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Treating the speech disorder in Parkinson's disease online

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Summary

The Lee Silverman Voice Treatment (LSVT) has been shown to be highly effective in treating the speech disorder in Parkinson's Disease (PD). However, patient access to this treatment remains limited in Australia, due to availability of speech pathologists, patient mobility and distance issues. We have investigated the feasibility and effectiveness of an Internet-based telerehabilitation application (eREHAB) for the delivery of the LSVT to persons with PD and disordered speech. Ten participants with PD and dysarthria were treated online with the LSVT for a total of 16 sessions. There were significant improvements in sound pressure levels for vowel prolongation, reading and conversational monologue ($P<0.01$), pitch range ($P<0.05$) and in perceptual features of pitch and loudness variability, loudness level ($P<0.01$) and breathiness ($P<0.05$). A participant satisfaction questionnaire indicated that 70% of participants expressed overall satisfaction with the online treatment. Telerehabilitation was feasible and effective in delivering the LSVT to people with PD.

Introduction

Parkinson's Disease (PD) is a progressive neurological disorder associated with significant physical, psychological and communicative impairments. One of the most distressing symptoms of PD is a speech disorder known as hypokinetic dysarthria which occurs in more than 75% of patients with PD, with the incidence and severity of the disorder increasing with disease progression.[1,2] The speech disturbance is characterised by monotony of pitch and loudness, imprecise articulation, reduced volume, and a breathy and hoarse vocal quality.[1,3] As a consequence of the speech impairment, the social, psychological and economic well-being of the person with PD are often seriously affected, such that the individual becomes increasingly isolated within his/her own family and the community at large.[2,4]

To date, the most effective treatment for the speech disturbance associated with PD is the Lee Silverman Voice Treatment (LSVT) programme developed by Ramig and colleagues.[5] This treatment has been shown to be effective in improving the speech and voice in 90% of persons with idiopathic PD and hypokinetic dysarthria, with the positive effects of this intervention being documented for up to two years post therapy.[6] The treatment is a structured programme delivered intensively in 16 sessions over four weeks. The aim is to increase vocal volume and physiological effort to produce a loud voice. Significant improvements in vocal parameters (volume, pitch and loudness variability, and vocal quality) articulation, rate of speech, intonation, speech intelligibility and functional communication have occurred as a result of this treatment.[7]

Despite the existence of this effective speech treatment, access to the LSVT for people with PD remains limited, particularly in regional and rural/remote areas of Australia. One barrier to accessing treatment is the limited availability of certified LSVT clinicians in these communities. There are persistent difficulties in recruiting and retaining speech pathologists in rural and remote settings in Australia[8] and the probability of a certified LSVT clinician working in these areas is extremely low. Another barrier to accessing treatment relates to mobility issues specific to this population. For many people with PD, their movement disorder alone may preclude or impede their attendance at a health care facility, in either an urban or rural environment. In addition, the majority of people with PD are elderly and frequently depend on a spouse of similar age, or carer, to assist them. This further complicates their access to services.

While there have been several telehealth applications developed to assess and treat various communication disorders,[9] there do not appear to have been any online

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applications specifically designed to treat the dysarthric speech disturbance associated with PD. The aim of the present study was to determine the feasibility and efficacy of an Internet-based telerehabilitation application specifically designed to deliver the LSVT online.

Methods

Ten participants (mean age 73 years, SD 10) were recruited to the study. They had been diagnosed with idiopathic PD by a neurologist, and with a perceptible hypokinetic dysarthria by a speech pathologist. The participants were 8 males and 2 females, with a mean post-onset duration of 5.7 years (range 1–14 years). The severity of dysarthria ranged from mild to moderate-severe. Participants were excluded from the study if they had a history of, or a co-existing neurological disorder other than PD, a previous history of speech disturbance prior to the present speech deficit, respiratory and laryngeal dysfunction unrelated to PD, or a positive history of alcohol abuse and/or dementia.

Equipment

The telerehabilitation system (eREHAB) used to administer the LSVT online provided videoconferencing via a 128 kbit/s Internet link. The system used two Web cameras at the patient's end (Figure 1), remotely controlled by the clinician's computer (Figure 2). A store-and-forward facility allowed the capture of high quality (PAL resolution) video and audio recordings for assessment and treatment purposes, from the second Web camera. The system's speech processor generated real-time calibrated sound pressure level (SPL) (dB-C) and peak frequency (Hz) during assessment and treatment tasks. This processor, in combination with a headset microphone worn by the participant, delivered continuous sound level and pitch data to the eREHAB system and then to the clinician in real-time. A text transfer facility enabled printed stimulus and treatment materials to be sent by the clinician to the participant's computer.

