/week for 4 weeks). Pre- and post-assessment measurements were taken in a face-to-face setting, however measures were obtained using the computer's speech processor for all participants. Post-treatment assessments were completed by randomly assigned SLPs where the SLP who provided treatment to any one participant could not complete the assessment for that particular participant.

On reassessment of the telerehabilitation group, the primary outcome measure of mean change in SPL during a 30s monologue was found to be 1.41dB at 95% CI, which lay within the predetermined ±2.25 dB non-inferiority margin. Analysis using a repeated-measures general linear model (GLM) of acoustic measures of SPL(dB) on sustained phonation, reading, and monologue tasks, as well as duration of phonation, and maximum fundamental frequency showed no significant effect ($p > 0.05$) for environment (telerehabilitation delivery vs. face-to-face delivery). All parameters listed above showed significant improvements with time ($p < 0.05$) with the exception of duration of phonation which showed no significant increase with time for either environment. Perceptual measures were rated using a DME scale, and analyzed using repeated-measures GLM. No significant main effects ($p > 0.05$) of environment were shown for all perceptual measures.

In addition, participants of the online delivery were administered a 5-point satisfaction questionnaire to rate their overall experience with the program. Satisfaction ranged from 'very satisfied' (29.41%), to 'more than satisfied' (52.94%), to 'satisfied' (17.65%).

## *Discussion*

While the authors of the studies described above are generally optimistic about the efficacy of telerehabilitation delivery of LSVT, there exist several methodological limitations to these studies which must be considered. All studies included in this review provided Level 1 experimental evidence.

The studies by Tindall et al. (2008), Theodoros et al. (2006), and Constantinescu et al. (2011) all offer compelling evidence of the efficacy of telerehabilitation delivery of LSVT. The study by Tindall et al. (2008) is unique in that it is the only study which attempted an alternative delivery method (not via computer). While the researchers followed standard LSVT protocol, due to the nature of the setup, they were required to instruct the participants to setup SPL meters themselves so that they could be read over the video feed by the treating clinician. This element of the setup may have introduced an element of inconsistency into the data (Constantinescu et al., 2011), however, as the setup of the meter was guided by the SLP, it is felt that the risk of variability was minimized. Furthermore, all assessment data were collected in face-to-face conditions, minimizing the possibility of context effects, although the effect may still have been present as the assessment procedures very closely resembled therapy activities.

Results obtained by Theodoros et al. (2006) showed considerable improvements in both acoustic and perceptual parameters, however, the study employed a small group size which may have affected the results.

Furthermore, while the researchers report that the results obtained in this study are similar to those reported in previous face-to-face trials of LSVT, they provide no statistical comparison to determine if they are truly similar to traditional methods. This study provides compelling evidence that a telerehabilitation model can produce significant effects in the treatment of vocal intensity in patients with PD. It does not, however, provide sufficient evidence to allow a clinician to assert that a telerehabilitation delivery of LSVT is as efficacious as face-to-face delivery of the program.

Theodoros et al. (2006) and Constantinescu et al. (2011) offer the most compelling evidence of the efficacy of this delivery model. Both studies were conducted in the same environment, using the same protocol, equipment, and software. While their identical setup provides consistency, which is desirable, all treatment in these studies was performed in a university laboratory setting, with a non-treating SLP present to ensure accuracy of setup of the equipment.

The delivery of the program in this manner has several implications: firstly, the studies do not allow any conclusions to be drawn regarding the efficacy of delivering the treatment to the participants' homes. The laboratory setting allows for a highly controlled environment, free of distractions and with minimal complications. These same conditions cannot be guaranteed in a patient's home. Secondly, the program was delivered over custom software on which all treating SLPs were trained prior to beginning delivery of treatment. Therefore, based on these two studies alone, no conclusions can be drawn about whether telerehabilitation delivery would be equally successful if the patients were using alternative software.

The protocol employed by Howell et al. (2009) necessitates extra consideration in interpreting the results achieved in the study. Due to the fact that the entire program was not delivered via telerehabilitation, it cannot be guaranteed that the face-to-face treatment did not bolster the results of the telerehabilitation sessions. Furthermore, because SPL measures were not taken during online sessions, participants were provided with reduced feedback during those sessions and so the delivery of the program does not replicate traditional LSVT protocol. Accordingly, a true comparison of the two delivery methods cannot be made. Additionally, patients had access to materials and recordings which they could review between sessions. This is also out of line with traditional LSVT protocol and may have served to improve the results seen in these participants.