Procedure

The participant, wearing a headset microphone positioned 5 cm from the corner of their mouth, sat in front of the eREHAB system and interacted with a clinician in another room via the videoconference link. Prior to, and following the treatment, each participant was assessed online by a researcher not involved in the treatment. Assessment involved measures of the average SPL of the participant's voice during the production of six sustained phonations of the vowel /a/, reading of a standard passage, and during a 30–40s sample of a conversational monologue. A measure of pitch range was determined from the difference between the means of the participant's highest and lowest pitch levels achieved during six pitch glides to highest and to lowest pitch levels, respectively, as measured by the eREHAB speech processor.

Perceptual ratings of the participant's reading and conversational monologue samples from audio recordings obtained online pre- and post-treatment were performed by two clinicians independent of the study. These samples were rated on a 5-point scale (1 = normal to 5 = severe impairment) according to seven parameters of speech and voice: overall speech intelligibility, articulatory precision, breathiness, hoarseness, pitch and loudness variability, and loudness level. The pre-and post-treatment speech samples were randomly recorded onto a CD with 30% of the samples (3 pre- and 3 post-treatment samples) repeated for intra-rater reliability analysis. Each clinician independently rated the samples and was permitted to listen to the recordings as many times as required to make a judgement.

Intra-class correlations revealed high inter-rater reliability (ICC = 0.75) across all 7 parameters rated with percentage levels of agreement between the raters ranging from 95 to 100% at ± 1 point on the rating scale. Intra-rater reliability was found to be high for both rater 1 (ICC = 0.92) and rater 2 (ICC = 0.94), with both raters achieving 100% level of agreement at ± 1 on the scale. Where the ratings differed by one or more points on the scale, these samples were re-rated in a subsequent session where the two clinicians conferred to produce a single consensus rating which was then used in the statistical analyses.[10]

Figure 1 Equipment at the patient's end

Figure 2 Equipment at the clinician's end

Each participant was treated by a certified LSVT clinician as prescribed by Ramig *et al.*[5] for one hour per day, 4 days per week, for 4 weeks. The treatment involved multiple repetitions of sustained phonation, pitch glides and functional phrases in a loud voice, as well as reading and conversational activities. In addition to the treatment sessions, the participant was required to complete daily homework exercises and functional communication assignments throughout the 4 week programme. Following the treatment, each participant completed a 7-item participant satisfaction questionnaire relating to the online environment including audio and visual quality, and overall satisfaction with the online treatment experience.

Results

The pre- and post-treatment results for measures of SPL and pitch range were analysed using paired *t*-tests to determine treatment effects ($P<0.05$). Results indicated significant increases in SPL for sustained phonation, reading and conversational speech for the group (Table 1). Similarly, a significant increase in mean pitch range ($t=2.5$; $P=0.032$) was identified pre (mean 157.8 Hz, SD 91.0) to post-treatment (mean 229.5 Hz, SD 88.5).

Comparisons of the perceptual ratings pre- and post-treatment using Wilcoxon signed ranks testing revealed significant improvements in the degree of breathiness in the voice, loudness level, and pitch and loudness variability pre- to post-treatment (Table 2). While improvements in hoarseness, speech intelligibility and articulatory precision were identified post-treatment, these changes were not found to be significantly different from pre-treatment ratings (Table 2).

Table 1 Pre- and post-treatment SPL recordings (dB)

Task	Pre-treatment mean (SD)	Post-treatment mean (SD)	*P*-value (*t*-test)
Sustained phonation	73.2 (3.1)	84.0 (3.5)	0.0001
Reading	65.1 (1.2)	72.6 (2.5)	0.0001
Monologue	64.5 (1.7)	70.0 (1.8)	0.0001

Table 2 Pre- and post-treatment perceptual ratings of speech (on a 5 point scale)