All pre- and post- assessment measures in Howell et al. (2009) were taken by the treating clinician. As well, tasks used to assess patients both pre- and post-treatment were similar to those used during the treatment phases. Due to the fact that explicit cueing has been shown to evoke increased vocal intensity in patients with PD without any prior therapy or training (Ho et al., 1999), these results may not accurately reflect the patients' performances outside of the therapy setting. Although not all studies discussed here used treating clinicians to perform assessments, many used assessment tasks similar to those used in therapy, and so this bias can be applied across the board. This highlights the need for clinicians to assess patients in more natural settings in order to obtain a more accurate picture of their abilities.

The case report by Constantinescu et al. (2010) offers suggestive evidence in favour of the efficacy of telerehabilitation delivery of LSVT. While the methodological execution of the study appears sound, it is difficult to make generalizations based on this evidence given that it describes only the results achieved by one individual. Further, the authors offer neither a statistical analysis of significance of pre- and post-therapy values attained by the participant, nor a statistical comparison of the current results to past results seen with traditional delivery methods. The authors report only that the participant's post-therapy values show improvement, are similar to those reported previously in face-to-face delivery methods and are similar to those reported for two groups of healthy adults speaking at a comfortable level. However no actual values for these other groups are reported.

In the four studies that examined participant satisfaction, participants reported high rates of satisfaction with the telerehabilitation delivery model. The participant of the case study by Constantinescu et al. (2001) even stated that he would prefer telerehabilitation to face-to-face visits with a therapist. The studies reported few technological difficulties in delivering therapy (Constantinescu, 2001; Theodoros, 2006; Constantinescu et al., 2010; Howell et al., 2009; Tindall et al., 2008). Difficulties included variable audio and video quality at times and delayed transmission, all of which were easily overcome and did not require any treatment sessions to be missed.

## *Conclusion*

The evidence offered by the studies described above is highly suggestive, however, it lacks consistency between studies. The lack of consistency makes it difficult to conclude at the current time that the telerehabilitation model is as effective as the traditional face-to-face delivery model.

Despite this, these studies demonstrate that pursuing a telerehabilitation model for delivery of LSVT to patients with PD is a promising avenue of research and should be further explored and developed. The results suggest that this method of therapy has the potential to be as effective as traditional face-to-face methods if applied correctly. Because LSVT is such a highly structured and standardized program, it lends itself well to a telerehabilitation delivery. Given the current results, with some development, LSVT via telerehabilitation should be able to maintain its high rate of success.

### *Clinical Implications*

The results of these studies suggest that a telerehabilitation delivery model for LSVT not only has the potential to be as efficacious as face-to-face therapy, but is also a feasible and desirable means of delivering therapy.

- It has the potential to deliver high quality therapy to those who live in remote areas or who are unable to attend therapy.
- Based on the cost analysis (Tindall et al., 2008), it may also serve as a cost-saving measure for those who are limited by financial constraints
- Patients with PD are highly susceptible to context effects (Ho et al., 1999), so the ability to take part in therapy in their own homes may diminish loss of learned skills when transferring from a clinical setting back to their home environment.

Review of the studies also brings to light several issues which need to be addressed prior to a conclusive decision regarding telerehabilitation being formulated:

i. Researchers should determine a protocol for delivery of therapy for each method of delivery. For example, a standard protocol for delivery over the Internet should be established; similarly, a protocol for delivery via videophone is also necessary.
ii. The efficacy of any one method (i.e, internet vs. videophone delivery) depends highly on the ability of the clinician and the patient to use the software or technology required. The necessity and feasibility of training one or both parties should be considered.
iii. Researchers should develop criteria outlining who might be a suitable candidate for telerehabilitation therapy.

The telerehabilitation method of delivering services to patients will likely become more feasible as the population ages, and greater numbers of patients seeking therapy are computer literate and are perhaps more comfortable with accessing services via telecommunication. The results of the studies discussed above demonstrate enormous potential for the field of telerehabilitation. There are many patients who live in remote areas or who cannot attend regular face-to-face therapy sessions who are likely to benefit from more convenient and less expensive therapy options. Therefore, a telerehabilitation model for delivery of LSVT therapy should continue to be pursued and further developed as a method of providing speech-language therapy to treat hypokinetic dysarthria in patients with PD.

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