Rating	Pre-treatment mean (SD)	Post-treatment mean (SD)	*P*-value (Wilcoxon signed ranks test)
Speech intelligibility	2.1 (0.87)	1.7 (0.94)	0.102
Articulatory precision	1.9 (0.87)	1.6 (0.96)	0.083
Breathiness	2.2 (0.63)	1.4 (0.51)	0.011
Hoarseness	1.9 (0.56)	1.6 (0.51)	0.083
Pitch variability	2.0 (0.47)	1.2 (0.42)	0.005
Loudness variability	2.3 (0.48)	1.3 (0.48)	0.008
Loudness level	2.4 (0.51)	1.4 (0.51)	0.008

The participant satisfaction questionnaire data revealed that 70% of participants were more than satisfied overall (ratings included 'satisfied', 'more than satisfied' and 'very satisfied') with the online treatment; the remaining 30% were very satisfied with the experience. With respect to audio quality, 90% of the participants rated this aspect of the system as adequate to excellent with 10% of participants rating it as inadequate. The visual quality of the system was rated as adequate or better by 70% of participants, while 30% considered the quality to be less than adequate.

Discussion

The results of the present study indicate that improvements in the dysarthric speech disturbance associated with PD can be achieved through the delivery of the LSVT across the Internet. Significant improvements in vocal volume in a variety of speech tasks and several perceptual features of voice and speech were achieved. These improvements were consistent with previously reported outcomes for the LSVT when delivered face-to-face. Previous studies have found post-LSVT increases in SPL of approximately 4.6 dB for conversational monologue, 8 dB for reading, and up to 14 dB for sustained phonation.[11,12] These increases are consistent with the values for SPL obtained in the present study for conversational monologue (5.5 dB), reading (7.5 dB) and sustained phonation (10.8 dB), indicating that the primary focus of the LSVT, increasing vocal volume, can be achieved online.

Breathiness, a common feature of the speech disorder in PD,[3] is considered to be associated with incomplete vocal fold adduction, reduced laryngeal muscle activation, abnormal vocal fold tension or movement, and/or stiffness and rigidity.[13,14] Previous studies have demonstrated significant improvements in perceptual ratings of breathiness of the voice following LSVT[15] consistent with concomitant improvements in acoustic and physiological characteristics of laryngeal function.[5,11,12,16] The significant improvement in perceived breathiness in the participants' voices in the current study post-LSVT is, therefore, consistent with previously reported effects of the LSVT delivered face-to-face.

Similarly, the significant improvements in perceived loudness level and pitch and loudness variability identified in the present study are consistent with previously reported treatment effects of the LSVT.[11] A soft vocal volume and reduced pitch and loudness variability are cardinal features of hypokinetic dysarthria.[3] The LSVT is specifically designed to improve the overall loudness level and variability of the person's voice through exercises to improve respiratory drive, vocal fold adduction and sub-glottal pressure. In addition, the treatment includes exercises to lengthen and shorten the vocal folds in order to facilitate greater variations in pitch of the voice.[5]

Although the results suggested a trend to improvements in perceived speech intelligibility, articulatory precision and the degree of hoarseness in the treatment group, the lack of significant change pre- to post-treatment may reflect the relatively small sample size, the predominantly mild speech disturbances exhibited by the participants and/or the inherent difficulties of perceptual rating. While the small group sample size may have contributed to the lack of significant improvements in these speech and voice features, it is also possible that the 5-point rating scale was insufficiently discriminating for persons with mild speech and voice disturbances and therefore, no significant treatment effect was determined for the group. It has also been reported that perceptual rating of vocal quality, such as hoarseness, is particularly difficult and thus less reliable than expected.[17] Future research involving larger numbers of participants exhibiting a wider range of severity of the speech disturbance may achieve different outcomes.

Positive feedback regarding the online treatment experience was obtained from the majority of participants indicating that online delivery of the treatment was acceptable. Some respondents, however, indicated that the audio and visual quality was less than adequate. As this application utilised an IP connection, the audio and visual quality of the eREHAB system was at times compromised by competing Internet traffic, which resulted in less than ideal audio and visual quality. Despite this problem all assessment and treatment sessions were completed by each participant. Although using a low speed bandwidth connection limited the performance of the current system to some degree, the application was designed to function in rural areas in Australia where low Internet connections exist.

In conclusion, the results of the study demonstrate the feasibility of an Internet-based telerehabilitation application designed to deliver the LSVT to persons with PD. Further research, involving larger numbers of participants, will now be required to validate the effectiveness of online LSVT compared to face-to-face treatment delivery.

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